Particulate Matter Health Effects - Biomass Burning

Ali Hamade

Alaska Section of Epidemiology

Dept. of Health and Social Services

Fairbanks North Slope Borough Assembly

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Biomass Smoke Sources

- Indoor
  - Woodstoves and boilers
  - Coal, pellet stoves
  - Fireplaces
  - Other heating devices
  - Not well ventilated
- Outdoor
  - Wood smoke (particularly inefficient burning)
  - Boilers

Biomass Smoke Sources

Outdoor-Indoor infiltration: Air pollution is not limited to the outdoors

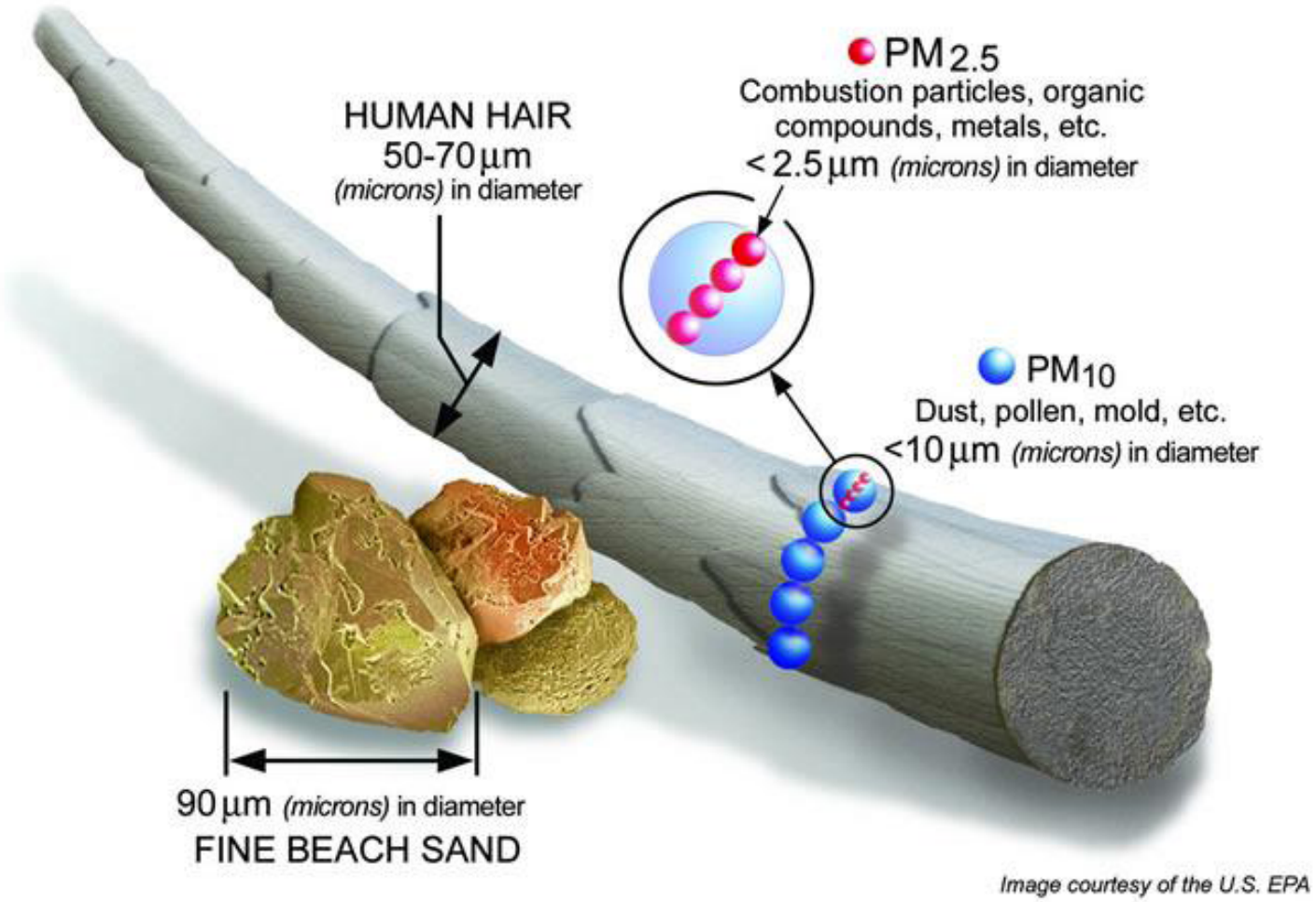
Similar to smoking, generating air pollution can affect not only you, but others around also

