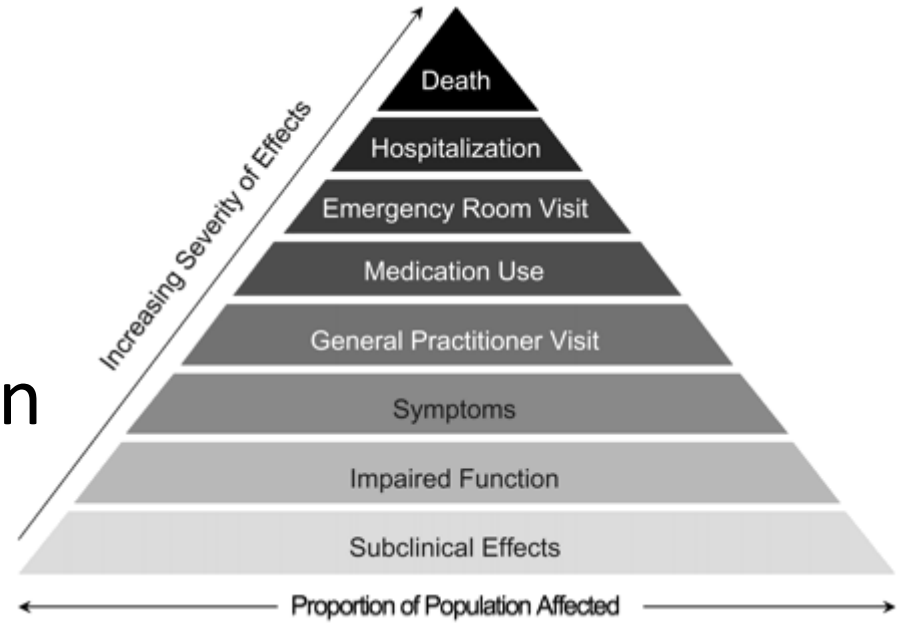
Air pollution and health

- Ambient air pollution (individual) **risk** is small…but large **exposed population = large population risk**
  - Drug abuse: Larger risk, smaller exposed population
- Major impacts are on chronic disease progression
- Diseases impacted by air pollution are multifactorial…
- …Air pollution as a contributing risk factor

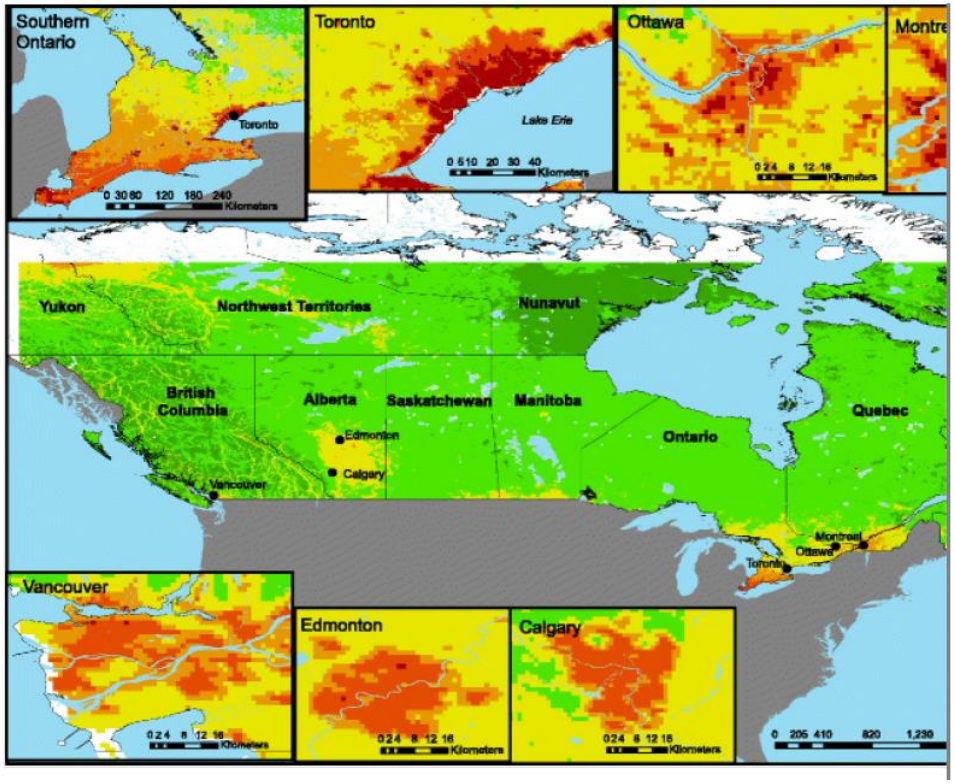
Air pollution and health

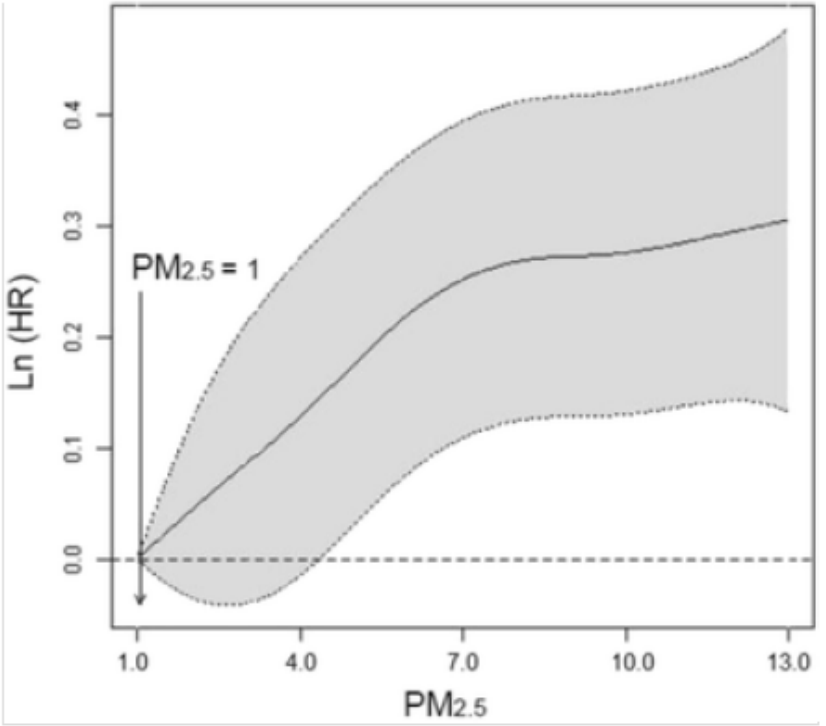
- On **days** with worse air quality, more people die*
- In **more polluted cities**, people die earlier than in less polluted cities…
- …and, in the **most polluted areas** of cities, there is an increased risk of dying



