Smoke gets in your Eyes, and Lungs, and...

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Smoke makes such a pretty picture!
Smoke, even from “controlled burns” adds to the smoke burden of the air shed and impacts the health of people who breathe it.
Wild Fire Smoke/
Controlled Burn
Those most at risk: children, elder, ill people with heart disease, diabetes, lung disease.
Over-all Effects:

- Watery eyes
- Irritated respiratory tract
- Reduced lung function
- Increased hospitalization for lung and heart problems
- Cancer induction
- Death from short- and long-term Exposure

Pyramid of Effects:

- Death
- Hospital Admissions
- Doctor visits
- Asthma attacks, medication use, symptoms
- Lung function changes, immune cell responses, heart rate or heart rate variability responses

Number of people affected
Weather and time-of-day effects

- The colder the day, the more woodstove/fireplace use and emissions
- The less atmospheric circulation, the higher the PM levels
  - Residential wood smoke in Olympia accounted for 50% to 85% days of PM on clear days
  - 80-90% of the PM measured in the PS area ambient air was due to use of wood burning devices during nighttime hours
Nighttime Burning - Jan. 9, 1992

Particulates

Micro Grams / Cubic Meter

00:15  02:15  05:15  07:45  10:15  12:45  15:15  17:45  20:15  22:45
Smoke is a local and regional problem: accumulates in low areas
Topography effects

Wood Smoke concentrates near valley floors with a consistent factor of two or three times between ridgeline and valley smoke levels.
The Yakima area is especially prone to high PM levels.

A close association between PM2.5 levels and days in hospital for respiratory illnesses is evident.
Inversions put the Lid on

- Lower-lying areas have much higher smoke values during temperature inversions: the cold air layer acts like a lid and lack of wind won’t let smoke blow away
What’s in Smoke and What are the Impacts?

- Smoke particles: small, less than one micron in diameter; behave like a gas
- Penetrate indoors and deep into the lung
- Have high surface area: adsorb other combustion products, catalytic surface
- Gaseous pollutants: CO, NOx, SOx, irritant gases (i.e., aldehydes)
What is smoke made of?

- Gaseous pollutants: CO, NOx, SOx, irritant gases (such as aldehydes)
- Particles are a complex mixture of extremely small solids and liquid droplets; behave like a gas and have high surface area: adsorb other combustion products act as a catalytic surface for Free Radical formation
Fine particle health effects

• Smoke particles of 1 micron and smaller enter indoors, and penetrate deep into lungs, where defenses are few.

• More than 2000 toxicological and epidemiological studies: FINE PARTICLES cause death and illness from both long term low level concentrations as well as air pollution episodes.
Volatile and Semivolatile Organic Compounds

- **Semivolatiles**: Formaldehyde, acrolein
  - highly irritating to eyes and respiratory membranes
- **Volatile**: BTEX = benzene, toluene, ethylbenzene, xylenes
Acrolein (an aldehyde)

- **Short term symptoms** include stinging and tearing eyes, nausea and vomiting.
- **Long term exposure risk** is: Chronic respiratory disease
Formaldehyde

- Short term symptoms include irritated eyes, nose and throat.
- Inflammation of mucous membranes
- Long term exposure risk is nasal and nasopharyngeal cancer.
Benzene

- Short term symptoms are headaches, dizziness, nausea and breathing difficulties respiratory, eye irritation.

- Long term exposure risks are anemia, liver and kidney damage, and cancer, especially leukemia, changes in blood cell ratios.
Carbon Monoxide

- Binds to hemoglobin 240 times more avidly than oxygen
- Affects *high demand organs* most:
  - brain = one-fiftieth body weight, uses one fifth of body oxygen
- Heart: *heart and circulatory system patients* most sensitive
Carbon Monoxide: the Great Imitator

- Headache, malaise, nausea
- Irritability, decreased attention, memory loss, sleep deficits, increased aggressiveness
- More frequent chest pain in cardiac patients
- Loss of consciousness, coma, death
Nitrogen Dioxide

- Results from high temperature flames: gas, tobacco, diesel hot wild fires
- Respiratory, eye irritant
- Immune suppresser
- Decreases mechanical respiratory defenses (mucociliary escalator)
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$_{2.5}$ (but are mostly very much smaller, < 1 micron)
Particles: What Are They?