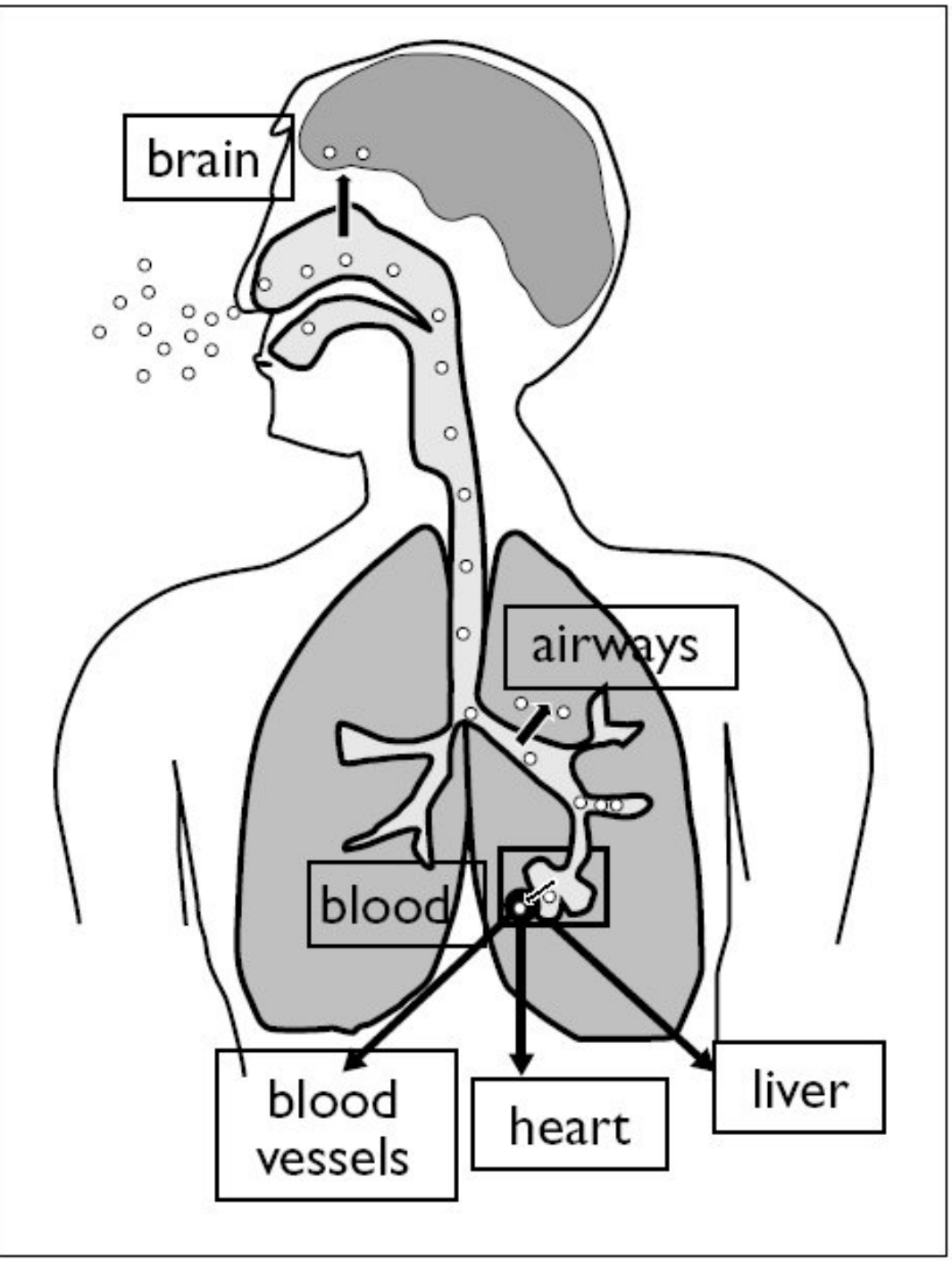
- Wood smoke can make children, adults, and the elderly sick to varying degrees

