Clean Cooking Fuels: What's the Big Deal?

Kirk R. Smith, MPH, PhD
Professor of Global Environmental Health
Director, Household Energy, Climate, and Health Program
University of California Berkeley
Patron, HEDON

Clean Cookstoves Forum
Phnom Penh, March 19, 2013

The Environmental Health Pathway


The three major solid fuels

The Environmental Health Pathway

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

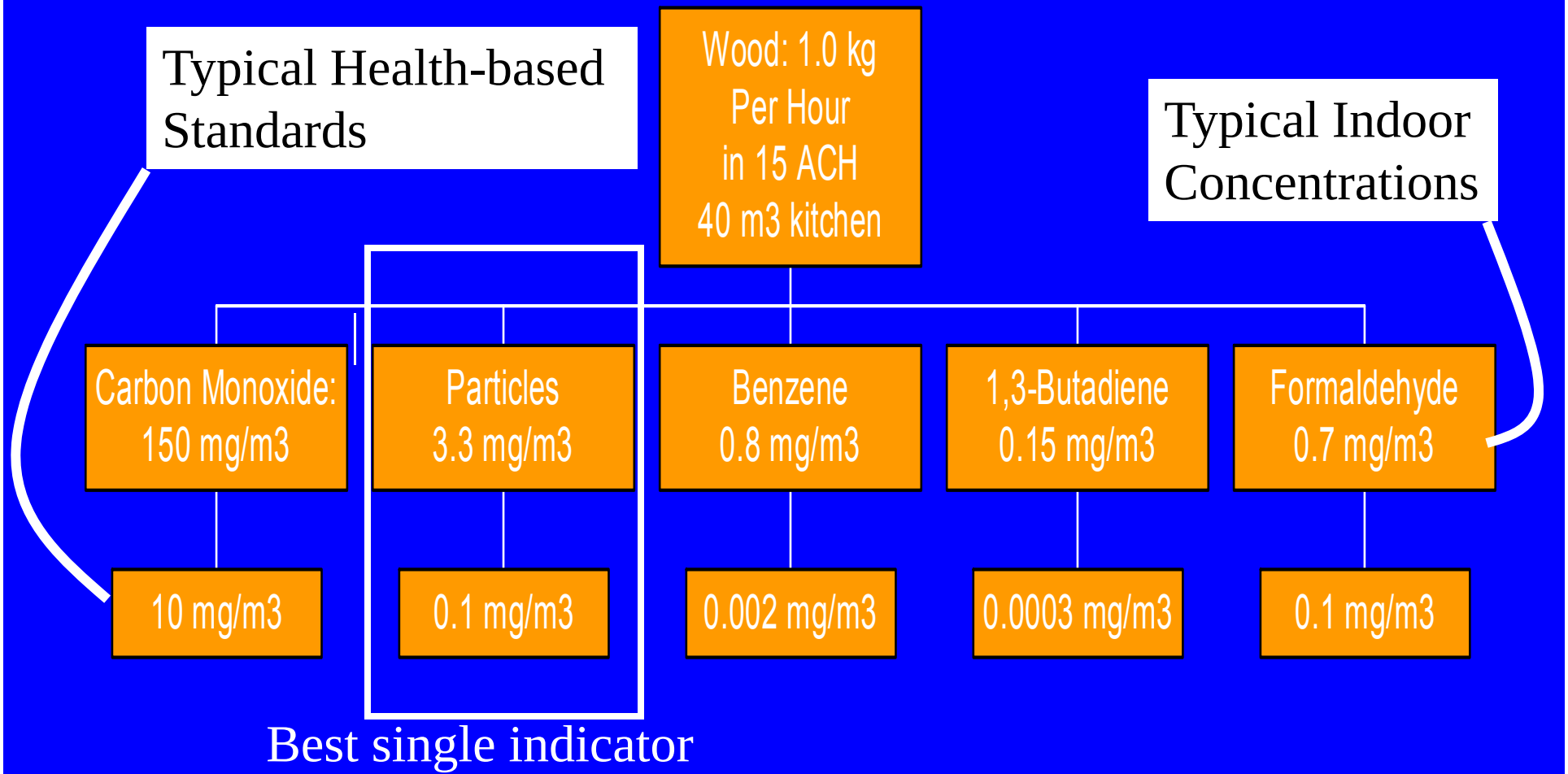
- Small particles, CO, NO_2
- Hydrocarbons
  - 25+ saturated hydrocarbons such as *n-hexane*
  - [illegible] *diene*
  - [illegible]
  - [illegible] *ne*
- O[illegible]
  - [illegible] *ein*
  - 25+ alcohols and acids such as *methanol*
  - 33+ phenols such as *catechol* & *cresol*
  - Many quinones such as *hydroquinone*
  - Semi-quinone-type and other radicals
- Chlorinated organics such as *methylene chloride* and *dioxin*

Typical wood cookfire: 400 cigarettes an hour worth of $PM_{2.5}$

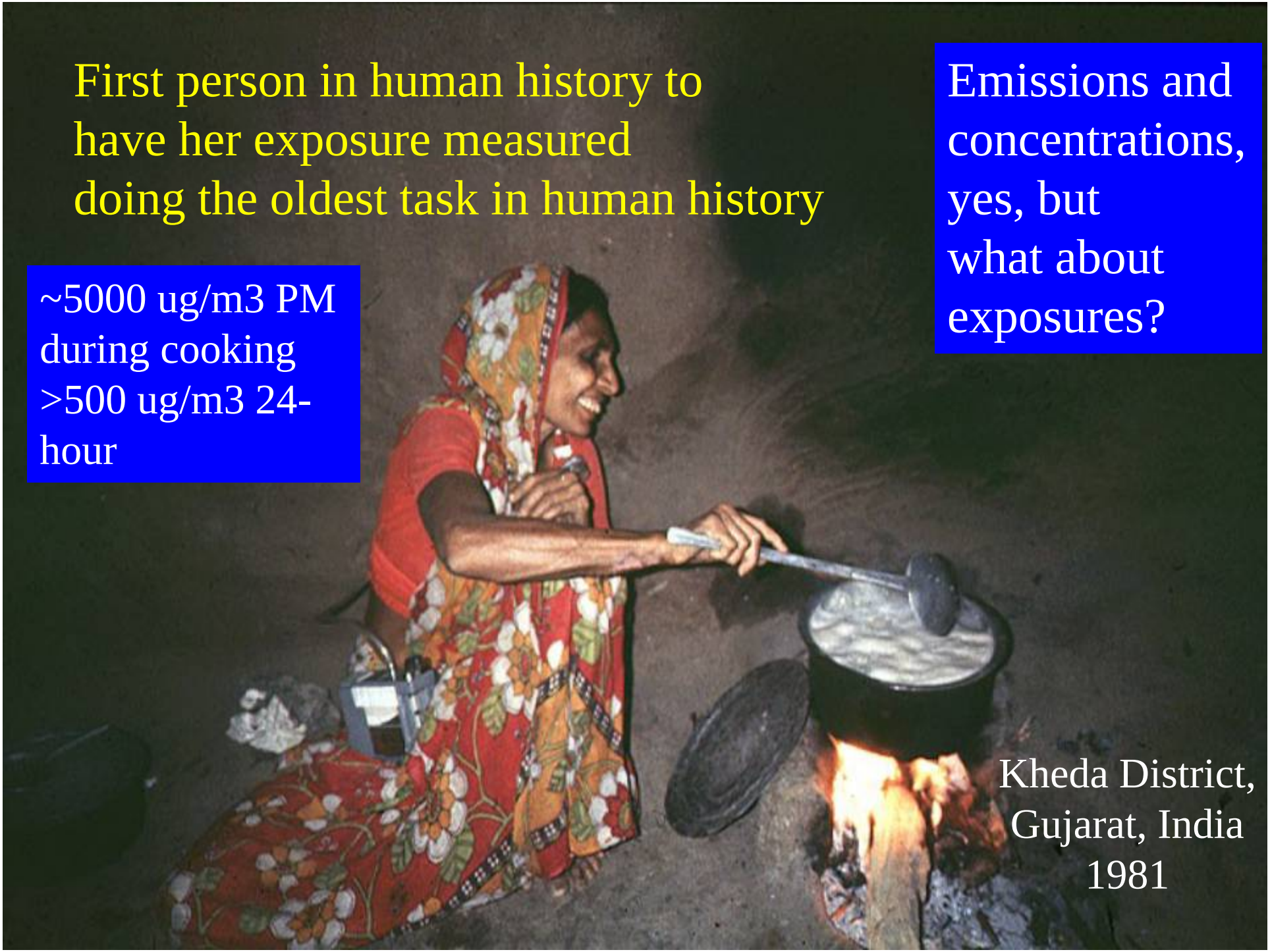
Source: Naeher et al, *J Inhal Tox*, 2007

The Environmental Health Pathway

Health-Damaging Air Pollutants From Typical Wood-fired Cookstove.



The Environmental Health Pathway


First person in human history to have her exposure measured doing the oldest task in human history
~5000 ug/m3 PM during cooking
>500 ug/m3 24-hour
Emissions and concentrations, yes, but what about exposures?
Kheda District, Gujarat, India 1981

The Environmental Health Pathway

How much $PM_{2.5}$ is unhealthy?

