

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

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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)





GILLIAN MITTELSTAEDT, TRIBAL HEALTHY HOMES NETWORK

HISTORICALLY...

Subsistence diet = higher intake of Omega 3 fatty acids

- Consumption rates: 42g/day -170g/day¹

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

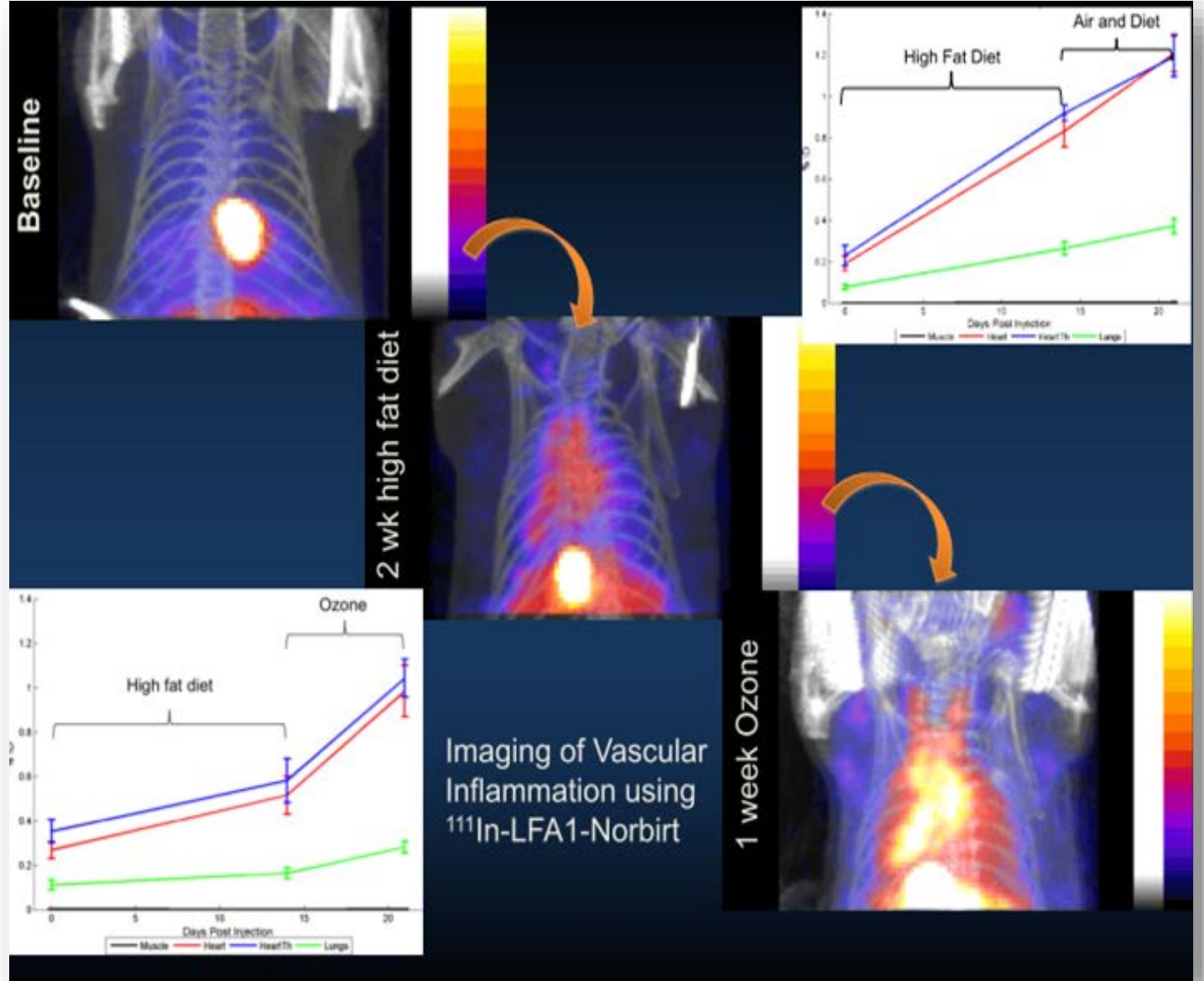
Duration of exposure

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

2. Ward BW, Schiller JS, Goodman RA. Multiple chronic conditions among US adults: a 2012 update. *Prev*

CHRONIC HEALTH CONDITIONS

Diabetes

Hypertension

Cardiovascular Disease

Chronic Obstructive Pulmonary Disease (COPD)

