Air Pollution and Respiratory Health Effects

March 3rd, 2006

Pennsylvania Department of Health
Bureau of Epidemiology

Mark V. White, M.D., M.P.H.
In general, increased air pollution and decreased air quality (indoor or outdoor) tend to be associated with:

increased respiratory health effects and/or exacerbations of respiratory health effects (especially asthma).

Sources:
1. Institute of Medicine (IOM). *Clearing the Air*. National Academy of Sciences, 2000
Common Air Pollutants / Exposures

- **Indoor Air**
  - animal dander/allergens (e.g. cockroach, cat, dog, dust mite)
  - environmental tobacco smoke (ETS)
  - fungi, mold, and pollen
  - volatile organic compounds (VOC)
  - radon

- **Outdoor Air**
  - Carbon Monoxide (CO)
  - Lead (Pb)
  - Particulate Matter (PM)
  - Ozone (O₃)
  - Nitrogen Oxides (NO₂, NOₓ)
  - Sulfur Dioxides (SO₂, SOₓ)

Source: http://www.epa.gov
Indoor Air

Americans spend majority of time indoors

- many adults work indoors, spend much of their time indoors
- children spend about 80%-90% of their time indoors

Studies have associated poor indoor air with increased respiratory illnesses

- indoor air especially affects young children, elderly, and those with chronic respiratory conditions
- general agreement that there is a need to control and reduce indoor exposures
- biologics, chemicals, and ‘indoor’ air contaminants can originate from outdoors

Sources:
1. Institute of Medicine (IOM). *Clearing the Air*. National Academy of Sciences, 2000
Outdoor Air

Americans do not spend much time outdoors

- many adults and children only spend around 10% of their time outdoors
- nonetheless, outdoor air quality is very important and pertinent

Studies have associated poor outdoor air with increased respiratory illnesses

- general agreement that there is a need to control and reduce outdoor exposures
- biologics, chemicals, and ‘outdoor’ air contaminants can migrate to indoors

Sources:
1. Institute of Medicine (IOM). Clearing the Air. National Academy of Sciences, 2000
Outdoor Air – Six Criteria Pollutants

1. Ozone (O$_3$)

2. Particulate Matter (PM$_{2.5}$ PM$_{10}$)

3. Carbon Monoxide (CO)

4. Nitrogen Dioxide (NO$_2$)

5. Sulfur Dioxide (SO$_2$)

6. Lead (Pb)

Source: http://www.epa.gov
Ozone (O₃)

• **What is it and from Where does it come?**
  - at ground level created by NOₓ and VOC chemical reaction in sunlight
  - “good” when high above earth, stratosphere (10-30 mi. high)
  - “bad” at ground-level, lower atmosphere
  - motor vehicle, industrial emissions, gasoline, chemical solvents emit NOₓ and VOC
  - sunlight, hot weather increase harmful concentrations of O₃

• **What are the Health Concerns, Impacts, and Effects?**

  **Respiratory**
  - irritate lung airways, cause inflammation, breathing difficulties, wheezing, coughing, pain with deep inspiration
  - people with respiratory problems most vulnerable, high levels can affect healthy people
  - repeated exposure to high levels for several months may cause lung damage, possibly permanent

Source:  http://www.epa.gov
Particulate Matter (PM$_{2.5}$), (PM$_{10}$)

- **What is it and from Where does it come?**
  - mixture of very small particles and liquid droplets
  - many components, nitrates, sulfates, organics, metals, soil, dust
  - "Coarse" particles 10 to 2.5 micrometers; roadways and dusty industries
  - "Fine" particles less than 2.5 micrometers; haze, smoke, power plants, industries, automobiles
  - average human hair is 70 micrometers in diameter

- **What are the Health Concerns, Impacts, and Effects?**

  **Respiratory and Cardiovascular**
  - size directly related to potential for health problems (deep lungs and possible bloodstream infiltration)
  - increased respiratory symptoms (airway irritation, coughing, breathing difficulty)
  - decreased lung function
  - asthma exacerbation/aggravation
  - development of chronic bronchitis
  - irregular heartbeat
  - premature death in people with lung or heart disease
  - people with lung or heart disease, children, older adults especially
  - healthy people may also experience symptoms

