One million premature deaths from cooking fuels in India: How estimated and what does it mean?

(the story of three journal articles)

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IIT-Delhi (Fall 2013)

First VPCI Honour Lecture
Vallabhbhai Patel Chest Institute, Delhi
Sept 26, 2013

Important Paper Published!

Circulation

JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association®

Chronic Cor Pulmonale in Delhi: A Study of 127 Cases

S. PADMAVATI and S. N. PATHAK

Conclusions

- A high incidence of cor pulmonale was noted in Delhi in an entirely nonindustrial population. [Even though smoking much more] (m)en were only slightly more affected than women and there was a preponderance of rural over urban cases.
- The patients were comparatively young, gave a short history of the underlying pulmonary disease, and presented with very florid signs of congestive heart failure on their first visit to hospital.
- It is postulated that this high incidence of cor pulmonale was the result purely of chronic respiratory infections that had remained untreated…

Etiology Speculation

- In the rural and semirural areas, the houses were mostly 1- or 2-roomed mud huts in which several members of the family lived together. There was no outlet for smoke with the result that the house was filled with smoke when the family meal was cooked.
- The fuel used almost universally is cow dung which is dried into flat cakes for this purpose. Probably from inadequate combustion, it emits a lot of smoke.

Did you notice this paper when it came out?

- Probably not, since it was 54 years ago!
- *Circulation.* 1959; 20:343-352
- Pioneering study, excellently done, and published a major journal, but
- Little notice and no serious work initiated except a few sporadic case accounts for the next 20+ years

In the 1980s, the first link to air pollution science

Atmospheric Environment Vol. 17, No. 11, pp. 2343–2362, 1983
Printed in Great Britain.

0004–6981/83 $3.00 + 0.00
Pergamon Press Ltd.

AIR POLLUTION AND RURAL BIOMASS FUELS IN DEVELOPING COUNTRIES: A PILOT VILLAGE STUDY IN INDIA AND IMPLICATIONS FOR RESEARCH AND POLICY

KIRK R. SMITH,*
Resource Systems Institute, East-West Center, 1777 East-West Road, Honolulu, HI 96848, U.S.A.

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National Institute of Occupational Health, Ahmedabad, India.

and

R. M. DAVE✠
Jyoti Solar Energy Institute, BVM Engineering College, Vallabh Vidyanagar, Gujarat, India, 388-120.

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-hours
>10x Indian standard
~50x WHO AQG

400 cigarettes/hour
smoke production

Kheda District
Gujarat, India
1981

Following decades

- In the 1980s, the first serious epidemiological studies in Nepal – MR Pandey et al. -- and more measurements in India and Nepal
- Then increasing measurement and health studies in the 1990s and first link to climate change in India and China
- Then, in the 2000s, hundred of studies around the world and the first RCT (child pneumonia in Guatemala)
- Culminating in the global finding that household air pollution from cookfuel is the most important environmental risk factor for health

Global Burden of Disease- 2010

- Involves hundreds of experts working on epidemiology and exposures related to specific diseases, injuries, and risk factors
- Core group brings the pieces together in common analytical frameworks.
- Coordinated by the Institute for Health Metrics and Evaluation at the University of Washington.
- Funded primarily by the Gates Foundation

Metrics

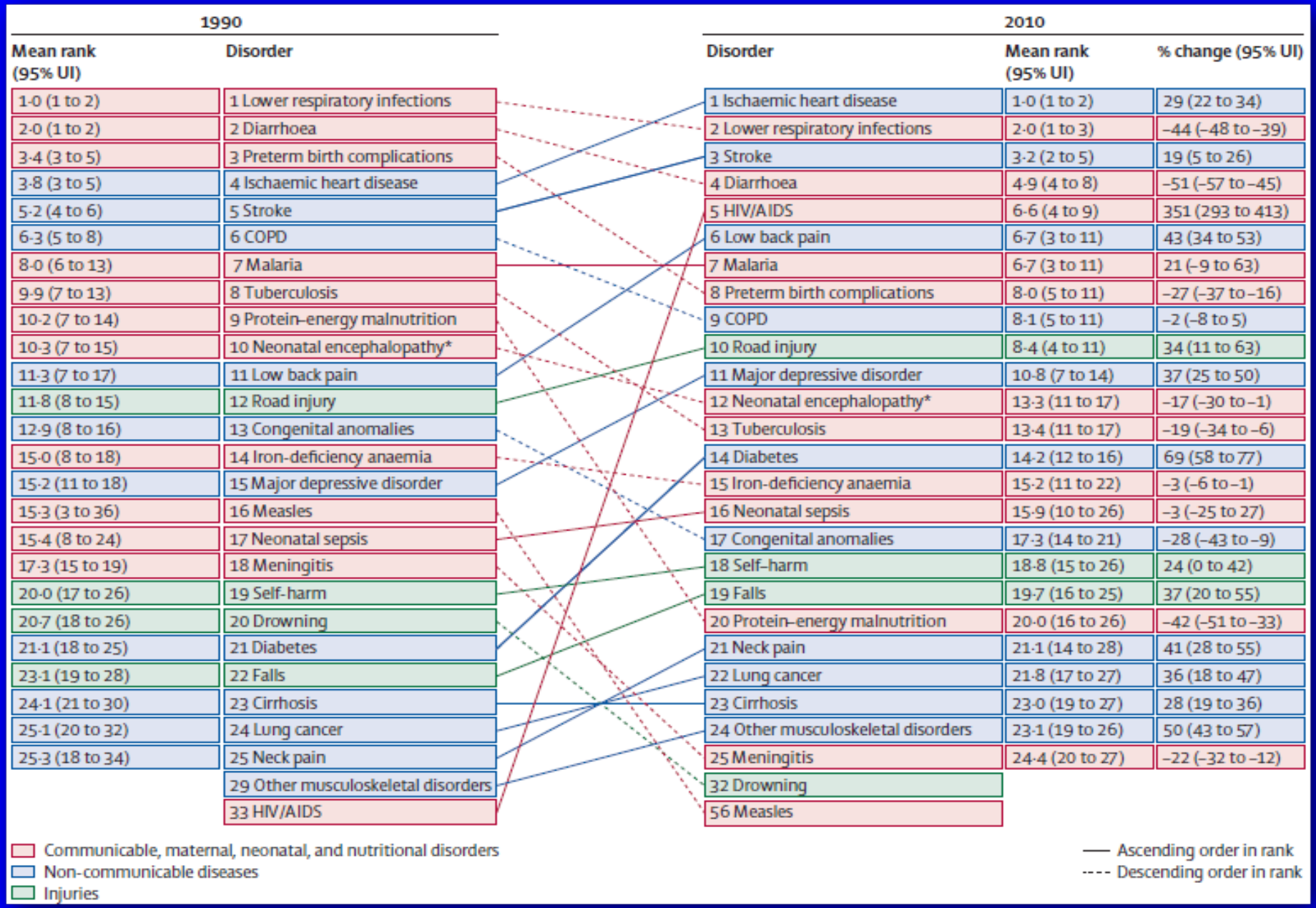
- Mortality – important, but can be misleading as it does not take age into account or years of illness/injury
  - Death at 88 years counts same as at 18, which is not appropriate
- Disability-adjusted Life Years (DALYs) lost do account for age and illness.
- GBD 2010 compares deaths against best life expectancy in world – 86 years

