

# The Largest Environmental Health Hazard in the World

Kirk R. Smith, MPH, PhD  
Professor of Global Environmental Health  
University of California, Berkeley

Haagen-Smit Award Presentation  
California Air Resources Board  
Sacramento June 24, 2015

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# The New York Times

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## ENVIRONMENT

### Toxic Tsunami threatening California

By OUR CORRESPONDENT

Evidence indicates that a wave of toxic material will soon be affecting California. As many as half of all households to be exposed to hazards from new technology far exceeding safety standards. Poor most hard hit. Thousands likely to die.

9 Comments

### A Mix of Emotions From Supporters of Confederate Flag



Senator Bernie Sanders of Vermont spoke last month at South Church in Portsmouth, N.H. Win McNamee/Getty Images

### Hurdle for Sanders Bid: Little Black Support

By PATRICK HEALY and JONATHAN MARTIN 7:00 AM ET

With a poll showing nonwhite voters strongly favoring Hillary Rodham Clinton, Bernie Sanders's capacity to win support among

## The Opinion Pages

### ROOM FOR DEBATE

**Threat of Homegrown Hate**  
How should we deal with domestic extremists like those who inspired Dylann Roof?

- Editorial: Trade Authority
- Friedman: Cold War Without the Fun
- Edsall: Why Don't the Poor Rise Up?
- Bittman: Trust me. Butter is Better.
- Op-Ed: I Can't Forgive Dylann Roof



NICHOLAS KRISTOF

### Corruption Is Killing Children in Angola

Western governments are buddying up to this oil-rich country, while ignoring its abysmal record on child mortality.

The New York Times

It will wash across the countryside  
exposing more than half California's population  
to a toxic soup containing

- Dozens of poisonous organic chemicals known to be mutagens, immune system suppressants, severe irritants, blood poisons, inflammation agents, central nervous system depressants, cilia toxins, endocrine disrupters, or neurotoxins.
- Several other chemicals firmly established as human carcinogens.
- Other toxic inorganic chemicals known to cause asphyxiation, stillbirth, infant death, heart disease, and severe acute and chronic lung disease.

# The Toxic Tsunami

- Will be the result of a process that pours this toxic soup directly into half of all US homes every day; all year; every year.
- Will expose families to toxic levels much higher than those of people living on top of toxic waste dumps, working in most heavy industries, or residing in the dirtiest cities
- Levels will be more than  $>10x$  more than set by international and national agencies to protect health
- Insidiously, it will target women and young children in these households

# Why would it happen?

- Because a technology will be widely promoted that takes perfectly safe natural material and converts 10% of it to toxins in the course of functioning. Sometimes as much as 20%
- The efficiency of the process is extremely low, leading to little human benefit per unit toxin created as well as waste of the natural resource.
- Instead of carefully disposing of this toxic material in safe places, this industry will spread the toxic soup by air right into neighborhoods where people live.
- All this, in spite of there being well-known alternative technologies available producing very little toxin.

# What might be the health consequences if this happens?

- An epidemic of a respiratory illness that kills children faster than SARS or Avian Flu – initiation to death in 2 days in some cases.
- So fast, that trying to apply medical care is often hopeless.
- Estimates are that soon it would be killing at least 60 California children a week, 3,000 a year

# What about adults?

- A growing impact on cardiovascular disease – stroke and heart attacks
- Starting with a rise in blood pressure and changes in the heart beat patterns
- Within a few years, 45 a week would be dying prematurely from this toxic mixture
- More than 16,000 Californians a year

# What else?

- Thousands of poor women would start to have their breath taken from them as their lung function is slowly eaten away by exposure to the toxins
- Thus, at tragically young ages they will become unable to breathe normally or do common tasks.
- Alarmingly, once affected, there is no known medical therapy to reverse the process.
- Unless the technology is stopped, in a few years more than 16 California women per week, 6000 per year, would start to die prematurely because their lungs would finally give out.

# Anything else?

- There are strong indications that the burden on households would include many other insidious diseases, such as
  - A major negative impact on babies' health and survival through reductions in growth before birth and prematurity
  - Increases in several types of cancer, including lung and throat
  - Damage to the eyesight of thousands of women
  - An increase in tuberculosis, one of the most important and intransigent of the re-emerging infectious diseases
  - Reduction in child cognitive capacity (learning ability or IQ)
  - Several types of birth defects

# What should the response be?

In fact, nothing will happen

— no one will notice

- Full time coverage by major news outlets as the disaster unfolds?
- Governor Brown will mobilize the national guard to protect California?
- Emergency legislation will be passed in Sacramento to provide funds for cleaner technologies?
- New laws and regulations will be passed by Congress so that it never happens again?

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## Homegrown Radicals More Deadly Than Jihadis in U.S.

By SCOTT SHANE 5:00 AM ET  
Counter to public perception, nearly twice as many people have been killed on American soil since Sept. 11, 2001, by white supremacists and other non-Muslim extremists than by radical Muslims, according to a research group.  
9 Comments

## A Mix of Emotions From Supporters of Confederate Flag



Senator Bernie Sanders in Portsmouth, N.H. Win McNamee/Getty Images

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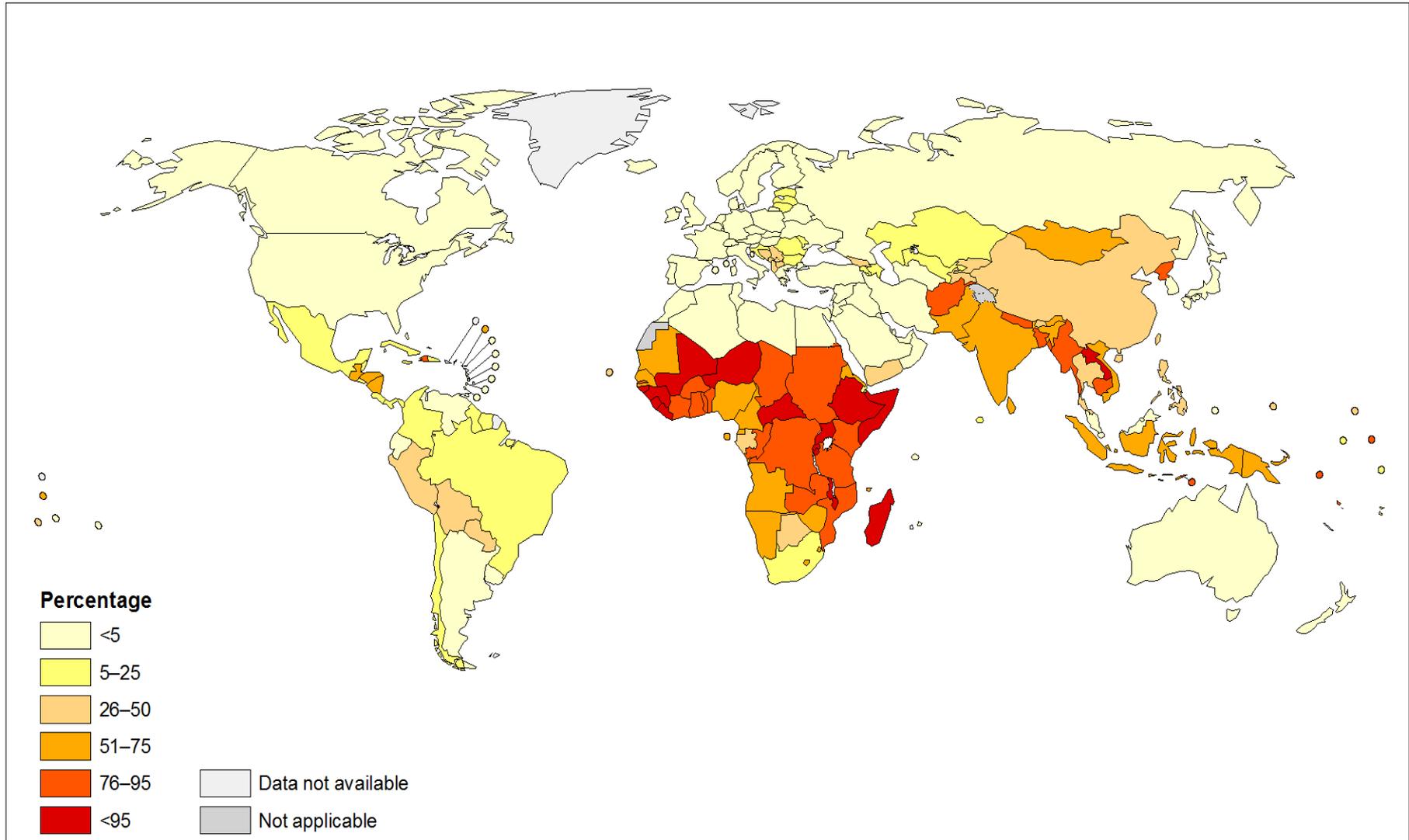
Everything stated about this Toxic Tsunami is true, as best we know, except for three aspects:

1. It is already happening
2. In 40% the world's households, but not in California
3. Due to lousy technology, but no industry is responsible  
- but rather poverty and apathy

The three major solid fuels



# Population Cooking with Solid Fuels in 2010 (%)



The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: World Health Organization  
Map Production: Public Health Information  
and Geographic Information Systems (GIS)  
World Health Organization



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# Woodsmoke is natural – how can it hurt you?

