

Every Breath You Take

**Health Effects of Air Pollution:
Why We Do the Work We Do**

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State is “in Attainment” NAAQS in most areas

- Spokane still has PM and CO problem
- Wallula has maintenance plan submitted
- **BUT** attainment does not mean “safe from death and illness”
- **Health effects (below annual standard of $15\mu/m^3$ and 24-hr standard of $65\mu/m^3$)**
- **Clean Air Act: NAAQS to “be protective of even sensitive populations with an adequate margin of safety”**

The Air We Breathe

- Is a **mixture** of gases and particles
- Breathing this mixture affects us **24 hours a day**, indoors and outside
- The mixture is different indoors and outside; the time we are exposed differs; we are affected differently
- The mixture depends on emissions from contributing sources



Air Pollution

**Makes Beautiful Sunsets
Impairs Visibility**

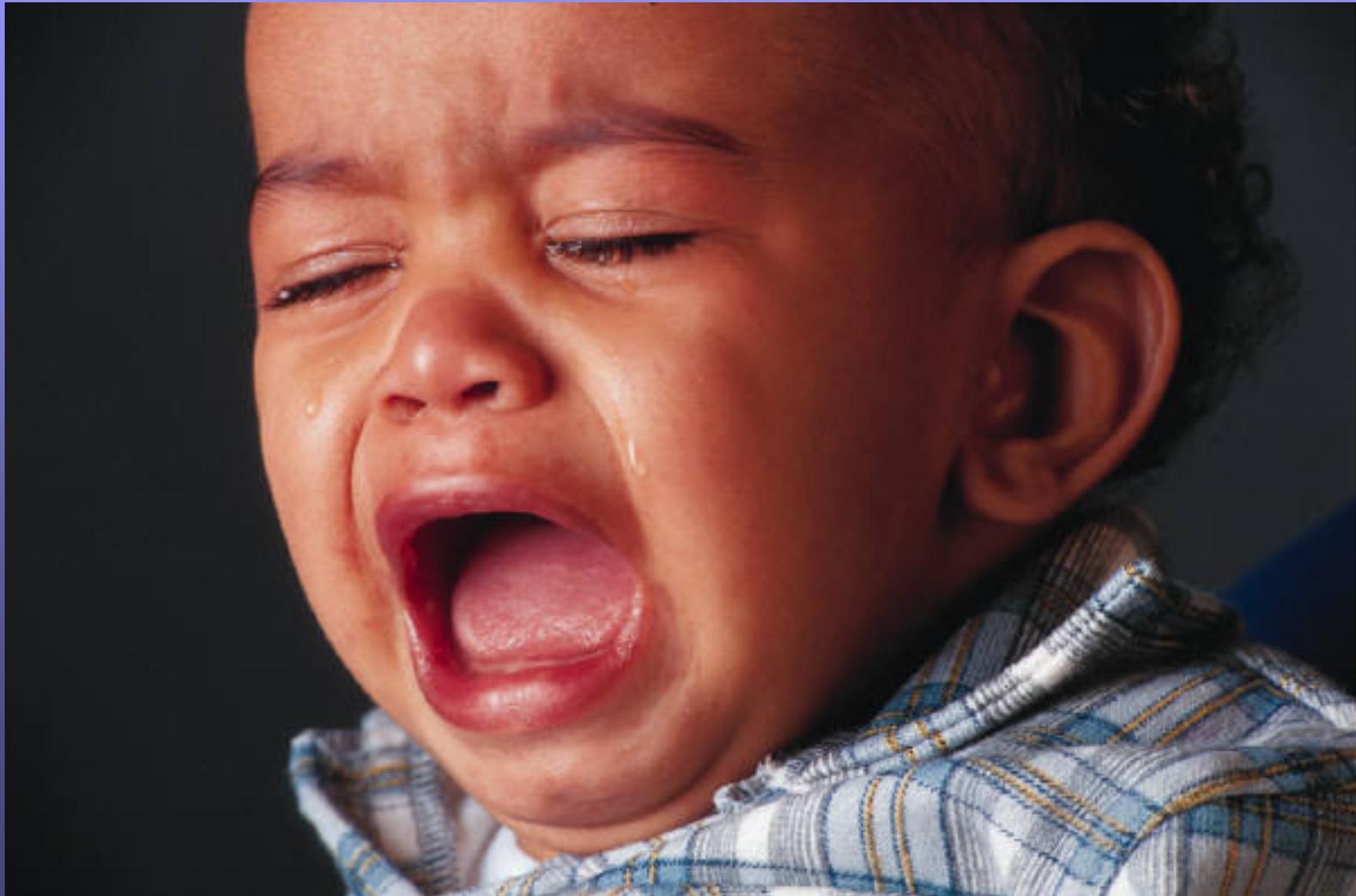
**Causes Death
And Illness**

Who is Affected?

People are affected

- **Because of *who they are*:**
age, state of health, genetic predisposition
- **Because of the *level of exposure***
higher level of exposure: greater effect
(proximity to source may determine level)

Children More Exposed More Susceptible



Children