Definitions

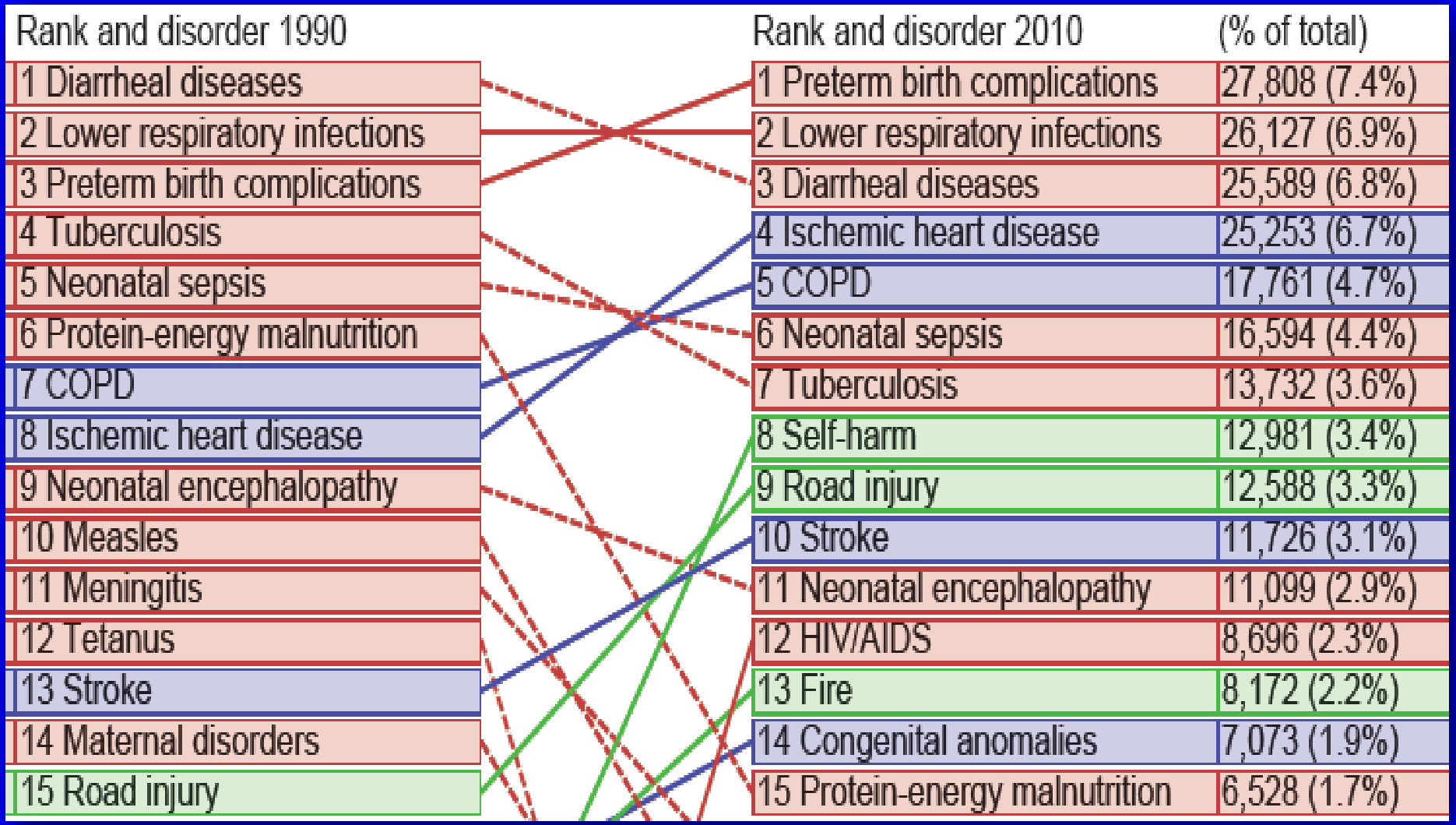
- **Global Burden of Disease (GBD)**
- Envelope of death, illness, and injury by age, sex, and region.
- Coherent – no overlap – one death has one cause

- **Comparative Risk Assessment (CRA)**
- The amount of the GBD due to a particular risk factor, e.g. smoking
- Not coherent – deaths can be prevented by several means

Leading causes of global disease burden, 1990 and 2010



GBD: Lost Life Years for India

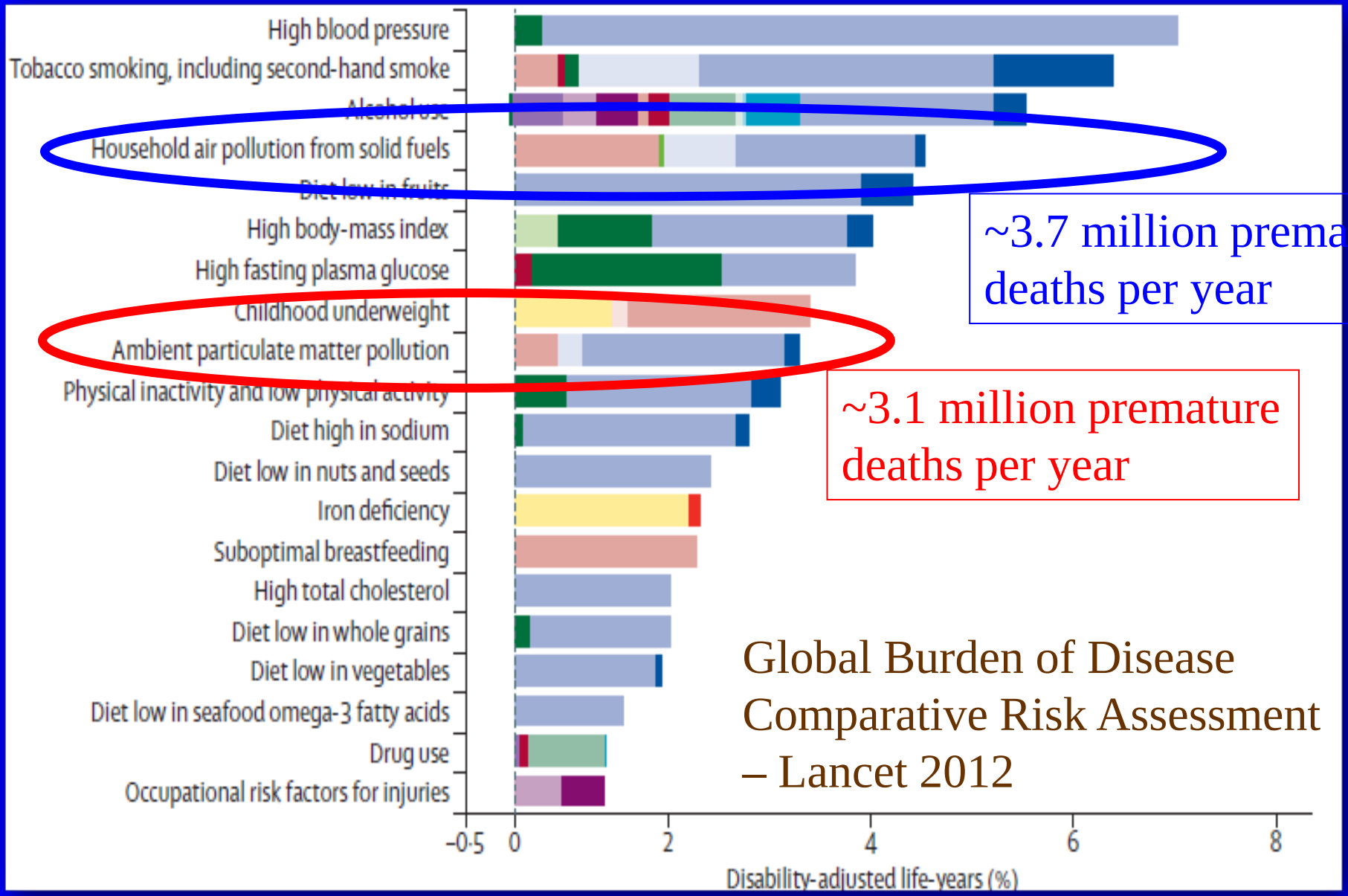


A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010

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 papers from the Global Burden of Disease -2010 Study in *The Lancet*, Dec 2012

