EXPOSURE TO WOODSMOKE:
A DISCUSSION OF THE HEALTH RISKS AND THE BURNING PRACTICES THAT REDUCE RISK

Gillian Gawne-Mittelstaedt, MPA
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Mechanisms

Remove biomass combustion appliance

Reduce emissions from combustion appliance

Better appliance (woodstove change-out)

Better operation of existing appliance (maintenance, repairs, user education)

Better fuel for existing appliance (drier, lower ash content, higher BTU)
THE STORY WE NEED TO TELL IS BIGGER THAN ASTHMA.

AND MORE COMPLEX.
HEADACHES
NAUSEA
EYE, NOSE AND THROAT IRRITATION
IMMUNE SUPPRESSION
SINUS AND LUNG INFECTIONS
MISCARRIAGES
PRE-TERM DELIVERY (11/11)
HISTORICALLY...

Subsistence diet = higher intake of Omega 3 fatty acids
  ▪ Consumption rates: 42g/day - 170g/day

TODAY...

Depleted fisheries and wildlife = less access, higher cost, lower quality, higher toxin level (PCBs, DDT, mercury, dioxins)
  ▪ Westernized diet = high in trans-fats
VARIABLES

Gender
Age
Genetics
Diet
Duration of exposure
Severity of exposure
Socioeconomics
Behaviors
VASCULAR INFLAMMATION
In the United States today, almost 1 in 2 Americans have a chronic disease. These 133 million Americans have greater susceptibility to woodsmoke.²

CHRONIC HEALTH CONDITIONS

Diabetes
Hypertension
Cardiovascular Disease
Chronic Obstructive Pulmonary Disease (COPD)
Cancer
Asthma
KEY MESSAGES

Mismatch in perception of wood smoke risk... across all communities, professions, ages, populations....

Public policy reality... a challenge that is not going away anytime soon...climate (wildfires), wood heat (economics)
Chart 2: Perceived Health Risks Associated with Woodsmoke

- Irritant to Eyes, Makes Asthma Worse: 80%
- Makes Asthma Worse: 64%
- Causes or Makes Infections Worse: 52%
- Can Cause Cancer: 30%
- Can Cause Heart Attacks: 20%
- Can Cause Strokes: 14%

GILLIAN MITTELSTAEDT, TRIBAL HEALTHY HOMES NETWORK
"Heating with wood...is proving to be the workhorse of residential renewable energy production."

- John Ackerly, Alliance for Green Heat
The fluctuating and high cost of fossil fuels continues to put pressure on households.

August 27, 1990

Fuel worries reviving sales of wood stoves

BOSTON (AP) — Sales of wood stoves are heating up again as people worry about the rising cost of fuel for the winter. Wood stoves have been both maligned and romanticized as having a certain pioneer mystique. While oil price hikes and tensions in the Middle East fanned sales in the 1970s and early 1980s, wood stoves also were the target of pollution restrictions and the source of fatal house fires.

Industry officials say stoves today have more sophisticated designs to remedy the old problems. Now wood stove makers and retailers are hoping to cash in on the trend and have increased sales expectations.

December 6, 2012

Fighting winter with fire? Wood-burning on the rise.

The number of U.S. homes relying on burning wood for heat is up 24 percent since 2006. But environmental concerns could quash further growth of wood-burning.

By David J. Unger, Correspondent / December 6, 2012

The number of homes relying on wood-burning as a primary heat source has increased by 24 percent since 2006. But environmental concerns could quash further growth of wood-burning.

GILLIAN MITTELSTAEDT, TRIBAL HEALTHY HOMES NETWORK
When you burn, what are the main reasons?

- **Saves Money**: 41%
- **Cannot afford the utility bill when using electric heat**: 7%
- **More comfortable**: 28%
- **Like the atmosphere and sound**: 31%
- **Reminds me of tradition and cultural events**: 10%
- **Wood is my only source of heat**: 21%
- **Other**: 10%
ECONOMICS + PERCEPTIONS

• Wood heating choices are often economic, yet wood heating practices, are based on intrinsic beliefs and attitudes about the relative safety of wood smoke.