Or, since wood is mainly just carbon, hydrogen, and oxygen, doesn't it just change to  $\text{CO}_2$  and  $\text{H}_2\text{O}$  when it is combined with oxygen (burned)?

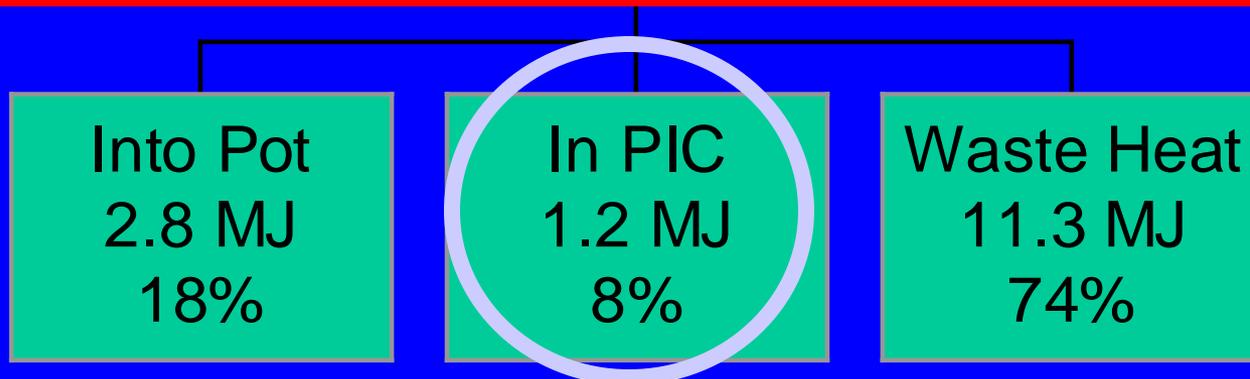


Reason: the combustion efficiency is far less than 100%

# Energy flows in a well-operating traditional wood-fired Indian cooking stove

A Toxic Waste Factory!!

Typical biomass cookstoves convert 6-20% of the fuel carbon to toxic substances



PIC = products of incomplete combustion = CO, HC, C, etc.

Source:  
Smith,  
et al.,  
2000

# Toxic Pollutants in Biomass Fuel Smoke from Simple (poor) Combustion

- Small particles, CO, NO<sub>2</sub>
- Hydrocarbons

Typical open cookfire releases  
400 cigarettes per hour  
worth of smoke

- 20+ aldehydes including *formaldehyde & acrolein*
- 25+ alcohols and acids such as *methanol*
- 33+ phenols such as *catechol & cresol*
- Many quinones such as *hydroquinone*
- Semi-quinone-type and other radicals
- Chlorinated organics such as *methylene chloride* and *dioxin*

Source: Naeher et al,  
*J Inhal Tox*, 2007

# Health-Damaging Air Pollutants From Typical Woodfired Cookstove in India.

Wood: 1.0 kg  
Per Hour  
in 15 ACH  
40 m<sup>3</sup> kitchen

Typical Health-based Standards

Typical Indoor Concentrations

Carbon Monoxide:  
150 mg/m<sup>3</sup>

Particles  
3.3 mg/m<sup>3</sup>

Benzene  
0.8 mg/m<sup>3</sup>

1,3-Butadiene  
0.15 mg/m<sup>3</sup>

Formaldehyde  
0.7 mg/m<sup>3</sup>

10 mg/m<sup>3</sup>

0.1 mg/m<sup>3</sup>

0.002 mg/m<sup>3</sup>

0.0003 mg/m<sup>3</sup>

0.1 mg/m<sup>3</sup>

Best single indicator IARC Group 1 Carcinogens

First person in human history to  
have her exposure measured  
doing the oldest task in human history

~5000 ug/m<sup>3</sup>  
during cooking  
>500 ug/m<sup>3</sup> 24-  
hour

Emissions and  
concentrations,  
yes, but  
what about  
exposures?



India, 1981

# How much PM<sub>2.5</sub> is unhealthy?

- WHO Air Quality Guidelines
  - 10 ug/m<sup>3</sup> annual average
  - No public microenvironment, indoor or outdoor, should be more than 35 ug/m<sup>3</sup>
- National Standards
  - California first and now USEPA: 12 ug/m<sup>3</sup>
  - China: 35 ug/m<sup>3</sup>
  - India: 40 ug/m<sup>3</sup>

# Intent to do Randomized Trial: Gold Standard in Health

- After first measurements in India – proposals to do RCT for child pneumonia
- 17 years later, funding achieved – NIH
- 10 years after funding, publication of primary results

# First randomized controlled trial in air pollution history

THELANCET-D-09-06268R3

S0140-6736(11)60921-5

Embargo: [add date when known]

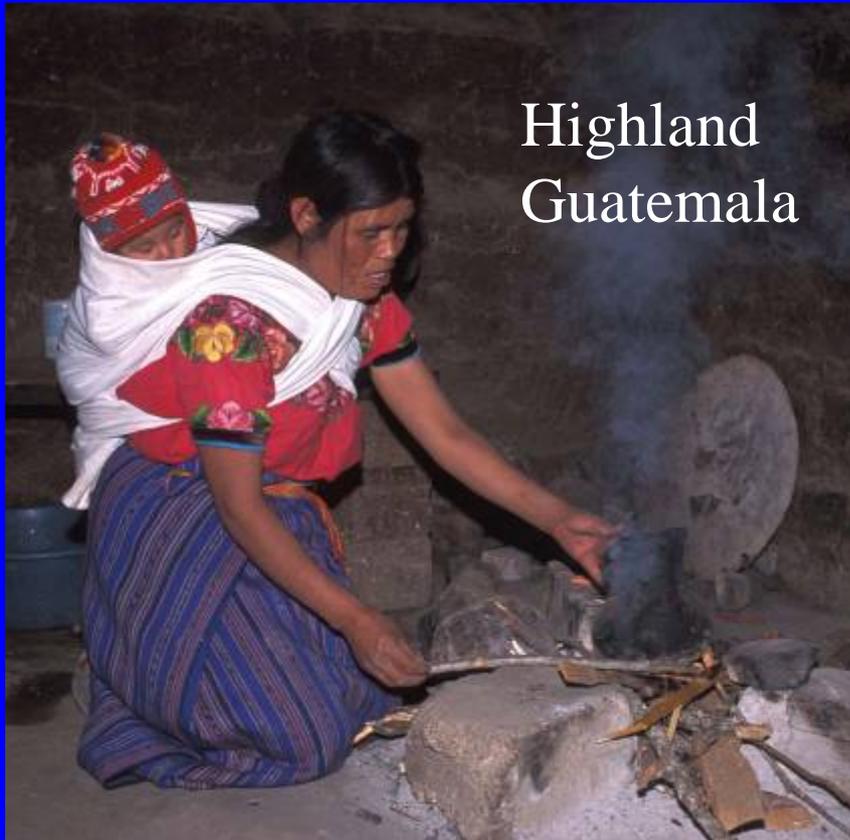
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## Effect of reduction in household air pollution on childhood pneumonia in Guatemala (RESPIRE): a randomised controlled trial