Components of Biomass Smoke

- **Particulate matter**
- Carbon monoxide
- Nitrogen Oxides, Ammonia, Sulfur Dioxide
- Aldehydes, Benzene
- Polycyclic Aromatic Hydrocarbons
  - *e.g.* benzo(a)pyrene
- Other chemicals and elements

Particulate Matter (PM) Size





Particulate Matter and Components Enter Lung and Reach Other Body Parts

Health Implications of Particulate Matter Exposure*

Short Term

- Asthma exacerbation
- Irritation
- Stroke
- Heart attack
- Hospitalization
- Death
- School days lost

Long Term

- Decline in lung function
- Lung cancer
- Heart disease
- Premature death

*Possibly wood smoke as well

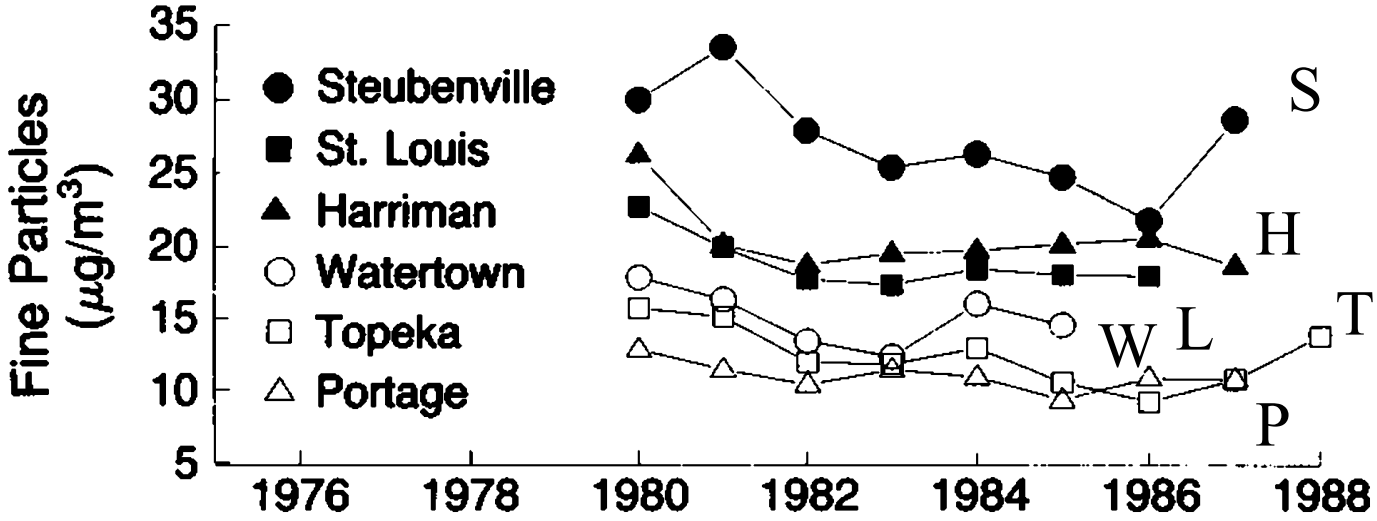
Susceptible and **Vulnerable** Populations