- WHO Air Quality Guidelines
  - 10 ug/m3 annual average
  - No public microenvironment, indoor or outdoor, should be more than 35 ug/m3
- USEPA
  - Was 15 ug/m3 until 2012: annual outdoors
  - Now 12 ug/m3
  - Same as California since ~2000

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‡, Theo Vos, Abraham D Flaxman, Goodarz Danaei, Kenji Shibuya, Heather Adair-Rohani, Markus Amann*, H Ross Anderson*, Kathryn G Andrews*, Martin Aryee*, Charles Atkinson*, Loraine 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 along with the other GBD papers on Dec 14, 2012 in *The Lancet*

Metrics

- Mortality – important, but can be misleading as it does not take age into account or years of illness/injury
  - Death at 88 years counts same as at 18, which is not appropriate
- Disability-adjusted Life Years (DALYs) lost do account for age and illness.
- GBD compares deaths against best life expectancy in world – 86 years

ALRI/
Pneumonia

COPD

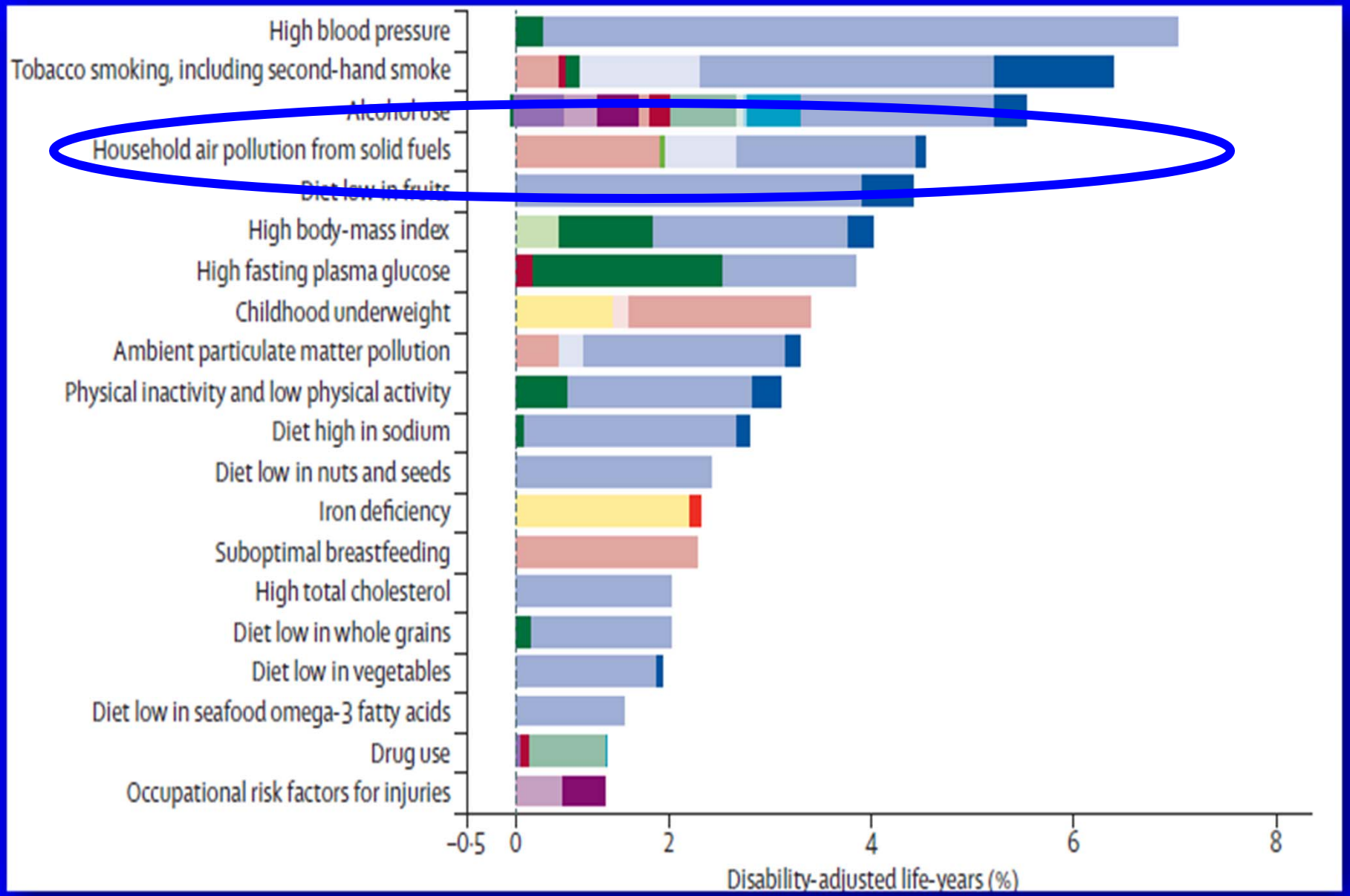
Lung cancer

Blindness
(cataracts, opacity)

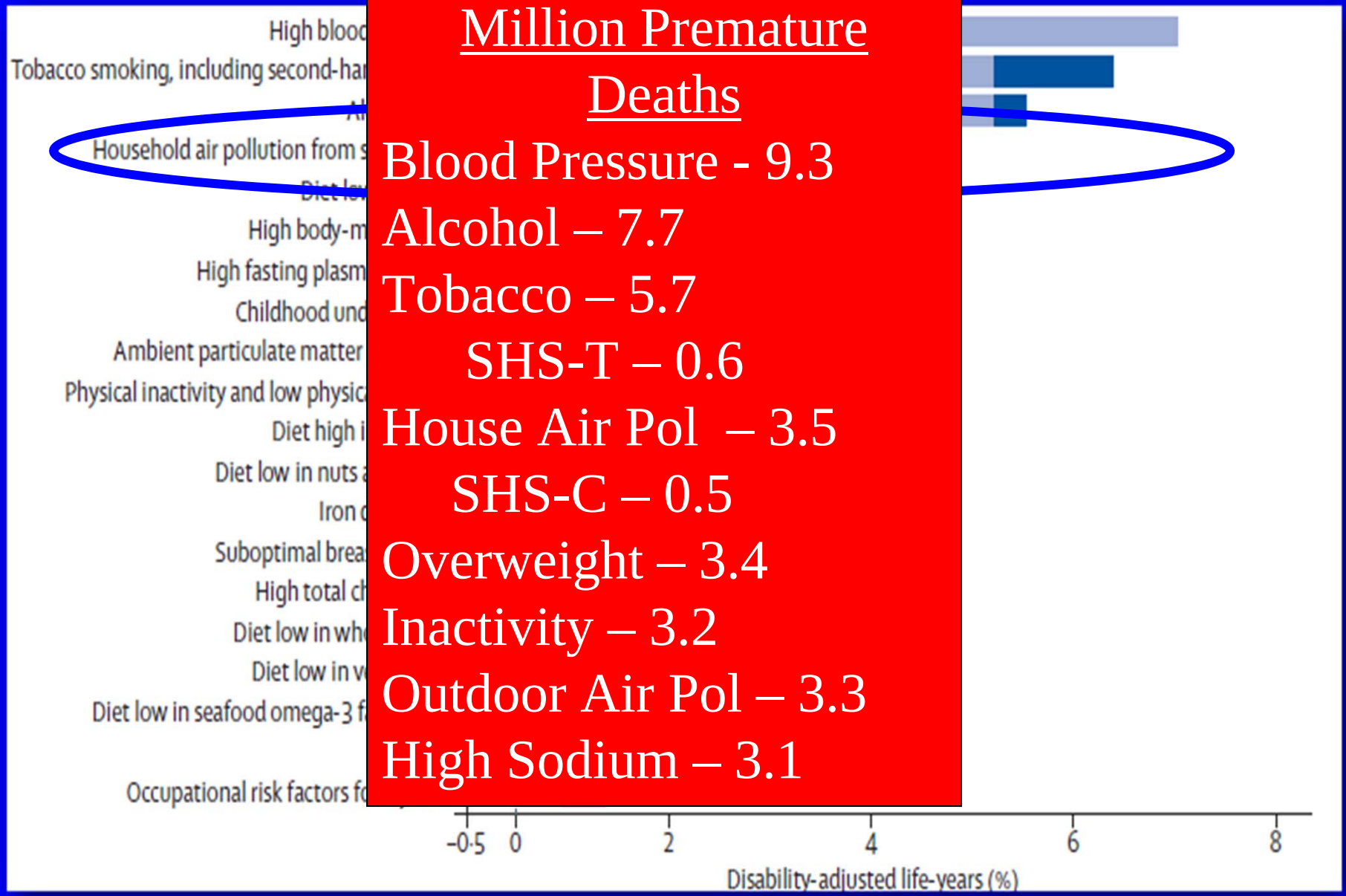
Heart disease
Blood pressure
ST-segment

These diseases are included in the
2010 Comparative Risk Assessment (released in 2012)