*Kirk R Smith, John P McCracken, Martin W Weber, Alan Hubbard, Alisa Jenny, Lisa M Thompson, John Balmes, Anaite Diaz, Byron Arana, Nigel Bruce*

Published Nov 2011

# RESPIRE: (Randomized Exposure Study of Pollution Indoors and Respiratory Effects)



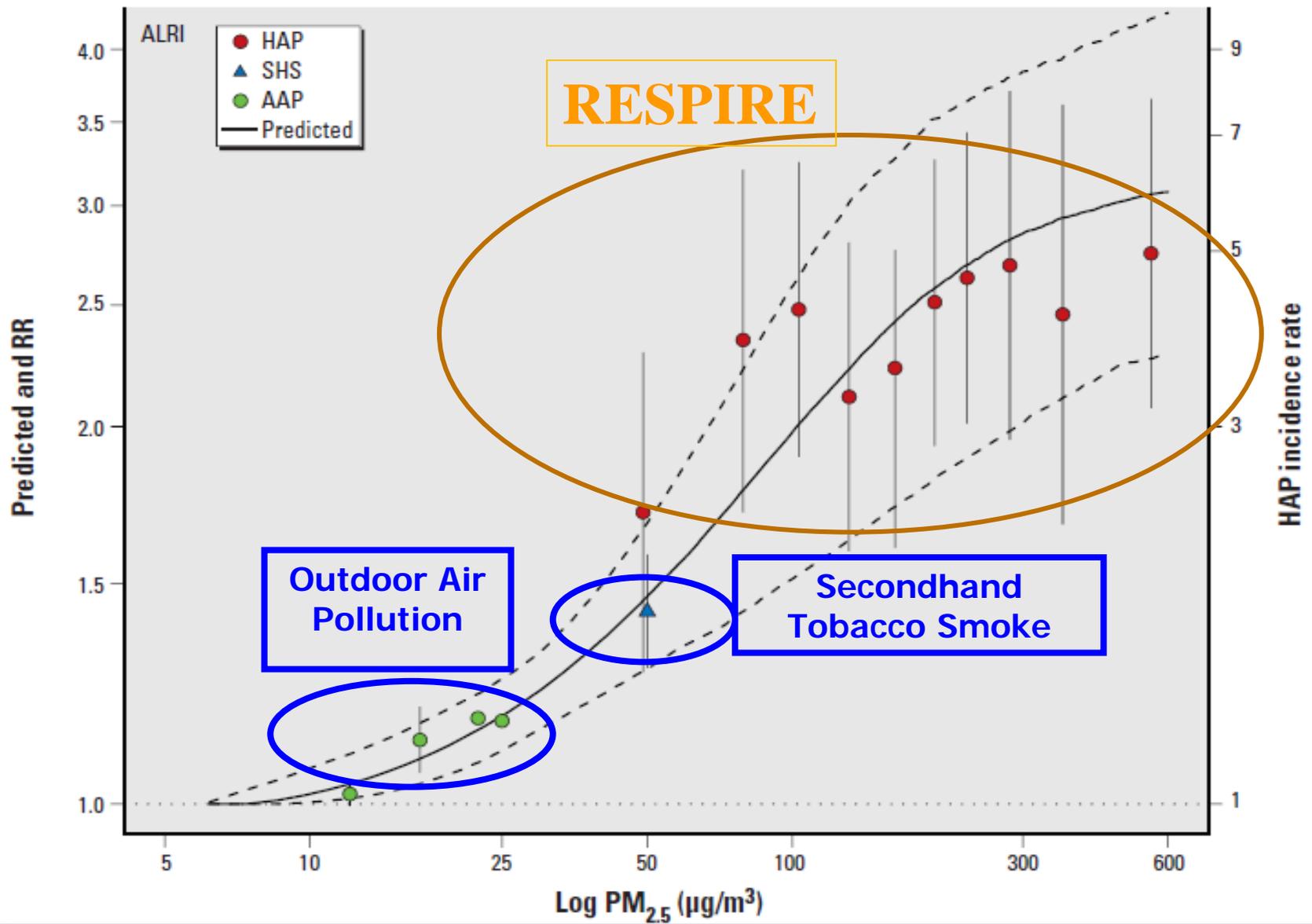
Traditional 3-stone open fire

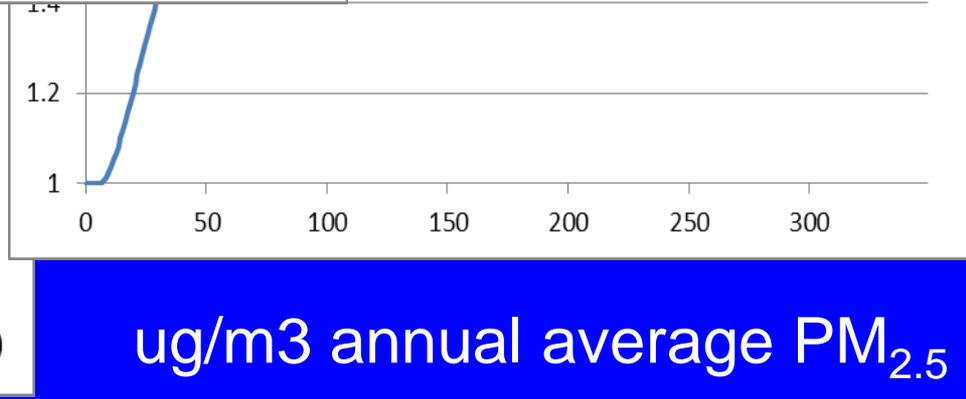
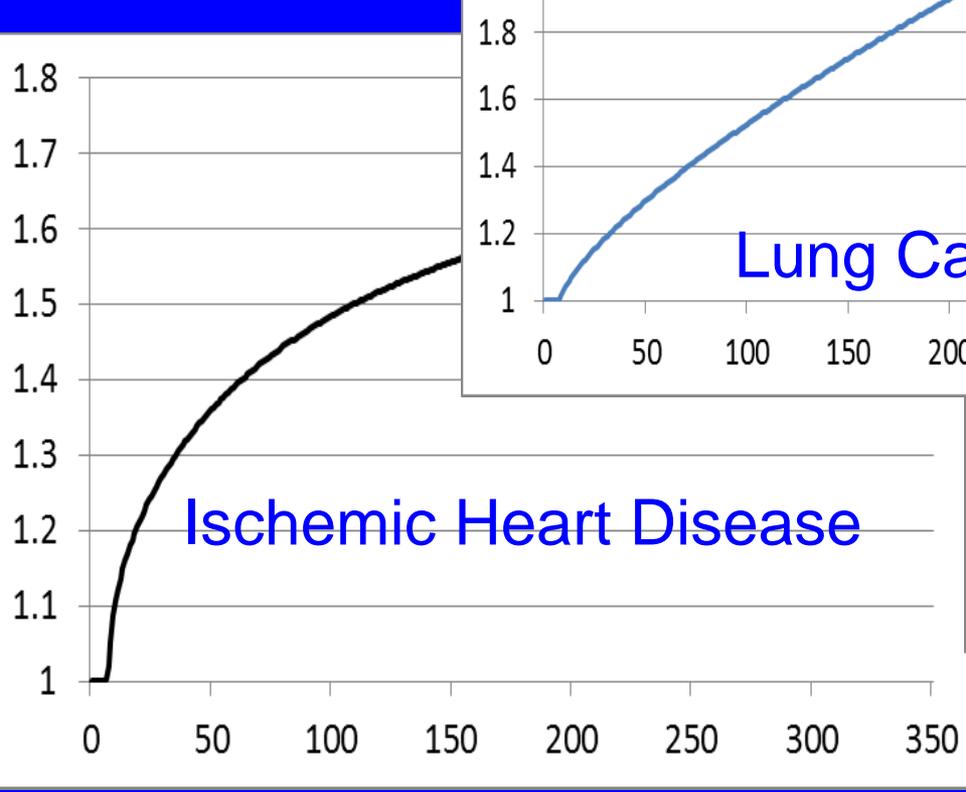
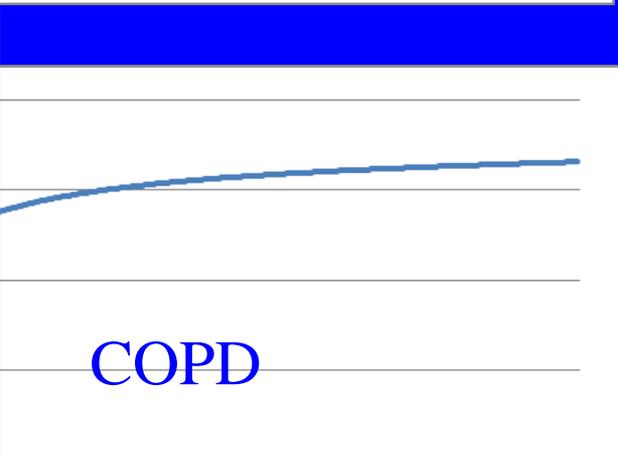