Top 20 Risk Factors for Health in 2010

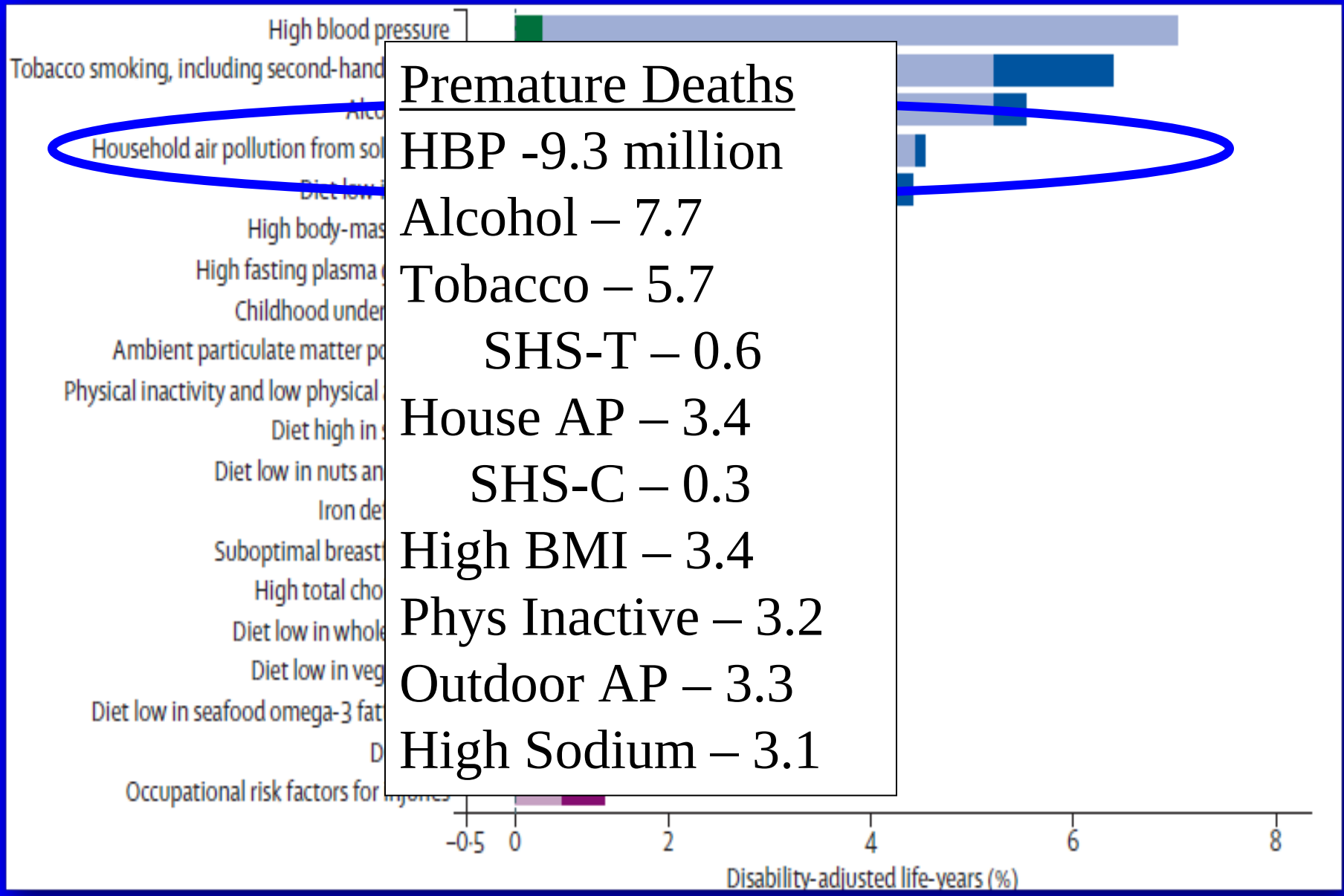


~3.7 million premat deaths per year

~3.1 million premature deaths per year

Global Burden of Disease Comparative Risk Assessment – Lancet 2012

Global DALYs 2010: Top 20 Risk Factors



Premature Deaths

HBP -9.3 million

Alcohol – 7.7

Tobacco – 5.7

SHS-T – 0.6

House AP – 3.4

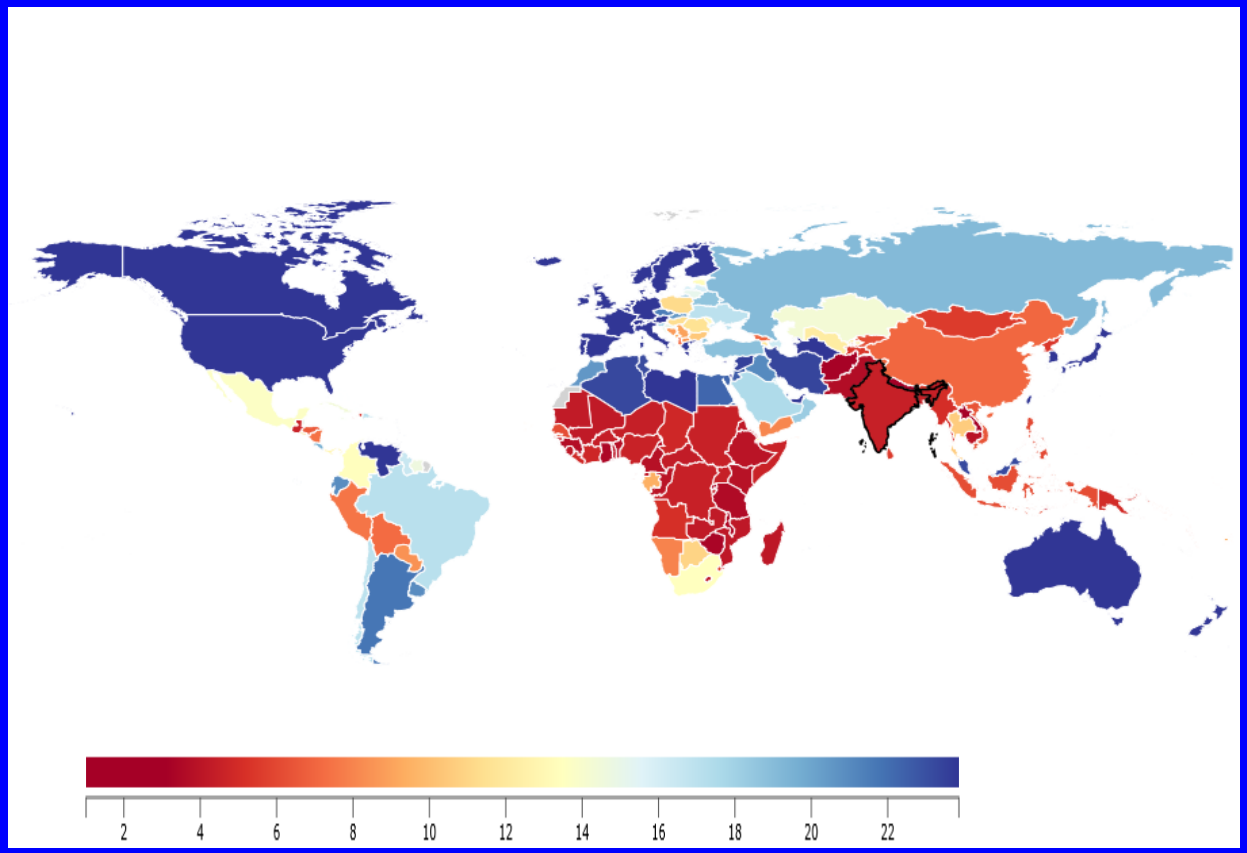
SHS-C – 0.3

High BMI – 3.4

Phys Inactive – 3.2

Outdoor AP – 3.3

High Sodium – 3.1



CRA results from GBD 2010: Ranking Household Air Pollution (HAP) across regions

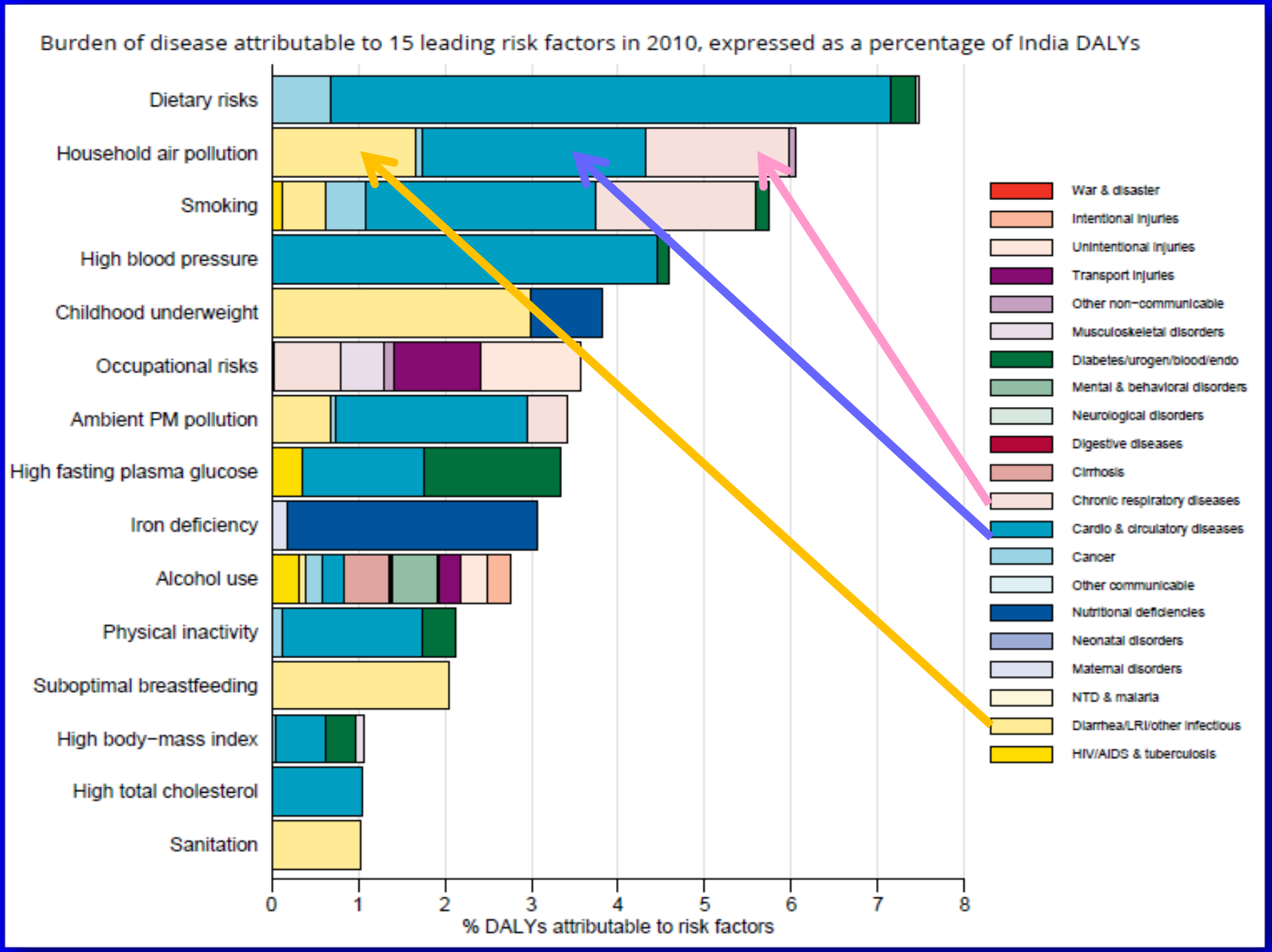
In country ranking for HAP

- Highest attributable disease burdens from HAP are in South Asia and Africa

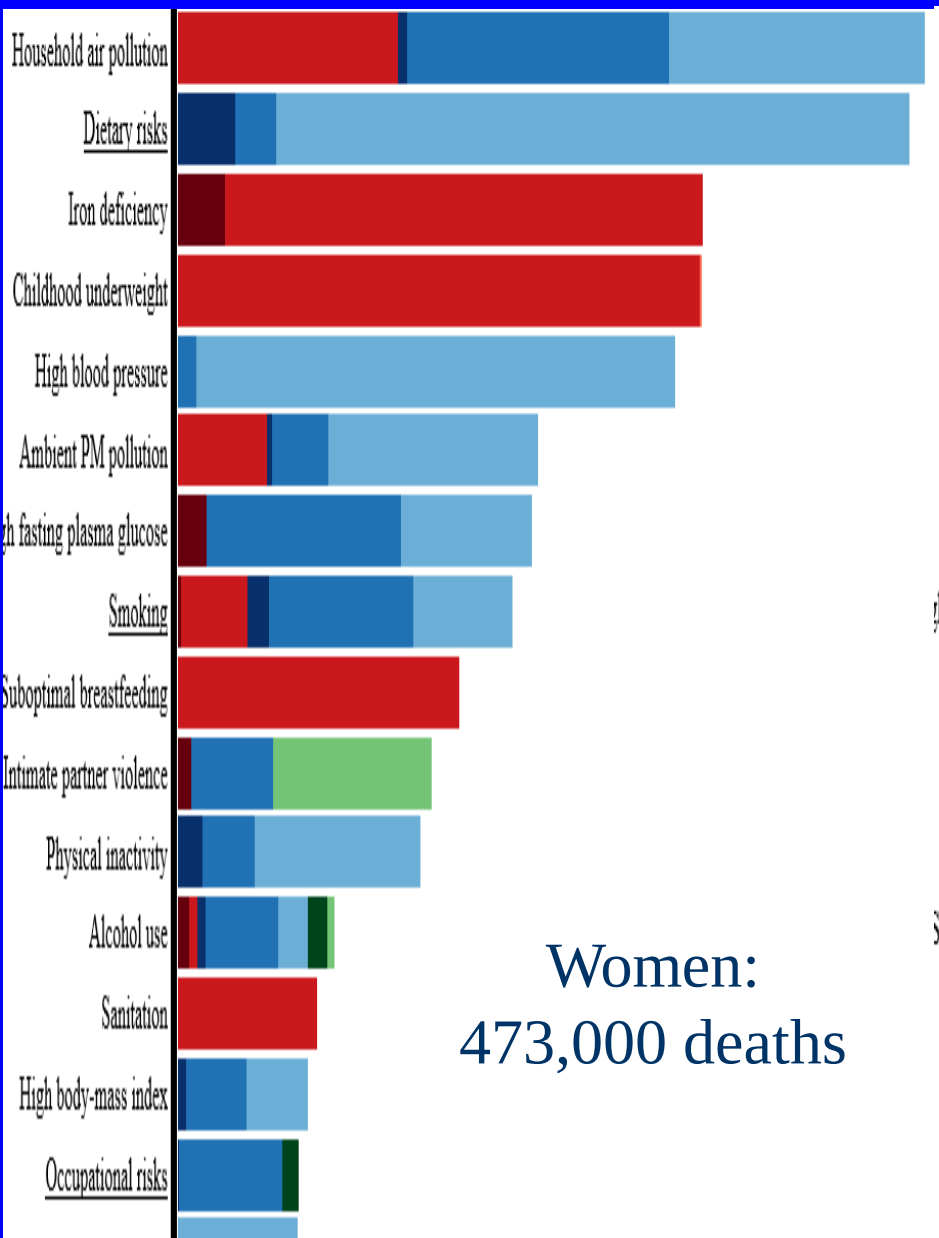
- HAP also among the highest ranking risk factors* in many countries

*among those examined

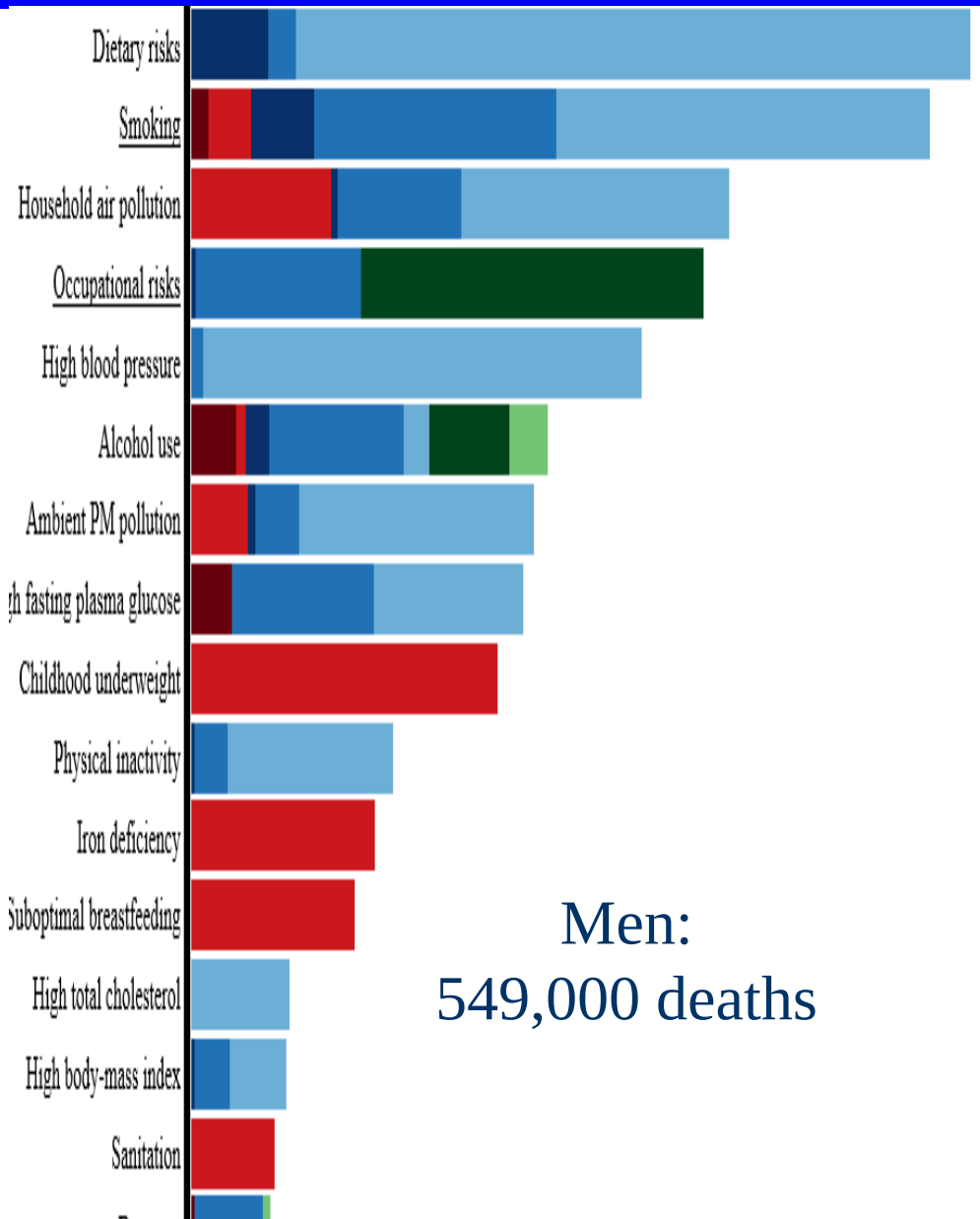
Lim et al, Lancet 2012


Burden of disease attributable to 15 leading risk factors in 2010, expressed as a percentage of India DALYs
Dietary risks
Household air pollution
Smoking
High blood pressure
Childhood underweight
Occupational risks
Ambient PM pollution
High fasting plasma glucose
Iron deficiency
Alcohol use
Physical inactivity
Suboptimal breastfeeding
High body−mass index
High total cholesterol
Sanitation
0
1
2
3
4
5
6
7
8
% DALYs attributable to risk factors
War & disaster
Intentional injuries
Unintentional injuries
Transport injuries
Other non−communicable
Musculoskeletal disorders
Diabetes/urogen/blood/endo
Mental & behavioral disorders
Neurological disorders
Digestive diseases
Cirrhosis
Chronic respiratory diseases
Cardio & circulatory diseases
Cancer
Other communicable
Nutritional deficiencies
Neonatal disorders
Maternal disorders
NTD & malaria
Diarrhea/LRI/other infectious
HIV/AIDS & tuberculosis