Larrieu et al. Am J Epidemiol, 2009

*out-of-hospital, >65 yrs





300,000 Adult Canadians (CCHS)

8 – 11 year follow-up

No evidence of threshold above 1 µg/m^3 minimum level

Pinault L, Tjepkema M, Crouse D, Weichenthal S, van Donkelaar A, Martin RV, Brauer M, Chen H, Burnett RT. Risk estimates of mortality attributed to low concentrations of ambient fine particulate matter in the Canadian Community Health Survey. Environmental Health. 2016. doi: 10.1186/s12940-016-0111-6

Particulate Matter

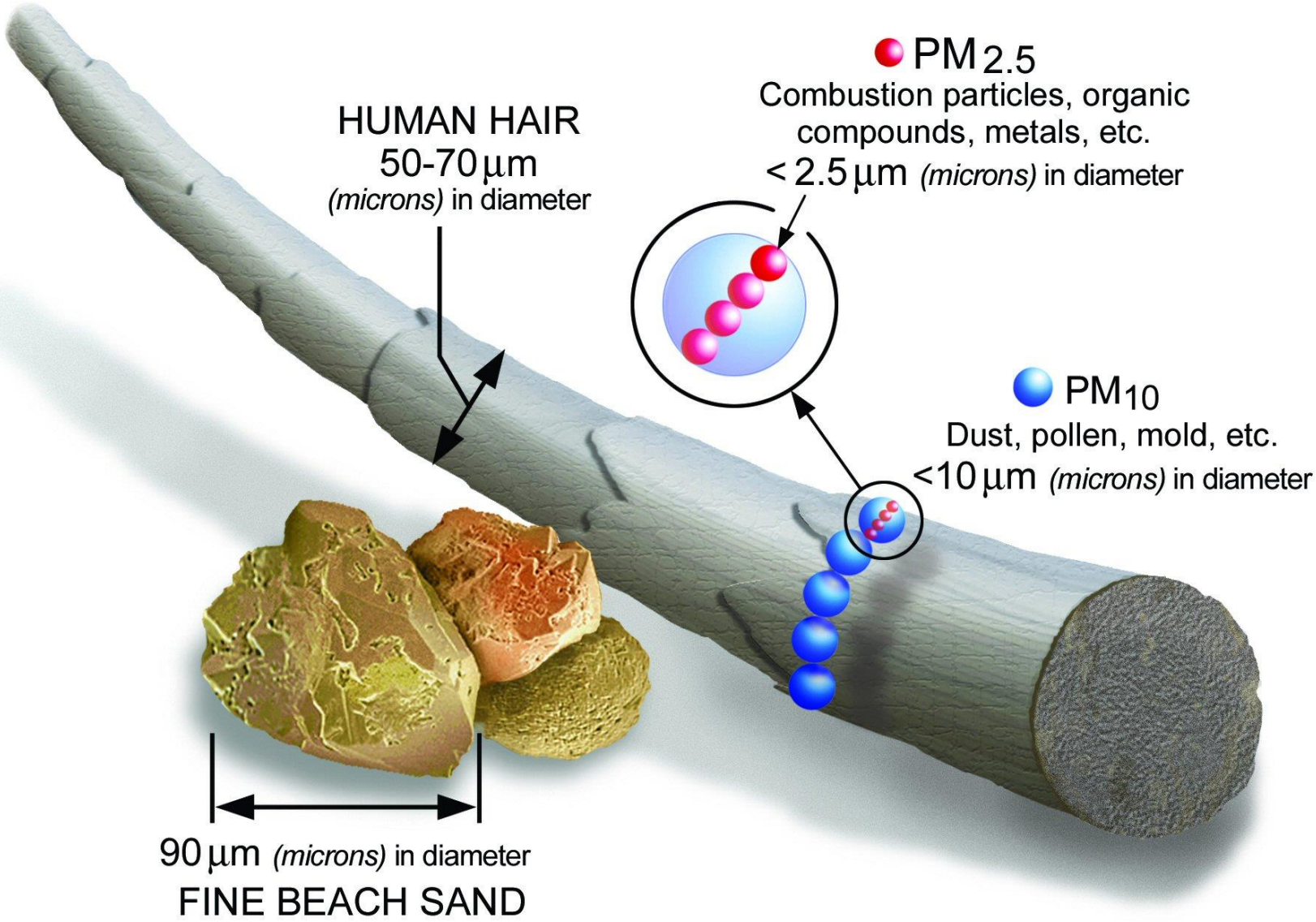
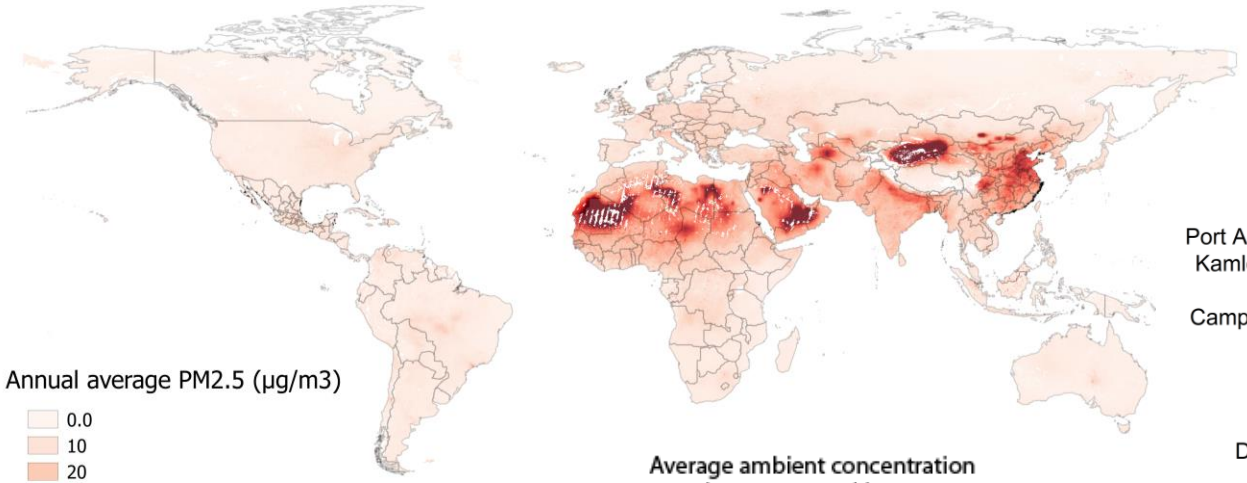
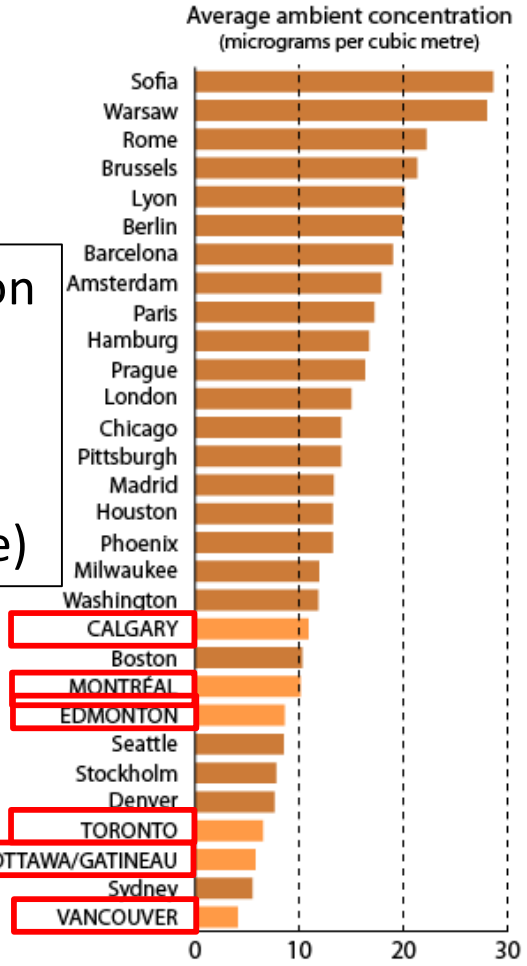