- **Breathe more air per body weight than adults**
- **Tend to be active, breathe more**
- **Mouth breathe when active, crying**
- **Lungs still developing in infants, small children**
- **Respiratory, immune, brain defenses not fully formed**

Older adults

- Lose Immune, Respiratory Defenses with Aging
- May have Lung Injury
- May have Atherosclerosis, other Heart or Circulatory Illness, Diabetes

Increased Exposure

- **Activity Increases** Respiratory Rate, Volume
- **Mouth Breathing**
- **Proximity to sources: higher levels**
- **Topography: those in valleys more exposed than those on ridges**
- **Temperature Inversions bottle up pollutants**

Who are the Villains?

- **Combustion particles and products** (nitrogen oxides, sulfur oxides, aldehydes, polycyclic aromatic hydrocarbons and many thousand others)
- **Gaseous solvents from industrial processes, combustion, products**
- **Ozone: formed when nitrogen oxides, and gaseous solvents are energized by UV in sunlight**

Particles: Vary in Size

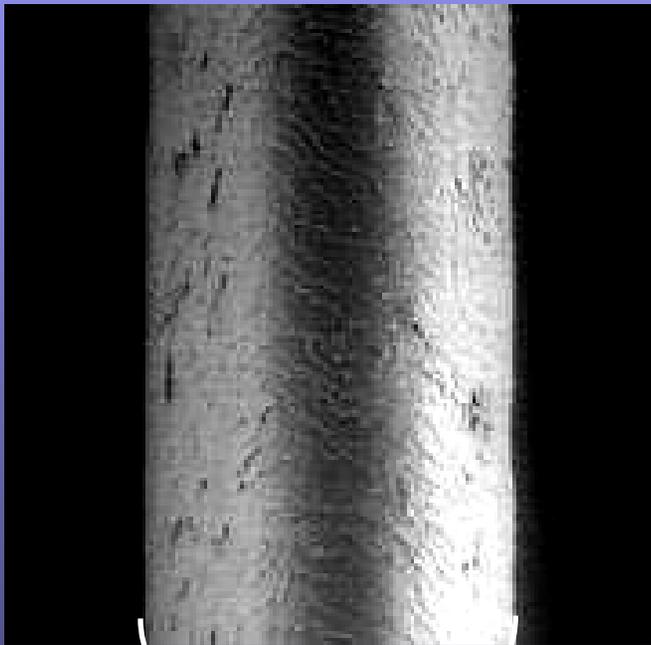
Measured by monitors as

- **Large: Total Suspended Particulate:** mostly crustal dust
- **Small: PM_{10} = 10 microns and less**
- **Fine and Ultra-fine: $PM_{2.5}$ = 2.5 microns and less, mostly smaller than one micron = Combustion particles**