Cancer

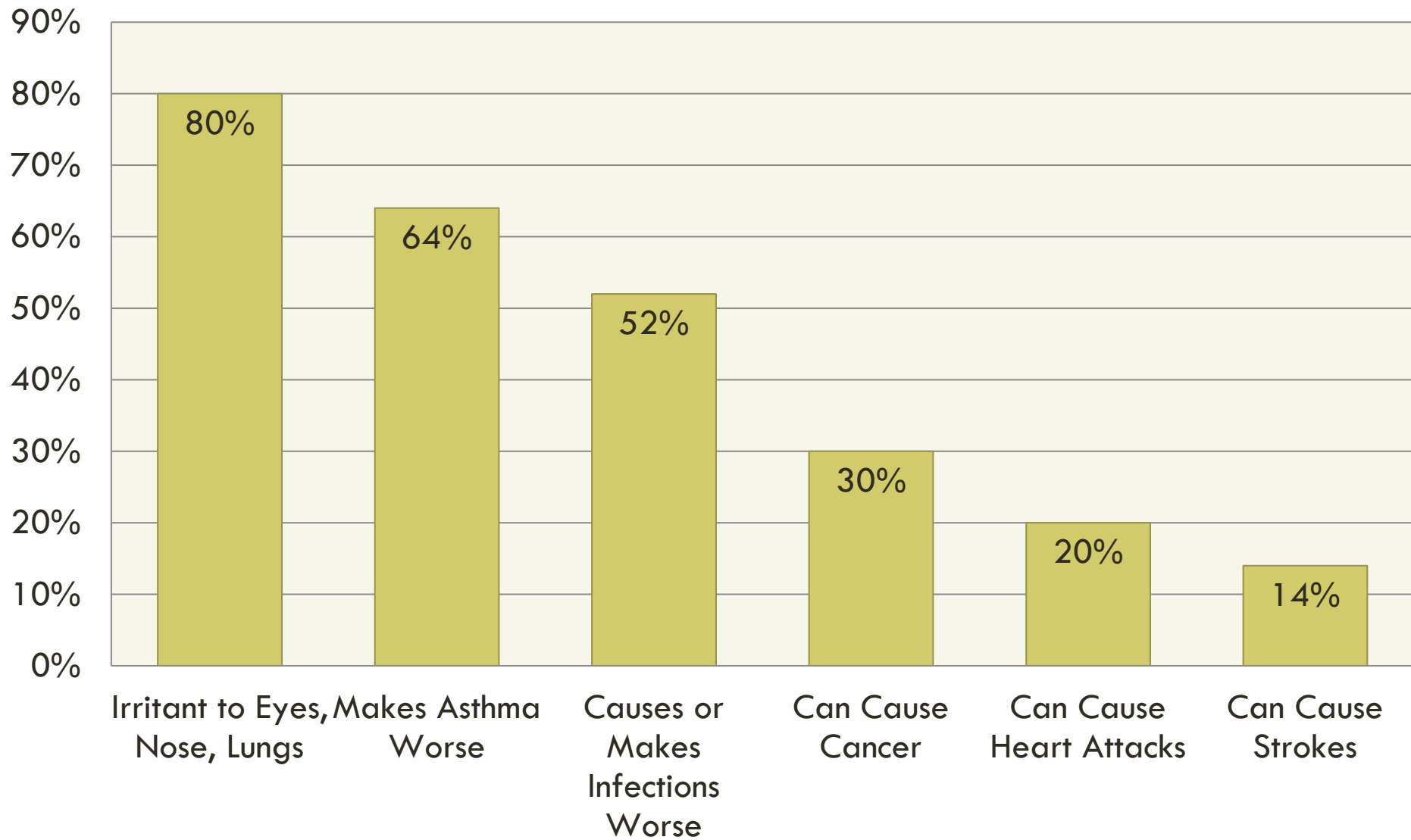
Asthma

KEY MESSAGES

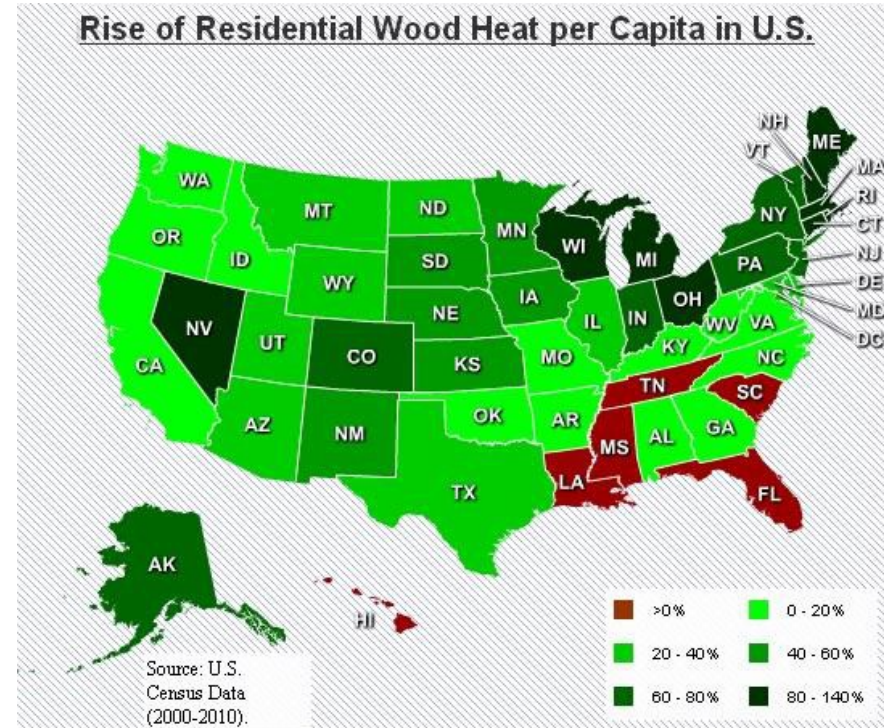
Mismatch in perception of wood smoke risk... across all communities, professions, ages, populations....

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



THE ENERGY PICTURE



“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

[Worcester Journal-World - Aug 27, 1990](#) [Browse this newspaper »](#) [Browse all news](#)

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

stove sales exceeded 1 million around the start of the 1980s, as large and small manufacturers proliferated around the country.

“Anybody that had a welding shop was putting together a wood stove back then,” Hermann said.

But for several reasons, the industry shrank quickly. Annual sales are now estimated around 225,000.

A big factor was the falling price of oil, which meant people no longer were looking for another energy source. Instead, wood stoves increasingly were bought for aesthetic reasons, which meant they were “competing with a new sofa or

December 6, 2012

ENERGY VOICES INSIGHTS ON THE FUTURE OF FUEL & POWER

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

The number of US 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

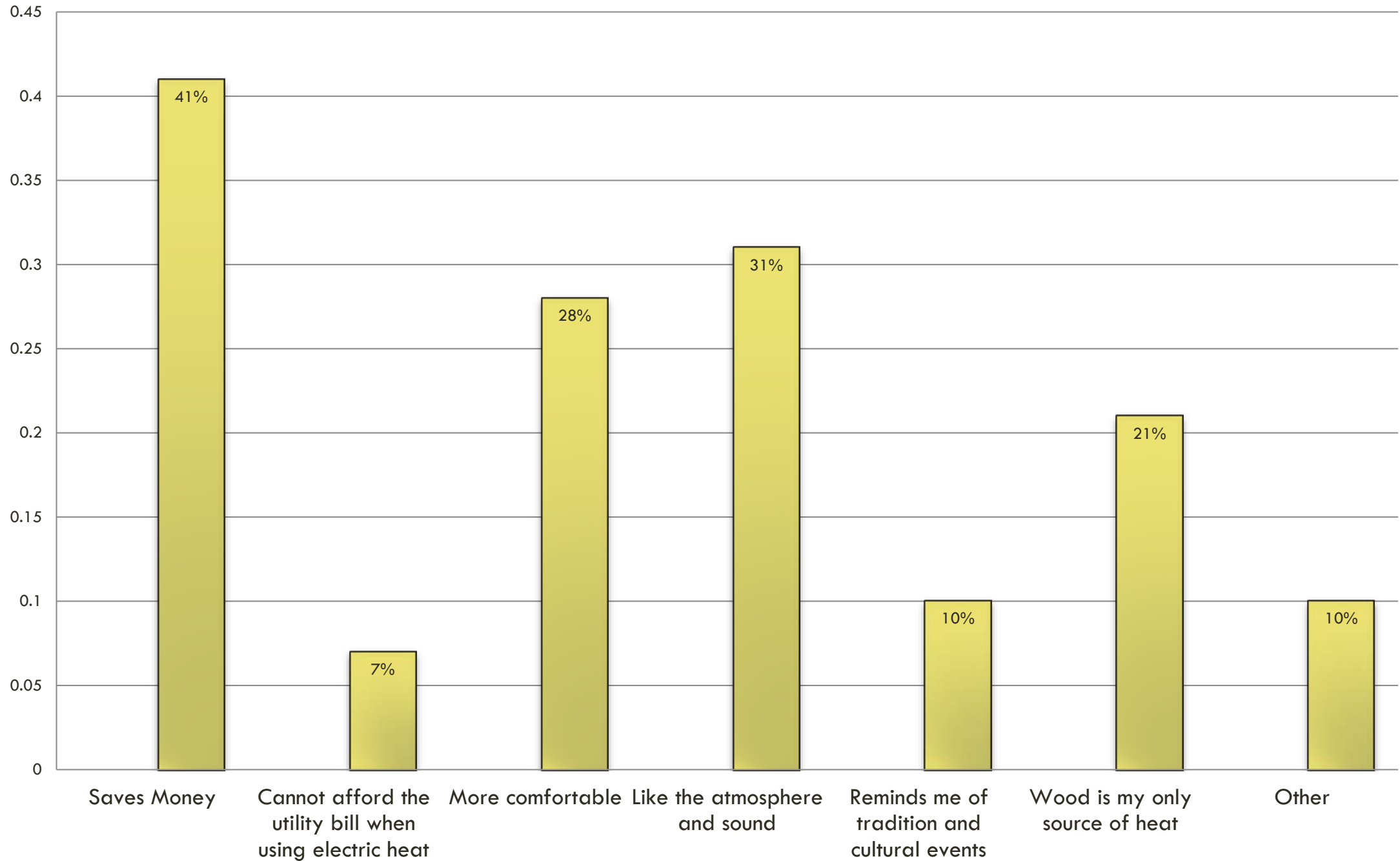


The number of homes relying on wood-burning as a primary heat source is projected to rise 3 percent this winter.

Pat Wellenbach/AP/File

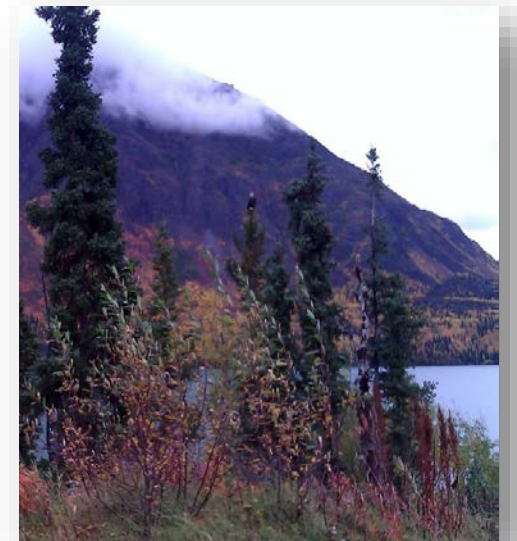
[+ Enlarge](#)

When you burn, what are the main reasons?