Global DALYs 2010: Top 20 Risk Factors



Global DALYs 2010: Top 20 Risk Factors



Million Premature Deaths

Blood Pressure - 9.3

Alcohol – 7.7

Tobacco – 5.7

SHS-T – 0.6

House Air Pol – 3.5

SHS-C – 0.5

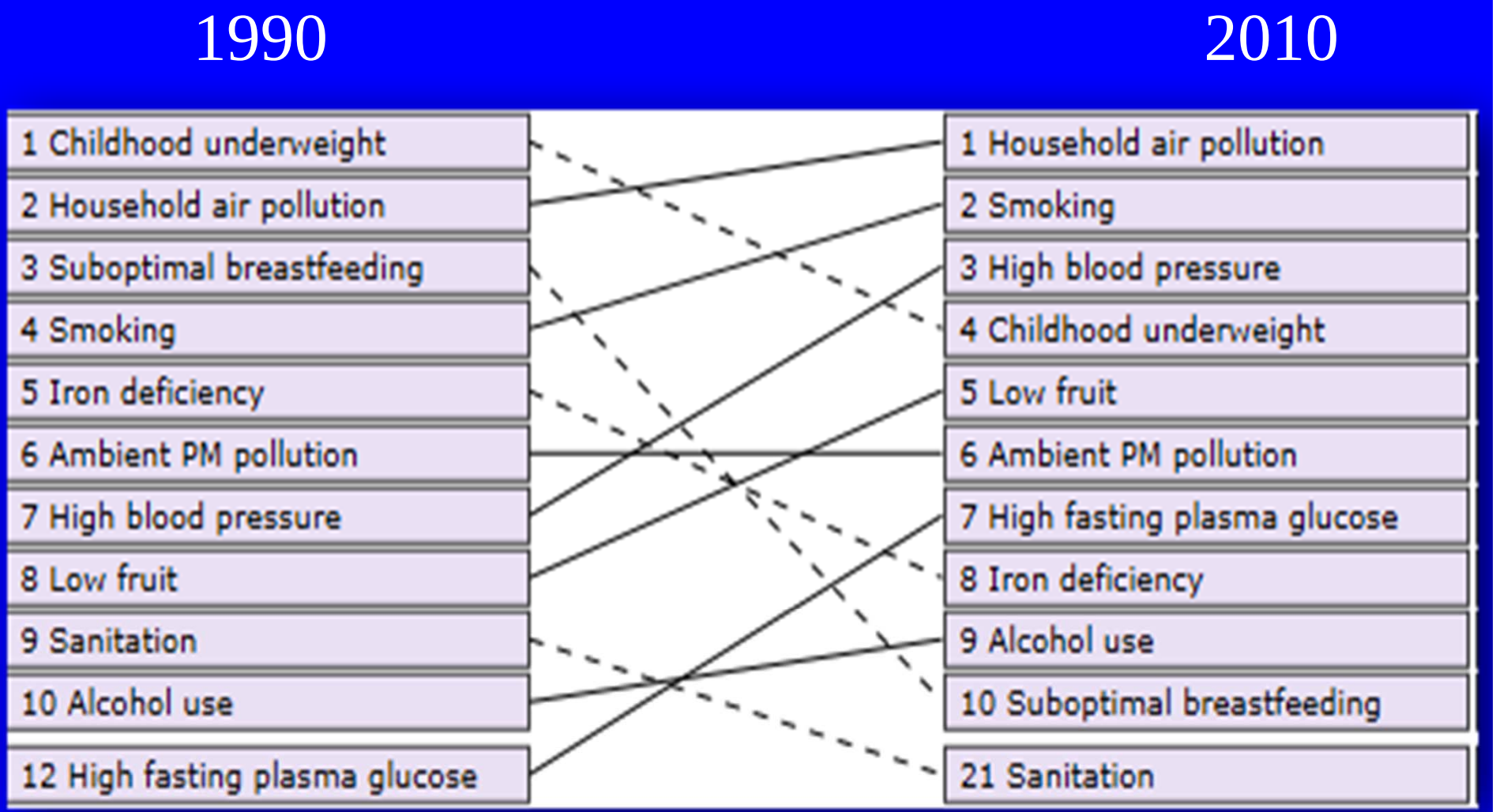
Overweight – 3.4

Inactivity – 3.2

Outdoor Air Pol – 3.3

High Sodium – 3.1

DALYS. South Asia by Risk Factor



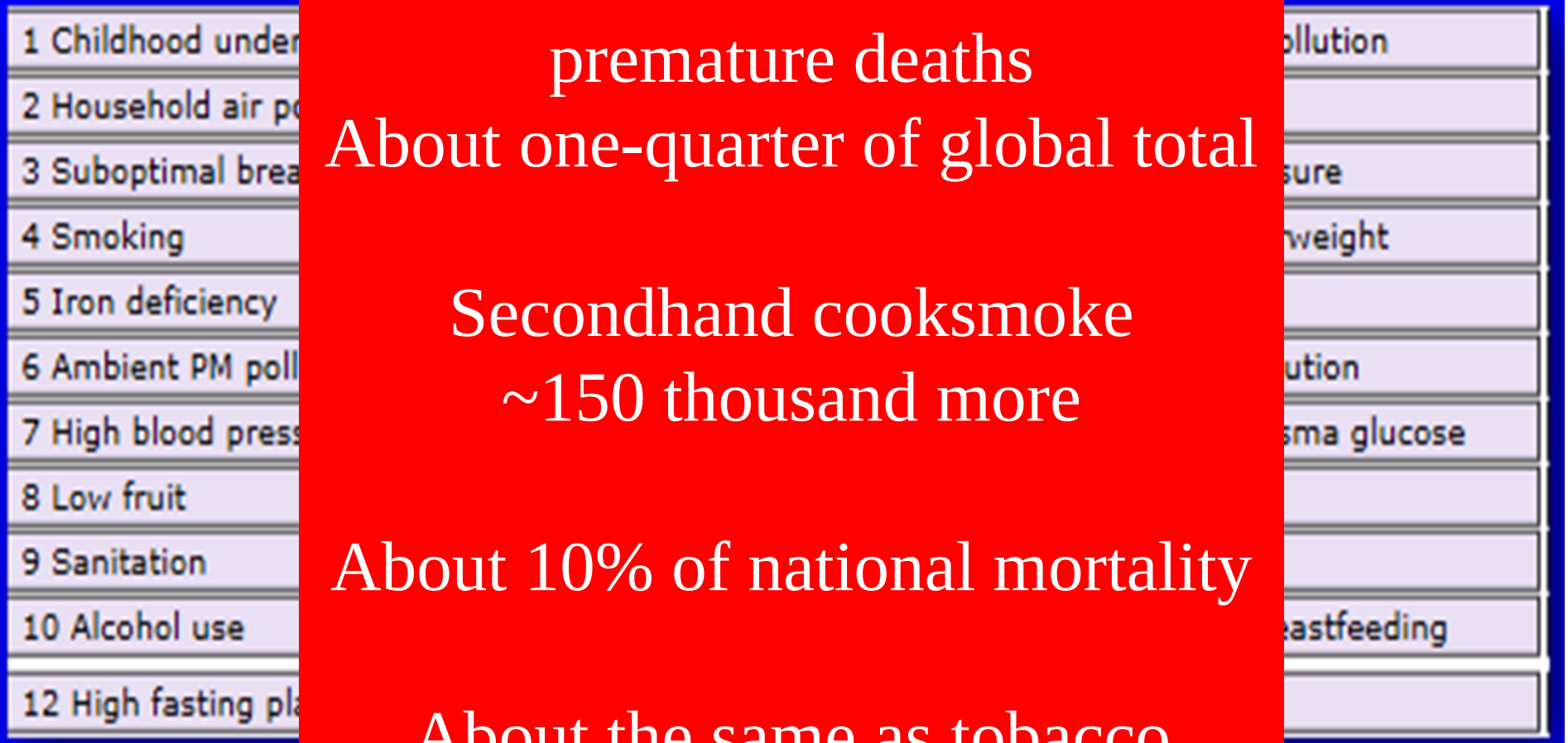
DALYS. South Asia by Risk Factor

HAP in India in 2010
~900 thousand annual
premature deaths
About one-quarter of global total

