How Air Pollution Is Affecting Our Health

Environmental Science Institute for Teachers
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Overview of NAAQS Review Process

- Peer-reviewed scientific studies
- Workshop on science-policy issues

Integrated Review Plan: timeline and key policy-relevant issues and scientific questions

Integrated Science Assessment: concise evaluation and synthesis of most policy-relevant studies

CASAC review and public comment

Risk/Exposure Assessment: concise quantitative assessment focused on key results, observations, and uncertainties

Policy Assessment: staff analysis of policy options based on integration and interpretation of information in the ISA and REA

EPA proposed decision on standards

Interagency review

Agency decision making and draft proposal notice

Public hearings and comments on proposal

Agency decision making and draft final notice

Interagency review

EPA final decision on standards
Human Lung

• Air conducting
  – Trachea
  – Bronchi
  – Bronchioles

• Gas exchange
  – Respiratory bronchioles
  – Alveoli
Ozone Irritates Airways

• Symptoms
  – Cough
  – Sore or scratchy throat
  – Pain with deep breath
  – Fatigue
• Rapid onset
• Asthma symptoms - greater in people with asthma, also occur in people without asthma
Variability in Lung Function Responses

FEV1, % CHANGE

BASELINE  2HR  4HR

-60 -40 -20 0
Ozone Causes Inflammation

- Ozone reacts completely in surface layer - forms reactive oxygen molecules
- Increases permeability of cells that line airways
- Influx of white blood cells and proteins
- Damages cells that line the airways
- Effect is greater 24 hours after exposure
- Increases airway reactivity
- Concern about repeated exposures
Short-Term $O_3$ Exposure and Respiratory Effects

- Lung function decrements
  - Large body of clinical, toxicological, and epidemiologic evidence
  - Epidemiologic evidence for children, especially asthmatics

- Respiratory symptoms and asthma medication use
  - Clinical and epidemiologic evidence

- Airway inflammation and oxidative stress
  - Large body of toxicological and clinical evidence
  - New epidemiologic evidence with parallel findings in asthmatic children

- Increased airway permeability, airways hyperresponsiveness, allergic responses, and susceptibility to infection
  - Large body of clinical and toxicological evidence

- Hospital admissions/ED visits
  - Consistent positive associations across endpoints
  - Stronger associations during the summer, specifically for asthma and COPD
Short-Term $O_3$ Exposure and All-Cause (Nonaccidental) Mortality

**Study**
- Gryparis et al. (2004; 57276)
- Bell et al. (2007; 93256)
- Schwartz (2005; 57333)
- Bell and Dominici (2008; 193828)
- Bell et al. (2004; 94417)a
- Levy et al. (2005; 74347)a
- Katsouyanni et al. (2009; 199899)
- Bell et al. (2005; 74345)a
- Ito et al. (2005; 74346)a
- Wong et al. (2010; 732535)
- Katsouyanni et al. (2009; 199899)
- Cakmak et al. (2011; 699135)
- Katsouyanni et al. (2009; 199899)b
- Samoli et al. (2009; 195855)
- Bell et al. (2004; 94417)a
- Schwartz (2005; 57333)
- Zanobetti and Schwartz (2008; 195755)
- Zanobetti and Schwartz (2008; 101596)
- Franklin and Schwartz (2008; 156448)
- Gryparis et al. (2004; 57276)
- Medina-Ramon and Schwartz (2008)
- Katsouyanni et al. (2009; 199899)
- Bell et al. (2005; 74345)a
- Katsouyanni et al. (2009; 199899)
- Katsouyanni et al. (2009; 199899)b
- Levy et al. (2005; 74347)a
- Ito et al. (2005; 74346)a
- Katsouyanni et al. (2009; 199899)
- Stafoggia et al. (2010; 625034)

**Location**
- APHEA2 (23 cities)
- 98 U.S. communities
- 14 U.S. cities
- 98 U.S. communities
- 95 U.S. communities
- U.S. and Non-U.S.
- APHENA-Europe
- U.S. and Non-U.S.
- PAPA (4 cities)
- APHENA-U.S.
- 7 Chilean cities
- APHENA-Canada
- APHENA-Canada
- APHENA-Canada
- APHEA2 (21 cities)
- 21 European cities
- 95 U.S. communities
- 48 U.S. cities
- 48 U.S. cities
- 18 U.S. communities
- APHEA2 (21 cities)
- 48 U.S. cities
- APHENA-Europe
- U.S. and Non-U.S.
- APHENA-Canada
- APHENA-Canada
- U.S. and Non-U.S.
- APHENA-Canada
- 10 Italian cities

**Lag**
- 0-1
- 0-1
- 0-6
- 0-6
- DL(0-2)
- DL(0-2)
- DL(0-2)
- DL(0-2)
- DL(0-2)
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- DL(0-2)
- DL(0-2)

**% Increase**
- All-Year
- Summer
- -1 1 3 5 7 9 11

*Effect estimates standardized to 20 ppb increase in 24-h avg; 30 ppb increase in 8-h max; and 40 ppb increase in 1-h max $O_3$ concentrations.