- Elderly, children
- Pre-existing heart and/or respiratory disease, allergies
- Certain genetic polymorphisms (*e.g.*, antioxidant related genes)
- Healthy subjects may also be affected; some may not

- Working or living downwind of heavy wood smoke burning
- Living in housing with indoor wood smoke burning or other fuel combustion that results in high concentrations of pollutants
- Labored breathing (heavy work, exercise)

Harvard Six Cities Cohort Study

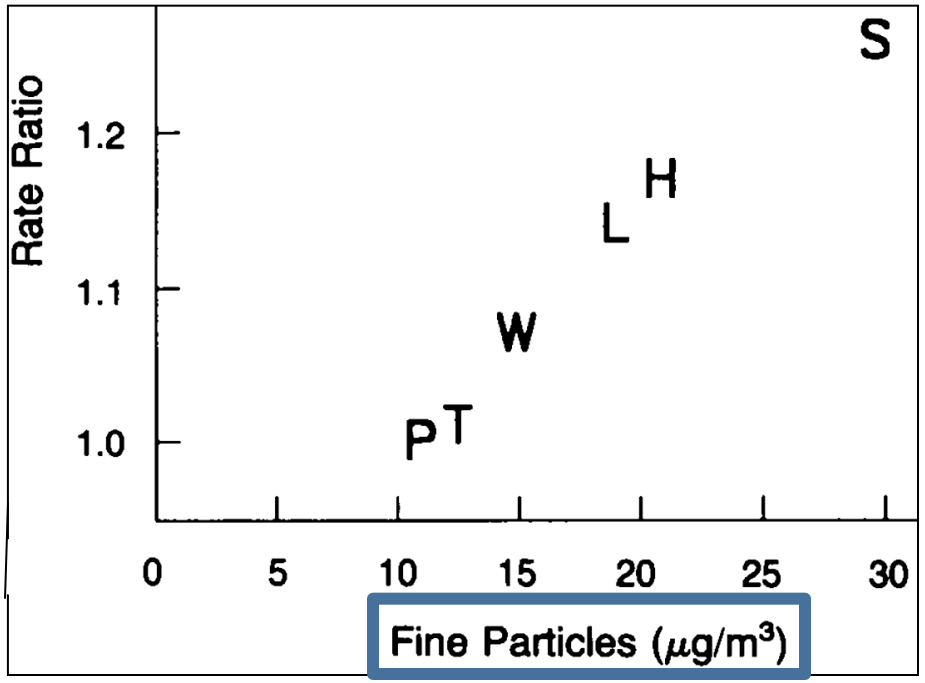
- U.S. cohort (1975-1988)
  - 8111 subjects (25-74 years old).
  - Six US Cities with varying air pollutant levels
- Controlled for sex, age, high school education, smoking, occupational exposure to dust and



Dockery et al., 1993. (329:1753-9, NEJM)

$PM_{2.5}$ and Long-term mortality across Six Cities

City-specific Mortality Rate Ratios vs. **Annual (yearly average)** PM2.5 concentrations



- Mortality Rate Ratios among Cities ($PM_{2.5}$)
  - 1.26 (95% CI: 1.08-1.47) → All-cause mortality
  - 1.37 (95% CI: 1.11-1.68) → Cardiopulmonary mortality

Dockery et al., 1993. (329:1753-9, NEJM)

American Cancer Society Cohort – Long-term mortality

- Nationwide U.S. cohort since 1982
  - Information from ~360,000-500,000 persons
- Investigated pollutant - long-term mortality associations
- Controlled for 44 individual and ecological covariates (e.g., BMI, smoking, income, education, A/C prevalence)

Krewski et al., 2009. HEI Report #140 (Latest cohort update)

Some factors associated with mortality

- Increased PM2.5 → Increased mortality
- Higher unemployment → Increased Mortality

- More AC Use → Decreased mortality
- Higher household income → Decreased mortality