Image courtesy of the U.S. EPA

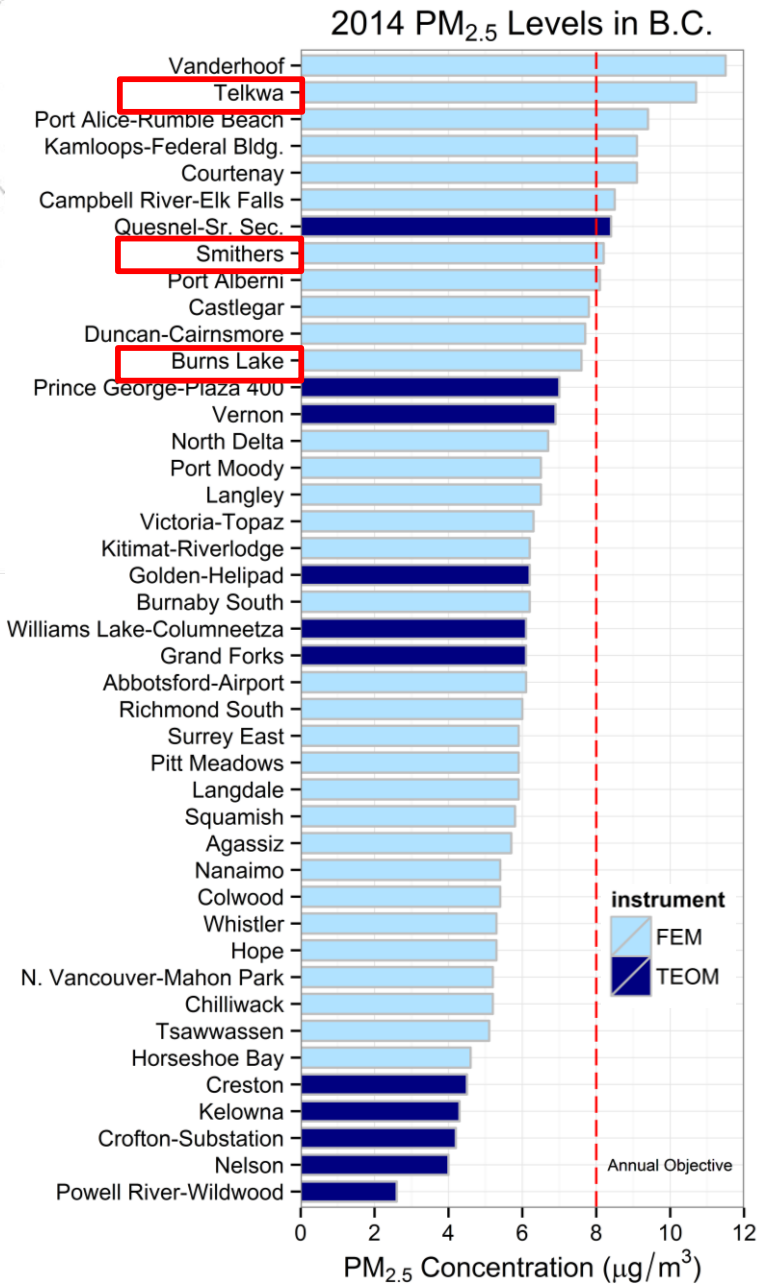


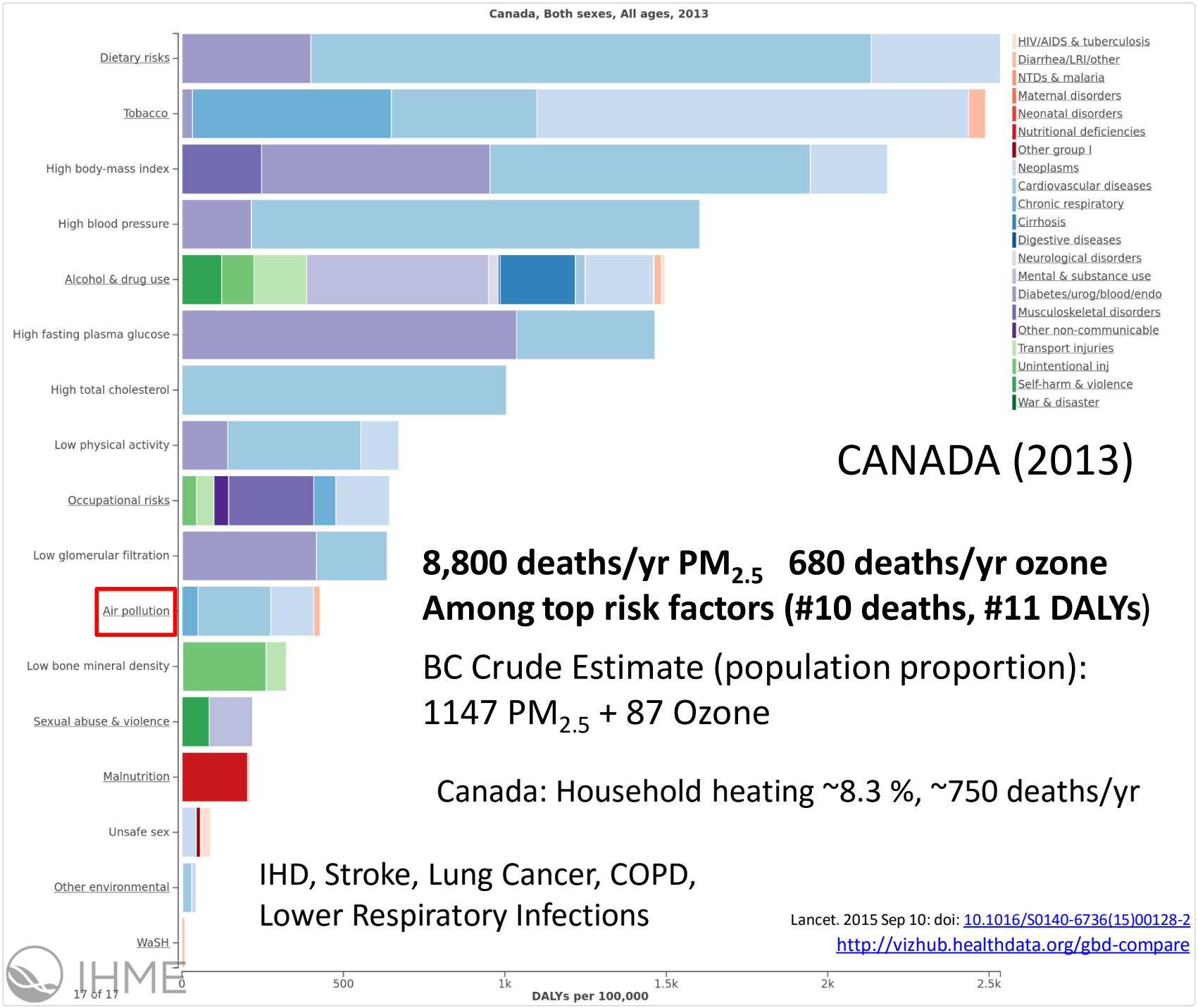
87% global population in areas exceeding WHO Air Quality Guideline (10 µg/m^3 $PM_{2.5}$ annual average)



Brauer et al., 2015
Environment Canada

BC State of the Air Report





CANADA (2013)

8,800 deaths/yr $PM_{2.5}$ 680 deaths/yr ozone
Among top risk factors (#10 deaths, #11 DALYs)

BC Crude Estimate (population proportion):
1147 $PM_{2.5}$ + 87 Ozone

Canada: Household heating ~8.3 %, ~750 deaths/yr

IHD, Stroke, Lung Cancer, COPD,
Lower Respiratory Infections

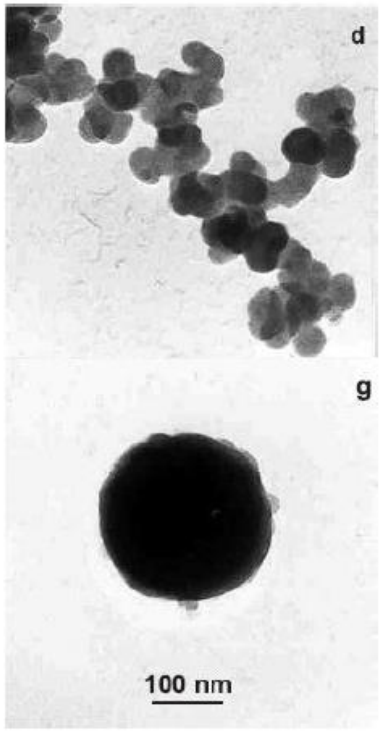
Lancet. 2015 Sep 10: doi: 10.1016/S0140-6736(15)00128-2
http://vizhub.healthdata.org/gbd-compare

Woodsmoke health effects

"….based on the current, limited experimental findings, we cannot conclude that exposure to residential biomass emissions in developed countries is less harmful than exposure to combustion particles from fossil fuel combustion."