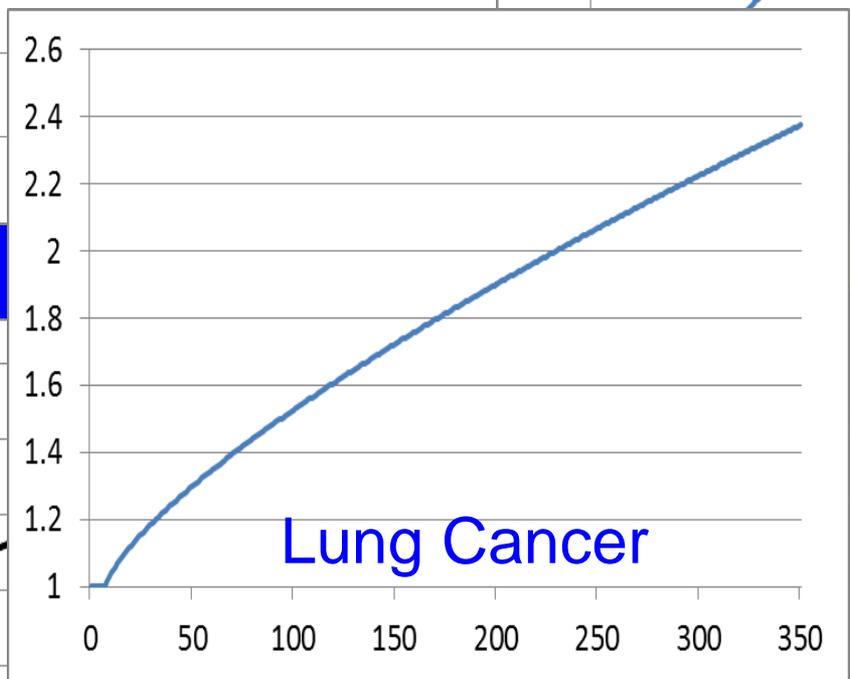
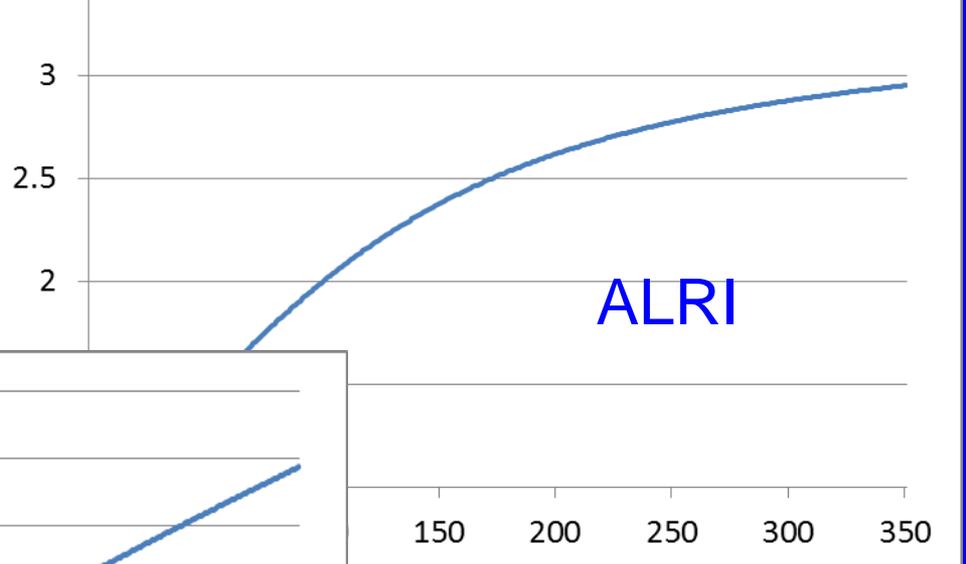
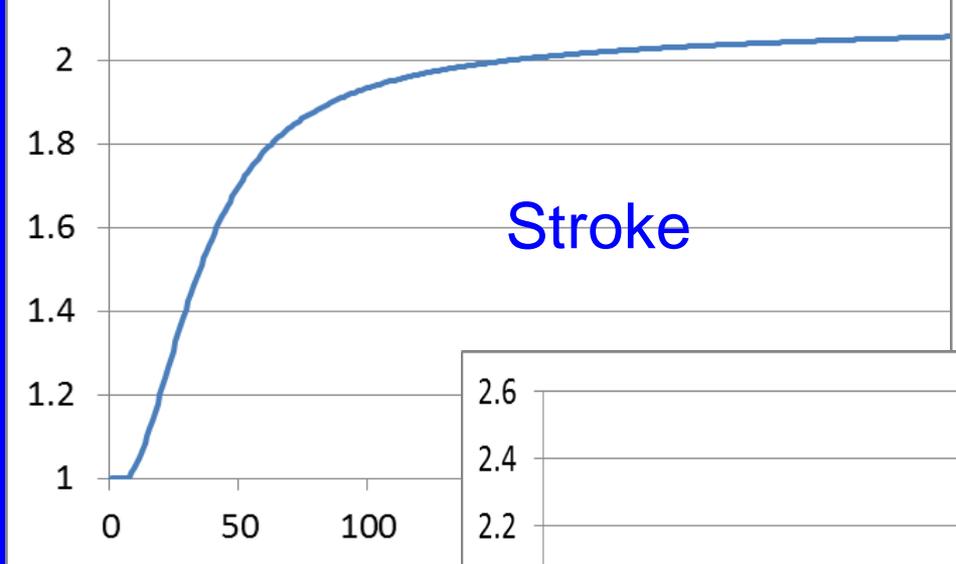


*Plancha* chimney wood stove

# Exposure-Response Curves

- By combining health effects studies of outdoor air pollution, secondhand tobacco smoke, HAP, and active smoking
- We now have exposure-response curves for 5 major diseases caused by combustion particle air pollution
- Including HAP