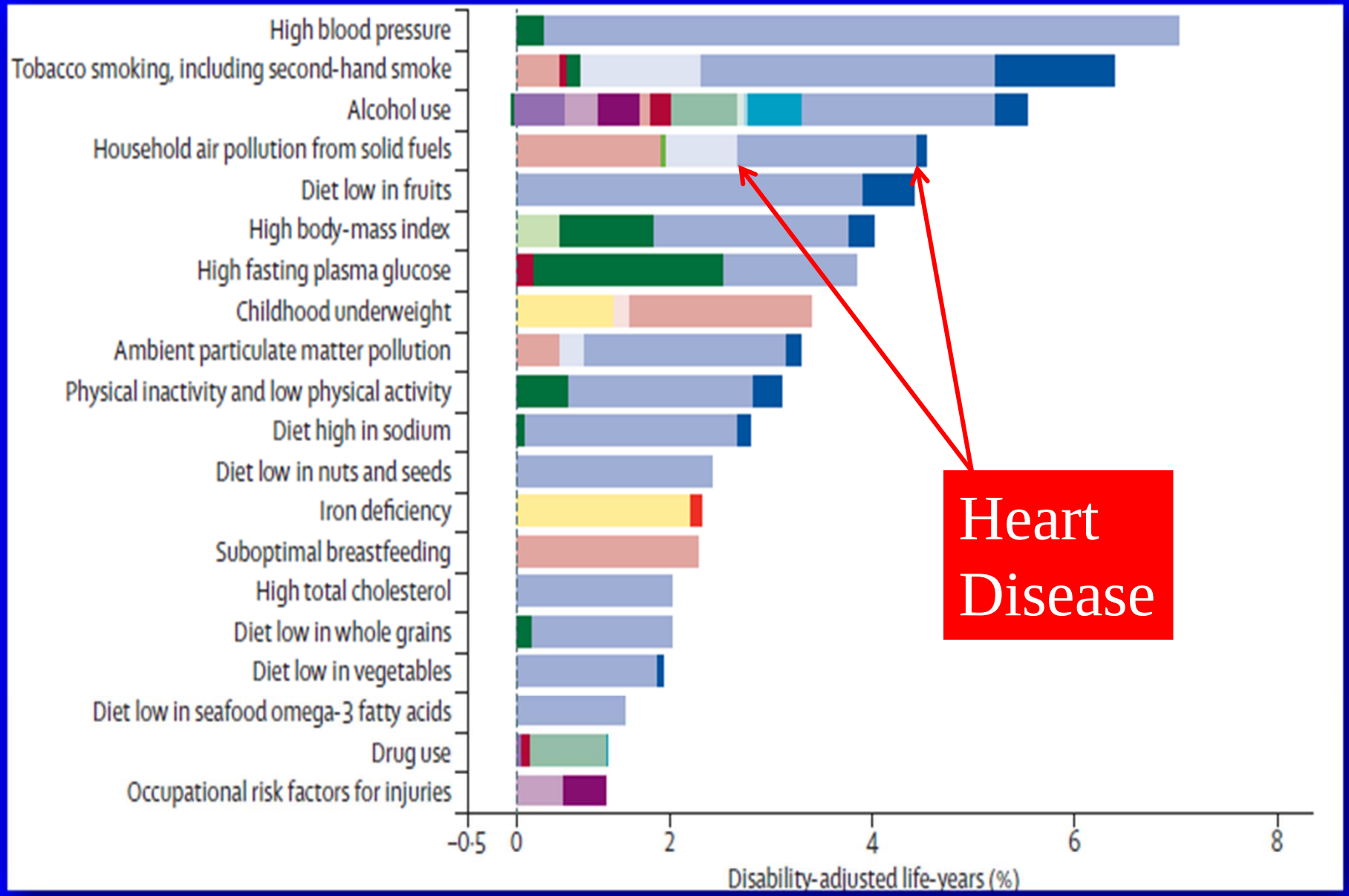
Secondhand cooksmoke
~150 thousand more

About 10% of national mortality

About the same as tobacco



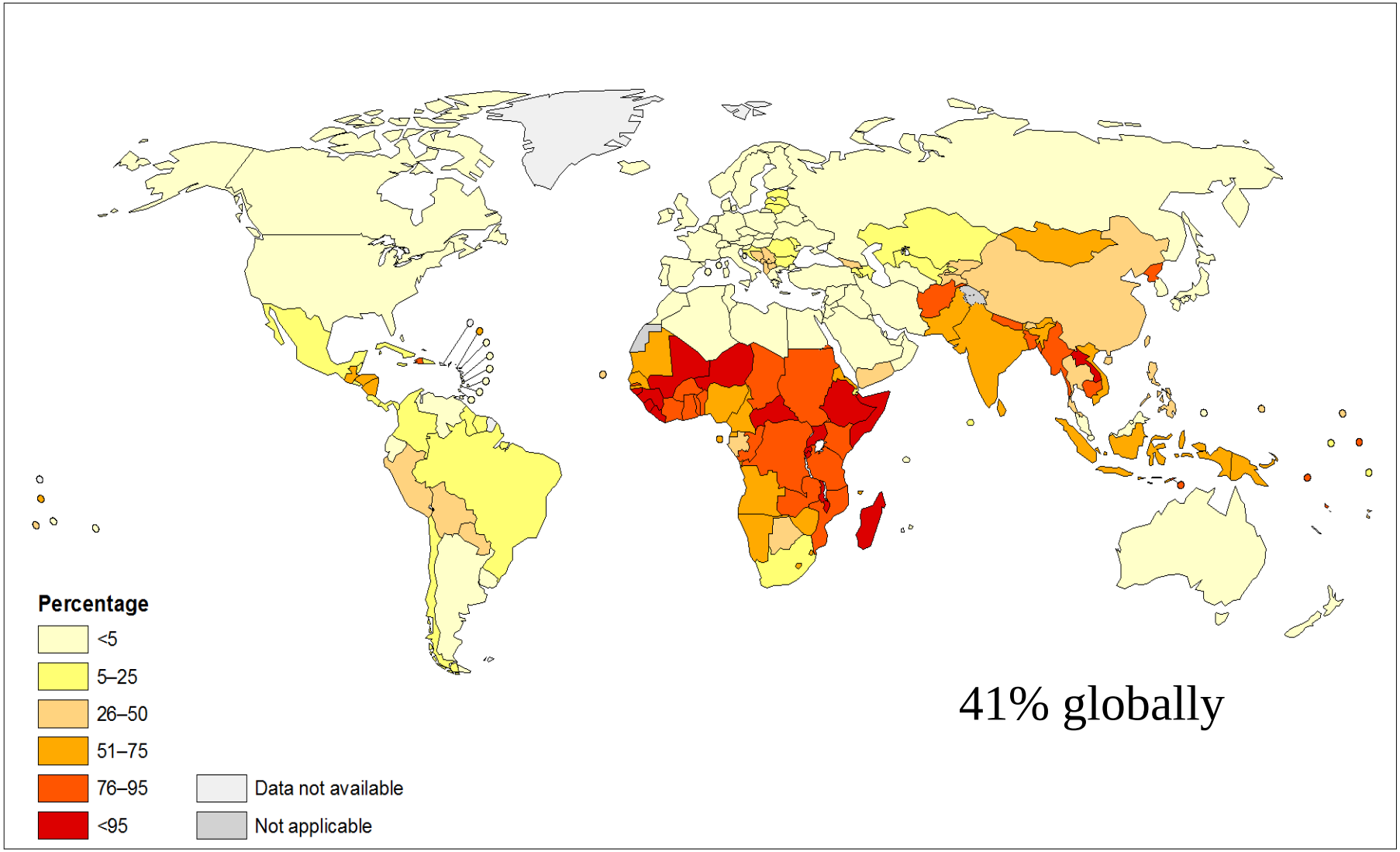
Global DALYs 2010: Top 20 Risk Factors



The framing

- Household air pollution from use of solid fuels for cooking
- Much less confusion with space heating than before, but not perfectly separated

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

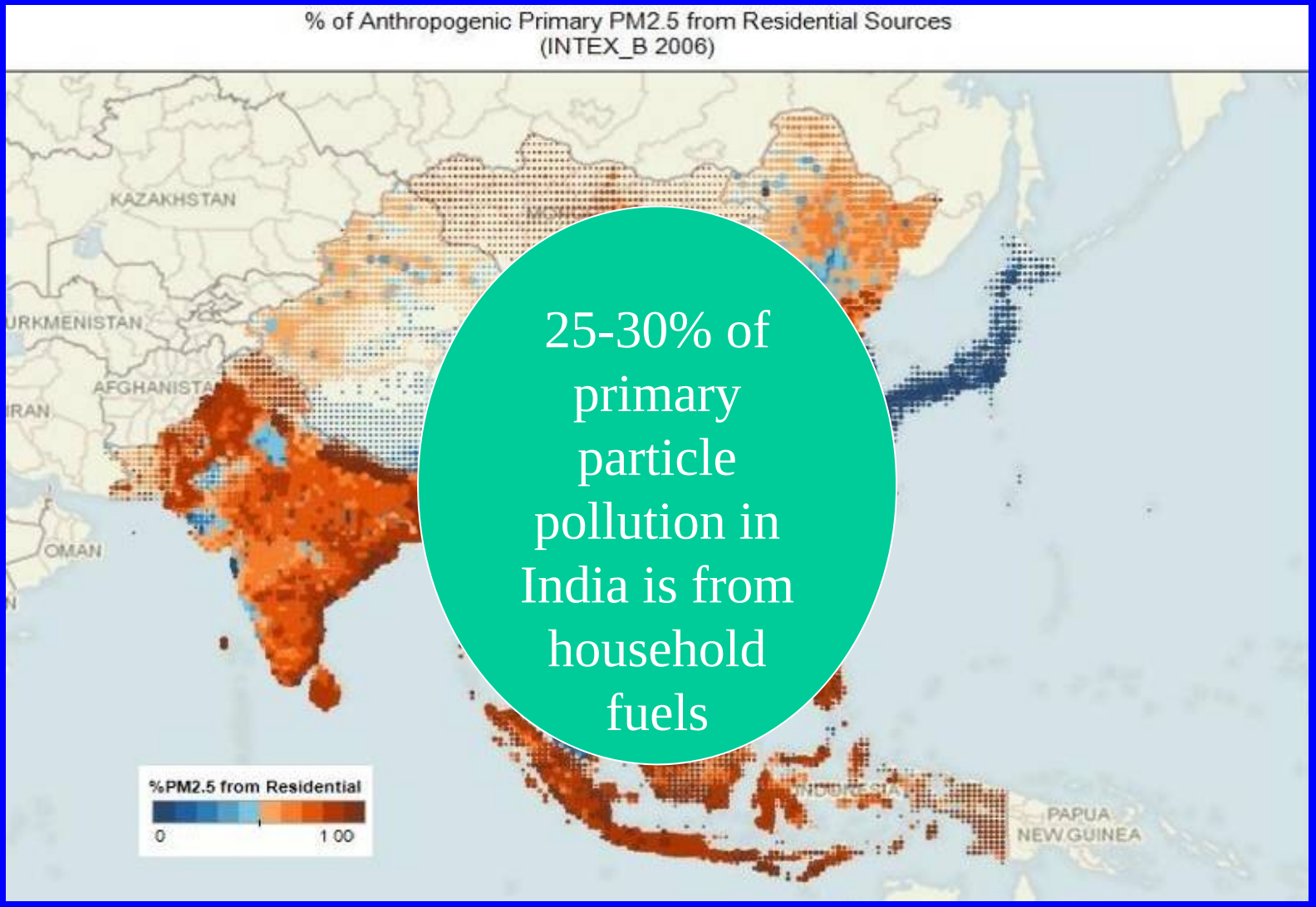
World Health Organization

© WHO 2012. All rights reserved.