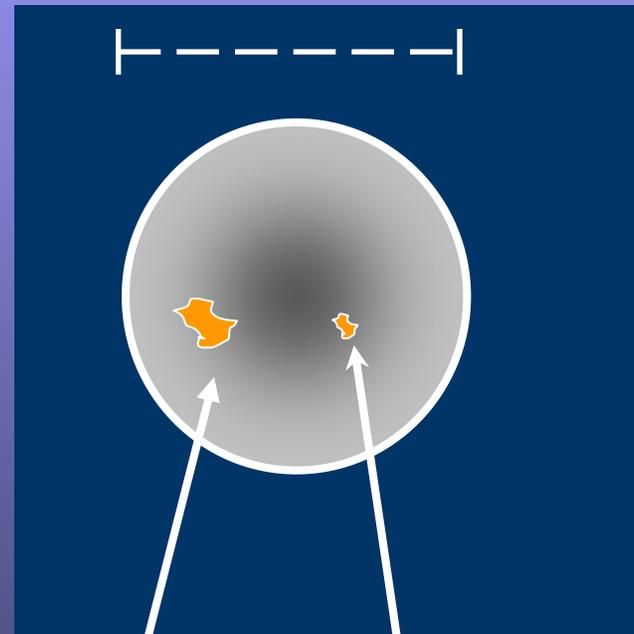
Particles: What Are They?

Airborne particles are a complex mixture of extremely small solids and liquid droplets

Hair cross section (70 μm)



Human Hair (70 μm diameter)



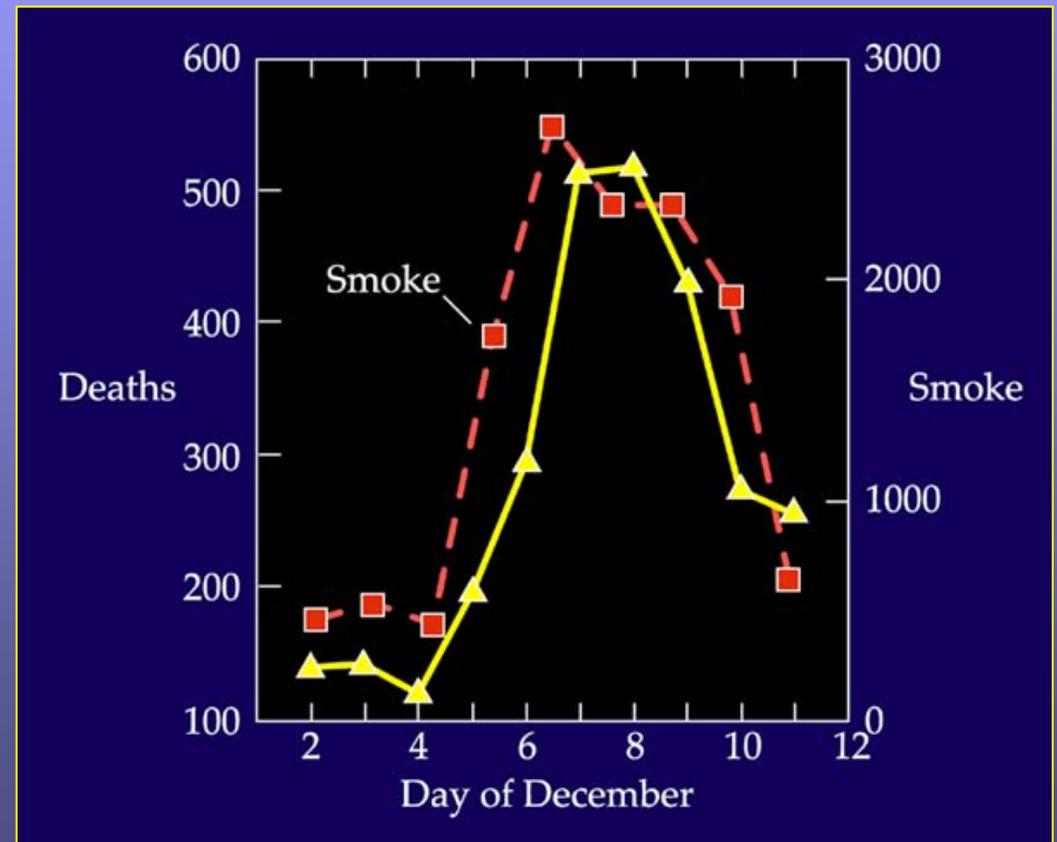
**PM₁₀
(10 μm)**

**PM_{2.5}
(2.5 μm)**

Combustion Particles

- **Most closely related to health effects (may act as surrogate for many air pollution effects)**
- **Very small (less than a tenth of a micron); distribute widely (NAAQS); go indoors**
- **Adsorb and carry other toxic combustion products on their surface and deep into the lung.**
- **Measured as and called PM_{2.5}**