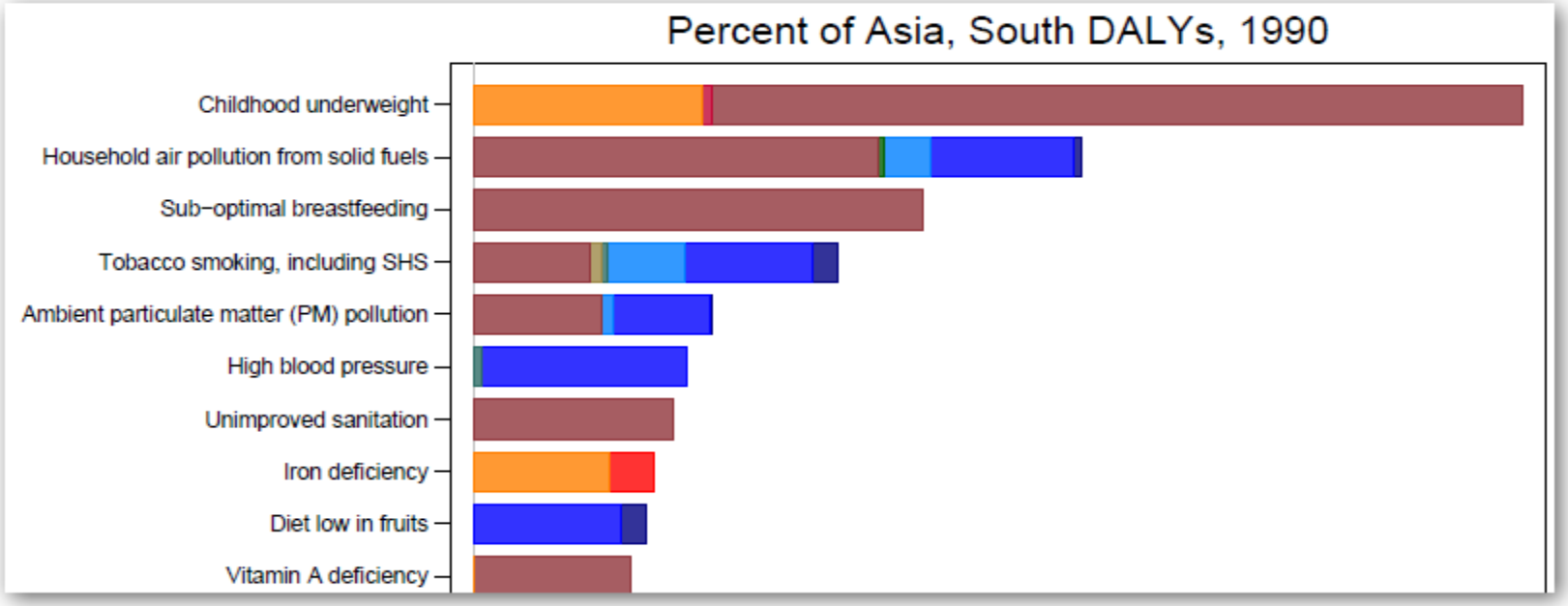
Top 15 causes of ill-health in India (GBD/CRA 2010)
HAP Total: ~1,000,000 premature deaths annually

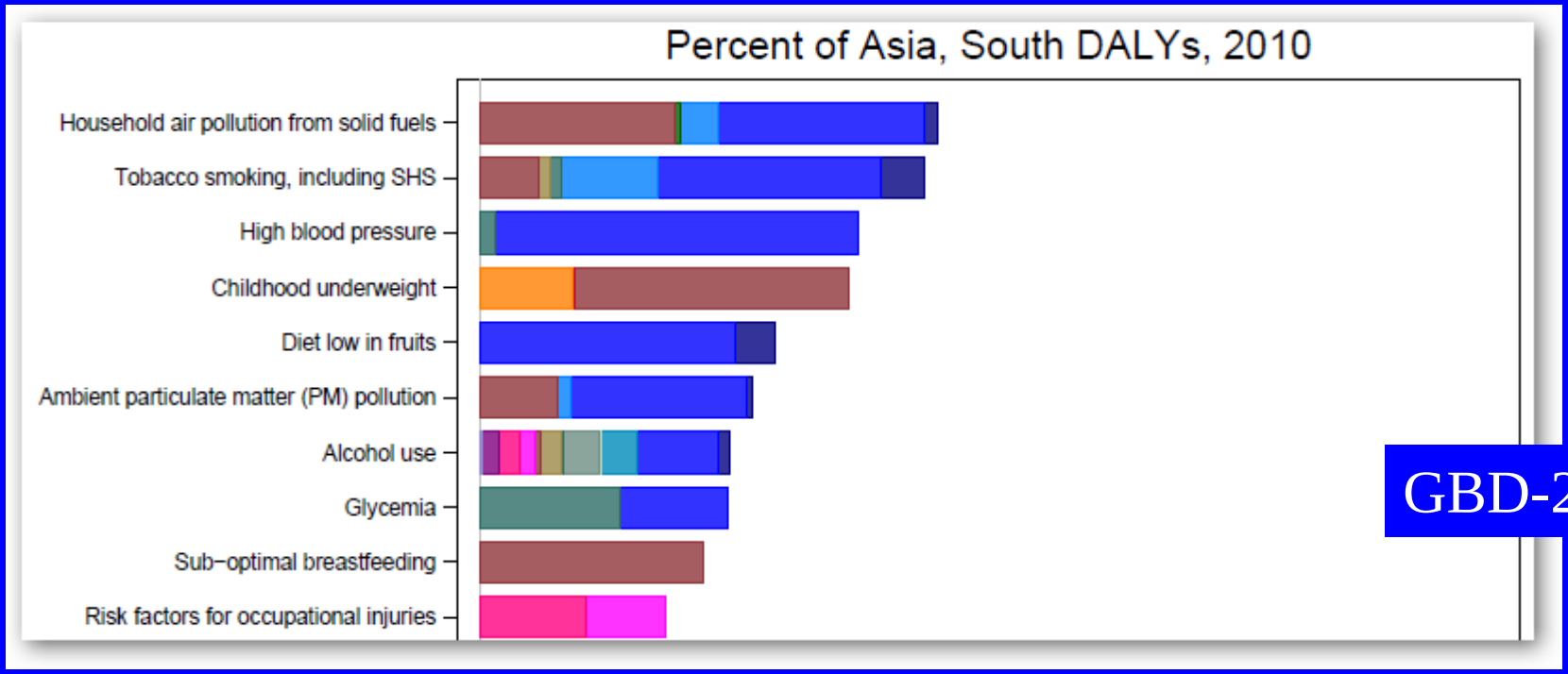


Women:
473,000 deaths



Men:
549,000 deaths


Percent of Asia, South DALYs, 1990
Childhood underweight
Household air pollution from solid fuels
Sub−optimal breastfeeding
Tobacco smoking, including SHS
Ambient particulate matter (PM) pollution
High blood pressure
Unimproved sanitation
Iron deficiency
Diet low in fruits
Vitamin A deficiency


Percent of Asia, South DALYs, 2010
Household air pollution from solid fuels
Tobacco smoking, including SHS
High blood pressure
Childhood underweight
Diet low in fruits
Ambient particulate matter (PM) pollution
Alcohol use
Glycemia
Sub−optimal breastfeeding
Risk factors for occupational injuries