Framing, cont.

- Not called “indoor” because stove smoke enters atmosphere to become part of general outdoor air pollution (OAP)
- HAP contributes about 16% to OAP globally, but much more in some countries
- Thus, part of the burden of disease due to OAP is attributable to cooking fuels in households ~500,000 premature deaths.

Percent Household Sources of all $PM_{2.5}$ Emissions



Source: Asian Emission Inventory for NASA INTEX_B 2006 (accessed 2010)

Chafe, 2010

Urban Beijing – Winter 2013
24-hr $PM_{2.5}$ (Jan 18-19): 334 µg/m^3

Source: PM data from US Embassy monitors in Beijing - https://twitter.com/BeijingAir
Photo from AP Images: http://seattletimes.com/html/nationworld/2020288471_chinapollutionxml.html

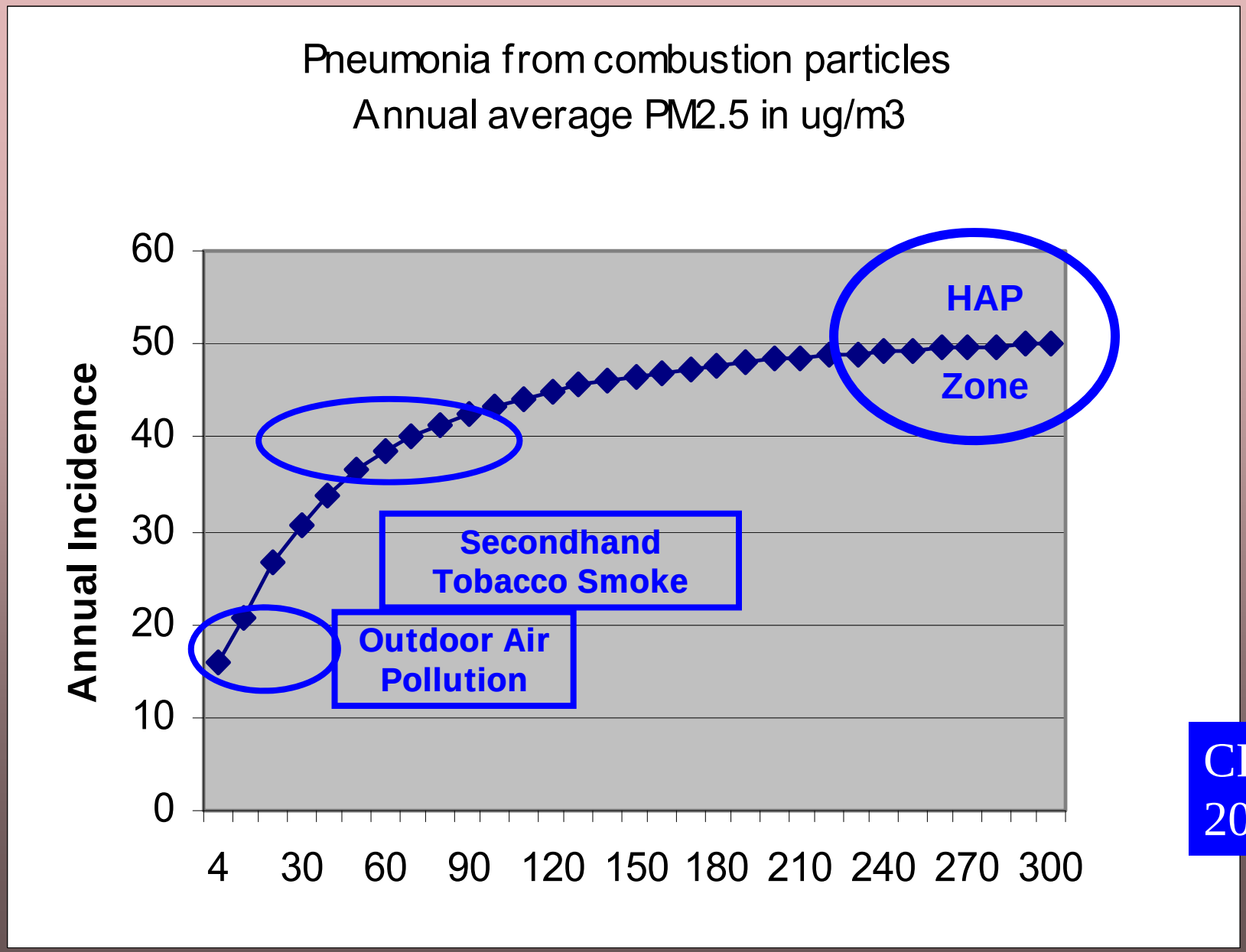
Rural Site outside Beijing
24-hr $PM_{2.5}$ (Jan 18-19): 695 $\mu g/m^3$

Source: Mean PM concentration from 2 gravimetrically calibrated DustTrak monitors on rooftops in ErHeZhuang Village, 40 km SW from central Beijing. Photos & measurements in village from Anna Zimmermann (Smith research group).

Important Message #1!

- Implied full health benefit from HAP reduction only potentially achieved by shifting to truly clean cooking – gas & electricity

Integrated Exposure-Response: Outdoor Air, SHS, and HAP



CRA, 2010

Important Message #2!

- Just because we know it is a risk does not mean that we know how to fix it.
- Think of poor water/sanitation and mosquitoes – 100 years knowing they are risks – still not fixed
- Poor people – no money to be made; no high-tech technologies; unhealthy alternatives are free; behavioral change required

Newborn Stove (NBS) Project

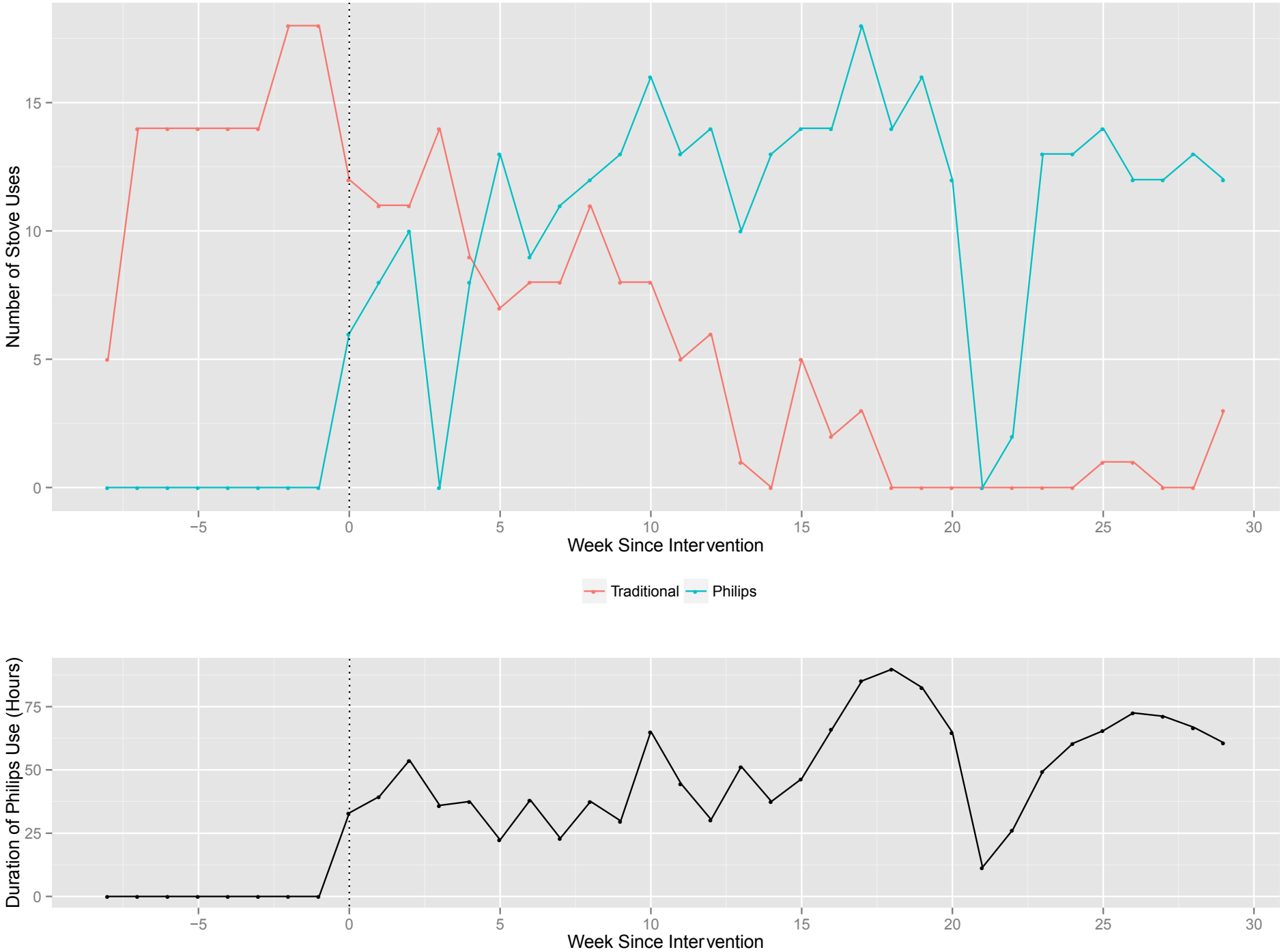
SOMAARTH Surveillance Site – Haryana ~200,000 people