ISA Figure 6-27
Respiratory Hospital Admissions by Daily Maximum Ozone Level, Lagged One Day

(Burnett et al, 1994)
California Children’s Health Study
Study of Effects of Long-term Exposures
CHS: Ozone and School Absences

- 20 ppb increase in O$_3$ associated with an 83% increase in school absences for acute respiratory disease (Gilliland et al., 2001)

- Large economic impact of pollution-related school absences (Hall and Lurmann, 2003)
### CHS: Ozone and New-onset Asthma

McConnell et al., 2002

<table>
<thead>
<tr>
<th>Sports</th>
<th>Low $\text{O}_3$ Towns</th>
<th></th>
<th></th>
<th>High $\text{O}_3$ Towns</th>
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<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>asthma</td>
<td>RR</td>
<td>#</td>
<td>asthma</td>
<td>RR</td>
</tr>
<tr>
<td>0</td>
<td>58</td>
<td>1.00</td>
<td></td>
<td>46</td>
<td>1.00</td>
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</tr>
<tr>
<td>1</td>
<td>50</td>
<td>1.28</td>
<td></td>
<td>40</td>
<td>1.28</td>
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<tr>
<td>2</td>
<td>20</td>
<td>0.82</td>
<td></td>
<td>16</td>
<td>1.28</td>
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<tr>
<td>≥3</td>
<td>9</td>
<td>0.79</td>
<td></td>
<td>20</td>
<td>3.31</td>
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</tr>
</tbody>
</table>
Sensitive Groups for Ozone

- People with asthma
- Children and older adults
- Outdoor workers and people who are active outdoors
- People with reduced intake of certain nutrients (e.g., vitamins C and E)
- People with certain genotypes, related to oxidative stress
Many U.S. cities saw a decrease in 2013 in the number of days when ozone levels reached “code orange” or “unhealthy for sensitive groups” on the Air Quality Index (AQI). A number of factors influence ozone formation, including emissions from cars, trucks, buses, power plants, and industries – and weather conditions. Weather is especially favorable for ozone formation when it’s hot, dry and sunny, and winds are calm and light. Weather conditions were much wetter than average in the U.S. during the summer of 2013, which limited ozone formation in many regions of the country.
Particle Pollution Disasters

Donora, PA at noon on Oct. 29, 1948

London buses are escorted by lantern at 10:30 in the morning.
Particle pollution is a complex mixture derived from many sources.
Particle Deposition

- Larger particles (> PM\textsubscript{10}) deposit in the upper respiratory tract
- Inhalable particles (\leq PM\textsubscript{10}) penetrate into lungs
- Some particles (e.g., less than 0.1 um) may enter bloodstream
- Particles may react, accumulate, be cleared or absorbed
Living in Areas with High Air Pollution Associated with Shorter Life Expectancy

- Linear relationship after control for traditional risk factors
Findings Replicated by Large American Study and Others

- >500,000 adults from 151 metropolitan areas
- Followed prospectively and controlled for traditional risk factors

American Cancer Society Cohort
Pope et al. 2002

Pope and Dockery 2006
Findings Replicated by Large American Study and Others

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American Cancer Society Cohort
Pope et al 2002

Pope and Dockery 2006
Strongest Associations For Cardiovascular Endpoints

No Effect Line

Strongest Associations For Cardiovascular Endpoints

No Effect Line
Small but Consistent Increases in Mortality with Short-Term Changes in PM
CHS: Low FEV$_1$ at Age 18 vs. Pollution

Gauderman et al., 2004
CHS: Lung Function Growth in Movers

Avol et al., 2001
Living Within 300 Meters of Local Roadways Affects FEV$_1$

Brunekreef et al., 1997
Traffic Exposures

• Traffic exposure linked to respiratory symptoms in several European studies
• San Francisco bay area study linking pollution exposures at schools to symptoms (Kim et al., 2004)
• CHS study of residential NO$_2$, traffic linked to asthma prevalence, symptoms, and medication use (Gauderman et al., 2005)
Sensitive Groups for PM

- People with cardiovascular disease
- People with lung disease
- Older adults
- Children
- People of lower socioeconomic status
<table>
<thead>
<tr>
<th>Descriptors</th>
<th>Cautionary Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good 0 – 50</td>
<td>No message</td>
</tr>
<tr>
<td>Moderate 51 – 100</td>
<td>Unusually sensitive individuals</td>
</tr>
<tr>
<td>Unhealthy for Sensitive Groups 101 - 150</td>
<td>Identifiable groups at risk - different groups for different pollutants</td>
</tr>
<tr>
<td>Unhealthy 151 - 200</td>
<td>General public at risk; sensitive groups at greater risk</td>
</tr>
<tr>
<td>Very Unhealthy 201 - 300</td>
<td>General public at greater risk; sensitive groups at greatest risk</td>
</tr>
</tbody>
</table>
Air Quality Index

- Pollutant-specific health effects and cautionary statements address question “who will be affected”
- Based on health information supporting EPA’s air quality standards (www.epa.gov/ttn/naaqs)

Dose = Concentration x Ventilation Rate x Time
   C - be active outdoors when air quality is better
   V - take it easier when active outdoors
   T - spend less time being active outdoors

- Pay attention to symptoms
- People with asthma – follow asthma action plan
- Coaches – rotate players frequently
- People with heart disease – check with your doctor
Welcome to EnviroFlash! Air quality affects how you live and breathe. Like the weather, it can change from day to day, or even hour to hour. Up-to-date information allows you to make decisions based on air quality forecasts. EnviroFlash comes to you through a partnership between the US EPA and your state or local air quality agency - notifying you about air quality so you don’t have to go searching for it.