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.**

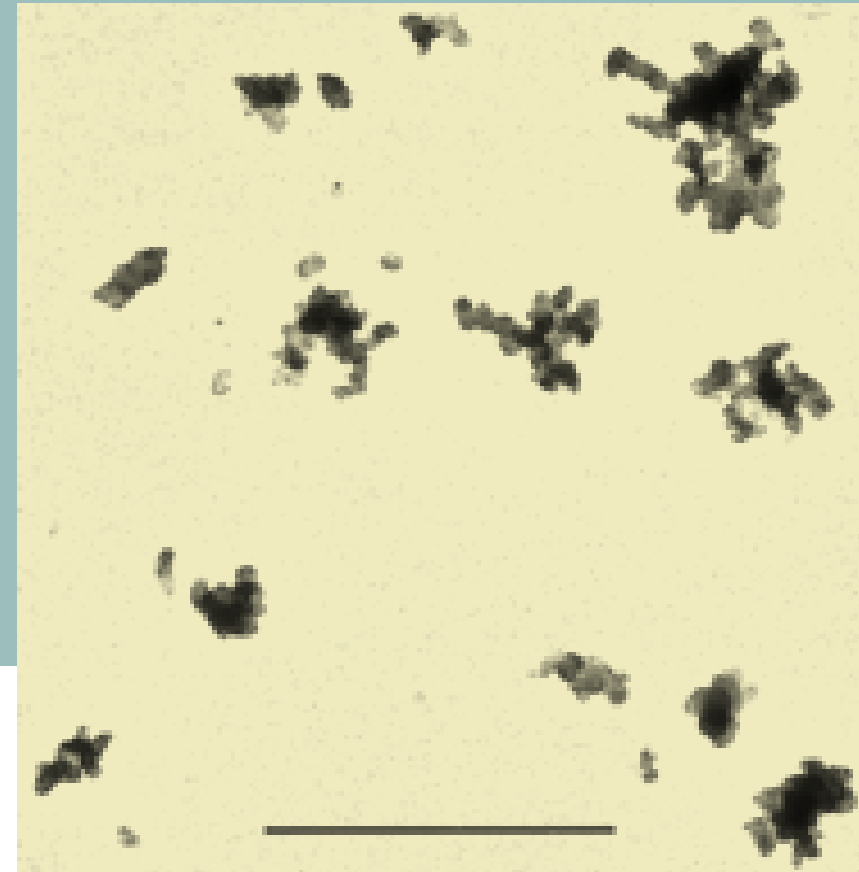


CHARACTERIZING THE RISKS

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

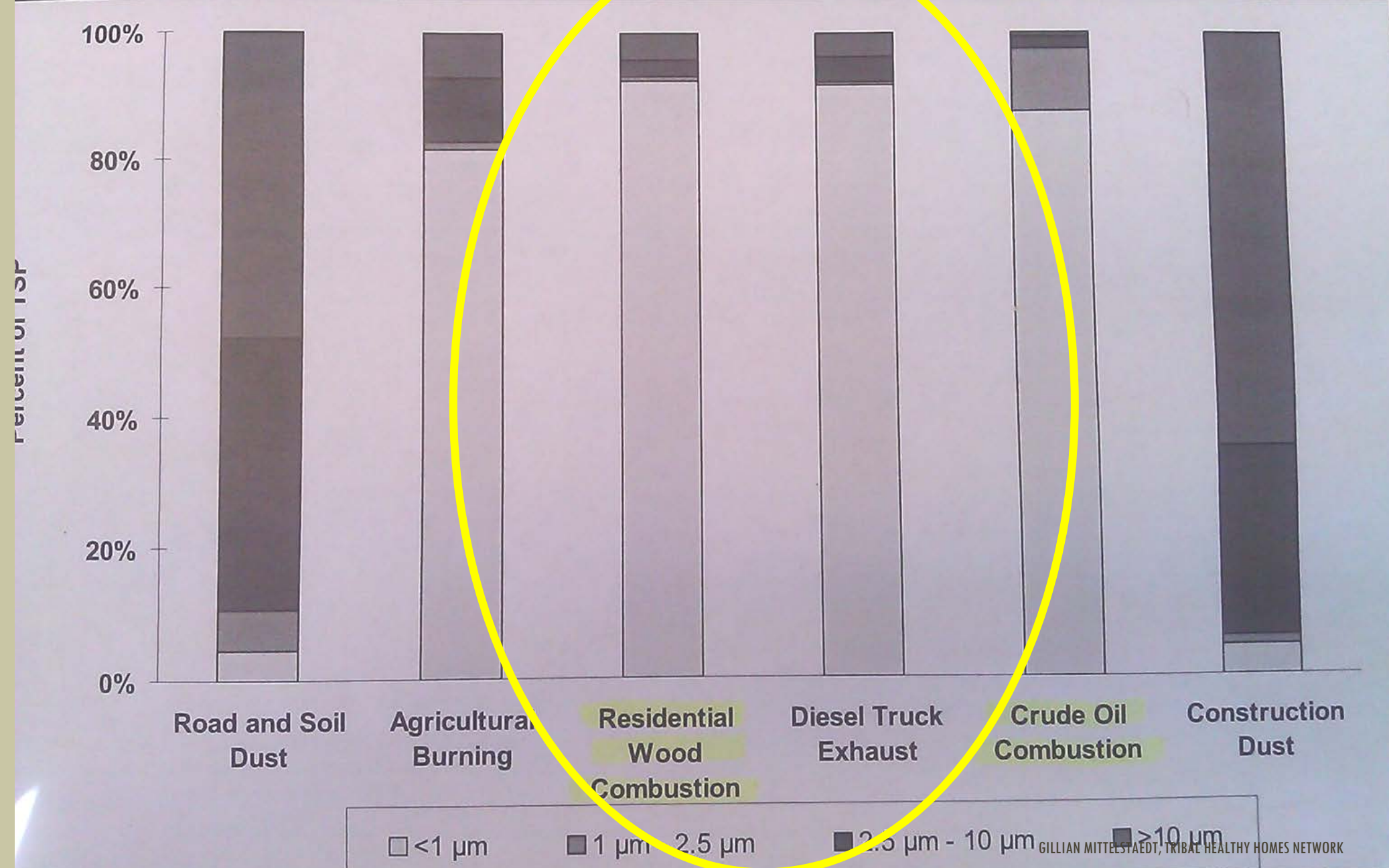
Physiochemical Properties of Wood smoke

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 .