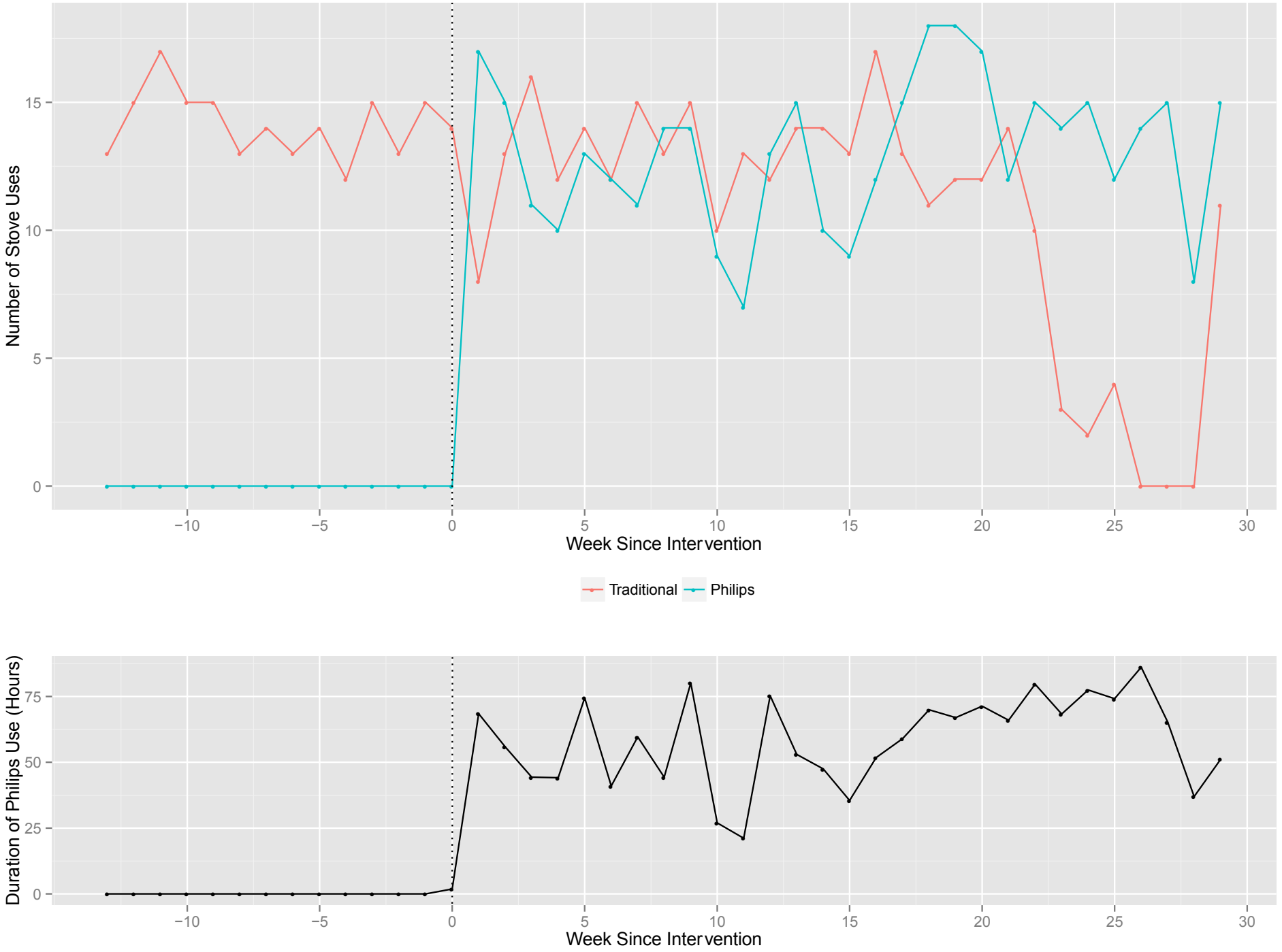
Berkeley, Columbia
INCLEN, SRU

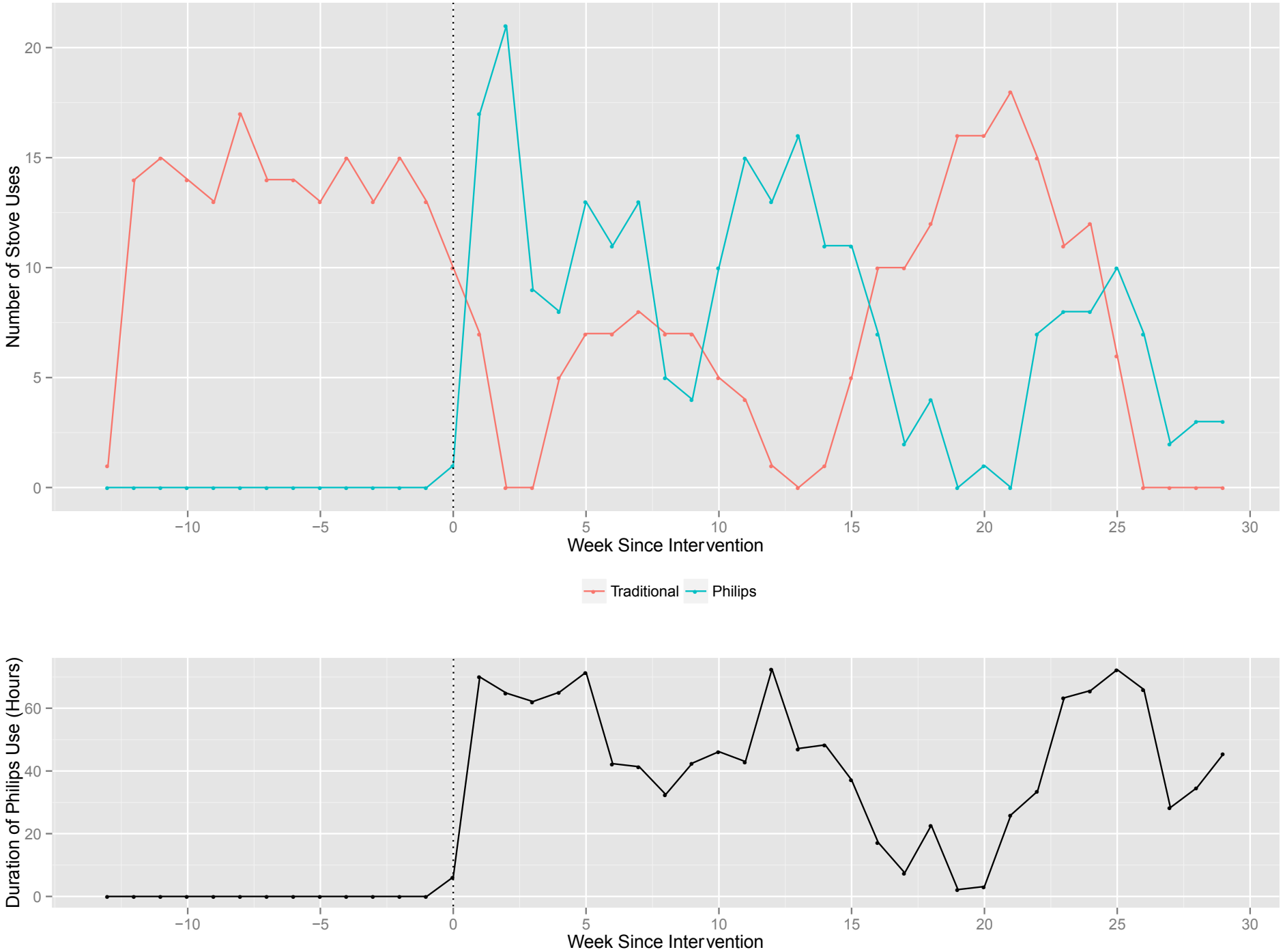
NBS Project

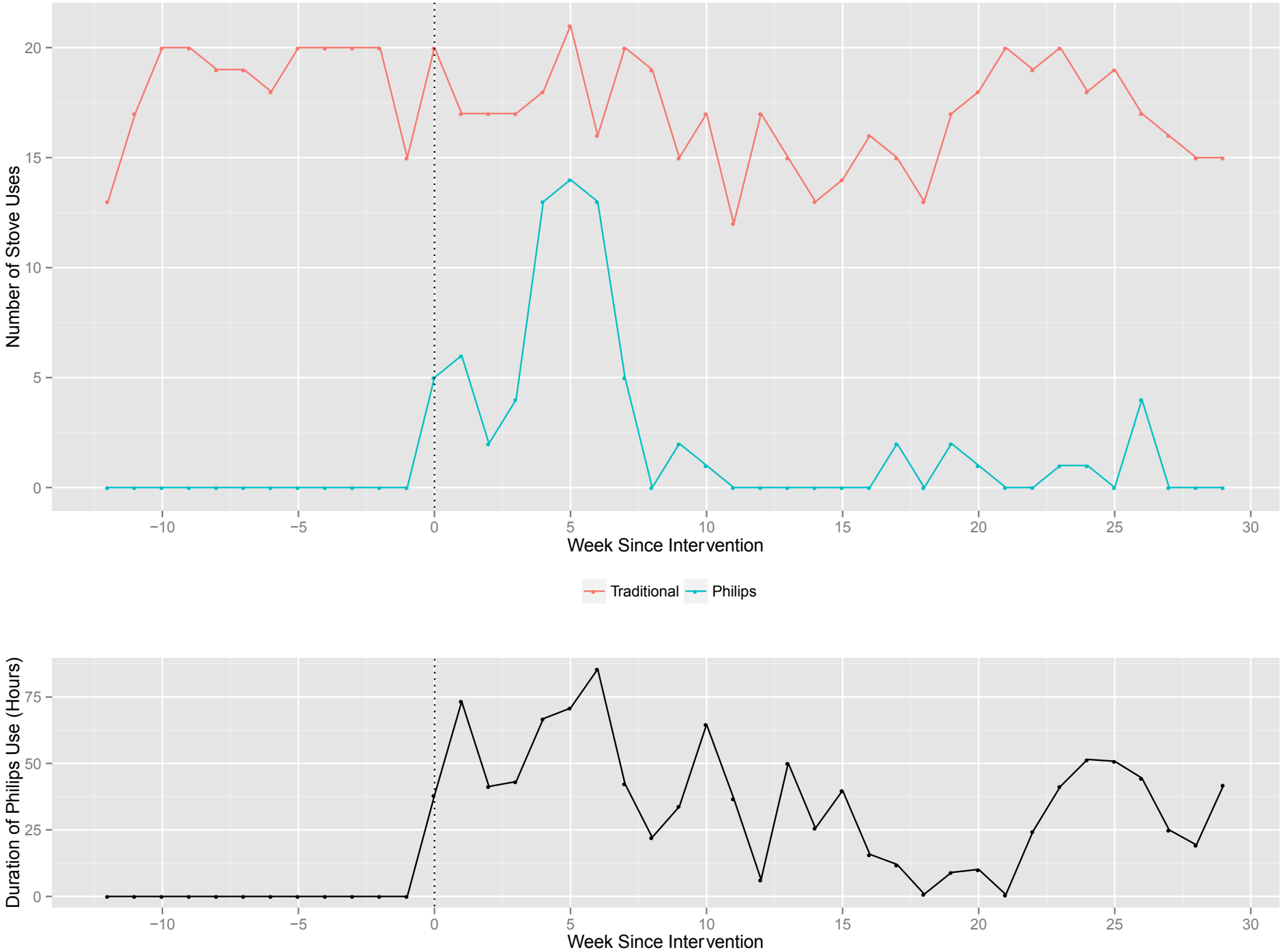
Introducing advanced combustion stoves to pregnant women through the official ante-natal care system in India

Monitoring air pollution, usage, and birth outcomes


Number of Stove Uses
15
10
5
0
−5
0
5
10
15
20
25
30
Week Since Intervention
Traditional
Philips
Duration of Philips Use (Hours)
75
50
25
0
−5
0
5
10
15
20
25
30
Week Since Intervention


Number of Stove Uses
15
10
5
0
−10
−5
0
5
10
15
20
25
30
Week Since Intervention
Traditional
Philips
Duration of Philips Use (Hours)
75
50
25
0
−10
−5
0
5
10
15
20
25
30
Week Since Intervention


Number of Stove Uses