Source: http://www.epa.gov
Carbon Monoxide (CO)

• **What is it and from Where does it come?**
  - colorless, odorless gas formed when carbon in fuel not burned completely
  - motor vehicle exhaust = 56% CO emissions nationwide
  - other non-road based vehicles (construction equip, boats) = 22%
  - industrial processes (metal, chemical manufacturing/processing), residential, natural = 22%

• **What are the Health Concerns, Impacts, and Effects?**

  **Cardiovascular**
  - people with heart disease, angina, congestive heart failure especially susceptible
  - for person with heart disease, single low-dose exposure may cause chest pain, reduced exercise tolerance

  **Central Nervous System**
  - vision problems, ataxia, mental acuity decrease, stupor (at high levels)
  - coma, death (at extremely high levels)

  **Respiratory**
  - CO contributes to formation of smog/ground level ozone, which can cause respiratory

Source: http://www.epa.gov
Nitrogen Oxides (NO$_x$)

• What is it and from Where does it come?
  -formed when fuels are burned at high temperatures
  -motor vehicles = 55% of NO$_x$ emissions
  -electric utilities = 22% of emissions
  -industrial/commercial/residential = 22% of emissions
  -all other sources = 1% of emissions

• What are the Health Concerns, Impacts, and Effects?

  **Respiratory**
  -react with ammonia, moisture, etc. to form nitrate particles, acid aerosols, NO$_2$
  -effects breathing, damages lung tissue, premature death
  -small particles penetrate deeply into sensitive areas of lung
  -cause or exacerbate respiratory diseases (e.g. emphysema, bronchitis)
  -react with volatile organic compounds (VOCs) and sunlight to produce ground level ozone/smog

  **Cardiovascular**
  -can exacerbate existing heart disease

Source: http://www.epa.gov
Sulfur Dioxide (SO$_2$)

- **What is it and from Where does it come?**
  - formed when fuel containing sulfur (e.g. coal, oil) is burned, when gasoline is extracted from oil, or when metals are extracted from ore
  - fuel combustion (utilities/electrical production) = 67% emissions
  - fuel combustion (industrial/heat production) = 18% emissions
  - all other sources = 15% emissions

- **What are the Health Concerns, Impacts, and Effects?**

  **Respiratory**
  - gaseous SO$_2$ short-term can cause temporary breathing difficulty, especially in asthmatics
  - gaseous SO$_2$ longer-term can cause respiratory illness
  - SO$_2$ reacts with other chemicals in the air to create tiny sulfate particles
  - Sulfate particles are associated with increased respiratory symptoms and disease, difficulty in breathing and premature death

Source: http://www.epa.gov
Lead (Pb)

• **What is it and from Where does it come?**
  - found naturally in the environment, as well as in manufactured products
  - historically, major air emissions sources were motor vehicles and industrial
  - currently, major air emissions sources are metals processing (52%), waste disposal (16%), fuel combustion (13%)

• **What are the Health Concerns, Impacts, and Effects?**

  **Central Nervous System**
  - low level exposure associated with learning deficits and lowered IQ
  - higher-level exposure associated with seizures, mental retardation, memory problems, behavioral and mood disorders

  **General**
  - associated with organ and system damage (kidney, liver, brain, heart, blood, nerves, bones, reproductive)
  - no specific respiratory effects