London Smog Episode



Air Pollution Health Effects

- **London Smog Studies**
- **Donora Pennsylvania**
- **Modern studies: Harvard Six Cities; American Cancer Society: prospective studies of exposure to air pollutants; risk (particulate matter as surrogate); more than 200 epidemiological studies, various designs**

Factors in Evaluating Epidemiological Results

- **Strength of association:** Consistent and significant associations among studies
- **Coherency and Consistency:** similar types of health effects across studies
- **From association** in individual studies **to CAUSATION** from body of studies

Studies of Fine Particle Health Effects

- **Associations between fine particles and death**
- **Associations between fine particles and illness**
- **From chronic exposure to low levels and air pollution episodes**

Health effects from long-term, low level exposures

Illness

- **increase in chronic respiratory illness**
- **decrease lung function in children**
(predisposes children to Chronic Obstructive Pulmonary Disease as adults)

Death

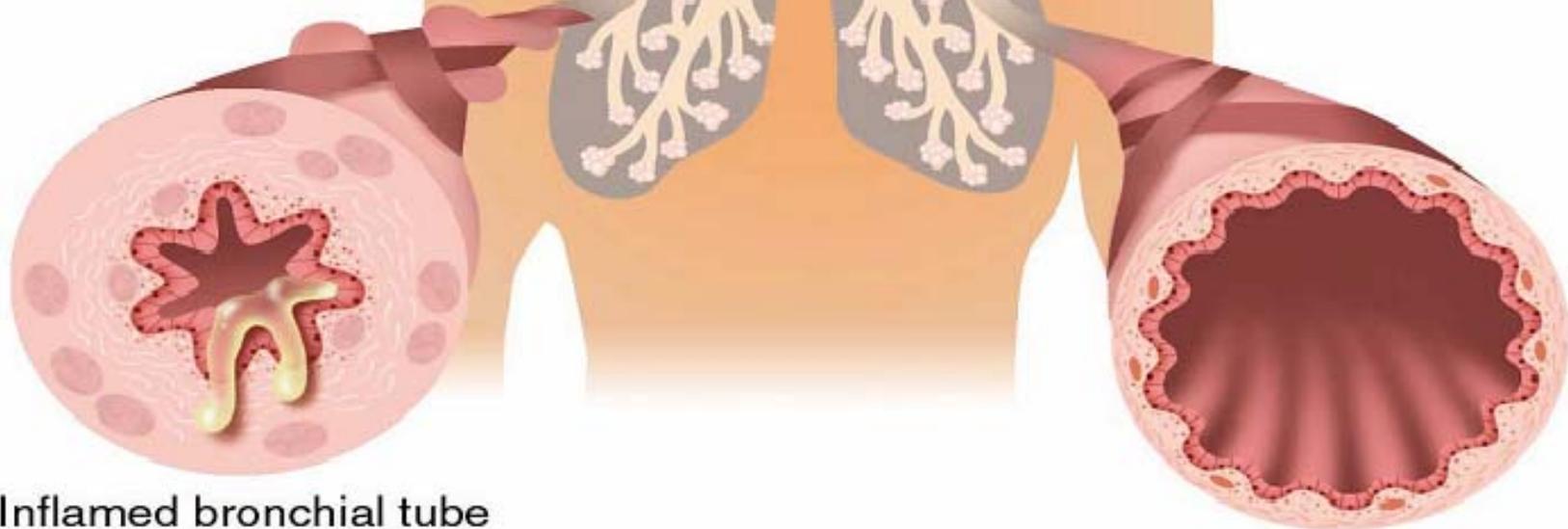
- **increases overall death rate (not just in individuals near death)**

Why asthma makes it hard to breathe

Air enters the respiratory system from the nose and mouth and travels through the bronchial tubes.

