Making the Connection: Health-Based Standards

Barbara Weller, Ph.D.
Outline of Presentation

- Health Protection and the Standards Setting Process
- Sensitive Groups
- Pollutants of Concern in the Valley
- Health impacts of Particulate Pollution
  - Studies used in Standards Setting
- Ozone Health Impacts
  - Ozone Standard
Ambient Air Quality Standards
WHAT IS AN AMBIENT AIR QUALITY STANDARD?

- **Legal definition of clean air**
- **Establish maximum allowable levels to protect your health and welfare**
- **Elements:**
  - Definition of the pollutant
  - Averaging time
  - Concentration
  - Monitoring method
- **Based solely on health and welfare**
The Standard Review Process

Draft Report - ARB & OEHHA

Public

Public Workshops

AQAC

AQAC Public Meetings

Final Staff Report

Public Workshops

Board Hearing

Initial public comment period

45-day public comment period
Air Quality Advisory Committee (AQAC) Review

- Required by State law
- Members appointed by University of California President

**Purpose of AQAC review:**
- Assess adequacy of scientific basis for proposed standards
- Assess adequacy of proposed standards to protect public health
Ambient Air Quality Standards

- **Children’s Environmental Health Protection Act**
- **Criteria Pollutants**
- **Priorities**
  - Particulate Matter
  - Ozone
  - Nitrogen Dioxide
# California Ambient Air Quality Standards

<table>
<thead>
<tr>
<th></th>
<th>24 Hour</th>
<th>Annual</th>
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<tbody>
<tr>
<td>PM10</td>
<td>50 ug/m3</td>
<td>20 ug/m3</td>
</tr>
<tr>
<td>PM2.5</td>
<td>Annual 12 ug/m3</td>
<td></td>
</tr>
<tr>
<td>Ozone</td>
<td>0.09 ppm</td>
<td></td>
</tr>
<tr>
<td>NO2</td>
<td>0.25 ppm</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>8 Hour</th>
<th>9.0 ppm</th>
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<tbody>
<tr>
<td>CO</td>
<td>1 Hour</td>
<td>20 ppm</td>
</tr>
<tr>
<td>SO2</td>
<td>24 Hour</td>
<td>0.04 ppm</td>
</tr>
<tr>
<td></td>
<td>1 Hour</td>
<td>0.25 ppm</td>
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</table>
# Health Benefits of Meeting the State Ambient Air Quality Standards*

<table>
<thead>
<tr>
<th>Health Effects</th>
<th>SJV</th>
<th>Statewide</th>
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<tbody>
<tr>
<td>Mortality</td>
<td>1,400</td>
<td>8,800</td>
</tr>
<tr>
<td>Hospital Admissions</td>
<td>1,200</td>
<td>7,700</td>
</tr>
<tr>
<td>School Absences</td>
<td>880,000</td>
<td>4,700,000</td>
</tr>
<tr>
<td>Work loss days</td>
<td>200,000</td>
<td>1,400,000</td>
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* Based on 1999-2000 air quality data
Our Focus is On Sensitive Populations

- Elderly
- Children
- Pre existing Disease
- Exposure
Sources and Levels of Pollutants of Concern

- **Particulate Matter**
  - Sources
  - Secondary Particulate Matter
  - Size Fractions
  - Levels in the Valley

- **Ozone**
  - Atmospheric Formation
  - Levels in the Valley
What is Particulate Matter?

A complex mixture that may contain:

- Soot
- Smoke
- Metals
- Elemental and Organic Carbon
- Nitrates
- Sulfates
- Acids
- Pollen
- Vegetation
- Dust
- Water
- Tire Rubber
Sources of Particles

- Fuel combustion
- Mechanical abrasion (brake wear, tire wear)
- Road dust (paved, dirt)
- Agricultural activities
- Fugitive dust
- Biological (pollen, fungi)
- Sea salt
- Meat cooking

Gas-to-particle Conversion (Secondary PM)

Directly Emitted (Primary PM)

- Fuel combustion
- Livestock
- Sewage
- Biogenic hydrocarbons
RELATIVE SIZES OF PARTICLES

PM in the air has 3 size ranges

- PM10 = Coarse + Fine + Ultra-Fine
- PM2.5 = Fine + Ultra-Fine
PM levels in the Valley