Source: [http://www.epa.gov](http://www.epa.gov)
Asthma Fast Facts

- In 2003, an estimated 1,127,000 Pennsylvania adults reported having ever been told by a health care professional that they had asthma.
  [11.9% adult prevalence, based on data from Behavioral Risk Factor Surveillance System (BRFSS) 2003]
- In the 2002-2003 school year, approximately 189,000 school children in Pennsylvania reportedly had a medical diagnosis of asthma.
  [9.2% school child prevalence, based on data from School Health Statistics 2002-2003]
- In 2003, approximately $386 million total charges for inpatient hospitalizations for asthma (not including the doctor or physician charges).
  [based on data from Pennsylvania Health Care Cost Containment Council (PHC4) 2003]
- In 2003, there were about 21,000 inpatient hospitalizations for asthma.
  [based on data from PHC4 2003]
- The age-adjusted rate of these hospitalizations is about 17 hospitalizations for asthma per 10,000 Pennsylvanians.
  [based on data from PHC4 2003]
- The average length of stay for these hospitalizations for asthma was just over 3 days per hospitalization.
  [based on data from PHC4 2003]
- The average charge for these hospitalizations for asthma (not including the doctor or physician charges) was $15,139 per hospitalization.
  [based on data from PHC4 2003]
- In 2003, 180 Pennsylvanians died due to asthma, which is a treatable disease.
  [based on data from Vital Statistics 2003]
Asthma Death Rates in PA (2000-2002)
Source: EpiQMS

Resident Deaths
Asthma

<table>
<thead>
<tr>
<th>Age Adjusted</th>
<th>Rate/100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0-1.4</td>
<td></td>
</tr>
<tr>
<td>1.5-1.9</td>
<td></td>
</tr>
<tr>
<td>2.0-2.4</td>
<td></td>
</tr>
<tr>
<td>2.5-2.7</td>
<td></td>
</tr>
<tr>
<td>ND/NA*</td>
<td></td>
</tr>
</tbody>
</table>

Pennsylvania
State
Rate: 1.2 [1.1 - 1.3]

Source: EpiQMS

### Resident Deaths
Asthma

<table>
<thead>
<tr>
<th>Year</th>
<th>2001-2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age:</td>
<td>All Ages</td>
</tr>
<tr>
<td>Sex:</td>
<td>Total</td>
</tr>
</tbody>
</table>

### Age Adjusted
Rate/100,000

- 0.8-1.1
- 1.2-1.5
- 1.6-1.9
- 2.0-2.5
- ND/NA*

### Pennsylvania
State
Rate: 1.2 [1.1 - 1.3]
Asthma Death Rates in PA (2002-2004)  
Source: EpiQMS

Resident Deaths  
Asthma

Pennsylvania  
State
Rate: 1.2 [1.1 - 1.3]

Year: 2002-2004
Age: All Ages
Sex: Total

Age Adjusted  
Rate/100,000

- 0.8-1.1
- 1.2-1.5
- 1.6-1.9
- 2.0-2.4
- ND/NA*

55
3
4
0
Chronic Lower Respiratory Diseases (Bronchitis, Emphysema, and Asthma)
Death Rates in PA (2000-2002)

Source: EpiQMS

Resident Deaths
Chronic lower respiratory diseases

Age Adjusted
Rate/100,000
- 24.7-34.2
- 34.3-43.8
- 43.9-53.4
- 53.5-63.0
- ND/NA*

Pennsylvania
State
Rate: 39.2 [38.6 - 39.8]
Chronic Lower Respiratory Diseases (Bronchitis, Emphysema, and Asthma) Death Rates in PA (2001-2003)
Source: EpiQMS

Resident Deaths
Chronic lower respiratory diseases

Year: 2001-2003
Age: All Ages
Sex: Total

Age Adjusted
Rate/100,000
- 26.5-33.6
- 33.7-40.8
- 40.9-48.0
- 48.1-55.1
- ND/NA*

State
Rate: 39.0 [38.4 - 39.5]
Chronic Lower Respiratory Diseases (Bronchitis, Emphysema, and Asthma)

Death Rates in PA (2002-2004)

Source: EpiQMS

Resident Deaths
Chronic lower respiratory diseases

Age Adjusted
Rate/100,000
- 25.4-32.7
- 32.8-40.1
- 40.2-47.5
- 47.6-55.0
- ND/NA*

Pennsylvania
State
Rate: 39.3 [38.7 - 39.8]