Size Distributions of Several PM Source Emissions



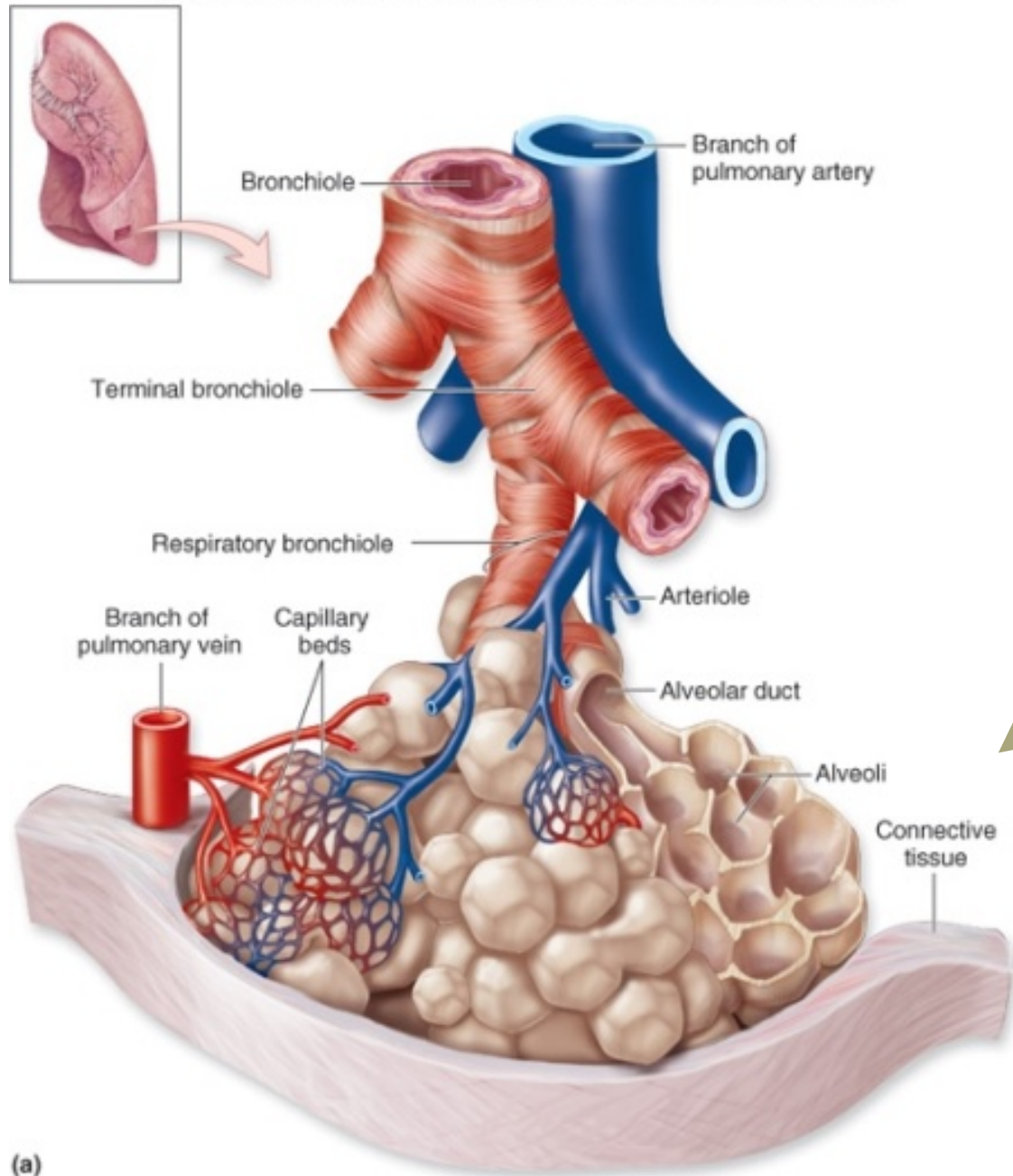
carbon monoxide	80-370	substituted naphthalenes	0.3-2.1
methane	14-25	oxygenated monoaromatics	1-7
VOCs* (C2-C7)	7-27	total particle mass	7-30
aldehydes	0.6-5.4	particulate organic carbon	2-20
substituted furans	0.15-1.7	oxygenated PAHs	0.15-1
benzene	0.6-4.0	Individual PAHs	10 ⁻⁵ -10 ⁻²
alkyl benzenes	1-6	chlorinated dioxins	1x10 ⁻⁵ -4x10 ⁻⁵
acetic acid	1.8-2.4	normal alkanes (C24-C30)	1x10 ⁻³ -6x10 ⁻³
formic acid	0.06-0.08	sodium	3x10 ⁻³ -2.8x10 ⁻²
nitrogen oxides	0.2-0.9	magnesium	2x10 ⁻⁴ -3x10 ⁻³
sulfur dioxide	0.16-0.24	aluminum	1x10 ⁻⁴ -2.4x10 ⁻²
methyl chloride	0.01-0.04	silicon	3x10 ⁻⁴ -3.1x10 ⁻²
naphthalene	0.24-1.6	sulfur	1x10 ⁻³ -2.9x10 ⁻²
		chlorine	7x10 ⁻⁴ -2.1x10 ⁻²

“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)

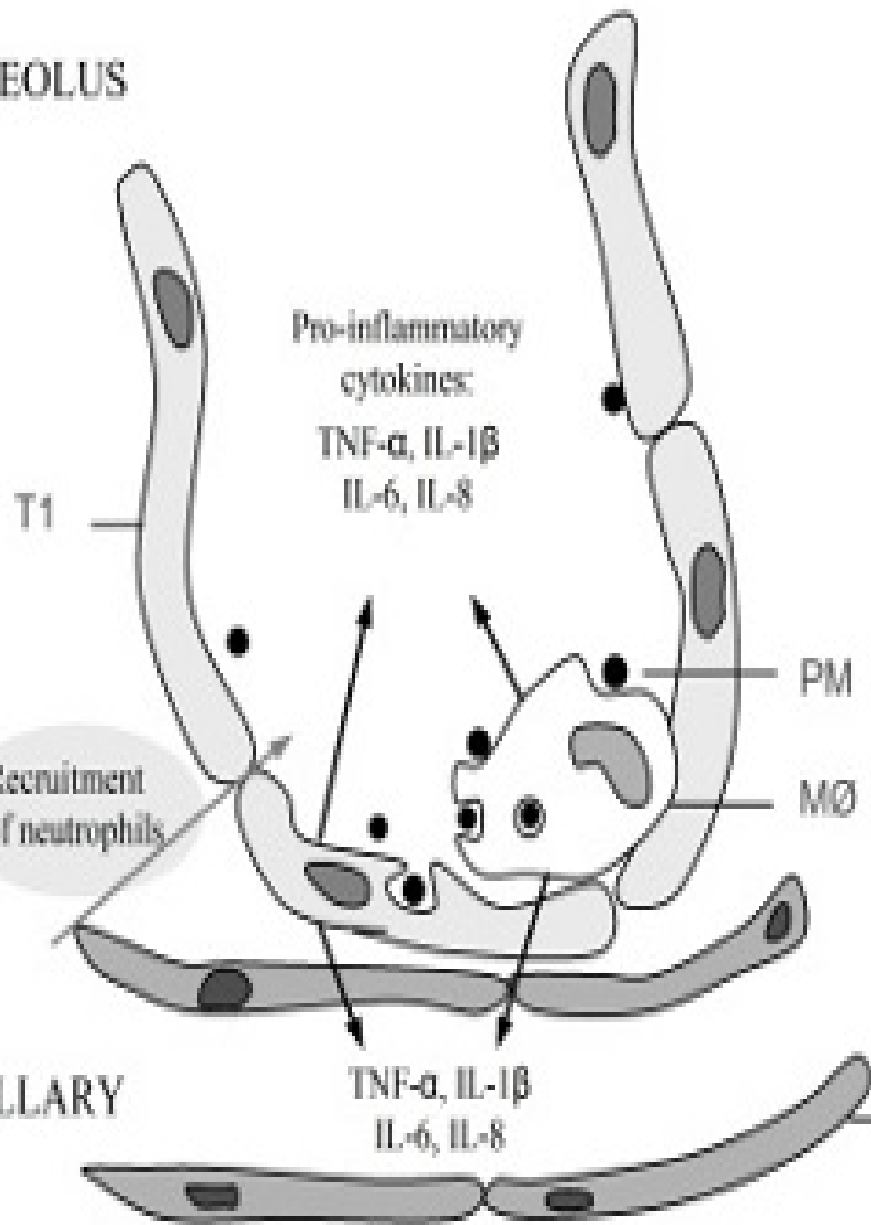
“Fine particles efficiently evade the mucociliary defense system and are deposited in the peripheral airways where they may exert toxic effects.”