In an asthmatic person, the muscles of the bronchial tubes tighten and thicken, and the air passages become inflamed and mucus-filled, making it difficult for air to move.

In a non-asthmatic person, the muscles around the bronchial tubes are relaxed and the tissue thin, allowing for easy airflow.



Inflamed bronchial tube of an asthmatic

Normal bronchial tube

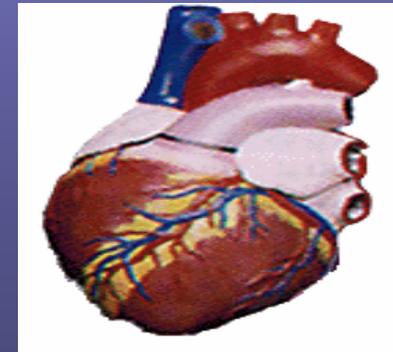
Observations of chronic particle health effects

- **aggravation of asthma**
- **inflammation of respiratory membranes**
- **bronchoconstriction**
- **impaired respiratory defense**
- **decreased heart rate variability**
- **accumulation of particles in lungs**



... and the Heart

- **Cardiovascular system effects**
 - Changes in heart rate and heart rate variability
 - Blood component changes
 - Cardiac arrhythmias
 - Atherosclerosis (hardening of arteries)
 - **Heart attacks**



Health effects from Air Pollution Episodes

Death: Cardiopulmonary

Illness: respiratory and heart

- **increase in respiratory symptoms**
- **increase ER visits**
- **increase in hospitalizations**
- **decrease lung function (children)**
- **decreased lung growth (children)**
- **increased medication use**

**When you can't breathe,
nothing else matters**



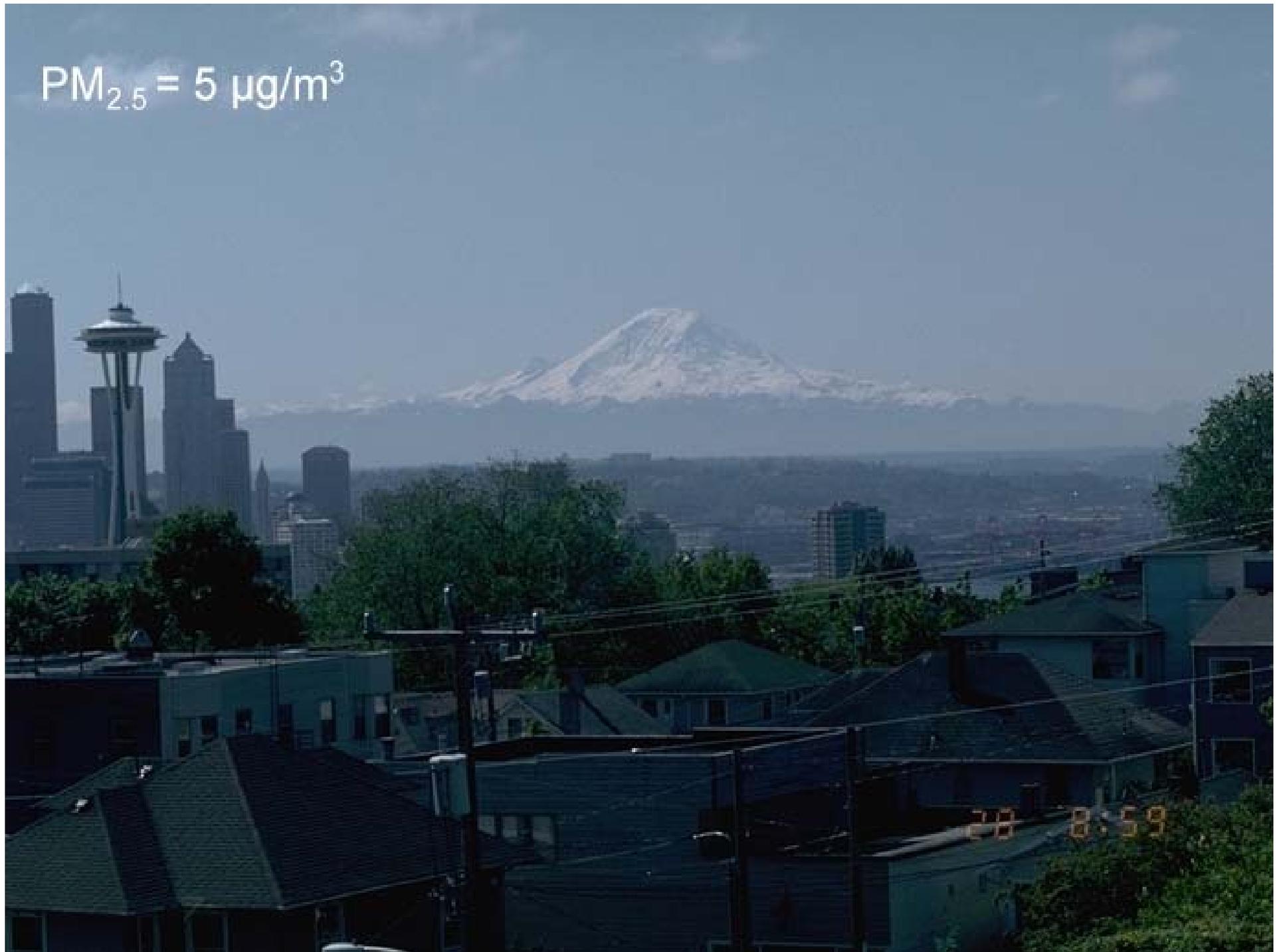
Measured “ancillary” effects (from short-term exposures)