San Joaquin Valley Air Basin Annual Average PM2.5

- Fresno
- Bakersfield
- Stockton
- U.S. Standard
- California Standard

Micrograms per cubic meter

1999 2000 2001 2002 2003 2004 2005
Ozone Formation

$h v + \text{NO}_2 \rightarrow \text{NO} + \text{O}$

+ RO2

Fuel Combustion

$\text{O}_3 + \text{NO}$

$\rightarrow \text{NO}_2 + \text{O}_2$

(ozone “scavenging” reaction)

Hydrocarbons convert NO to NO2 without using ozone
Ozone in the Valley

San Joaquin Valley Air Basin Ozone Exceedance Days

Number of Days

Year
Health Effects Studies

- Controlled human exposure studies
- Controlled animal exposure
- Epidemiology
Health Impacts of PM

- **Disease Impacts**
  - Mostly Cardiovascular Impacts
  - Inflammation

- **Premature Death**
  - Key Health Studies
  - Recent Findings
  - Studies used in Standards
Cardiovascular Impacts

- Acute Effects
- Chronic Effects
- Traffic Effects
Particulate Air Pollution and Fatal Coronary Heart Disease: Women may be at Greater Risk

Chen et al. 2005
Chronic Cardiovascular Impacts of PM Pollution

- **Cardiovascular disease (heart disease and stroke)**
  - Leading cause of death in US
  - Heart disease kills 30% of Californians
- **Atherosclerosis is the primary cause of heart disease and stroke**
- **Atherosclerosis is an inflammatory disease**
- Ambient levels of particle pollution (PM2.5) may contribute to atherosclerosis through an inflammatory response
- Atherosclerosis results from a complex process and this response may be the result of a combination of various urban pollutants interacting with host factor

Traffic Effects

- Long-term exposure to PM associated with increased deaths from heart and lung disease, including lung cancer
- Living near a major roadway associated with increased death from heart and lung disease
- In-vehicle exposures important to overall exposure to vehicle-related pollutants
Epidemiology Studies
PM Premature Death
Progression of Key Health Studies

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
Death Risk and Long-term PM
Harvard Six-Cities Study

Dockery et al., 1993
Follow-up Studies

- ACS Study '95
- 6 Cities Study '93
- AHSMOG

Reanalysis
Dr. Krewski et al. (2000)

Follow-up Studies
Dr. Pope et al. (2002)

Follow-up Studies
Jerrett et al. '05
Laden et al. '06

BETWEEN CITIES

BETWEEN CITIES

IMPROVED EXPOSURE

IMPROVED EXPOSURE
Exposure Surface PM2.5

Jerrett et al. 2005
Jerrett’s Results

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

<table>
<thead>
<tr>
<th>Cause</th>
<th>PM2.5 only</th>
<th>PM2.5 + Confounders</th>
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</thead>
<tbody>
<tr>
<td>ALL CAUSES</td>
<td>1.24</td>
<td>1.15</td>
</tr>
<tr>
<td>ISCHEMIC HEART DISEASE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CARDIO-PULMONARY</td>
<td></td>
<td></td>
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<tr>
<td>LUNG CANCER</td>
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</tbody>
</table>

Sample sizes:
- ALL CAUSES: Sample size 5,856
- ISCHEMIC HEART DISEASE: Sample size 1,462
- CARDIO-PULMONARY: Sample size 3,136
- LUNG CANCER: Sample size 434

Jerrett et al. 2005
Comparison of Results
National (Pope et al.) versus LA (Jerrett et al.)

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

- ALL CAUSES
  - Pope et al. 2002: 1.06
  - Jerrett et al. 2005: 1.15

- CARDIOPULMONARY
  - Pope et al. 2002: 1.09
  - Jerrett et al. 2005: 1.10
Health Benefits of PM Control Intervention Studies

Winter Hospital Admissions for Children

- Other Interventions
- CHS relocation (improved lung function growth)
- Dublin coal ban
- Erfurt, Germany reunification
- Hong Kong sulfur reduction
- Ongoing
- An Opportunity?
- Diesel retrofits