Sigsgaard T et al. Health impacts of anthropogenic biomass burning in the developed world. Eur Respir J. 2015. doi: 10.1183/13993003.01865-2014

PM composition

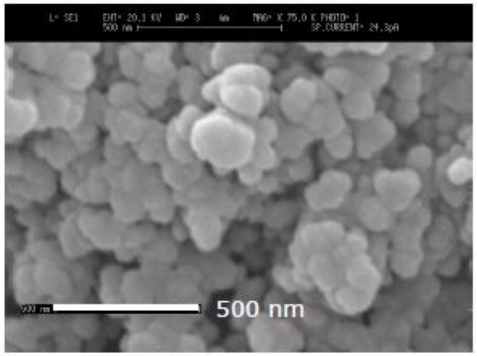


Wood smoke soot

Wood smoke organic particles (low-temp combustion)

"conventional"

from *Kocbach et al, Science of the Total Environment, 2005*)

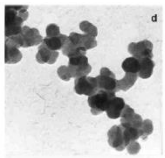


"Good" wood pellet combustion PM (alkali salt particles)

"advanced"

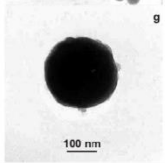
from *Boman et al, Energy and Fuels 2011;25:(1):307-314*

Combustion conditions, composition & toxicity



Wood smoke soot

BC

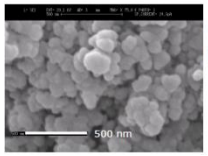


Wood smoke organic particles (low-temp combustion)

Org

from *Kocbach et al, Science of the Total Environment, 2005*)