- **restricted activity days**
- **school absences**
- **lost work days**
- **health care costs**

Data for **Death/Illness** from short-term exposure to $\text{PM}_{2.5}$

- clear, consistent, significant association when mean 24-hr $\text{PM}_{2.5}$ concentrations are:
 - 20 g/m^3 : *increased mortality : heart and respiratory patients*
 - *between 15-21 g/m^3 : increased hospital admissions, respiratory symptoms*
 - Current “health-based”
24-hr NAAQS = 65 g/m^3

$PM_{2.5} = 5 \mu\text{g}/\text{m}^3$



$PM_{2.5} = 15 \mu\text{g}/\text{m}^3$

long-term mortality
ER visits-asthma
hospital admissions
respiratory symptoms
acute bronchitis



$PM_{2.5} = 25 \mu\text{g}/\text{m}^3$

long-term mortality
ER visits-asthma
hospital admissions
respiratory symptoms
acute bronchitis
lung function decrements
short-term mortality

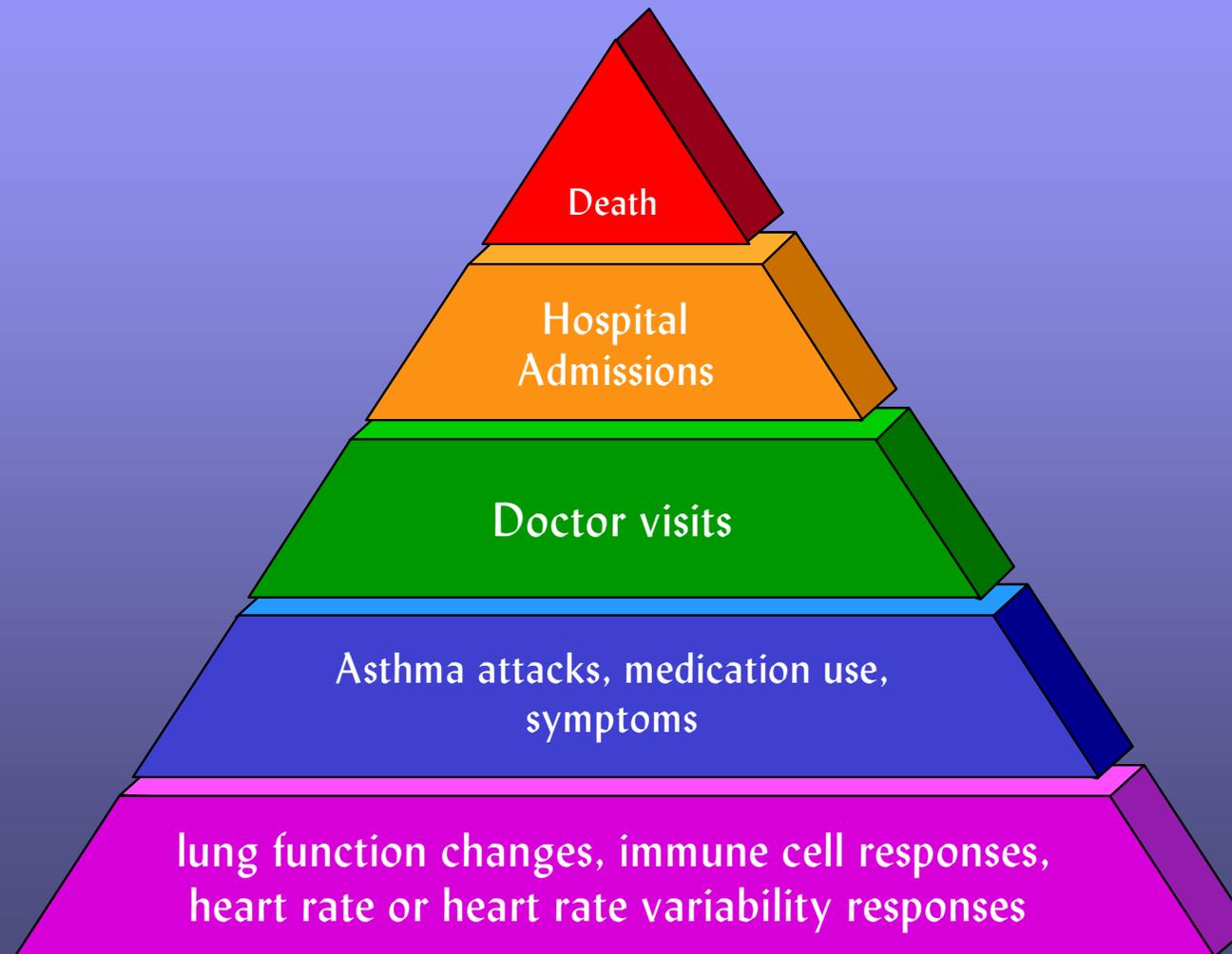


$PM_{2.5} = 30 \mu\text{g}/\text{m}^3$

long-term mortality
ER visits-asthma
hospital admissions
respiratory symptoms
acute bronchitis
lung function decrements
short-term mortality

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“Pyramid of Effects”

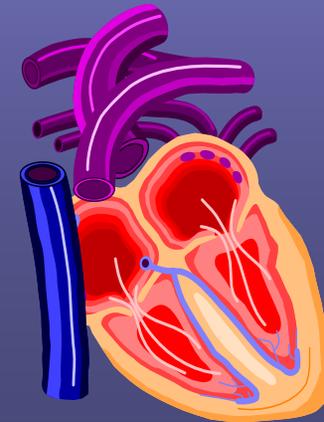
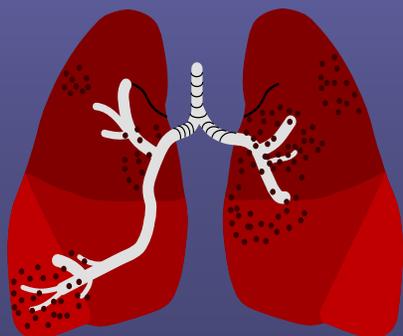
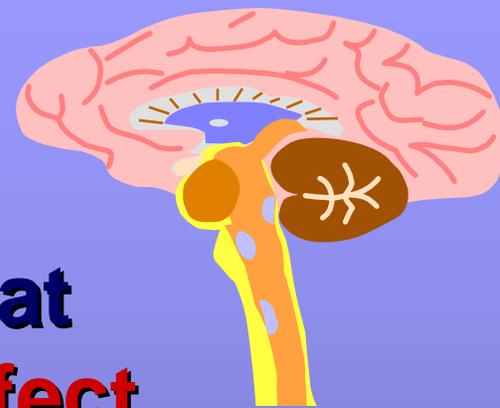


Who **dies** from short-term exposures to fine particles?