Utah Valley Steel Mill Closure
PM Standards Based Mainly on Epidemiological Data

- Represent real-world exposures and health outcomes
- Can examine different population segments (e.g. children, asthmatics, elderly)
- For gaseous pollutants, air quality standards based in part on controlled exposure studies
- Since PM composition is complex, epidemiological studies are more relevant
Basis of the Particulate Matter Standards

- ACS Study ‘95
- 6 Cities Study ‘93
- AHSMOG

Reanalysis
Dr. Krewski et al. (2000)
## Existing Annual Average Standards for Particulate Matter

<table>
<thead>
<tr>
<th>Organization</th>
<th>PM measure</th>
<th>Concentration ($\mu$g/m$^3$)</th>
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<tbody>
<tr>
<td>U.S. EPA</td>
<td>PM10</td>
<td>--</td>
</tr>
<tr>
<td>European Union</td>
<td>PM10</td>
<td>40</td>
</tr>
<tr>
<td>European Union</td>
<td>PM10</td>
<td>20</td>
</tr>
<tr>
<td>California</td>
<td>PM10</td>
<td>20</td>
</tr>
<tr>
<td>U.S. EPA</td>
<td>PM2.5</td>
<td>15</td>
</tr>
<tr>
<td>California</td>
<td>PM2.5</td>
<td>12</td>
</tr>
</tbody>
</table>
Particulate Matter Health Effects Summary

- PM responsible for most of the serious health effects known from exposure to ambient air pollutants
  - Message is not “more people are dying” but rather “air pollution is the hidden cause of deaths that were previously attributed to other causes”
  - PM related mortality is associated with cardiovascular changes
- Annual-average standards most important to attain
  - U.S. EPA standards not health-protective
- Exposure and toxicity of particles appear to vary
- Future research includes health effects of ultrafine particles
What Are the Health Effects of Ozone?

- **Disease**
  - Reduced lung function
  - Respiratory symptoms
  - Airway inflammation
  - Increased hospital and ER usage
  - Increased school absenteeism
  - Asthma induction in active children (needs confirmation)

- **Death**
  - Recent findings
Controlled Human Studies
(1 to 3 Hours): Lowest Concentrations Showing Effects

1. Decreased Lung Function: 0.12 ppm
2. Increased Respiratory Symptoms: 0.12 ppm
3. Increased Airway Resistance: 0.18 ppm
4. Airway Inflammation: 0.20 ppm
Studies of Multi-Hour Ozone Exposures: Lowest Concentrations Showing Effects

1. Decreased Lung function: 0.08 ppm
2. Increased respiratory symptoms: 0.08 ppm
3. Increased airway reactivity: 0.08 ppm
4. Airway inflammation: 0.08 ppm
5. No effects reported at 0.04 ppm
Some Individuals Are Particularly Responsive (6.6 hr exposure)

Folinsbee et al., 1991
Basis for Ozone Standard Recommendations
Basis for 1-Hour Standard

The current 1-hr standard is 0.09 ppm

- Controlled human exposure studies report lung function and symptoms effects at 0.12 ppm
- Epidemiologic studies suggest adverse effects below 0.12 ppm, but relevant averaging time and concentration difficult to determine
- Studies on ER visits for asthma suggest a lowest effect level between 0.075 and 0.11 ppm
Basis for 8-Hour Standard

The 8-hr standard is 0.070 ppm

- Controlled human exposure studies report symptoms, lung function changes, and airway responsiveness effects at 0.08 ppm
- 26% of individuals exhibited large changes with 6.6 hr exposure to 0.08 ppm
- Studies at 0.04 and 0.06 ppm reported no significant effects
Ozone Health Effects

- **Disease Effects**
  - Asthma Effects
  - Reduced Lung Function

- **Death**
  - New association of Ozone and mortality
  - Study of 29 cities in Europe implicates summer ozone concentration (Gryparis et al. 2004)
  - Study of 95 largest U.S. cities implicates both summer and all-year ozone concentrations (Bell et al. 2004)
    - Controlled for PM10 and weather
    - Multi-day concentrations increase effect
  - Levy 2004
Conclusion

- Particulate Matter and Ozone are responsible for most of the health impacts seen with pollutant exposure
- Ambient Air Quality Standards are set to protect the most sensitive citizens
- The Standards are under continual review
- More Research is needed to define the Health impacts of air pollution
Thank you