20
15
10
5
0
−10
−5
0
5
10
15
20
25
30
Week Since Intervention
Traditional
Philips
Duration of Philips Use (Hours)
60
40
20
0
−10
−5
0
5
10
15
20
25
30
Week Since Intervention

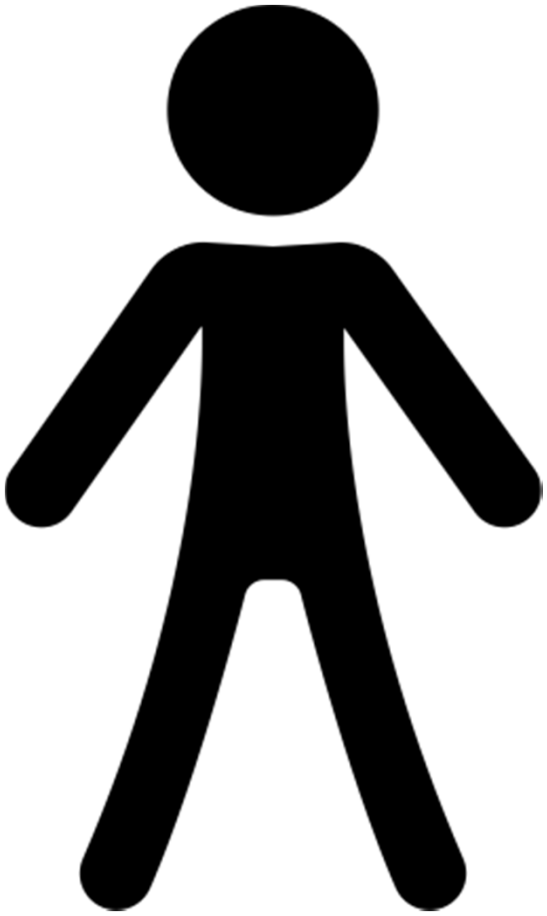

Number of Stove Uses
20
15
10
5
0
−10
−5
0
5
10
15
20
25
30
Week Since Intervention
Traditional
Philips
Duration of Philips Use (Hours)
75
50
25
0
−10
−5
0
5
10
15
20
25
30
Week Since Intervention

For behavioral changes
like other aspects of HAP studies,

You don’t get what you
expect, but what you inspect

What is to be done?

A fresh look



World cooking in Pictograms –

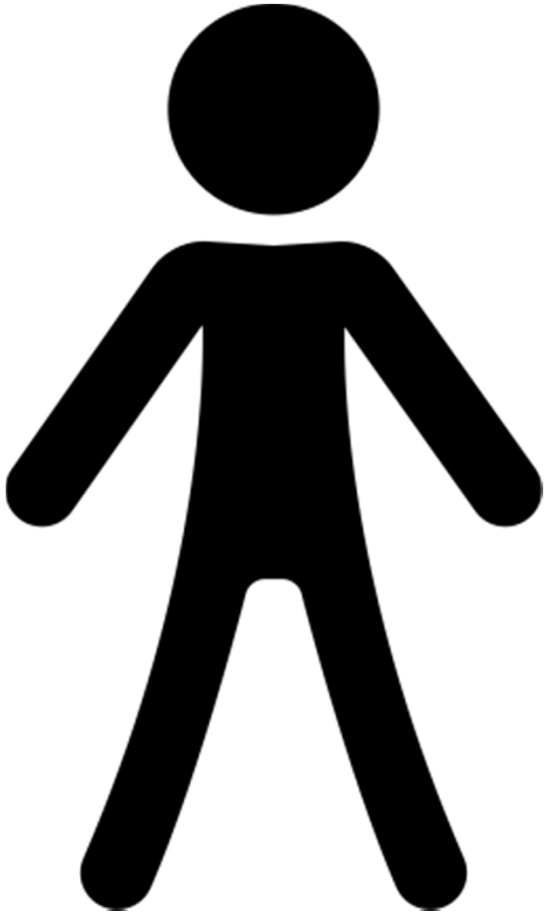
One billion people each

With apologies to
Hans Rosling at Gapminder*

*”Magic Washing Machine”