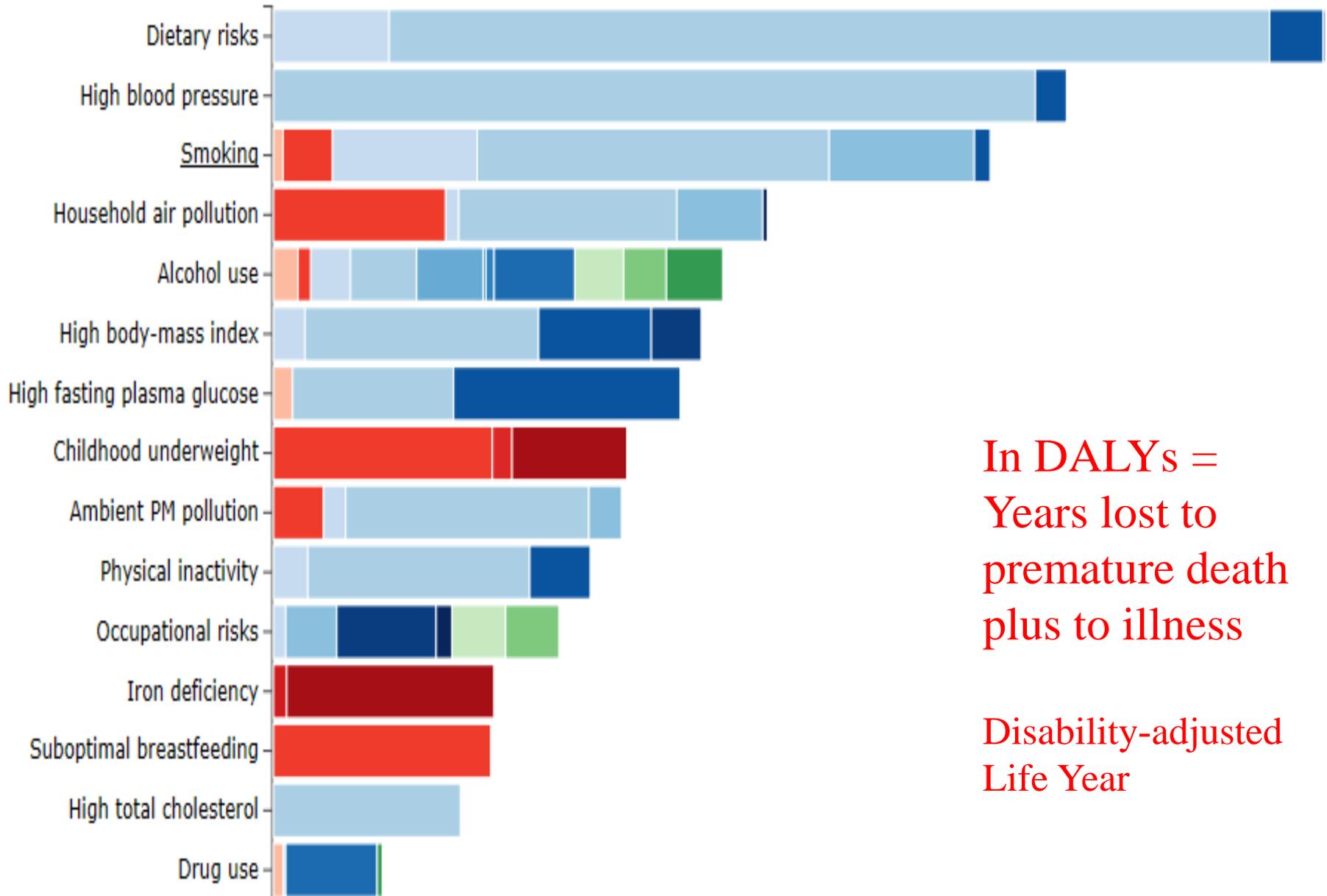
ug/m3 annual average PM<sub>2.5</sub>

# A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010

Stephen S Lim<sup>‡</sup>, Theo Vos, Abraham D Flaxman, Goodarz Danaei, Kenji Shibuya, Heather Adair-Rohani\*, Markus Amann\*, H Ross Anderson\*, Kathryn G Andrews\*, Martin Aryee\*, Charles Atkinson\*, Lorraine J Bacchus\*, Adil N Bahalim\*, Kalpana Balakrishnan\*, John Balmes\*, Suzanne Barker-Collo\*, Amanda Baxter\*, Michelle L Bell\*, Jed D Blore\*, Fiona Blyth\*, Carissa Bonner\*, Guilherme Borges\*, Rupert Bourne\*, Michel Boussinesq\*, Michael Brauer\*, Peter Brooks\*, Nigel G Bruce\*, Bert Brunekreef\*, Claire Bryan-Hancock\*, Chiara Bucello\*, Rachelle Buchbinder\*, Fiona Bull\*, Richard T Burnett\*, Tim E Byers\*, Bianca Calabria\*, Jonathan Carapetis\*, Emily Carnahan\*, Zoe Chafe\*, Fiona Charlson\*, Honglei Chen\*, Jian Shen Chen\*, Andrew Tai-Ann Cheng\*, Jennifer Christine Child\*, Aaron Cohen\*, K Ellicott Colson\*, Benjamin C Cowie\*, Sarah Darby\*, Susan Darling\*, Adrian Davis\*, Louisa Degenhardt\*, Frank Dentener\*, Don C Des Jarlais\*, Karen Devries\*, Mukesh Dherani\*, Eric L Ding\*, E Ray Dorsey\*, Tim Driscoll\*, Karen Edmond\*, Suad Eltahir Ali\*, Rebecca E Engell\*, Patricia J Erwin\*, Saman Fahimi\*, Gail Falder\*, Farshad Farzadfar\*,