GBD-2010

HAP mortality in India in 2010

~10 lakh annual premature deaths

-About one-quarter of global total

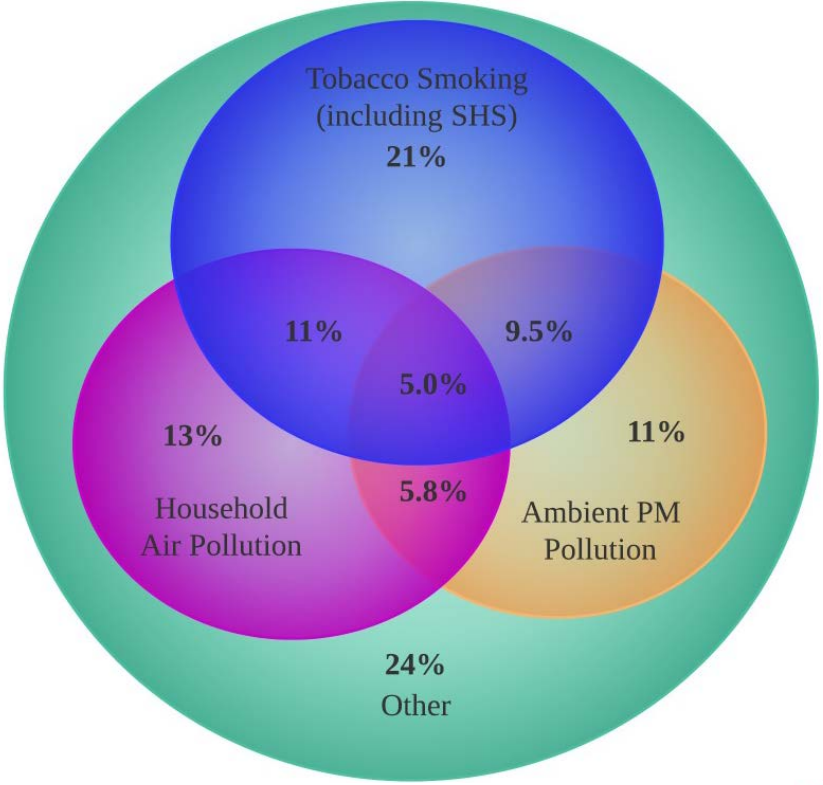
-Secondhand cooksmoke ~1,5 lakh more

-About 10% of national mortality

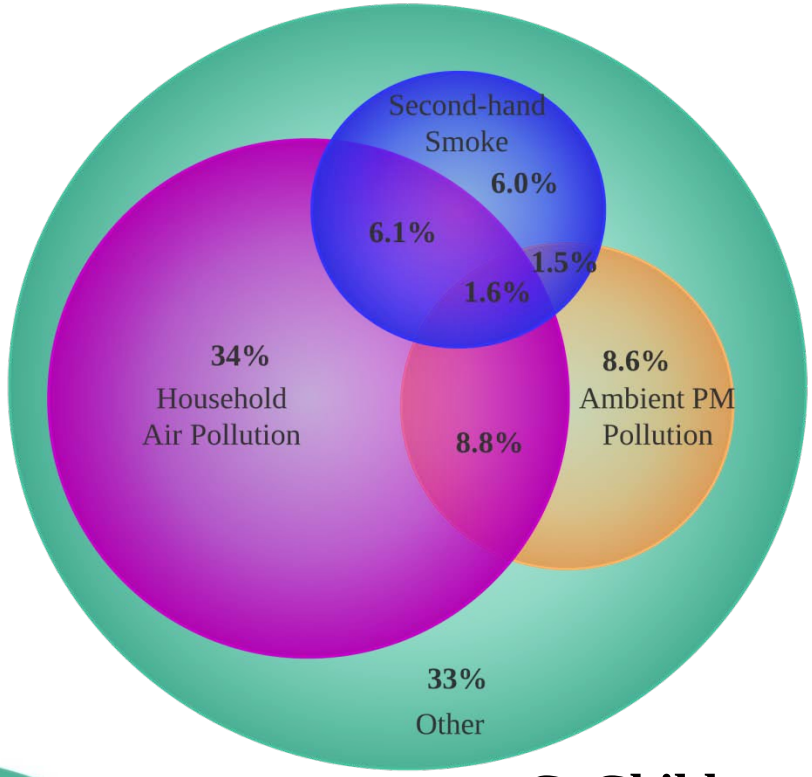
-About the same as tobacco

-About 50% more than outdoor air pollution, which is about 600k

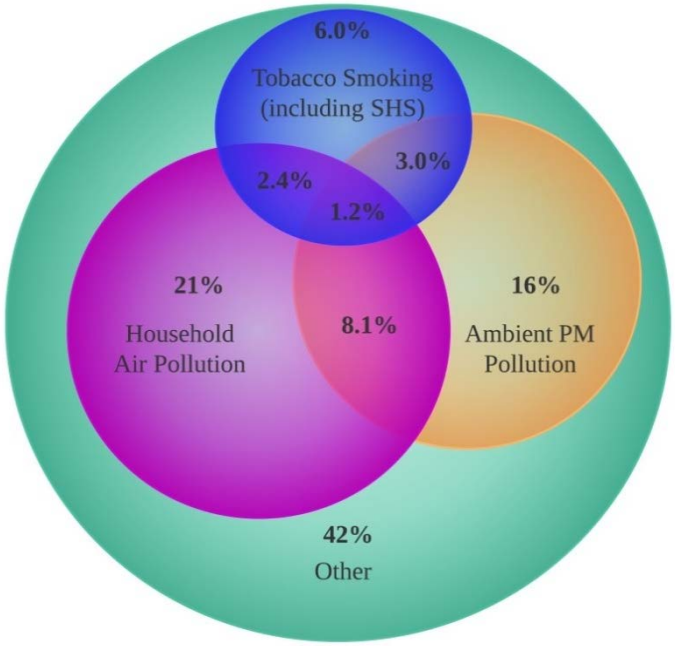
n.b. these estimtes can be compared but not added as there are overlaps



A. Male IHD: 17,102,900 DALYs



C. Child ALRI 17,139,800 DALYs



B. Female IHD 9,092,910 DALYs

India: IHD and child ALRI

Framing

- Five major diseases now accepted to be caused by HAP
- Adults
  - Lung cancer
  - Chronic obstructive pulmonary disease
  - Cataracts
  - Cardiovascular disease – IHD and stroke
- Pneumonia in children

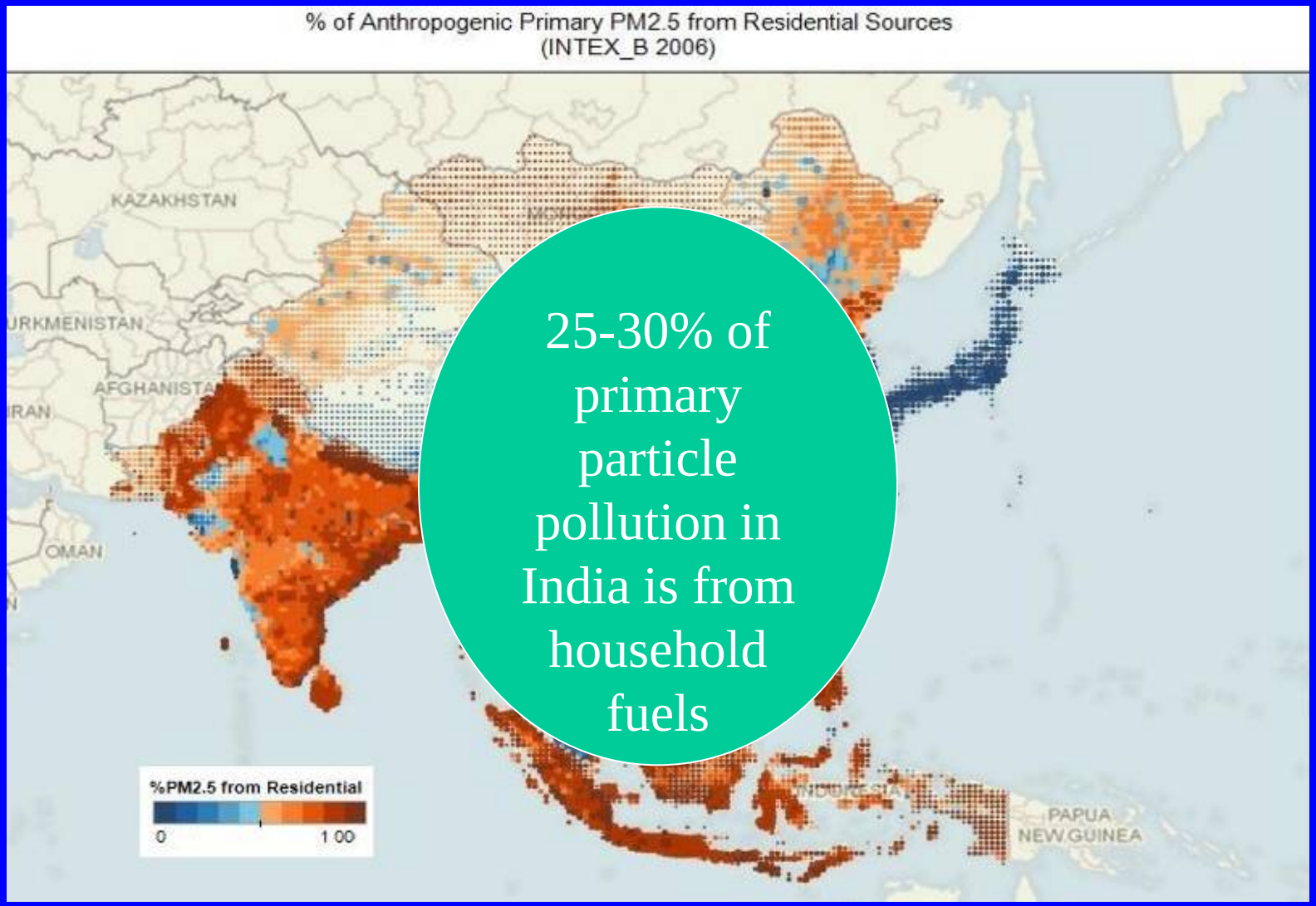
Framing, cont

- Two – COPD and cataracts -- use studies of health by fuel type for risk estimates
- CVD, lung cancer, and child pneumonia rely on risks determined by exposures derived from national model using ~600 household measurements in India (Balakrishnan et al., 2013)
- India itself not a small sample as it has more than one-quarter of the world total.
- Assumption is that rest of world, on average, similar.