An online subscription page allows you to sign up, edit your profile, or cancel the service. After you choose the type and frequency of service you want, EnviroFlash will be sent to your email or cell phone as specified.
AirNow App on Smart Phones

The Air Quality Index (AQI) for NW Coastal LA, CA

Pollutant: PM2.5 - Moderate 57

Pollutant: OZONE - Good 41

Air Quality Index Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>AQI Range</th>
<th>What Can You Do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good (0-50)</td>
<td>No action required. A good day for outdoor exercise!</td>
<td></td>
</tr>
<tr>
<td>Moderate (51-100)</td>
<td>Some people are unusually sensitive to air pollution. If you are one of them, take steps to reduce prolonged or heavy exertion outdoors</td>
<td></td>
</tr>
<tr>
<td>Unhealthy for Sensitive Groups (101-150)</td>
<td>It's still OK to exercise outdoors, but if you're in a sensitive group, take steps to reduce prolonged or heavy exertion. Examples: Take a walk instead of a run; weed the garden instead of doing heavier chores like spreading mulch, or exercise</td>
<td></td>
</tr>
</tbody>
</table>

For more detailed information, visit [www.airnow.gov](http://www.airnow.gov)
School Flag Program and School Activity Guidelines

- Helps school and community be aware of daily air quality conditions
- Participating schools raise a flag in front of the school that signals the air pollution forecast for that day
- By comparing the colored flags to the Air Quality Index (AQI), members of the school can tell what daily air quality is, and adjust activities to reduce children’s exposure to air pollution as needed
- We have partnered with CDC on air quality and outdoor activity guidelines for schools
- We have developed a picture book that explains AQI and flag program to children
Web Courses for Healthcare Providers

- Updated ozone Web course
  - Offers CME credit from the American Academy of Family Physicians (AAFP)
  - Supporting tools
- PM Web course
  - Developing with CDC
  - CDC will offer CME credit
  - Will contain section on emergency situations
• Issue: Heart disease is the number one killer for women but many women think of a heart attack as a problem for men.
  – Each year, about 400,000 women in the U.S. die from heart disease; > 42 million women are currently living with cardiovascular disease.
  – Heart disease kills more women than the next seven causes of death combined
• Webinars are a key communications mechanism
• Provides information about where people can find out about daily air quality in their own community to reduce unhealthy exposures.
  – EPA has developed related materials, such as downloadable fact sheets, for use by healthcare providers
• EPA partnering with organizations such as American Heart Association, American College of Cardiology, CDC and CDC’s Million Hearts Campaign
AQI Curriculum for Children and Students

Colorful lessons and games for children and students

Air Quality Index Kids Website
Teacher's Reference

Clean Air and Dirty Air

On a clear breezy day, the air usually feels nice and clear. Clean air is air that has no pollutants (dirt and chemicals) in it. Clean air is good for people to breathe.

On gray, wet, or rainy days, it may not be easy to see far away, and water may collect on the street. During cold, wet days, people may stay inside, and it may be too cold or wet to go outside. Dirty and smelly air may make it hard to see and breathe. Dirty air can make you sick.

What is pollution?

Pollution is a problem because it can make the air and water dirty. When people burn gasoline or wood, they make pollution. Some pollution comes from factories, and some pollution comes from homes. Pollution can harm people, animals, and plants. Air pollution can make people sick. Too much pollution can make it hard to see. Smoke and smog from factories can make it hard to breathe. Some pollution can make plants and animals sick.

Smoke from factories can make it hard to see. Some pollution can make people sick. It is important to keep air clean and not pollute the air.

How Can I Tell if the Air is Clean or Dirty?

You can tell if the air is clean or dirty by looking at the sky. When the sky is clear, you can see for miles. When the sky is cloudy, you can only see a short distance. When the sky is yellow or orange, the air is dirty.

For information about pollution:
http://www.epa.gov/cleantea
Pollutant-Specific Information
Public Health Benefits of the AQI

- Surveys indicated that 50 to 80% of public aware of AQI
  - Of those, 50% report taking exposure reduction measures
- People who are susceptible, more likely to report taking measures, including older adults, children, and people with heart or lung disease
- Activity studies provide evidence of exposure reduction
- Health studies provide evidence of reductions in hospital admissions and emergency department visits for asthma due to advisories

Mansfield et al., 2007

Neidell and Kinney 2009