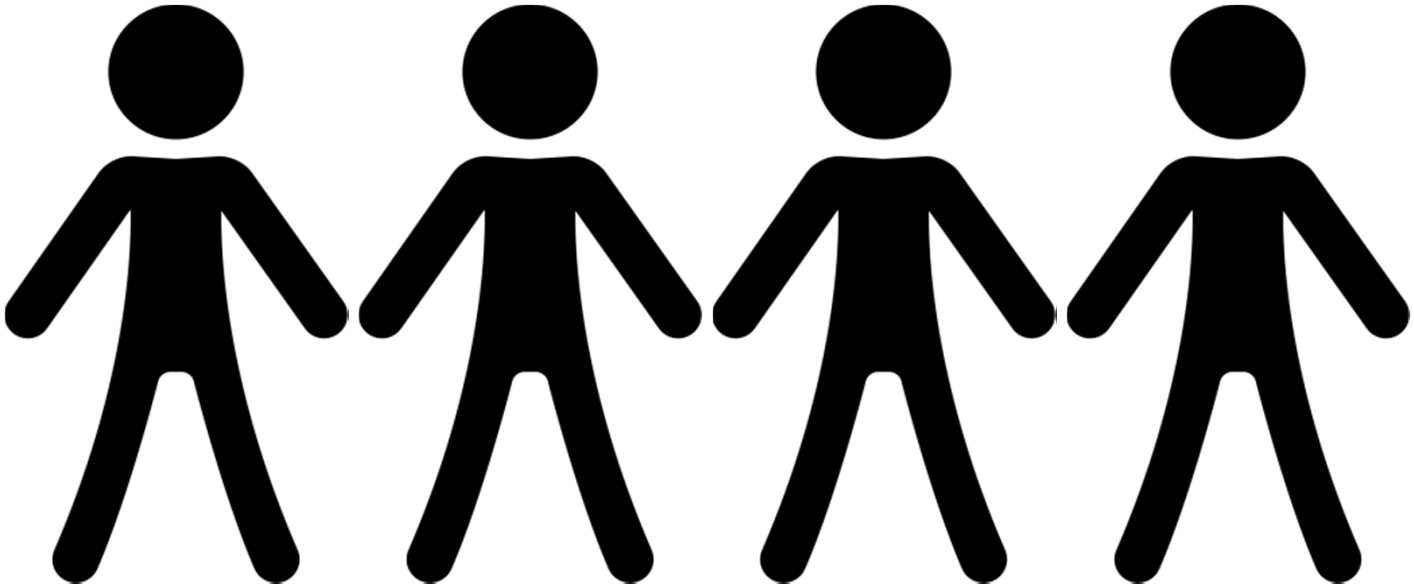
And thanks to Ajay Pillarisetti

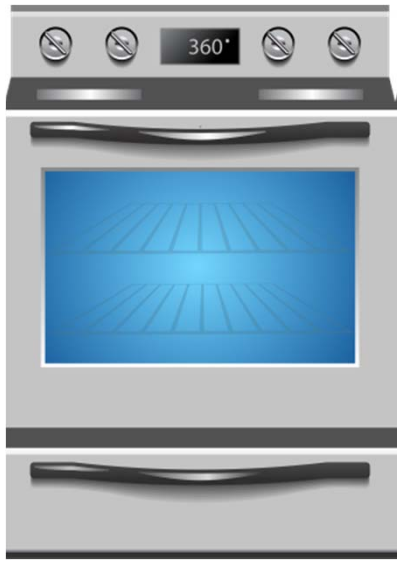
What do the richest one billion people cook with?



Gas or electric stoves

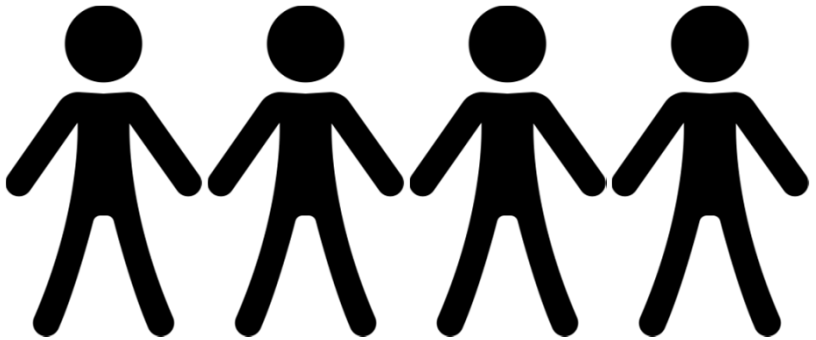
Plus





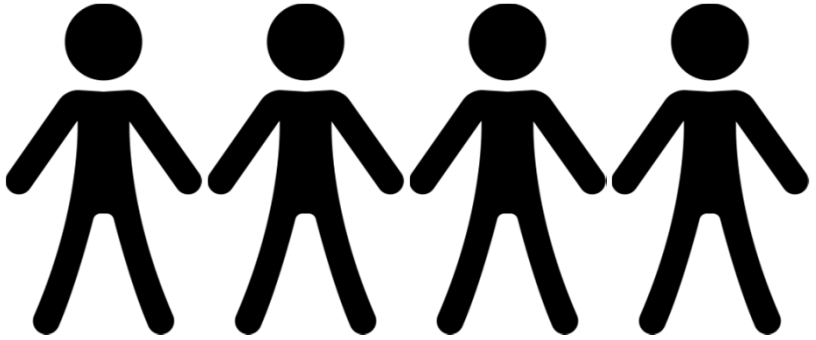
~4 billion worldwide cook with liquified petroleum gas, natural gas, and electricity

What about the other 3 billion?



SMOKING SECTION

NON-SMOKING



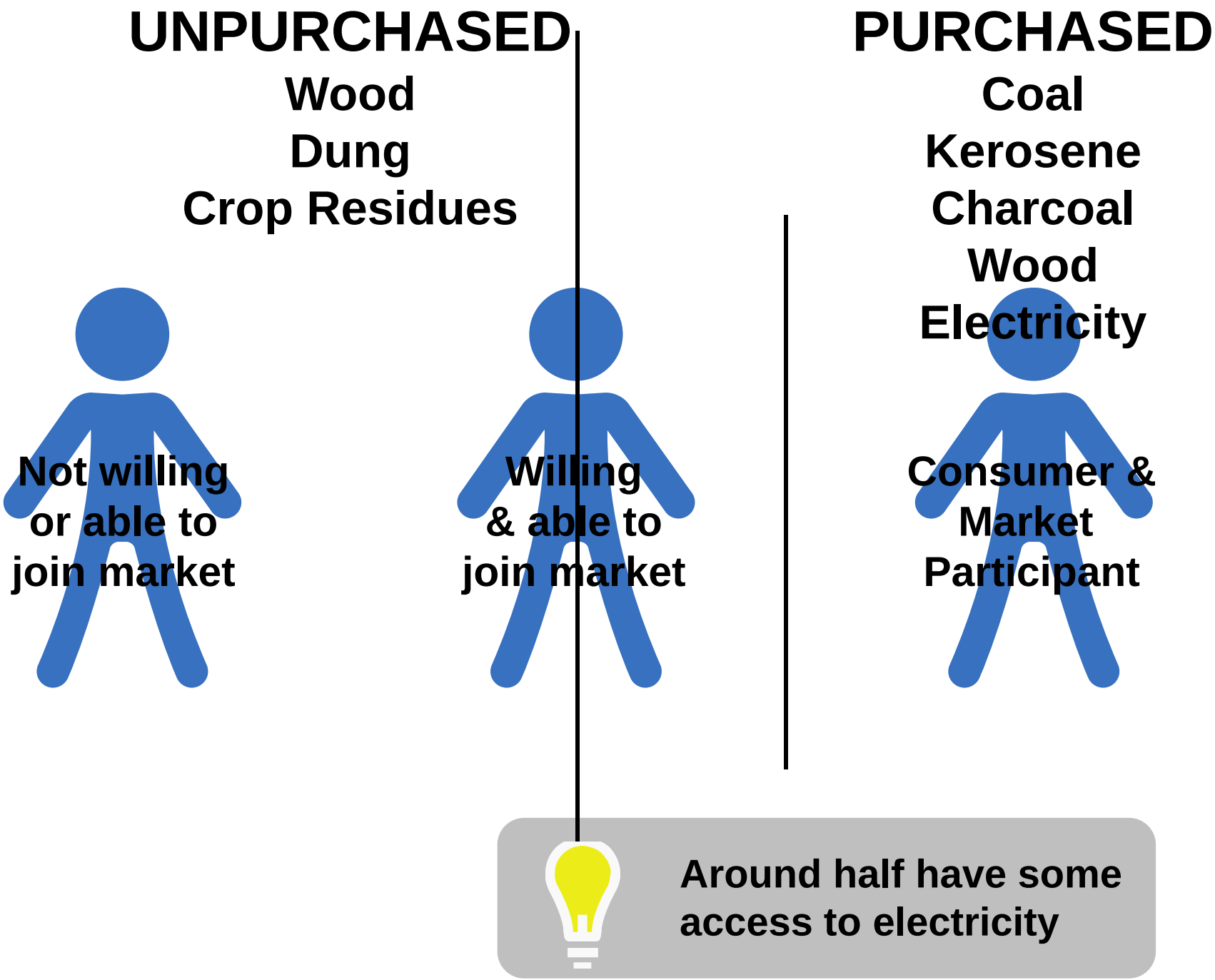
LPG

Natural Gas

Electricity

MARKET BASED OPTIONS

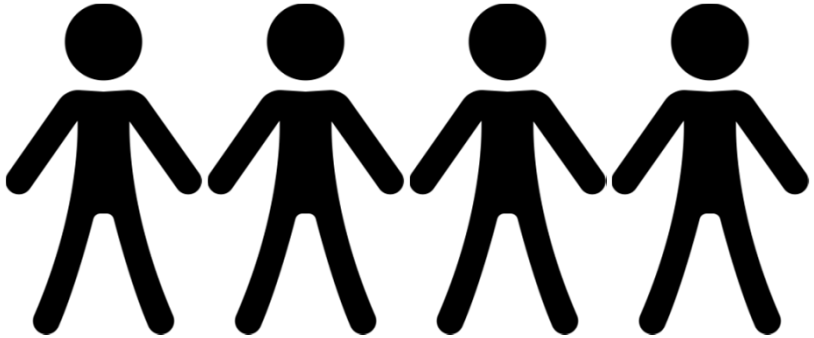
NON-SMOKING


UNPURCHASED
Wood
Dung
Crop Residues
PURCHASED
Coal
Kerosene
Charcoal
Wood
Electricity
Not willing or able to join market
Willing & able to join market
Consumer & Market Participant
Around half have some access to electricity

UNPURCHASED
NO MARKET ACCESS

UNPURCHASED
BUT WILLING TO USE THE MARKET

PURCHASED
MARKET USER



SMOKING

NON-SMOKING

UNPURCHASED
NO MARKET ACCESS

UNPURCHASED
WILLING TO USE THE MARKET

Incentives to move to new cooking technologies?
Subsidized fuel / capital cost?
Access to infrastructure and improved markets?

ELECTRICAL APPLIANCES

PHILIPS BLOWER STOVE

PELLETS

Market-ready advanced stoves + fuels

Many thanks

Funders for HAP CRA
USEPA
Shell Foundation
For NBS Project
World Bank
CDC/GACC
World Lung Foundation