Source: Krewski et al., 2009. HEI Report #140

Health Effects of Wood Smoke (Atlanta, GA)

- Sarnat *et al.* (2008)
- Investigated association between source of PM2.5 pollution and emergency department visits (3 years of data)
- Calculated Relative Risk (RR) – the ratio of probability of emergency visit in those exposed to PM2.5 versus non-exposed
  - If RR larger than 1.00, then bad health effects are possible)

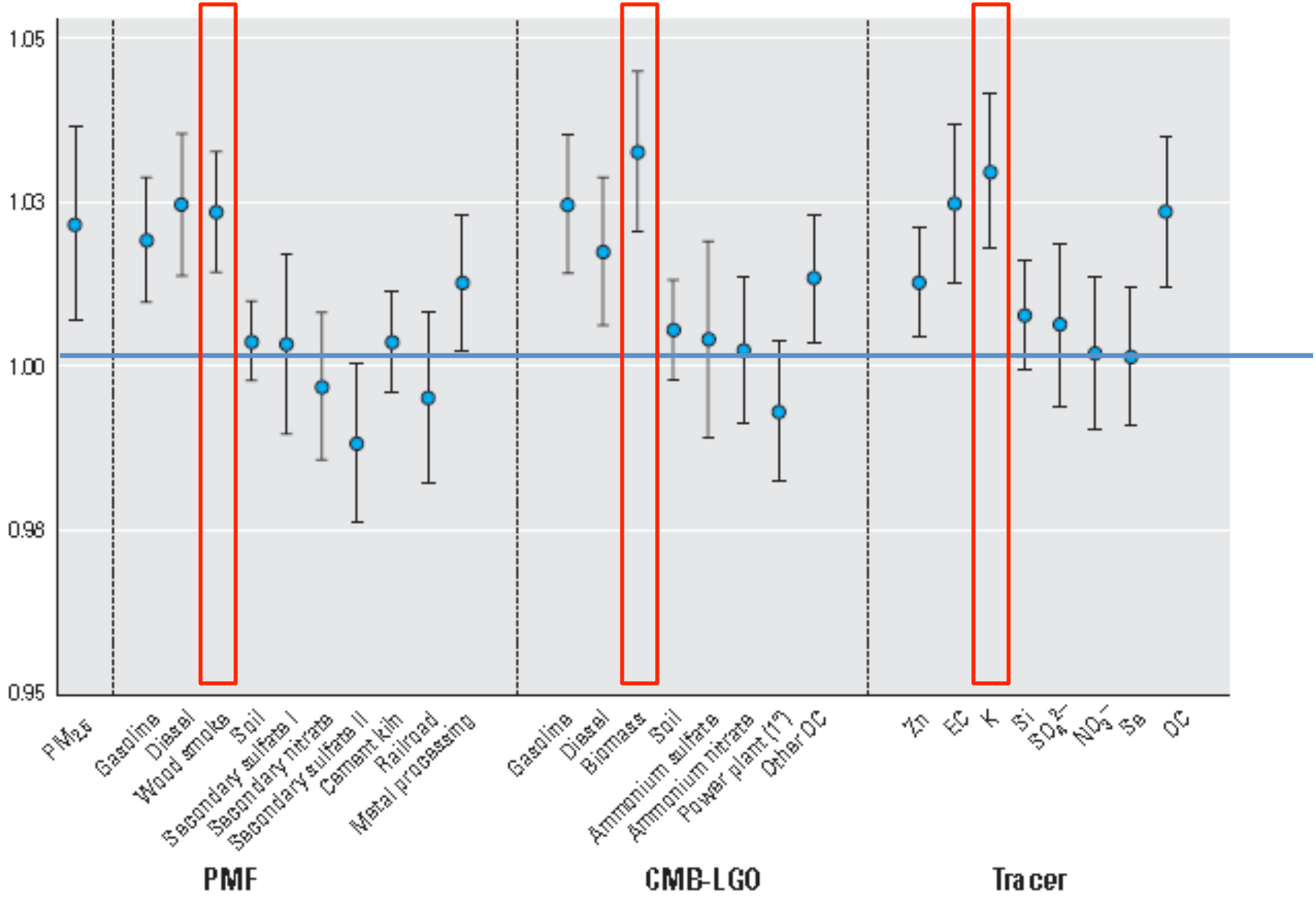


Figure 3. RRs and 95% CIs per IQR increase from same-day lag models for the association of ED visits for all CVD with daily source-apportioned ambient $PM_{2.5}$ (Atlanta, GA, November 1998–December 2002).

Environmental Health Perspectives, Sarnat *et al*. (2008)

Result

$PM_{2.5}$ from biomass combustion (forest burning and residential wood combustion), diesel, and gasoline associated with increased risk of emergency department visits for cardiovascular disease.

Short-Term Health Effects of Wood Smoke (Christchurch, NZ)

- McGowan *et al.* (2002)
- **Investigated association between hospitalization rate for adults/children with cardiac and respiratory disorders and PM_{10} (1988-1998)**
- > 90% of PM comes from the city's 47,000 wood burners and open fires during winter
- Winter PM = 4 X Summer PM

Risk of Hospital Admissions associated with PM10

- Increased risk of
  - Heart Failure
  - Acute Respiratory Infections
  - Asthma
  - Chronic Lung Disease
  - Pneumonia/influenza
- No Increased risk of
  - Appendicitis
  - Ischemic heart disease
  - Dysrhythmia

