Stronger Relationship Between Particulate Matter (PM) and Premature Death

March 23, 2006
Overview

- Health Effects and confirmatory evidence
- Air quality standards and regulations are increasingly reliant on these study results
- Key studies of mortality effects (premature death)
- A new California-based study (Jerrett et al.) indicates we are underestimating mortality
- Implications for ARB Programs
What We’ve Learned to Date

- ~9,000 Californians die prematurely, in 2000, due to particulate matter and ozone exposure above State ambient air quality standards
- Exposures to air pollution can shorten life by about 14 years for people who die prematurely
- Value of preventing premature death is $7.9 million (2005 dollars) by U.S. EPA
- Californian’s have a disproportionate share of PM exposure
Scientific Confirmatory Evidence

- Observed health improvements following significant emission reductions
  - Coal ban in Dublin, Ireland
  - Sulfur reduction in Hong Kong
  - Steel mill closure in Utah Valley
  - Children’s Health Study
Death Rates After Coal Ban, Dublin Ireland

- Non-trauma
- Cardiovascular
- Respiratory
- Other Non-trauma

% Change
-18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18

Total Non-trauma Cardiovascular Respiratory Other Non-trauma
Death Rates for Two Age Groups after Sulfur Restriction, Hong Kong

- 15-64 years
- 65+ years

All causes
Cardiovascular
Respiratory

% Change
-1.8%  -2.8%  -2.4%
-1.6%  -2.4%  -2.4%
-4.8%  -4.2%  -4.8%

Courtesy of Robert O'Keefe, Health Effects Institute
13-Month Steel Mill Strike, In Utah

Winter Hospital Admissions for Children

- Bronchitis & Asthma
- Pneumonia & Pleurisy
- Total Respiratory

Cases

- Open (1985/86)
- Closed (1986/87)
- Open (1987/88)
Relocation and Lung Function, Children’s Health Study California

- Children’s Health Study followed relocated children from the larger study
- Decrease in PM10 exposure associated with an increase in lung function growth rate
- Increase in PM10 exposure associated with a decrease in lung function growth rate
Support of ARB’s Programs

- Set State particulate and ozone standards below the level of adverse health impacts and urged U.S. EPA to do the same.
- Health benefits of State standard attainment.
- Health benefits of adopting diesel control measures to cut PM exposure 85% by 2020.
- Added “lives saved” to cost-effectiveness calculations.
Cost-Effectiveness

- Compare Health Benefits with Control Costs
- Methods endorsed by NAS, U.S. EPA, WHO

- Diesel PM Regulations
  - $4 to $28 of benefits per $1 of control

- Goods Movement Plan
  - $3 to $8 of benefits per $1 of control
Where do These Numbers Come From?

Key PM Mortality Studies
Progression of Key Health Studies

- ACS Study ‘95
- 6 City Study ‘93
- AHSMOG ‘99
- U.S. EPA PM2.5 Standard 1997
- Reanalysis Dr. Krewski et al. (2000)
- CARB PM2.5 Standard 2002
Follow-up study:
- Yielded a higher risk of 6% for all cause of premature death for each increase of 10 ug/m3 increase of PM2.5.
- Lung cancer association
Spatial Analysis of Air Pollution and Mortality in Los Angeles

Jerrett et al. (2005)
Study Population

SAME
- American Cancer Society (ACS) Cohort
- 1982 at recruitment - both males and females were 30 or older
- Comprehensive questionnaire
  - Diet, smoking history, occupational, education, alcohol use, weight, etc.

DIFFERENT
- National versus Los Angeles
- 51 cities versus LA region only
- 500,000 versus 22,905
- ACS Cohort Size
Methods

SAME

- PM2.5 only
- 44 confounders

DIFFERENT

- LA study
  - Additional confounding factors such as income, education and crime rate
- Exposure
  - National: average PM2.5 for a city assigned same value to all participants in city
  - LA: PM2.5 data from 23 sites for 2000 then modeled and assigned to zip-codes
Air Quality Data in Jerrett Study

Interpolated Surface of PM2.5

Courtesy of Dr. Michael Jerrett, USC
Jerrett’s Results

Death Associated Per Increase in 10 µg/m³ PM2.5

<table>
<thead>
<tr>
<th>Condition</th>
<th>Sample Size</th>
<th>Relative Risk Estimate</th>
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<tbody>
<tr>
<td>ALL CAUSES</td>
<td>5,856</td>
<td>1.24</td>
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<tr>
<td>ISCHEMIC HEART DISEASE</td>
<td>1,462</td>
<td>1.15</td>
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<tr>
<td>CARDIO-PULMONARY</td>
<td>3,136</td>
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<tr>
<td>LUNG CANCER</td>
<td>434</td>
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PM2.5 only
PM2.5 + Confounders
Comparison of Results
National (Pope et al.) versus LA (Jerrett et al.)

Death Associated Per Increase in 10 µg/m³ PM2.5

- **ALL CAUSES**
  - Pope et al. 2002: 1.06
  - Jerrett et al. 2005: 1.10

- **CARDIOPULMONARY**
  - Pope et al. 2002: 1.09
  - Jerrett et al. 2005: 1.10
Summary of Jerrett’s Results

- Within-city exposure gradients show PM2.5 effects on premature death 2.5 x higher than across-city studies, but uncertainty range is wider

- Strongest effects from PM2.5 with ischemic heart disease and all-cause deaths
Strengths of Jerrett et al. Follow-up Study

- Studied real people in California environment
- More accurate PM exposure measurements
- More typical mixtures of air pollution, including freeway emissions
- Captured potentially vulnerable groups
Weaknesses of Jerrett’s work

- Less statistically robust
- Dividing analyses (cities, causes of death, sub-populations) increases range of uncertainty
- Not all potential confounders measured (stress, other pollutants)
- May not be representative of other CA regions
Where the Science is Going?

- Supports general conclusion on association of PM exposure and premature death
- Strengthens association with cardiovascular impacts of PM
- Improves on exposure characterization
- Provokes issue of underestimation
Next Steps

- Replicate in Other Large Cities

- Pooling
  - Blend strengths of LA study with greater statistical certainty of national study
  - Review results of new studies to be published later this year
  - Consistent methodologies with other environmental agencies
  - Peer review methodology
Policy Implications

- **Air Pollution Causes Premature Death**
  - Greater share of total CA deaths than estimated to date, but range would widen
  - Will increase public demand for progress

- **Particulate Matter Standards**
  - Stronger support for standard attainment
  - Attainment provides larger benefits
  - Current CA standard protective enough
Policy Implications, continued

- **Diesel Regulations**
  - Health benefits greater than previously estimated
  - More cost-effective than previously thought

- **Communications / Public Education**
  - Need to get revision right and explain basis
  - Message is not “more people are dying” but rather “air pollution is the hidden cause of deaths that were previously attributed to other causes”
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