CRA published on Dec 14, 2012  
in *The Lancet*

Global, DALYs  
Both sexes, All ages, 2010



In DALYs =  
Years lost to  
premature death  
plus to illness

Disability-adjusted  
Life Year

# Premature Deaths

HBP -9.3 million

Tobacco – 5.7

SHS-T – 0.6

House AP – 3.5

SHS-C – 0.5

Overweight – 3.4

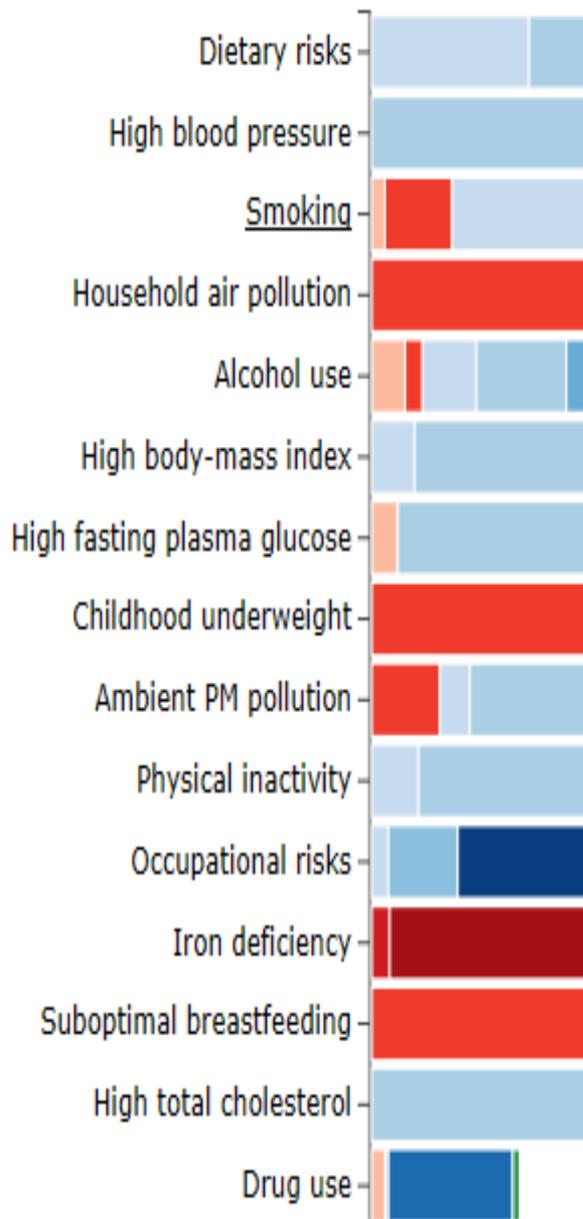