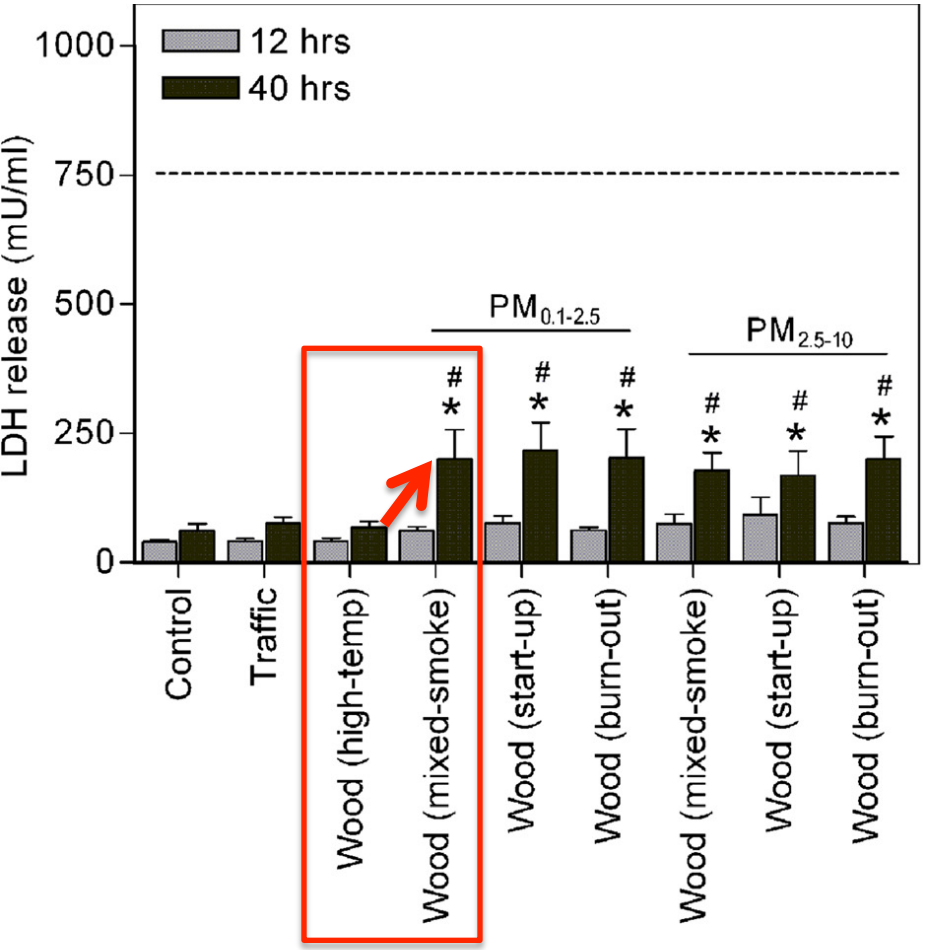
McGowan et al., 2002

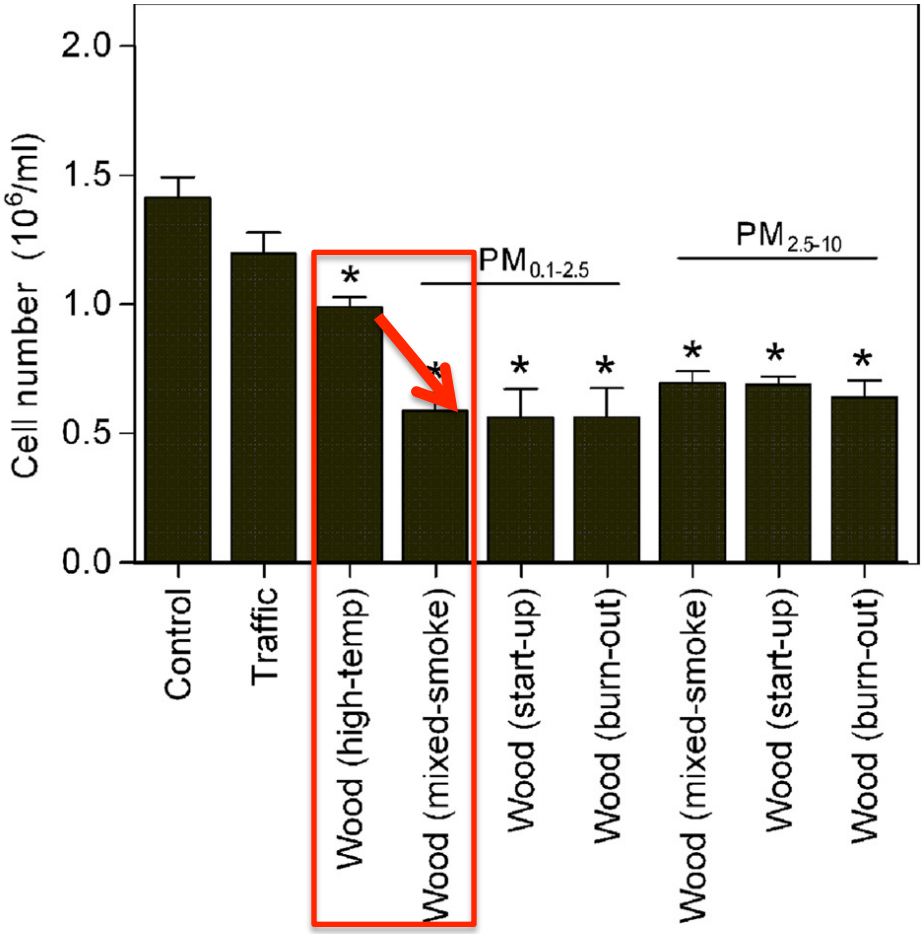
Wood Smoke and Children's Health

- Wood smoke associated with decreased lung function tests results in children (6-13 years old) in wood smoke-impacted area of Seattle (Allen et al., 2008)

- 1,100 Old Wood Stove changeout intervention in Libby, Montana suggests a relation between decreased school absences and decreased air pollution levels (Noonan et al., 2011)