More Toxic

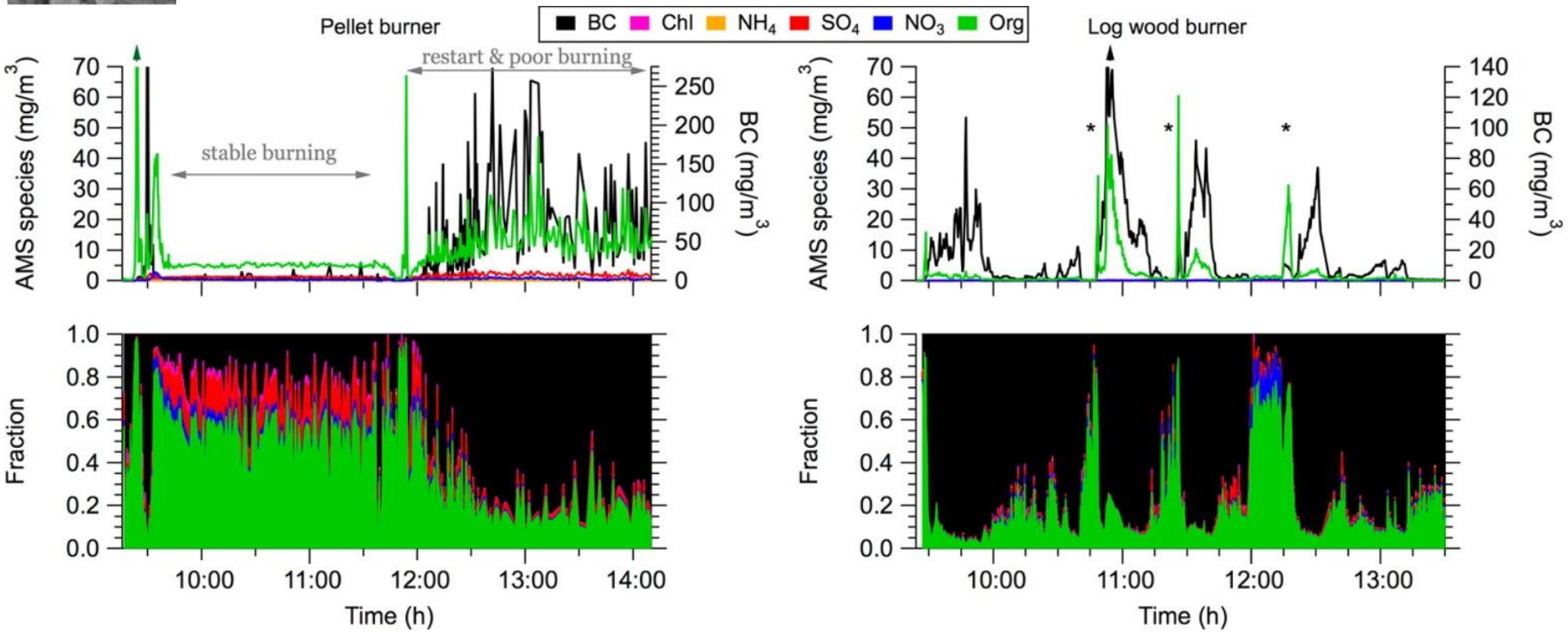


"Good" wood pellet combustion PM (alkali salt particles)

Chl NH_4 SO_4 NO_3

from *Boman et al, Energy and Fuels 2011;25:(1):307-314*

Less Toxic



M. F. Heringa; P. F. DeCarlo; R. Chirico; A. Lauber; A. Doberer; J. Good; T. Nussbaumer; A. Keller; H. Burtscher; A. Richard; B. Miljevic; A. S. H. Prevot; U. Baltensperger; *Environ. Sci. Technol.* **2012,** 46, 11418-11425. DOI: 10.1021/es301654w

Combustion source	Emissions (mg/MJ)	Composition
Open fireplace	160 – 910	
Conventional woodstove	50 – 2100	
Conventional log boilers	50 – 2000 (50 – 250)	
‘Modern” woodstoves log/chip boilers	34 – 330 5 – 450	
Pellet stoves/boilers	10 - 50	

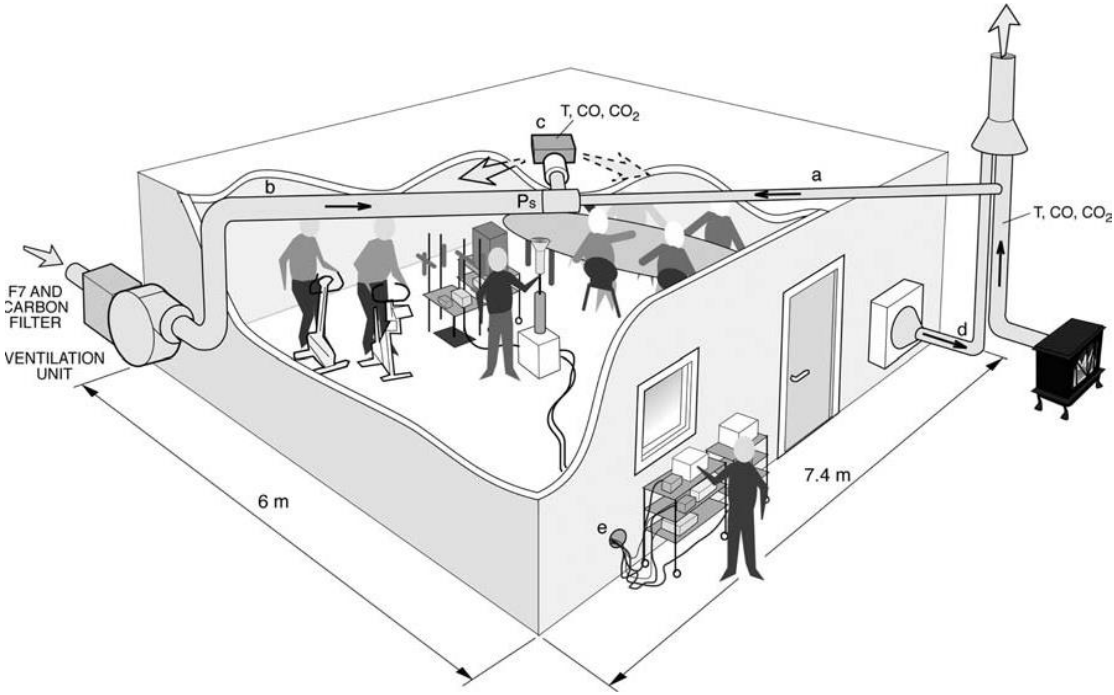
adapted from: Kocbach Bølling et al. 2009