Phys Inactive – 3.2

Outdoor AP – 3.3

High Sodium – 3.1

Alcohol – 3.0

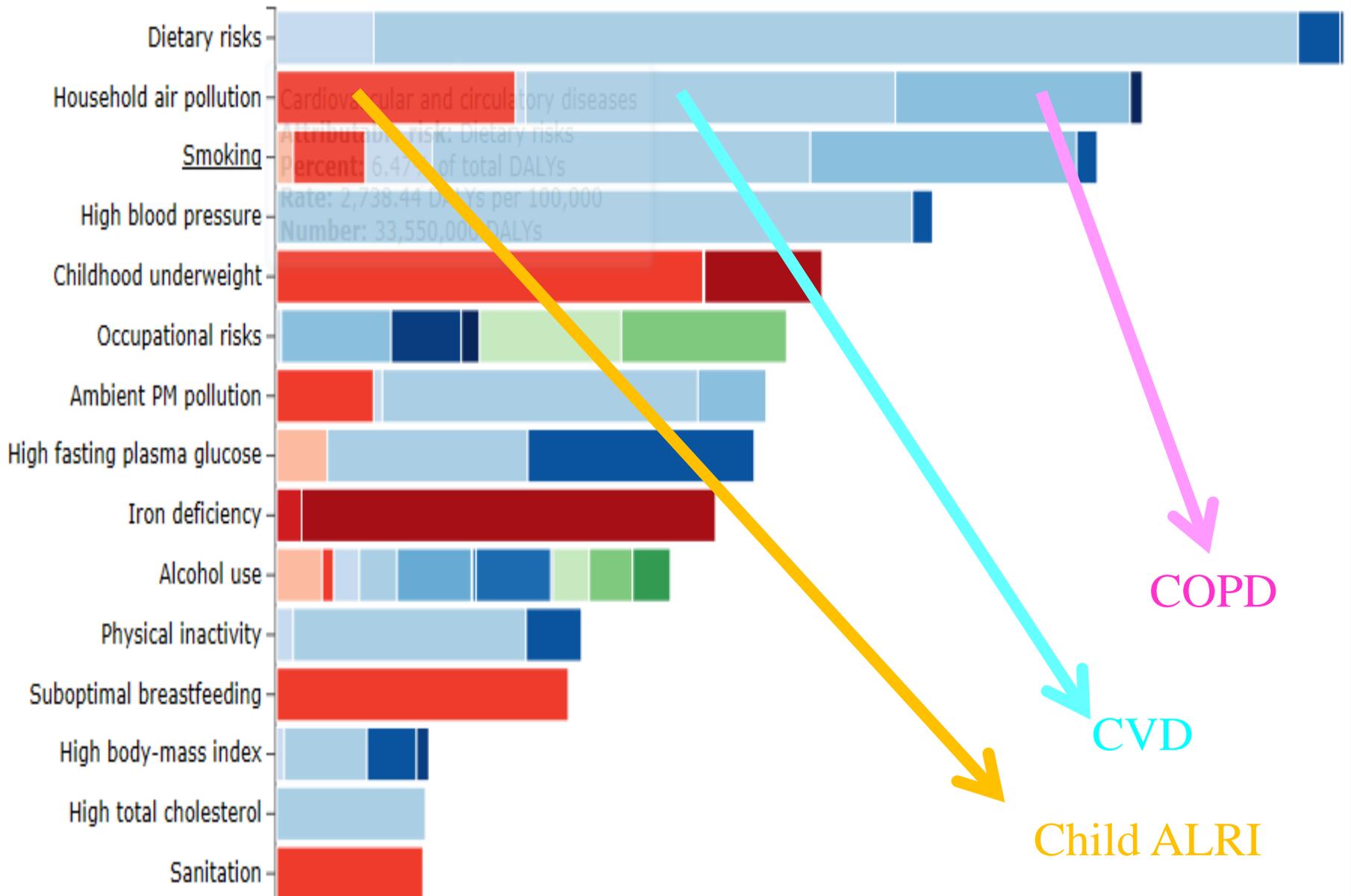
Child malnutr – 1.0



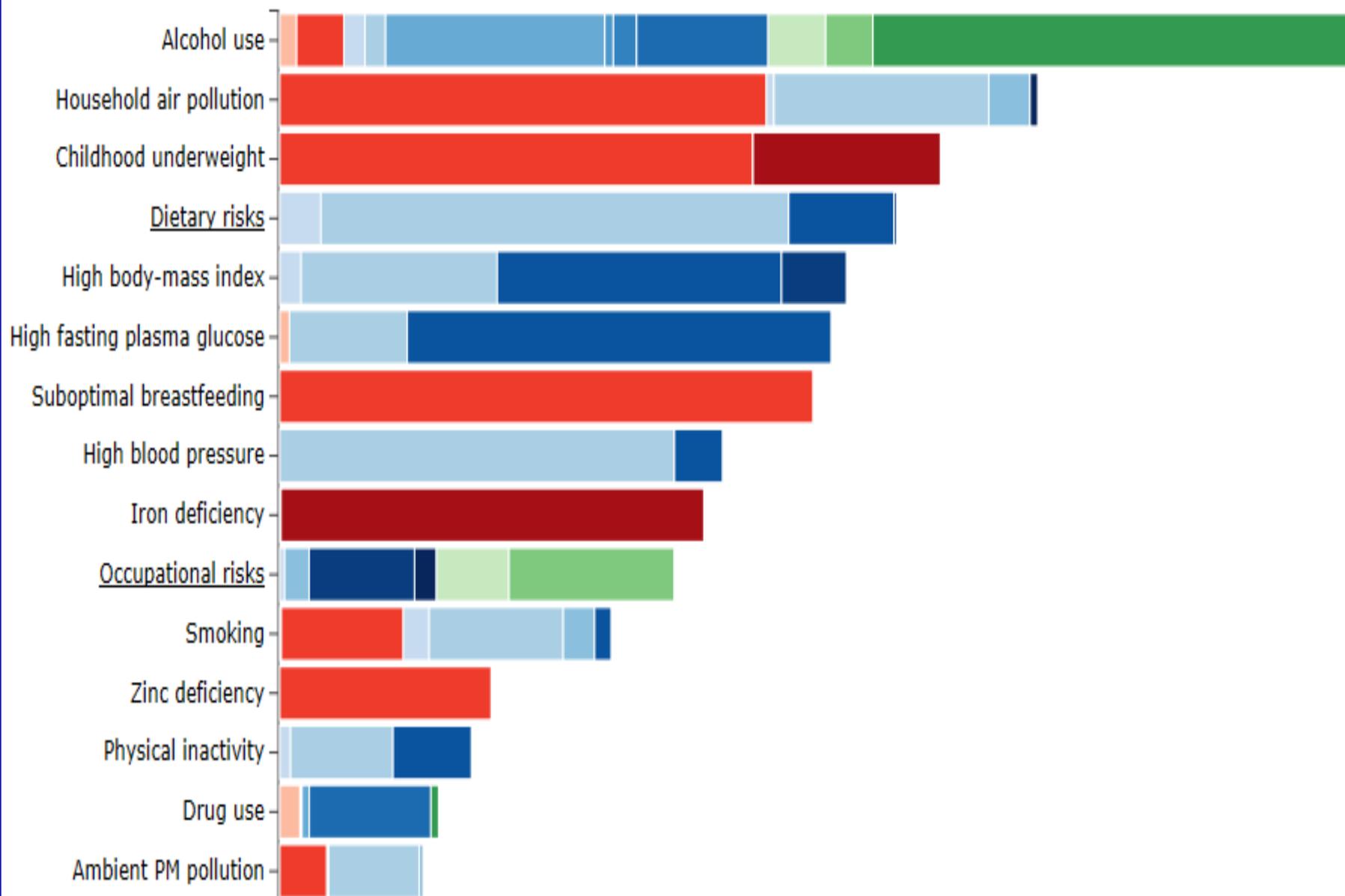
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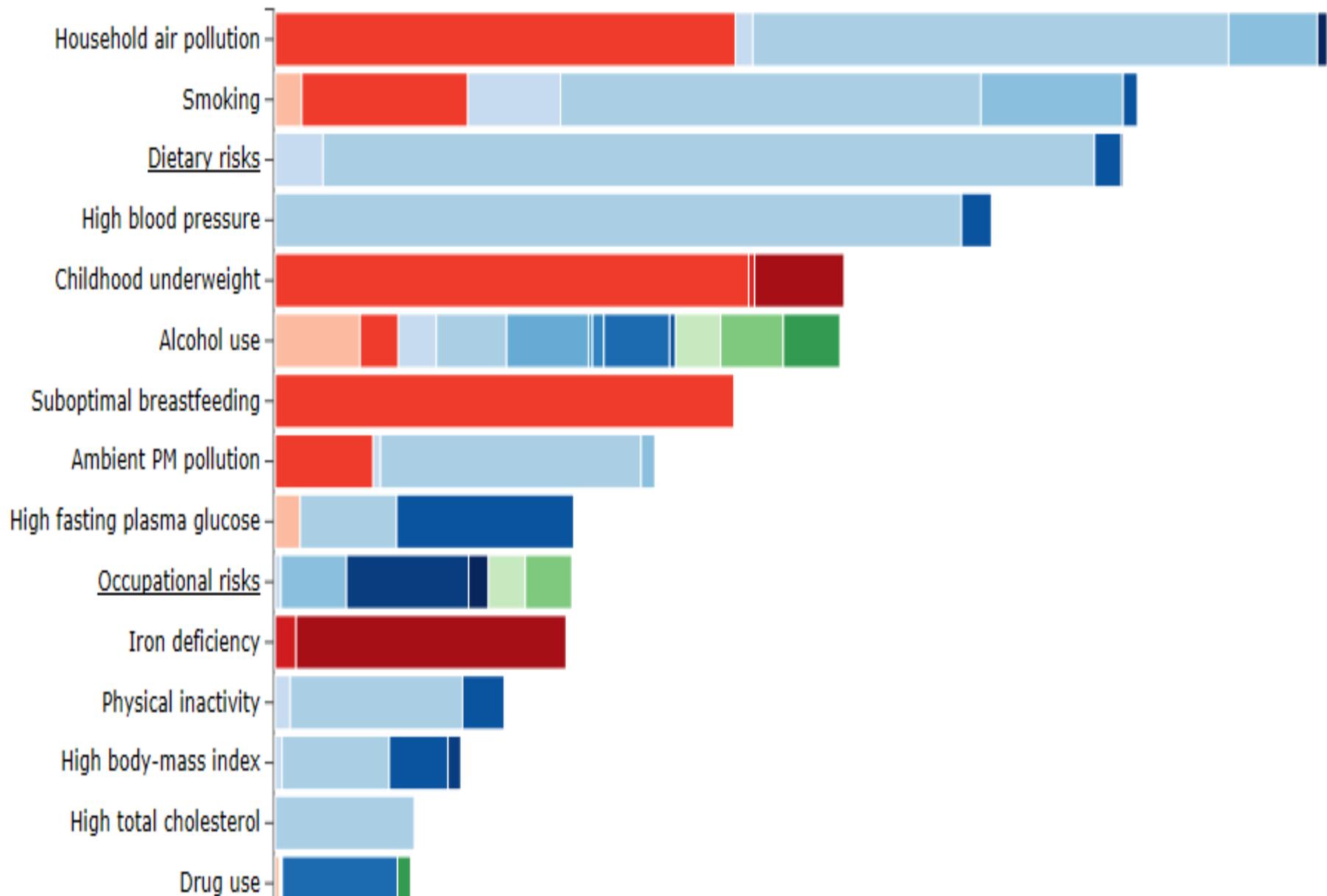
India, DALYs  
Both sexes, All ages, 2010