Kirk et al, Berkley study, 2005



(a)

ALVEOLUS



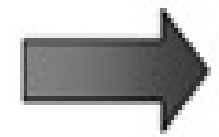
Pro-inflammatory
cytokines:
TNF- α , IL-1 β
IL-6, IL-8

Recruitment
of neutrophils

CAPILLARY

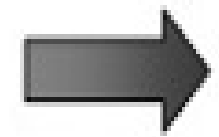
TNF- α , IL-1 β
IL-6, IL-8

Local
inflammation



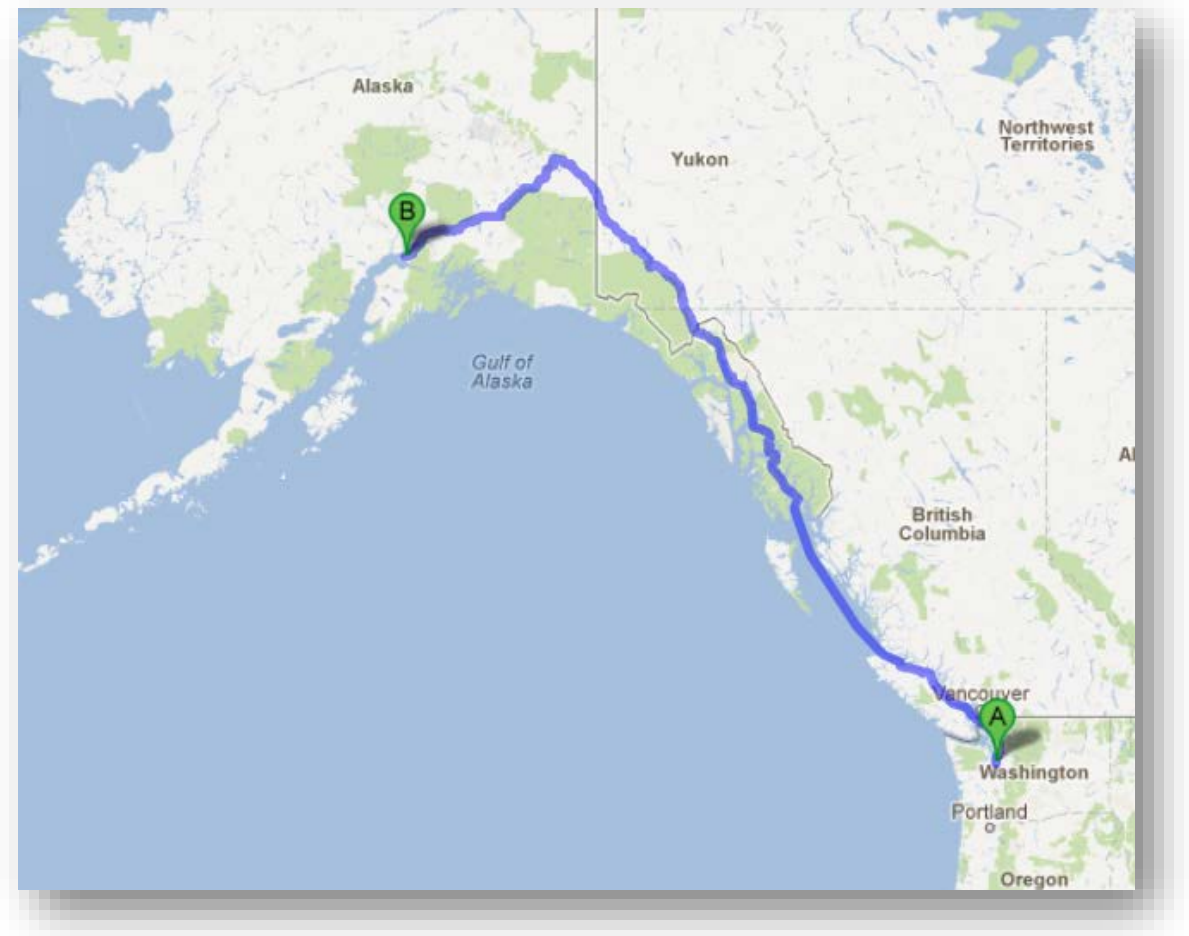
ASTHMA
COPD
FIBROSIS
CANCER

Systemic
inflammation



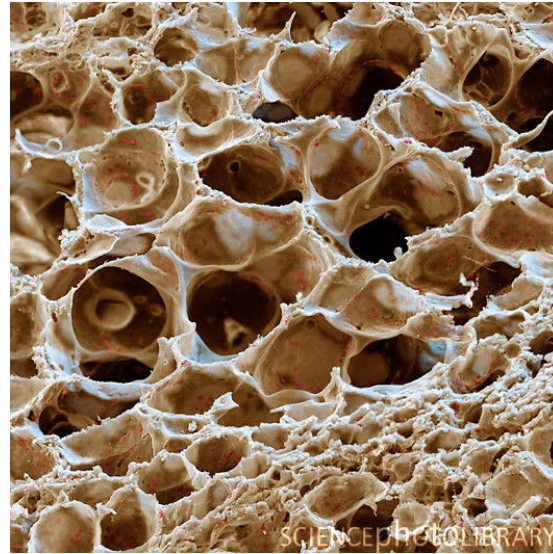
ATHEROSCLEROSIS
HEART ATTACK
STROKE

This network (our “Respiratory System”) is enormous... almost **1500 miles of airways.** Stretched out, they would reach from Seattle to Anchorage.

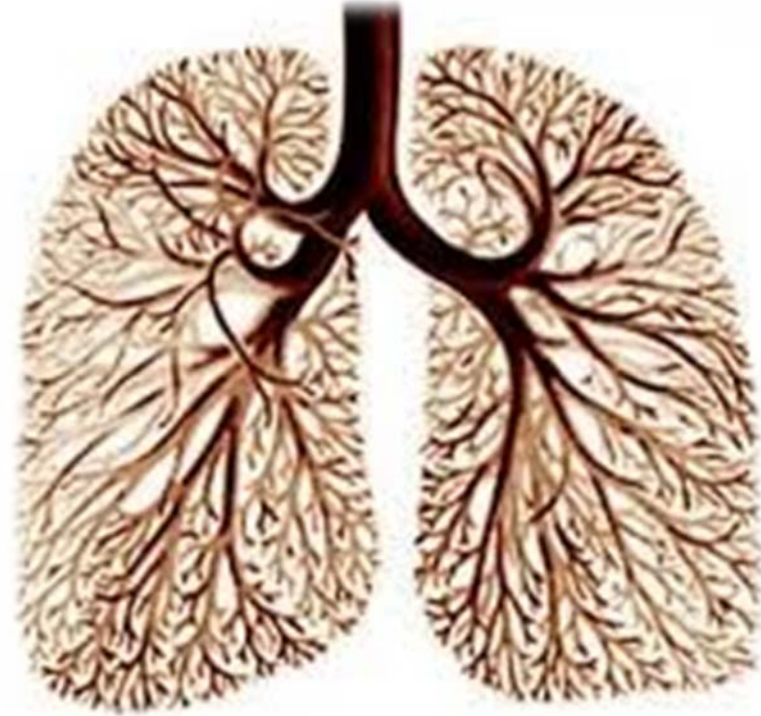


At the end of the tubes, we have thousands of tiny air sacs....

If you laid them out flat, they would **cover an entire tennis court**, or about 750 square feet.