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

- Human Hair (70 µm diameter)

Hair cross section (70 µm)

- PM$_{10}$ (10 µm)
- PM$_{2.5}$ (2.5 µm)

M. Lipsett, California Office of Environmental Health Hazard Assessment
Size matters

- Fine and ultra-fine particles behave like a gas:
  - penetrate indoors from outside air
  - penetrate deep into lungs
- Fine particles have greater aggregate surface area
- Adsorb toxic combustion products, metals, atmospheric air toxics, carry them deep into the lung; are a catalytic surface for free radical, reactive oxygen species formation
Respirable Particles

Coarse particles = upper respiratory system

Fine particles = lower respiratory system
Health Effects

Can range from those that are transient and only affect productivity to those that are long-term and produce chronic or severe effects or even disability, and death.
Health effects from air pollution episodes

Death (from cardiopulmonary disease and cancer)

Illness
- increase in respiratory symptoms
- increase ER visits
- increase in hospitalizations
- decrease lung function (children)
- decreased lung growth (children)
- increased medication use
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 (smoke affects growth and function of lung)
- Respiratory, immune, brain defenses not fully formed
Short Term Exposure Effects in Children

- declines in asthmatic children’s pulmonary functions;
- increased rates of emergency department admissions for asthma in children;
- increased rates of asthma symptoms among asthmatic children 5-13
Infant respiratory symptoms

- Prospective cohort study (Triche et al., 2002. Am J Respir Crit Care Med 166: 1105-1111)
- Association with Indoor heating sources
  - total days cough: wood stove use
  - episodes, days of wheeze: gas space heater
  - episodes cough: kerosene heaters
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 (autonomic control and resiliency of heart)
  - Blood component changes: decreased clotting time
  - Cardiac arrhythmias
  - Heart attacks, congestive heart failure
  - Atherosclerosis (hardening of arteries)
Older adults

- May have Lung Injury from work or other exposures, smoking
- Lose Immune, Respiratory Defenses with Aging
- May have Atherosclerosis, other Heart or Circulatory Illness, Diabetes
Short-term Effects in Elders

• increased rates of hospital admissions among people < 65 for asthma;
• increased rates of hospital admissions among people ≥ 65 for any cardiovascular problem;
• increased rates of hospital admissions for respiratory disease among people > 65
• increased rates of emergency department visits among persons < 65 for asthma
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 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)
Smoke is carcinogenic

Wood Smoke Versus Cigarette Smoke

An EPA Study concludes that breathing wood smoke particles during high pollution days is equivalent to smoking 4 to 16 cigarettes.

"Some of the same strong cancer causing chemicals found in cigarette smoke have also been found to be abundant in wood smoke."

Source: Cooper [1980]

Particulate Pollution Project

The Dangers of Particulates
Recent studies on cancer re wood smoke exposure

• Pinto et al., 1998 Brazil: cancer of mouth pharynx, larynx linked with use of wood stoves (case-control study in Int J Epi 27: 936-940)

• Delgado et al., 2005. Lung cancer pathogenesis 39 % of lung cancer pts studied, cancer associated with wood smoke; wood smoke induced same enzymes as tobacco smoke. (Chest 128[10]: 124-131)
Pyramid of Effects

- Death
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Wood smoke may be dear to our hearts, but it hurts them, our lungs, and is to die for.
Citations

- Karmen, Wahhaj, and Ysidom. 1998. Acute respiratory infections (ARI) and indoor air pollution (with emphasis on children under five in developing countries). EHP Activity No. 283-CC, USEPA