• Perceptions are difficult to modify in light of a 790,000-year relationship with fire - food preparation, spiritual and cultural events, and basic survival.
CHARACTERIZING THE RISKS

1. Physiochemical properties of woodsmoke and lung/environment interface

2. Cardiovascular outcomes – particulates

3. Infectious outcomes – PAHs and immune suppression

4. Chronic exposure outcomes - mutagenic and carcinogenic properties

5. Cumulative risk
Physiochemical Properties of Wood smoke

Over 90% of woodsmoke particles are smaller than 1 micron - behaving more like a gas than a particle.

Electron micrograph of wood smoke particles. Bar = 1 μm.
<table>
<thead>
<tr>
<th>Compound</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>carbon monoxide</td>
<td>80-370</td>
</tr>
<tr>
<td>methane</td>
<td>14-25</td>
</tr>
<tr>
<td>VOCs* (C2-C7)</td>
<td>7-27</td>
</tr>
<tr>
<td>aldehydes</td>
<td>0.6-5.4</td>
</tr>
<tr>
<td>substituted furans</td>
<td>0.15-1.7</td>
</tr>
<tr>
<td>benzene</td>
<td>0.6-4.0</td>
</tr>
<tr>
<td>alkyl benzenes</td>
<td>1-6</td>
</tr>
<tr>
<td>acetic acid</td>
<td>1.8-2.4</td>
</tr>
<tr>
<td>formic acid</td>
<td>0.06-0.08</td>
</tr>
<tr>
<td>nitrogen oxides</td>
<td>0.2-0.9</td>
</tr>
<tr>
<td>sulfur dioxide</td>
<td>0.16-0.24</td>
</tr>
<tr>
<td>methyl chloride</td>
<td>0.01-0.04</td>
</tr>
<tr>
<td>napthalene</td>
<td>0.24-1.6</td>
</tr>
<tr>
<td>substituted napthalenes</td>
<td>0.3-2.1</td>
</tr>
<tr>
<td>oxygenated monoaromatics</td>
<td>1-7</td>
</tr>
<tr>
<td>total particle mass</td>
<td>7-30</td>
</tr>
<tr>
<td>particulate organic carbon</td>
<td>2-20</td>
</tr>
<tr>
<td>oxygenated PAHs</td>
<td>0.15-1</td>
</tr>
<tr>
<td>Individual PAHs</td>
<td>10^-5-10^-2</td>
</tr>
<tr>
<td>chlorinated dioxins</td>
<td>1x10^-5-4x10^-5</td>
</tr>
<tr>
<td>normal alkanes (C24-C30)</td>
<td>1x10^-3-6x10^-3</td>
</tr>
<tr>
<td>sodium</td>
<td>3x10^-3-2.8x10^-2</td>
</tr>
<tr>
<td>magnesium</td>
<td>2x10^-4-3x10^-3</td>
</tr>
<tr>
<td>aluminum</td>
<td>1x10^-4-2.4x10^-2</td>
</tr>
<tr>
<td>silicon</td>
<td>3x10^-4-3.1x10^-2</td>
</tr>
<tr>
<td>sulfur</td>
<td>1x10^-3-2.9x10^-2</td>
</tr>
<tr>
<td>chlorine</td>
<td>7x10^-4-2.1x10^-2</td>
</tr>
</tbody>
</table>
“The small diameters of the primary particles provide a large surface area per mass.... Thus, **carbon** aggregates may act as carriers that transport toxic or biologically active compounds into the lung.

Dasch, 1982; Evans et al., 1981; Tesfaigzi et al., 2002. (Kocbach, 2008)
“Fine particles efficiently evade the mucociliary defense system and are deposited in the peripheral airways where they may exert toxic effects.”

Kirk et al, Berkley study, 2005
This network (our “Respiratory System”) is enormous... almost 1500 miles of airways. Stretched out, they would reach from Seattle to Anchorage.
At the end of the tubes, we have thousands of tiny air sacs....