Framing, cont.

- Not called “indoor” because stove smoke enters atmosphere to become part of general ambient air pollution (AAP)
- HAP contributes about 12% to AAP globally, but much more in some countries – 25% in India
- Thus, part of the burden of disease due to AAP is attributable to cooking fuels in households ~400,000 premature deaths.

%$PM_{2.5}$ from "Residential" Emissions from INTEX_B



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

Chafe, 2010

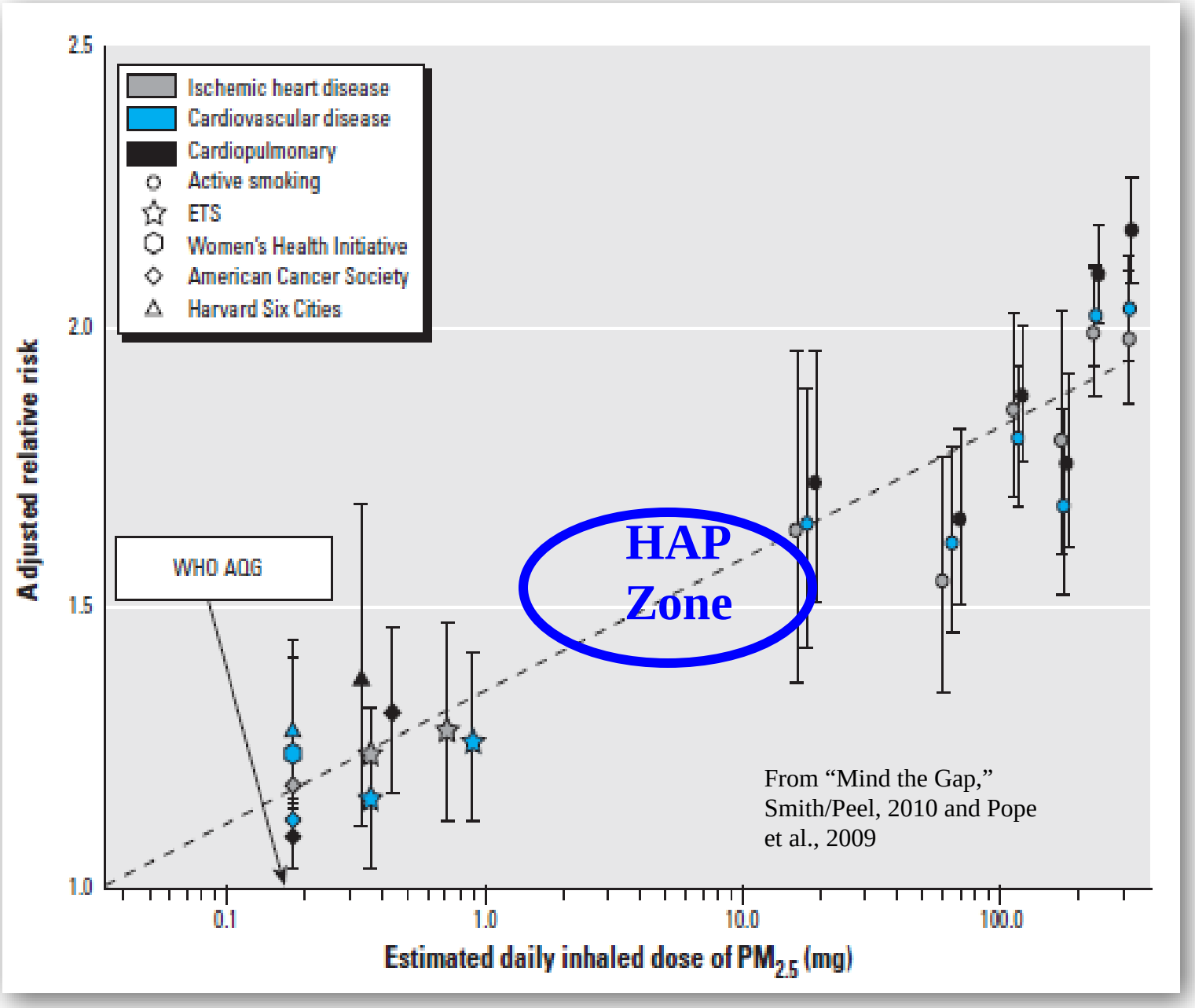
Framing, cont.

- Much effort made to make estimates consistent across the four combustion particle groups in the new GBD/CRA
- Active tobacco smoking, household air pollution, secondhand tobacco smoking, and ambient air pollution
- HAP and AAP use the same counterfactual level for nearly all diseases: ~7 µg/m3 annual mean annual $PM_{2.5}$ concentration
- Roughly equivalent to cooking with a vented gas stove or electricity

New Category of Evidence for CVD

- Few direct studies of CVD and HAP, yet
  - But studies showing effects on blood pressure and ST-segment, important disease signs
- Epidemiologic evidence shows clear, consistent evidence of increasing risk across exposures to combustion particles
  - at higher exposures – Active smoking
  - and lower exposures – Ambient air pollution and secondhand tobacco smoke

Heart Disease and Combustion Particle Doses



From "Mind the Gap," Smith/Peel, 2010 and Pope et al., 2009

Chimney Stove Intervention to Reduce Long-term Wood Smoke Exposure Lowers Blood Pressure among Guatemalan Women

John P. McCracken,[1,2] Kirk R. Smith,[3] Anaité Díaz,[4] Murray A. Mittleman,[1,5] and Joel Schwartz[1,2]

EHP, 2007

Indoor Air Pollution and Blood Pressure in Adult Women Living in Rural China

Jill Baumgartner,[1,2,3] James J. Schauer,[3,4] Majid Ezzati,[5] Lin Lu,[6] Chun Cheng,[6] Jonathan A. Patz,[2,3,7] and Leonelo E. Bautista[2]