Combustion source	Emissions (mg/MJ)	Composition
Open fireplace	MORE TOXIC	
Conventional woodstove		
Conventional log boilers		
‘Modern” woodstoves log/chip boilers		
Pellet stoves/boilers	LESS TOXIC	

adapted from: Kocbach Bølling et al. 2009

Controlled human exposure studies

- **Subjects exposed to realistic (high) concentrations (~250 $\mu g/m^3$) of woodsmoke for 4 hrs**
  - **Increases in measures of inflammation, oxidative stress post-exposure compared to clean air**

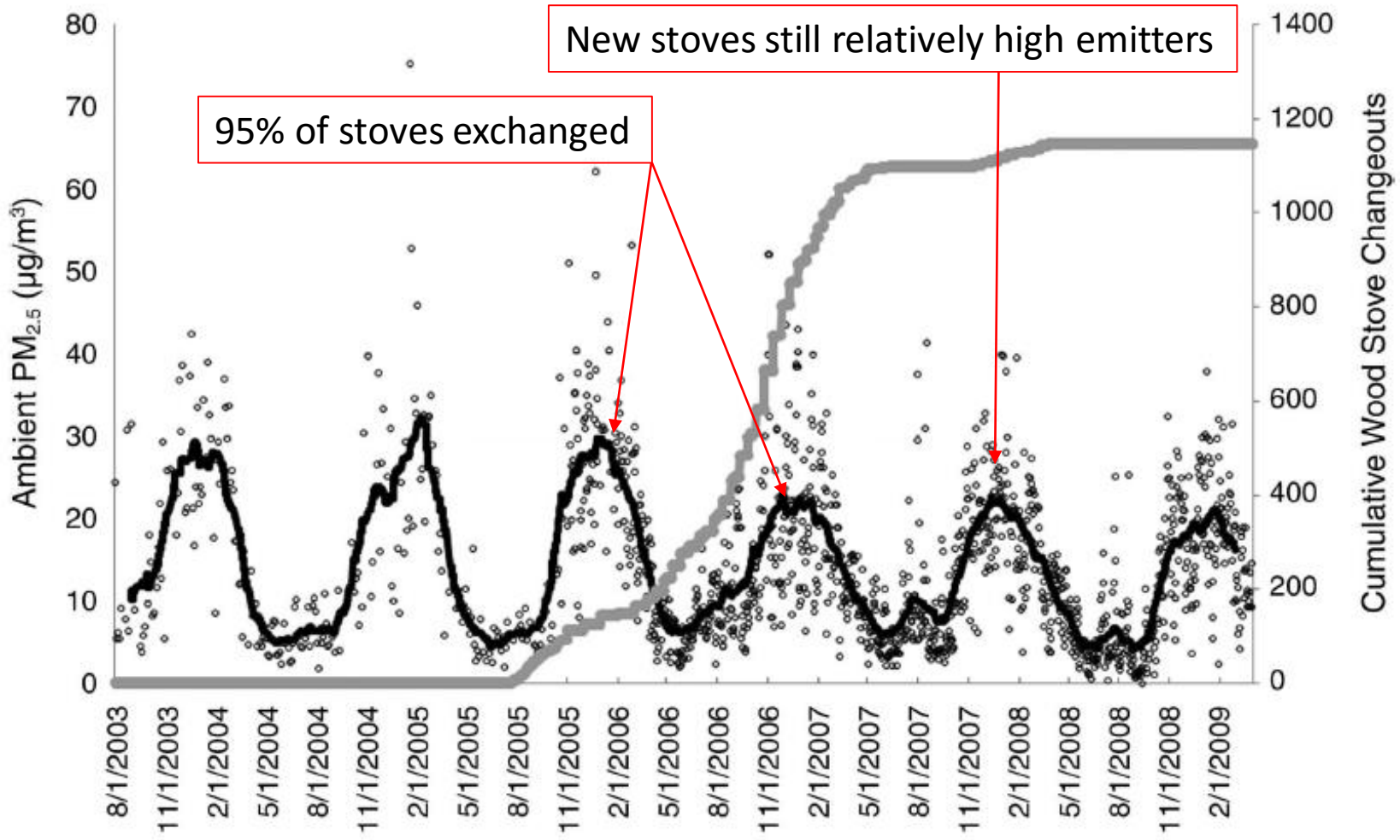


- **Pellet stove incomplete combustion**
  - **No inflammation**
  - **Early adaptive protective response**

Sallsten, G et al. Experimental wood smoke exposure in humans. *Inhal. Toxicol*. 18(11):855–864.; Barregard L et al. Experimental exposure to wood-smoke particles in healthy humans: effects on markers of inflammation, coagulation, and lipid peroxidation. Inhal Toxicol. 2006 Oct;18(11):845-53.; Danielsen PH et al. Oxidatively damaged DNA and its repair after experimental exposure to wood smoke in healthy humans.. Mutat Res. 2008 Jul 3;642(1-2):37-42.; Barregard L et al. Experimental exposure to wood smoke: effects on airway inflammation and oxidative stress.. Occup Environ Med. 2008 May;65(5):319-24.

Sehlstedt, M., R. Dove, et al. (2010). "Antioxidant airway responses following experimental exposure to wood smoke in man." Particle and Fibre Toxicology 7(1): 21.