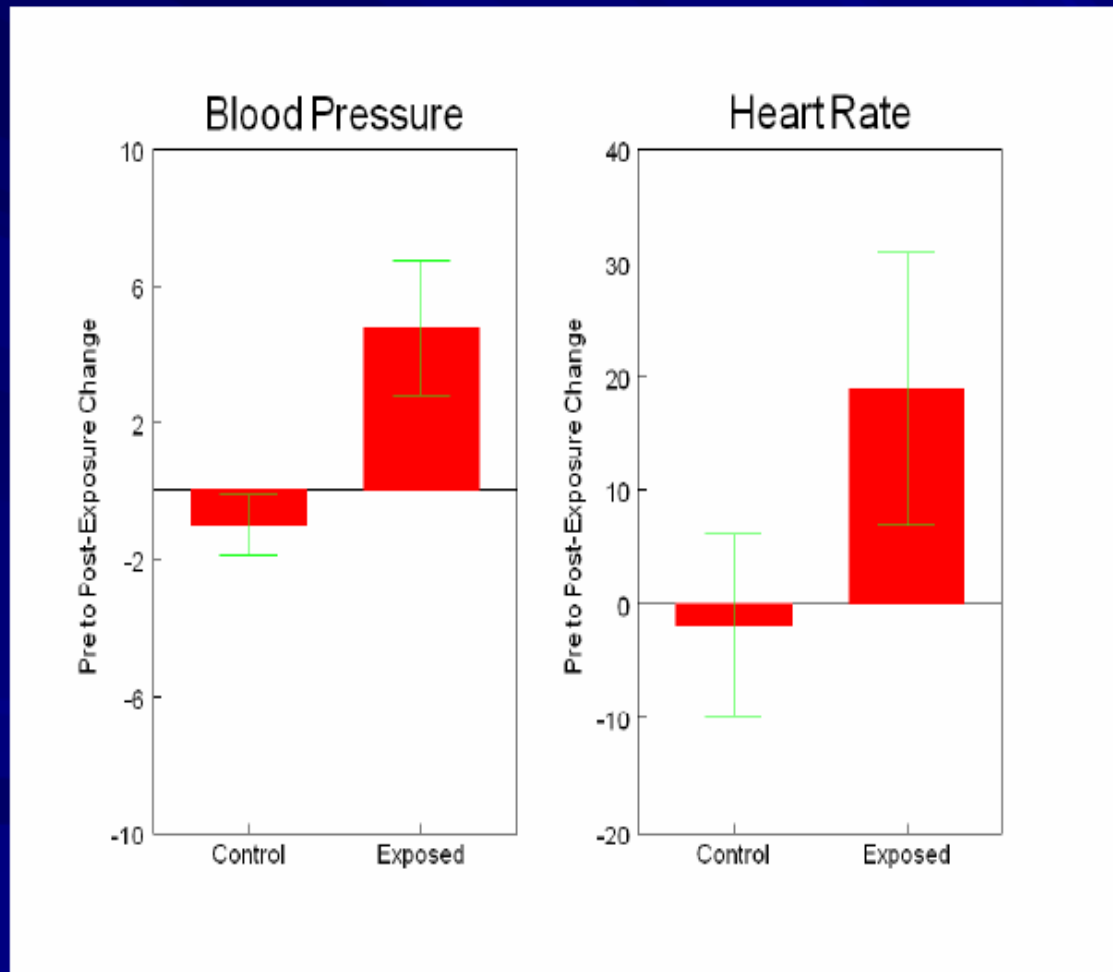
SURFACE AREA OF THE
LUNGS IS 80 TIMES
GREATER THAN THE
SURFACE AREA OF AN
AVERAGE-SIZED ADULT'S
SKIN.



CHARACTERIZING THE RISKS

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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

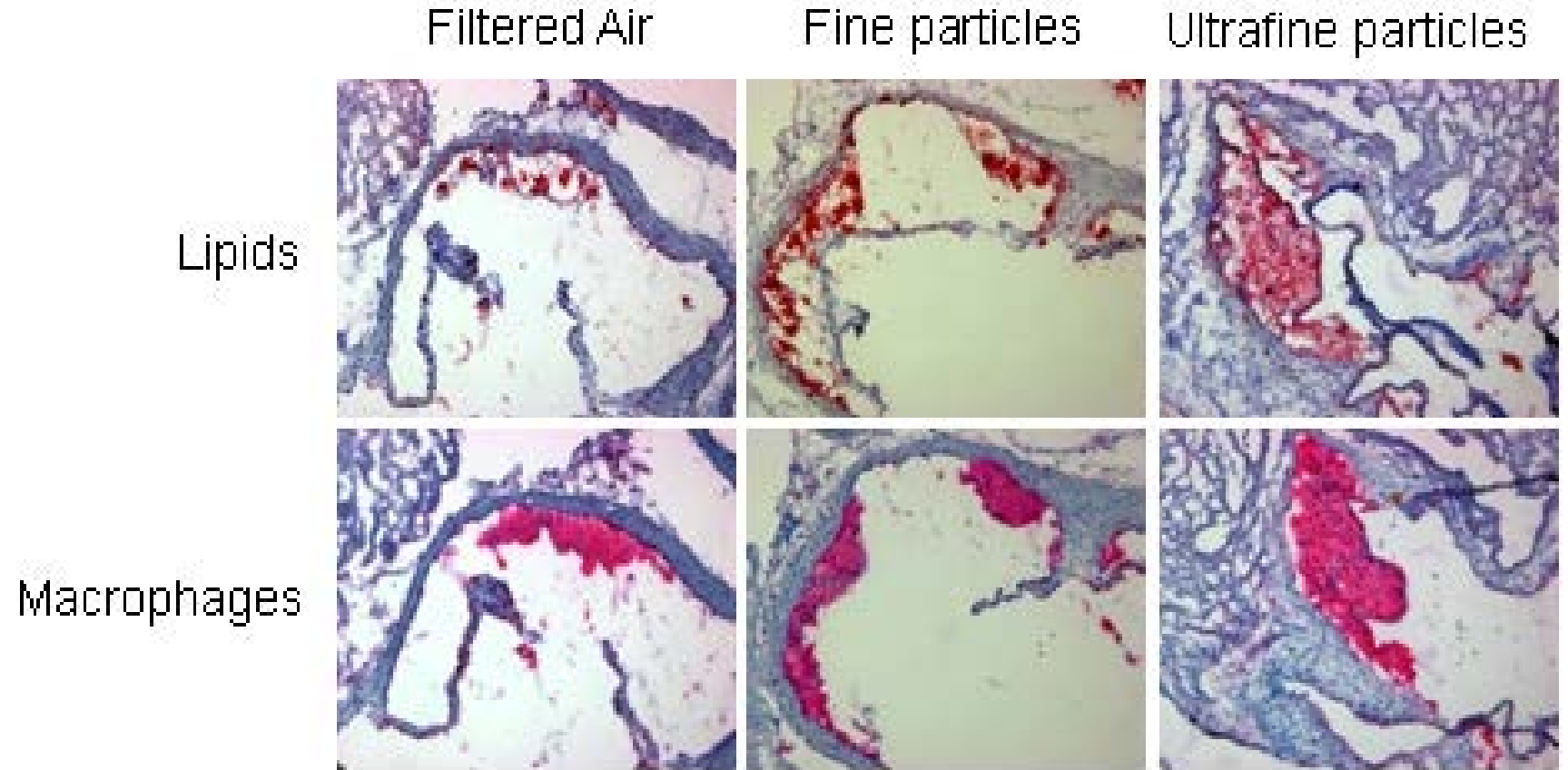
2004 - Concluded that exposure to air pollution contributes to cardiovascular illness and mortality.
2010 – Update to add that short-term exposure can increase the risk of heart attack, stroke, arrhythmias and heart failure in susceptible people.

AMERICAN HEART ASSOCIATION
2004 SCIENTIFIC STATEMENT

“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.**”

Source: Utah Physicians for a Healthy Environment Web Page. Citations: Brook R, Rajagopalan S, Pope CA, Brook J, Bhatnagar A, et al. AHA Scientific Statement: Particulate Matter Air Pollution and Cardiovascular Disease; An Update to the Scientific Statement From the American Heart Association. Circulation. 2010;121:2331-2378. Peters, A, and Pope, CA III Editorial, Lancet. Vol 360, Oct 19, 2002. Pope CA III, Muhlestein JB, May HT et al. Ischemic Heart Disease Events Triggered by Short-term Exposure to Fine Particulate Air Pollution. Circulation 2006, 114:2443-2448.

PLAQUE DEVELOPMENT



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.**

CHARACTERIZING THE RISKS

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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.”