If you laid them out flat, they would cover an entire tennis court, or about 750 square feet.
SURFACE AREA OF THE LUNGS IS 80 TIMES GREATER THAN THE SURFACE AREA OF AN AVERAGE-SIZED ADULT’S SKIN.
CHARACTERIZING THE RISKS

1. Physiochemical properties of woodsmoke and lung/environment interface

2. Cardiovascular outcomes – particulates

3. Infectious outcomes – PAHs and immune suppression

4. Chronic exposure outcomes - mutagenic and carcinogenic properties

5. Cumulative risk
Blood Pressure and Heart Rate Were Increased After CAPs Exposures

Kleinman et al., 2004
“Epidemiological studies have associated exposure to particles less than 10 μm in diameter with increased pulmonary and cardiovascular morbidity and mortality.”

Franklin et al., 2007; Katsouyanni et al., 2001; Metzger et al., 2004; Ostro et al., 2006; Pope III et al., 2002; Zanobetti et al., 2000
2004 - Concluded that exposure to air pollution contributes to cardiovascular illness and mortality.

2010 – Update to add that short-term exposure can increase the risk of heart attack, stroke, arrhythmias and heart failure in susceptible people.
“As with cigarette smoke the effect can be almost immediate and chronic exposure to even low concentrations of pollution are associated with an acceleration of atherosclerosis and significant arteriole narrowing and stiffness. “

Red staining in sections of the aorta represents lipid and macrophage content, which are part of the atherosclerotic plaque development. **Exposure to ultrafine particles shows highest degree of plaques.**
1. Physiochemical properties of woodsmoke and lung/environment interface

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Woodsmoke contains a complex mixture of chemicals, including carbon monoxide, nitrogen oxides, volatile organic compounds, and Polycyclic Aromatic Hydrocarbons (PAHs)...
“Our findings indicate that hospital admissions for childhood respiratory diseases, especially pneumonia, are associated with exposure to woodsmoke, PM$_{2.5}$ and its constituents.”

*Naehler et al, 2007*
Immune suppression and wood smoke

1 in 4 Alaska Native babies hospitalized each year

Over 50% of children have Reactive Airway Disease

Bronchiectasis still common

High rates of invasive pneumococcal disease
“Despite the direct causes of pneumonia and other respiratory infections being biologic in nature, the effect of air pollution on the development of severe cases requiring hospitalization is especially plausible in children, because particulates likely hamper the ability of an already immature immune system to clear bacteria and other pathogens from the lung.” Deitert et al, 2002
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The EPA estimates that a single fireplace operating for an hour and burning 10 pounds of wood will generate 4,300 times more PAHs than 30 cigarettes. PAHs are carcinogenic.

In a separate study, average levels of PAHs were 300 – 500% higher in wood-burning homes.

Relative amount of free radicals present in various effluent

1x = 3x10^16 s
10x = 3x10^17

Forchhammer et al, 2012

Forchhammer et al, 2012

Gillian Mittelstaedt, Tribal Healthy Homes Network
“...wood smoke particulates were found to be more powerful than other kinds of air pollution in causing potentially cancerous changes to DNA."

Journal of Chemical Research in Toxicology, Steffen Loft

The white area shows where cancer-causing woodsmoke chemicals altered and damaged the DNA in lung cells.
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5. Cumulative risk and indoor/outdoor correlation
CUMULATIVE RISK FACTOR EXAMPLES

- **Location**
  - Near-roadway (strong association with lung impairment)
  - Residential, School and Workplace
  - Rural and Urban (e.g., agricultural burning, slash burning vs industrial emissions, ports)
- **Duration**
Local Exposures: Living within 300m of major roadways affects lung function

Lung Function
FEV1 (Liters)

Number of Heavy Duty Vehicles Per Working Day

(Brunekreef et al 1997, Netherlands)
Figure 1. Prevalence of COPD by years of exposure to wood smoke.
INDOOR EXPOSURE

• Literature – What does the data say

• Variables – What are the determinants of higher or lower indoor exposure – and what do these mean from a practice and policy standpoint?
BURNING PRACTICES THAT REDUCE RISK
Mechanisms

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