Wood Burning Temperature
Toxicity of smoke

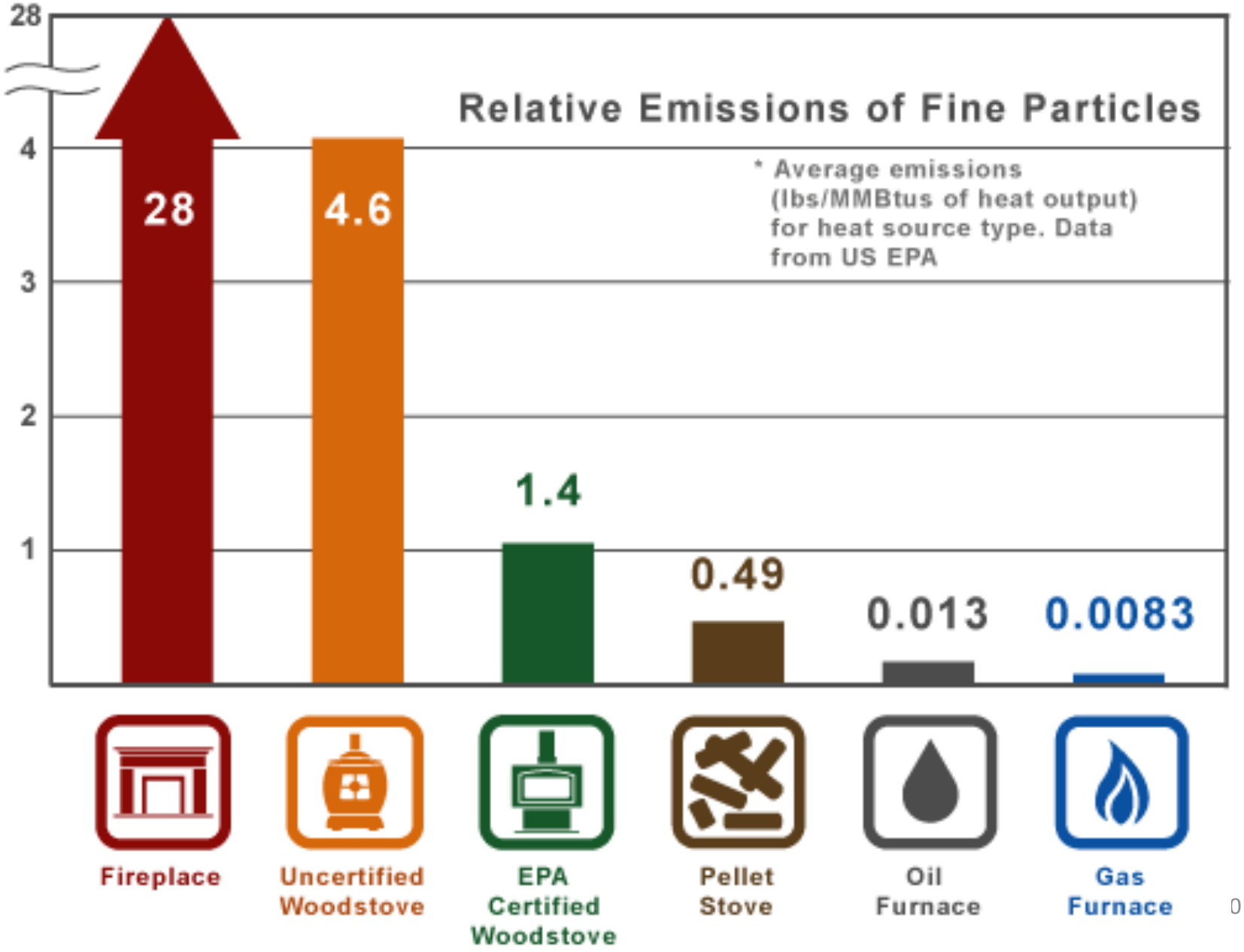




Increased toxicity to cells **Decreased survival of cells**

Bolling et al., 2012

Boiler/Stove Selection Can Make a Difference



ali.hamade@alaska.gov

Thanks!