Naeher et al, 2007

Immune suppression and wood smoke

1 in 4 Alaska Native babies hospitalized each year

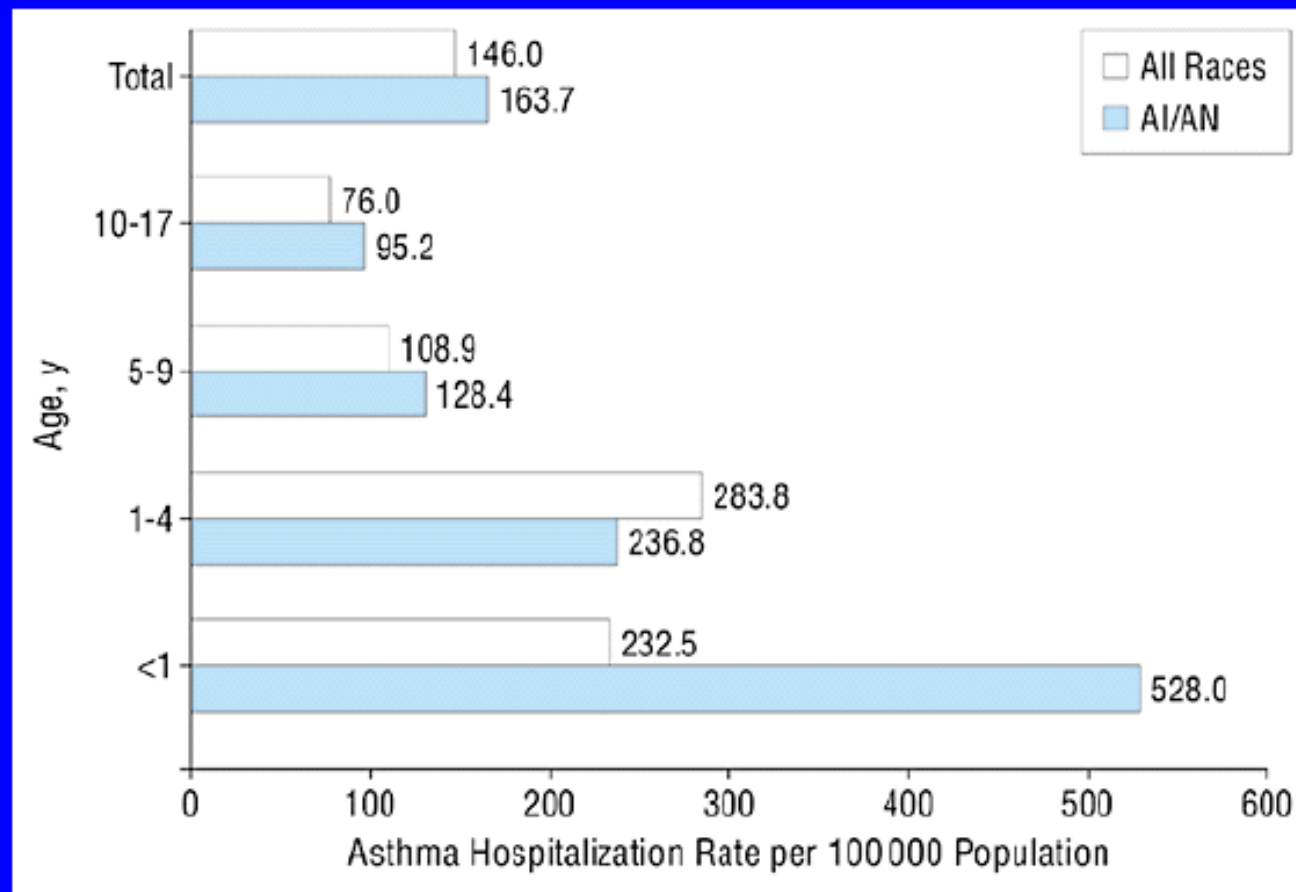
Over 50% of children have Reactive Airway Disease

Bronchiectasis still common

High rates of invasive pneumococcal disease



Asthma hospitalization by age: American Indian & Alaskan Native vs. All WA State children



Liu, L. L. et al. Arch Pediatr Adolesc Med 2000;154:991-996.

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ARCHIVES OF
PEDIATRICS
& ADOLESCENT MEDICINE

- “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*

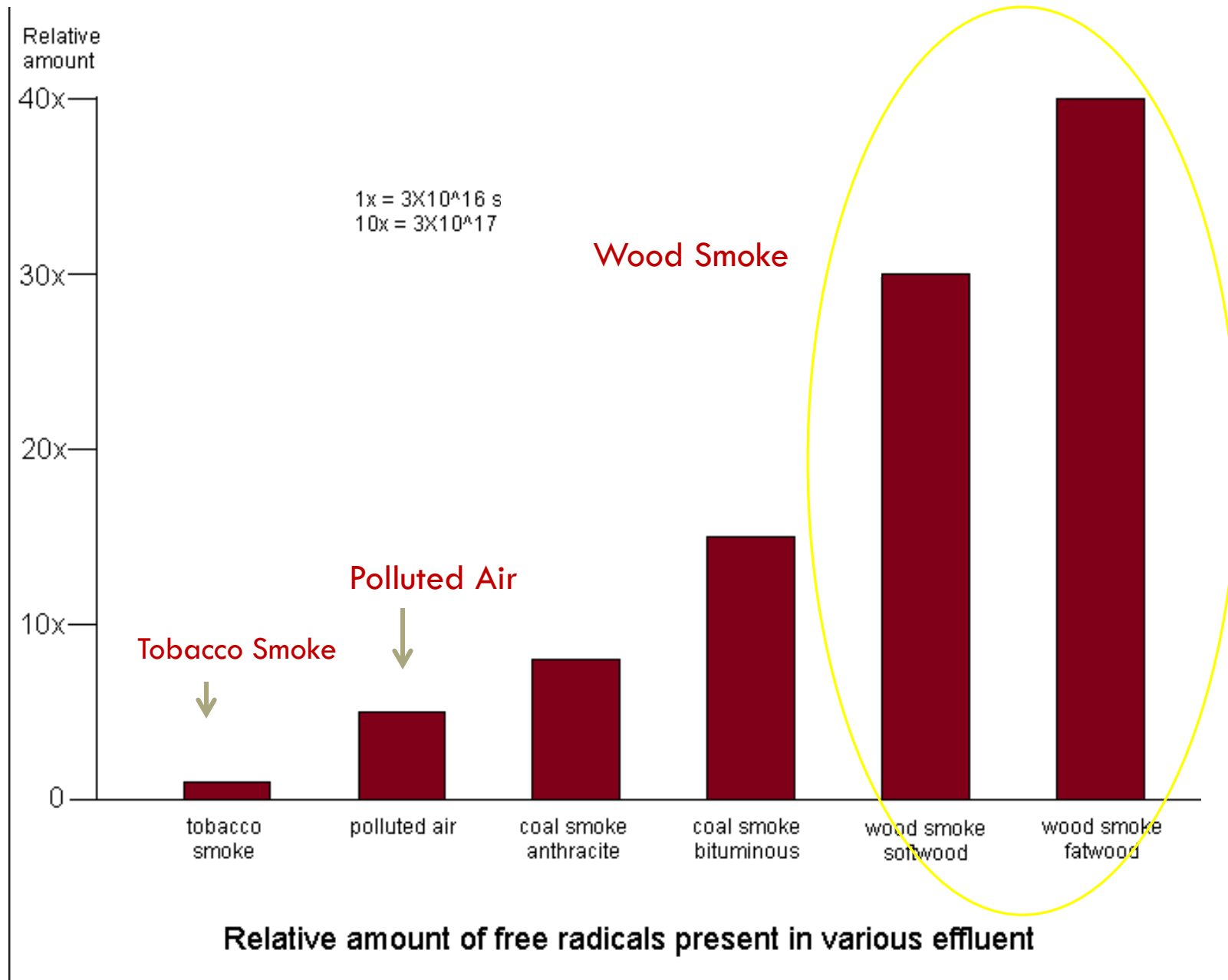
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The EPA estimates that a single fireplace operating for an hour and burning 10 pounds of wood will generate 4,300 times more PAHs than 30 cigarettes. PAHs are carcinogenic.