- individuals with **chronic pulmonary disease**
 - bronchitis, emphysema, asthma
- individuals with **cardiovascular disease**
- individuals with **infections**
 - flu, pneumonia
- elderly
- infants

Health Effects

Can range from those that are **transient and only affect productivity** to those that are **long term**, produce chronic or severe effects or even **disability, and death**



Options for Proposed Revision of Fine PM 24-hour NAQQS

- **Index:** $PM_{2.5}$
- **Concentrations:**
 - * **30-25 $\mu\text{g}/\text{m}^3$** (with annual remaining @ 15 $\mu\text{g}/\text{m}^3$) **OR**
 - * **40-35 $\mu\text{g}/\text{m}^3$** (with annual changed to 13-12 $\mu\text{g}/\text{m}^3$ range)
- **Form:** **99th percentile 3-year arithmetic average**
(greater risk reduction than 98th percentile)
- **use highest monitor averages: eliminating spatial averaging across monitors in an area gives greater risk reduction**

Options for Proposed Revision of Annual Fine PM NAAQS

- **Index:** $PM_{2.5}$

- **Concentration:**

***Retain 15 $\mu\text{g}/\text{m}^3$ annual $PM_{2.5}$ (with 24-hour standard revised to 35-25 $\mu\text{g}/\text{m}^3$ and with 99th percentile form for 24-hr standard (24-hr standard controlling) OR:**

***Revise annual $PM_{2.5}$ to 14-12 $\mu\text{g}/\text{m}^3$ range (with 24-hour standard @ 40-35 $\mu\text{g}/\text{m}^3$) (annual standard controlling)**

- **Form:** 99th percentile

Options for New 24-hour Thoracic Coarse Particle Standard

Replace current PM_{10} 24-hr standard so as to protect against respiratory health effects

- Index: $PM_{10-2.5}$ (10 μ as upper cut-point; 2.5 μ as lower cut-point; not include fine particles)
- Concentration and Form:
 - 65-70 $\mu\text{g}/\text{m}^3$ @ 98th percentile OR
 - 75-85 $\mu\text{g}/\text{m}^3$ @ 99th percentile;possible consideration of:
 - 30 $\mu\text{g}/\text{m}^3$ @ 98th percentile OR
 - 35 $\mu\text{g}/\text{m}^3$ @ 99th percentile

Diesel Particle Emissions: More Toxic



Diesel:

More Toxic Fine Particles

- **Small** ($\sim 0.2 \mu$), large surface area (**90 m²/ gram diesel soot**)
- **High temperature combustion produces nitrated PAH, arene compounds: highly carcinogenic**
- **Type of fuel** (high vs low sulfur); **more particles, depending on engine technology**; **metals, other contaminants**

Carcinogenic Effects

- **Causal for lung cancer (fulfills epidemiological criteria for causality)**
- **3 more lung cancers per 10,000 exposed (California EPA unit risk factor)**
- **Other cancers probable: bladder, liver, blood and lymphatic cancers**

Other Health Effects from Diesel Exhaust

- Increase in chronic respiratory symptoms:

bronchitis

cough

wheezing

phlegm

- Decreased lung function
- Causes allergy, immune, reproductive and developmental effects

Ozone

- Formed in air from Hydrocarbon and Nitrogen Oxide emissions energized by UV
- State near violation of standard in recent years

Ozone

- **Deep lung irritant** (at end of airways and alveoli); causes lung swelling and fluid accumulation, loss of elasticity: harder to breathe
- **Reduces lung function:** exertion increases ventilation and O₃ effect;
- **Prematurely ages lung**
- **Symptoms of cough, throat irritation, SOB, chest pain, nausea, makes asthma worse; ↑ hospital admissions; ER visits**
- **New asthma and asthma worsening with exposure**

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Impairs Visibility

Hurts Our Ecosystem

**Causes Death
And Illness**