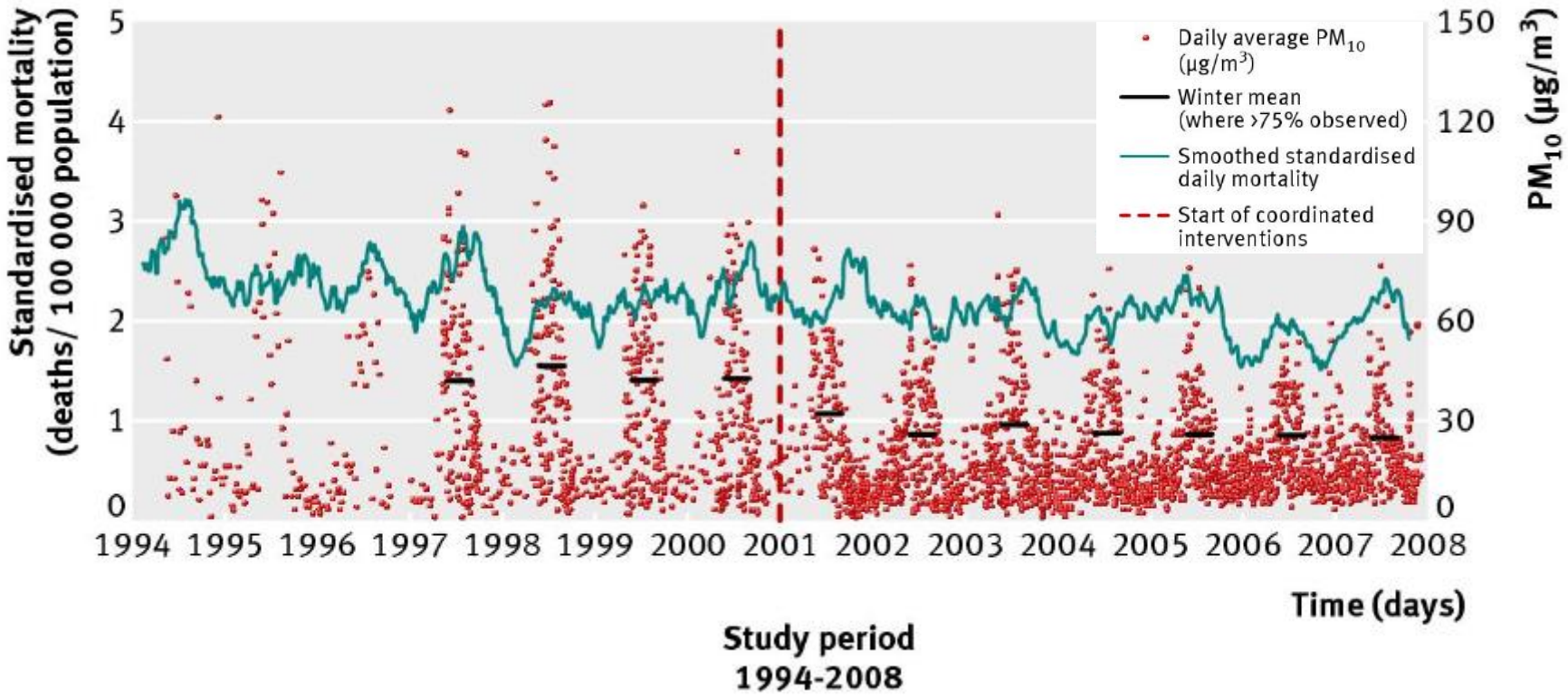
Libby, Montana stove exchange



- ~30% reduction in winter $PM_{2.5}$
- ↓ in childhood wheeze, itchy eyes, sore throat, cold, bronchitis, influenza, throat infections
- School absence associations inconsistent

A rural community intervention targeting biomass combustion sources: effects on air quality and reporting of children's respiratory outcomes. **Noonan CW**, Ward TJ, Navidi W, Sheppard L. Occup Environ Med. 2012

Tasmania woodstove → electricity

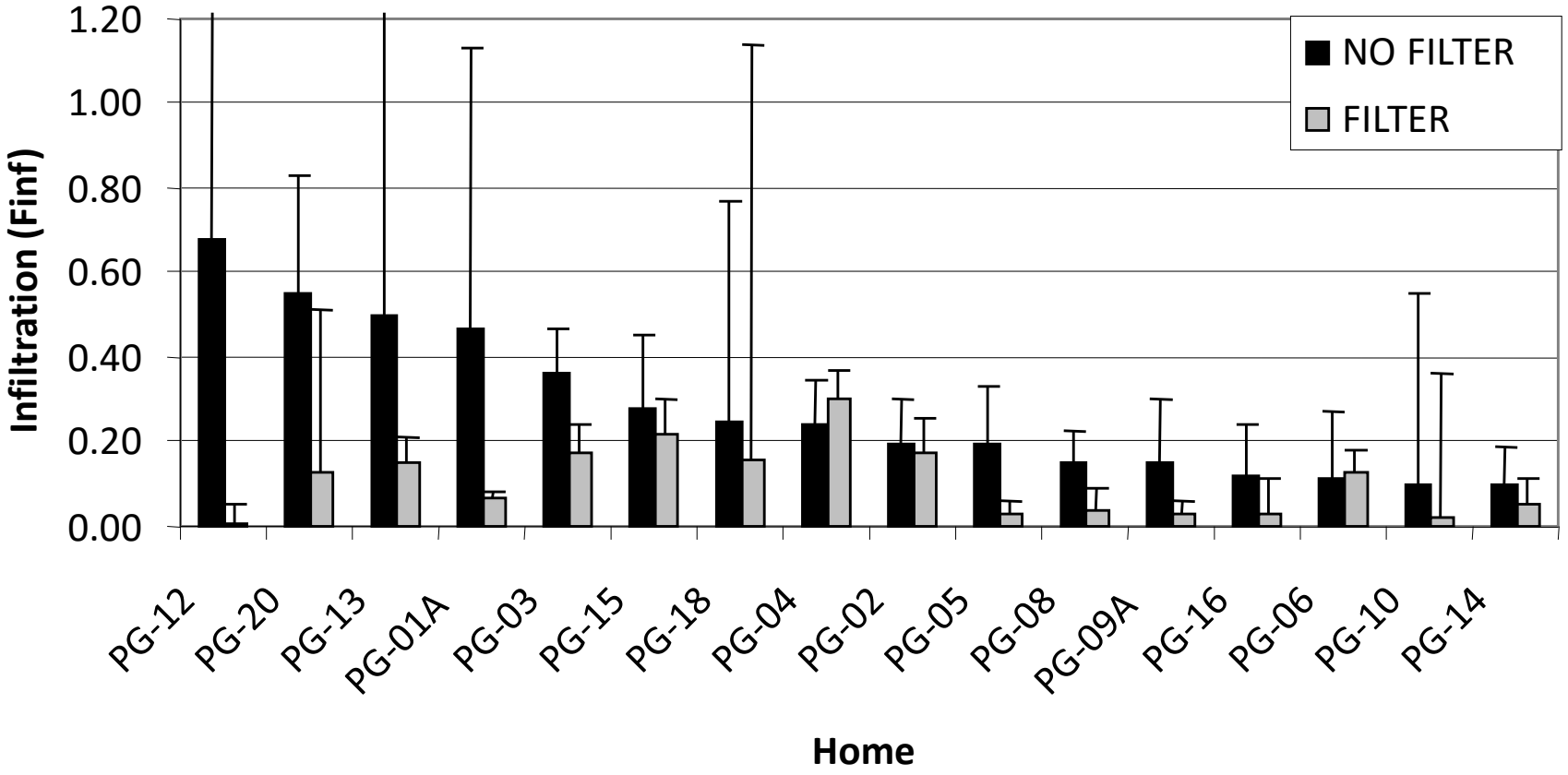


- ~39% reduction in winter PM_{10}
- ↓ winter cardiovascular (-19.6%) and respiratory (-27.9%) mortality
- Similar decreases not observed in control community