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

Gustafson P, Barregard L, Strandberg B, Sällsten G. 2007. J Environ Monit. 9(1):23-32
20 Gustafson P, Ostman C, Sällsten G. 2008. Environ Sci Technol. 42(14):5074-80. |



*Forchhammer
et al, 2012*

“...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.

CHARACTERIZING THE RISKS

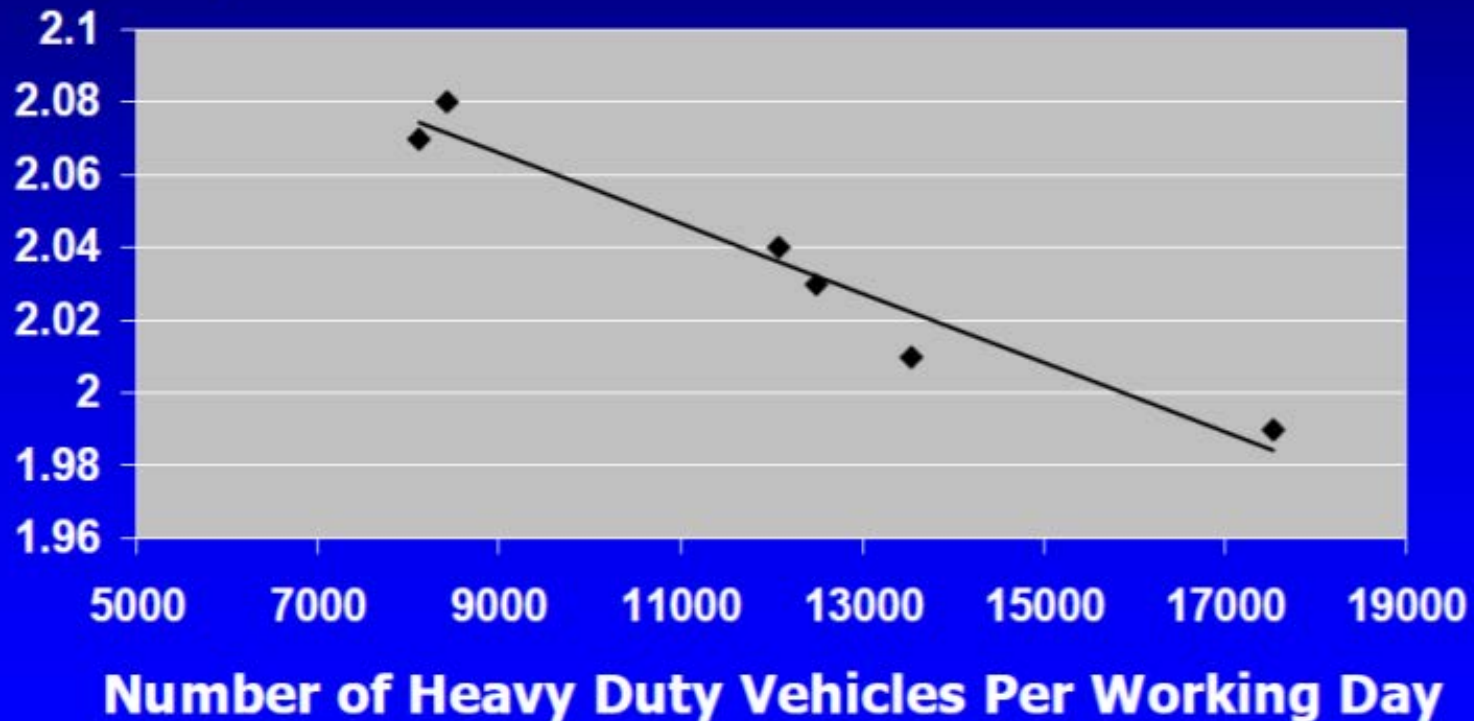
1. Physiochemical properties of woodsmoke and lung/environment interface
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5. Cumulative risk and indoor/outdoor correlation

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

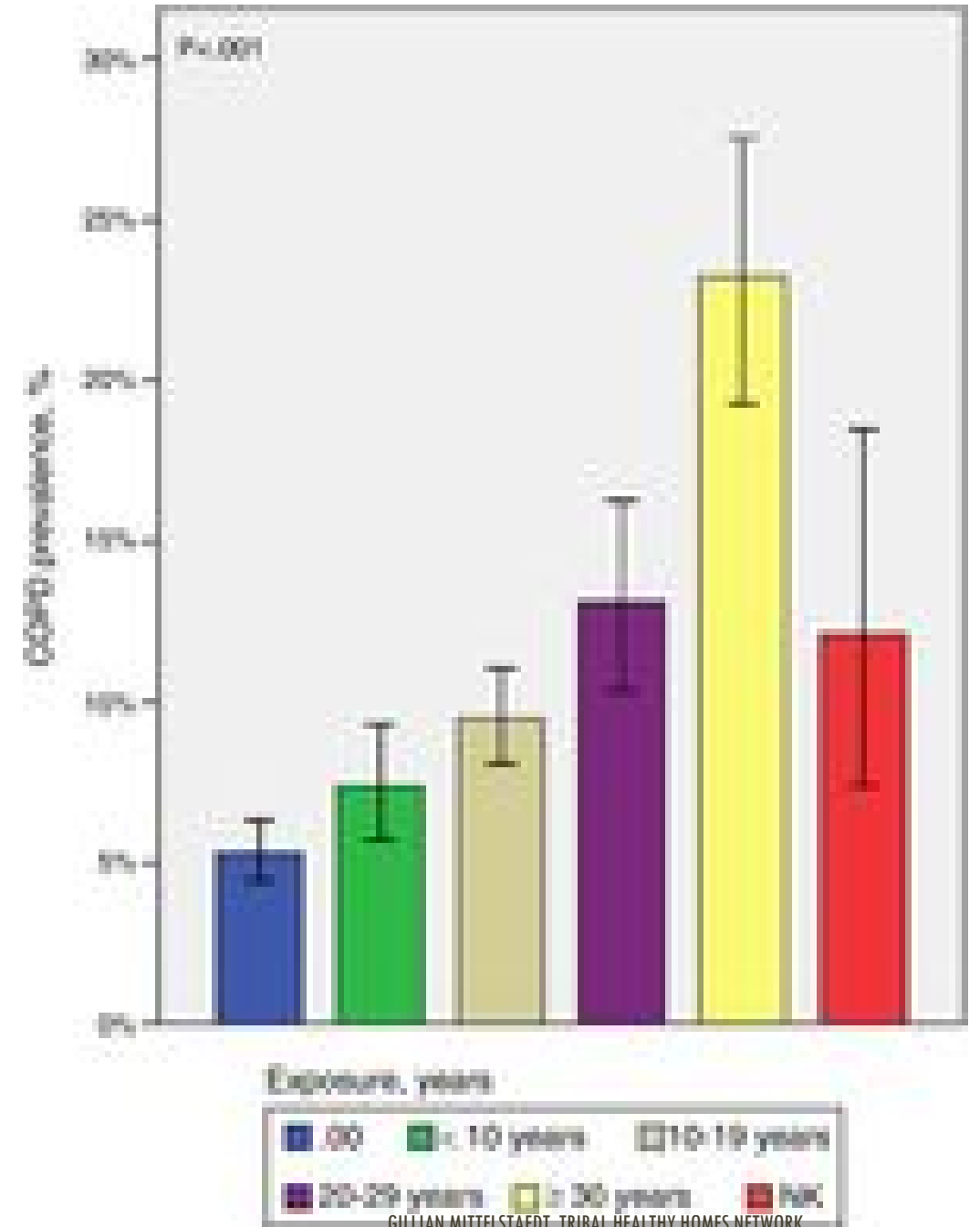
Lung Function
FEV1 (Liters)



(Brunekreef et al 1997, Netherlands)

EXAMPLE

Figure 1. Prevalence of COPD by years of exposure to wood smoke.⁴⁰



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?*

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