Guatemala, DALYs  
Both sexes, All ages, 2010

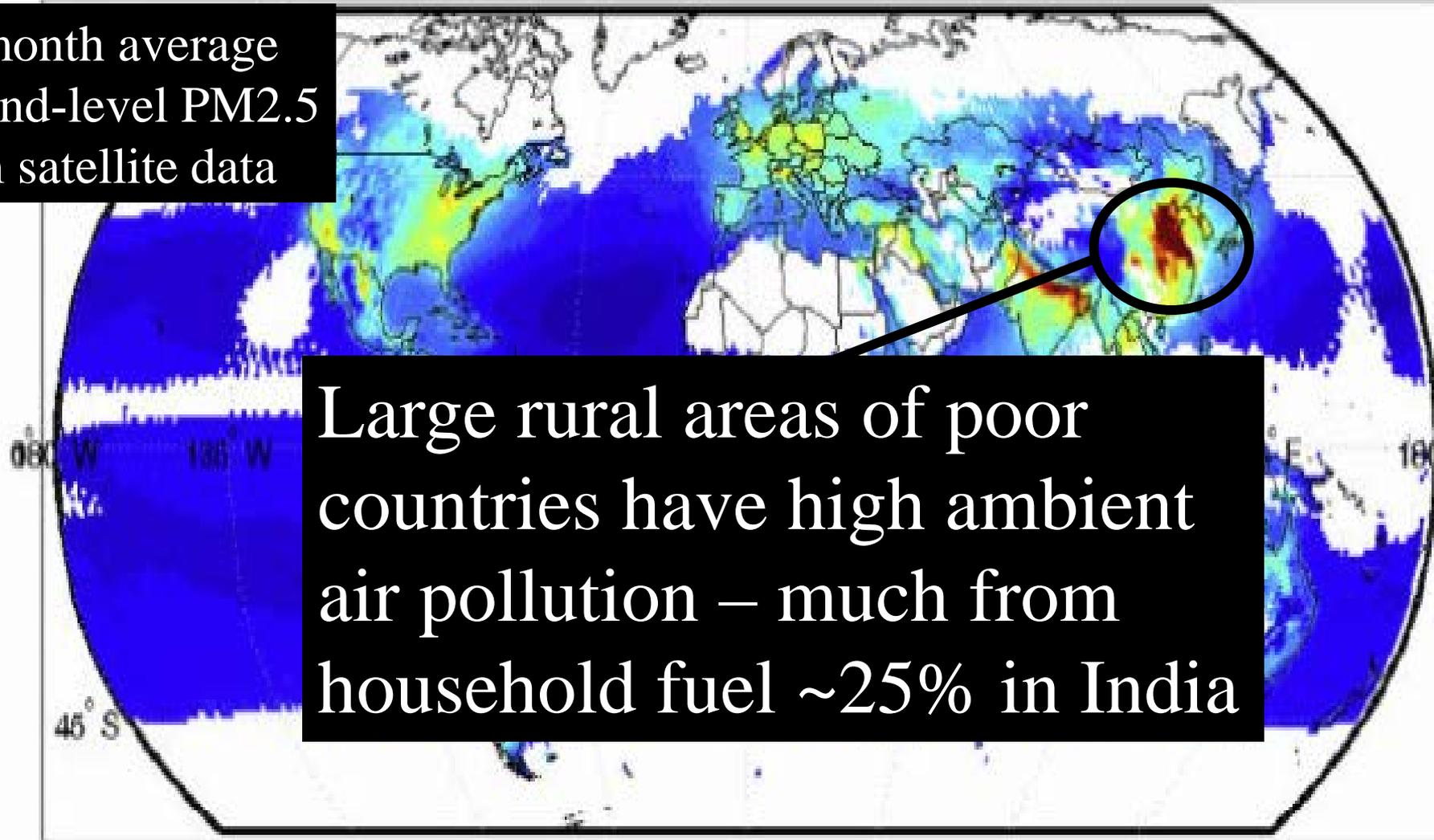


Laos, DALYs  
Both sexes, All ages, 2010

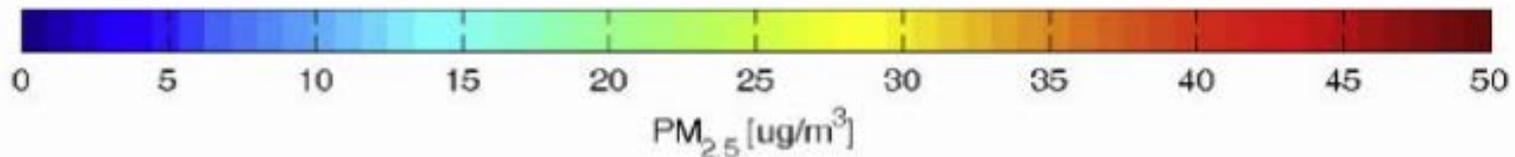


20-month average  
ground-level PM<sub>2.5</sub>  
from satellite data

MODIS

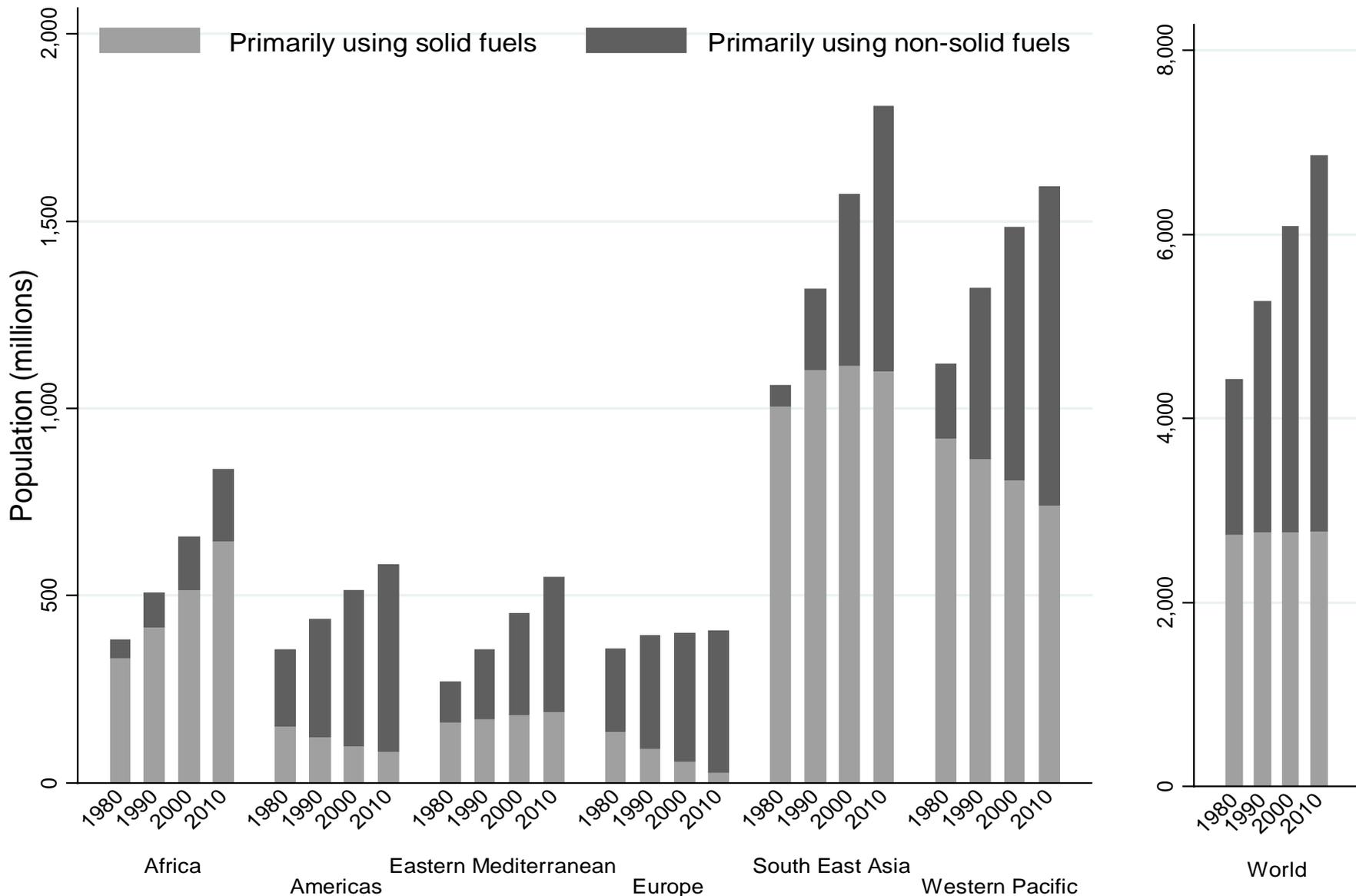


Large rural areas of poor  
countries have high ambient  
air pollution – much from  
household fuel ~25% in India



# What can be done about HAP in poor countries?

- #1 Wait for development to occur?
- No change in 30 years!



# Total Population Cooking with Solid Fuels

# What can be done? - continued

- #2. Promote clean fuels, e.g. LPG
- Many countries have had success in promoting LPG into poor populations faster than just with population/economic growth
- Requires financial and policy commitment
- Programs need to be targeted to poor
- Not sustainable or affordable to subsidize for all

# What can be done? - continued

- #3. Promote modern clean technologies, e.g. electric induction cookstoves
- Safer, faster, cleaner, and more efficient than any other cooking system
- Needs electricity – but half of solid-fuel households have it
- Requires less subsidy than LPG
- Ecuador changing out all households to induction stoves by 2017.

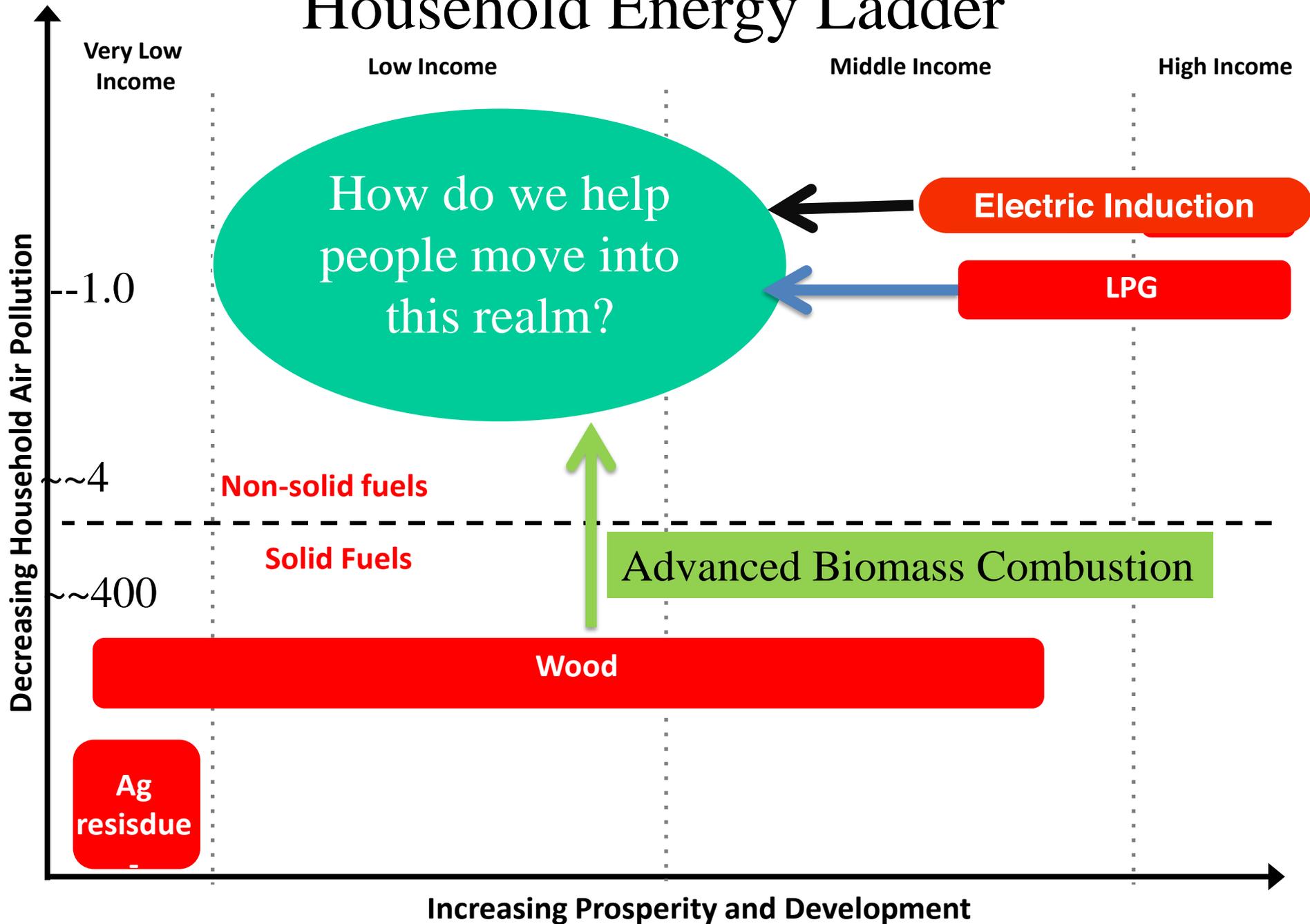
# What can be done? - continued

- #4. Promote advanced combustion biomass cookstoves that are cleaner
- A small number are available today that seem sufficiently clean in the lab to try in real households
- All use forced draft -- a small fan -- but can obtain power via solar PV
- Program costs are lower than LPG or electric
- But total expected health benefits are also lower

# Two major strategies

- Make the available clean – much better combustion of biomass fuels
- Make the clean available – promote clean fuels to poor populations
- Both approaches needed

# Household Energy Ladder



# Muchas gracias

Publications and presentations  
available on  
my website

Easiest just to “google”

Kirk R. Smith