Evaluation of interventions to reduce air pollution from biomass smoke on mortality in Launceston, Australia: retrospective analysis of daily mortality, 1994-2007. Johnston FH, Hanigan IC, Henderson SB, Morgan GG. BMJ. 2013

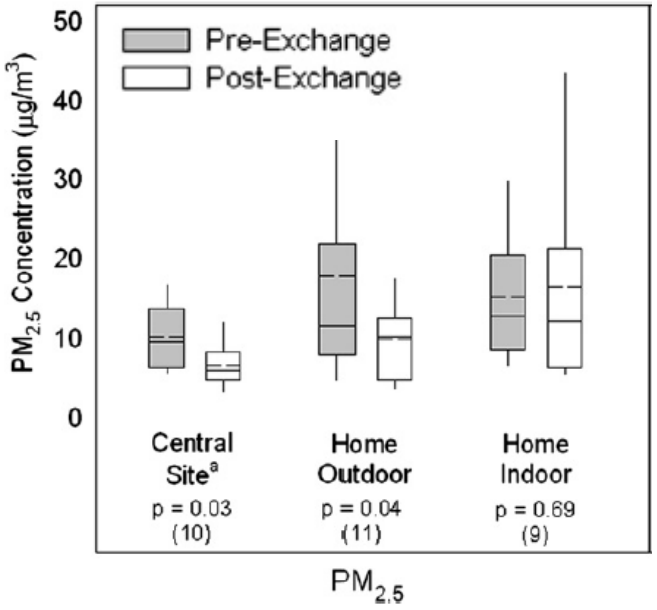
Particle infiltration

Mean infiltration: 27% no filter, 10% with filter

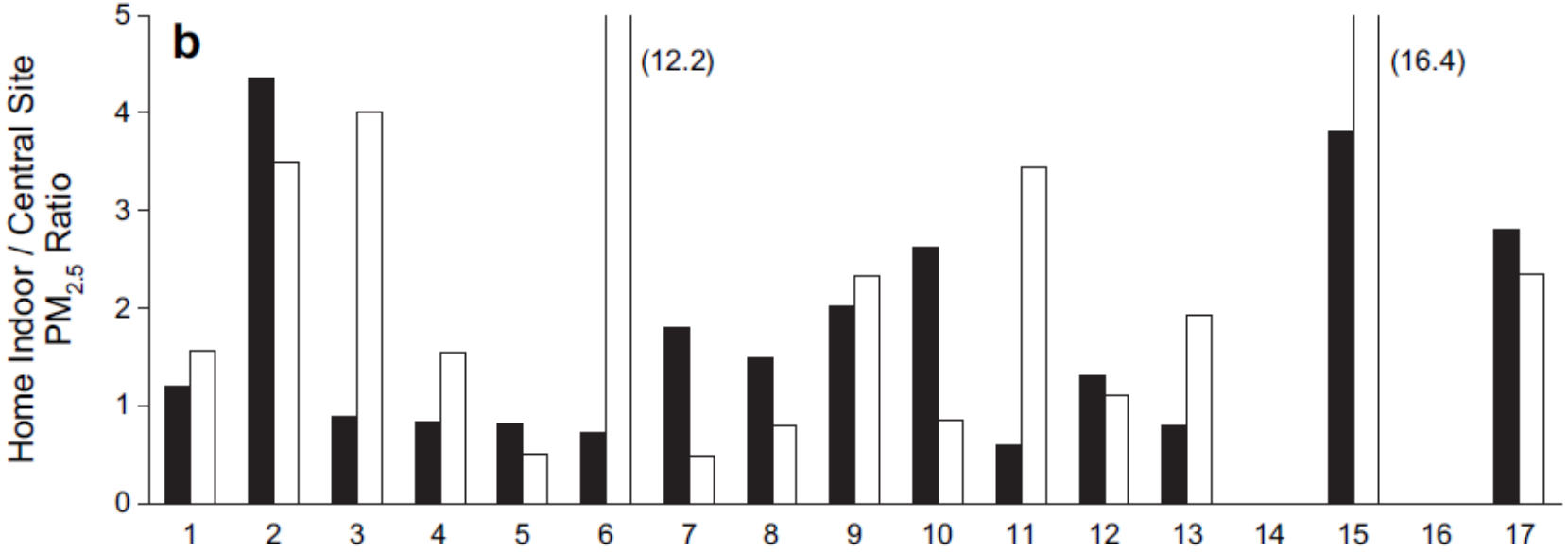


Barn P, Larson T, Noullett M, Kennedy S, Copes R, Brauer M. Infiltration of forest fire and residential wood smoke: an evaluation of air cleaner effectiveness. J Expo Sci Environ Epidemiol. 2008 Sep;18(5):503-11

Stove exchange and indoor levels



Allen RW, Leckie S, Millar G, Brauer M. The impact of wood stove technology upgrades on indoor residential air quality. Atmospheric Environment, 2009, 43: 5908–5915



Epidemiology

- "…emissions from current biomass combustion products **negatively affect respiratory and, possibly, cardiovascular health**…"
- "Epidemiological studies strongly suggest that there are **adverse health effects related to short-term as well as long-term exposure to biomass smoke** in the developed world. Intervention studies performed, to date, suggest **beneficial health effects of reducing exposure to biomass smoke**."
- We recommend that **emissions from biomass combustion should be kept to a minimum to protect public health**."

Sigsgaard T et al. Health impacts of anthropogenic biomass burning in the developed world. Eur Respir J. 2015. doi: 10.1183/13993003.01865-2014

New regulations

- 2016-17: Only wood and pellet stoves, boilers, furnaces certified to meet new US EPA or CSA emission standards legal to sell in B.C.
- 30 m setback for new Outdoor Wood Boilers (OWBs); Phase-out of older OWBs
- Prohibit burning of undesirable fuels, such as garbage, plastics and treated wood

Thank you!

Questions?

michael.brauer@ubc.ca