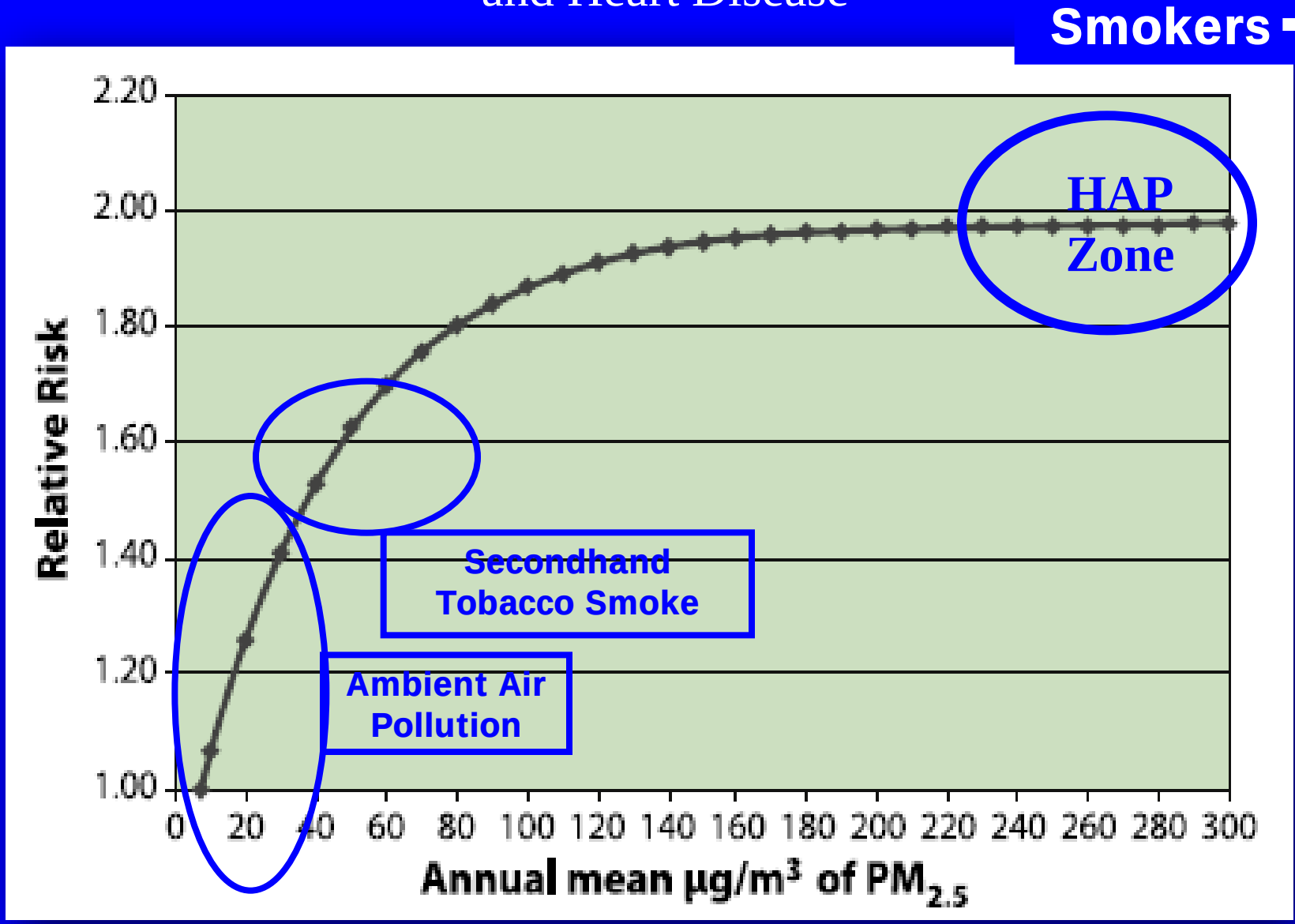
EHP, 2011

Intervention to Lower Household Wood Smoke Exposure in Guatemala Reduces ST-Segment Depression on Electrocardiograms

John McCracken,[1,2] Kirk R. Smith,[2] Peter Stone,[3] Anaité Díaz,[4] Byron Arana,[4] and Joel Schwartz[1]

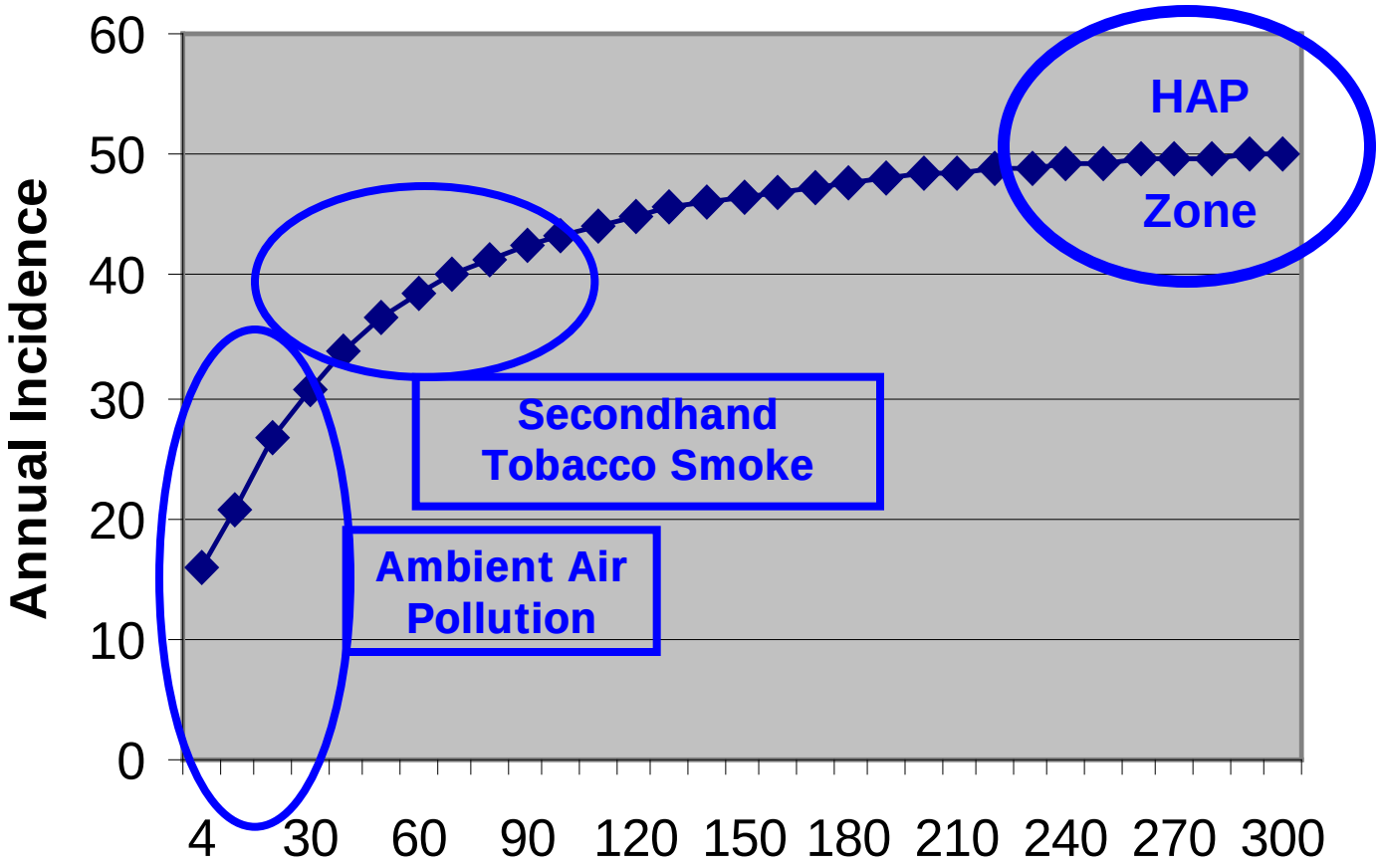
EHP, 2011

Integrated Exposure-Response: Ambient Air, SHS, and Smoking and Heart Disease



CRA, 2011

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



CRA, 2010

Bottom Lines

- One of the top risk factors in the world for ill-health.
- Most important environmental risk factor among all examined
- Biggest impact in adults ~3 million premature deaths (two-thirds the DALYs)
- Still important for children ~500,000 deaths (one-third the DALYs)
- Important source of outdoor air pollution
- Impact going down slowly because background health conditions improving
- Actual number of people affected is not going down

Not all diseases included

- Many with evidence not included yet
  - Low birth weight
  - TB
  - Other cancers – cervical, upper respiratory, etc
  - Cognitive effects
  - Pneumonia in adults
- Can expect that HAP effects, over time, will be found for nearly all the many dozen diseases found for smoking.
- But at lower risk levels

Biggest impacts from smoking

- Lung cancer
- Heart disease of various kinds
- Chronic obstructive lung disease
- Stroke
- Same adult impacts as HAP

What other cancers from smoking?

- “Traditional” smoking cancers: oral cavity, pharynx, larynx, oesophagus, pancreas, urinary bladder, and renal pelvis
- Newly confirmed cancers: nasal, sinus, nasopharynx, stomach, liver, kidney, uterine cervix, oesophagus, and leukaemia

Review of Epi Evidence: Lung Cancer, 2004

Birth defects due to smoking in pregnancy include

- **cleft lips and cleft palates**,
- **neural tube defects**
- shortened or missing arms and legs,
- gastrointestinal abnormalities,
- being born with their intestines hanging outside the body
- heart defects
- baby boys born with undescended testes.

Human Reproduction Update, 2009

Infectious disease and smoking

- pneumonia
- TB
- meningococcal disease
- otitis media
- influenza

Archives of Internal Medicine, 2004

Other impacts of smoking

- preterm delivery,
- stillbirth,
- low birth weight, and
- sudden infant death syndrome (SIDS)
- lower bone density in older women.
- cataracts
- IQ and cognitive impacts (SHS)

CDC, 2012

Caveats

- Not all important risk factors were included in the GBD analysis, e.g.
  - None for malaria, HIV, child vaccinatable diseases, or road traffic accidents
- Portions of HAP CRA still under journal review – will likely be some small changes
- Full description of the HAP CRA just accepted for publication in the *Annual Review of Public Health*

Bottom Lines

- We understand the risks of combustion particles not only from a large number of studies in households, but also from studies of outdoor air pollution, secondhand smoke, and active smoking.
- Over time, we can expect that nearly every effect found in smokers will be found from household smoke, but a lower risk levels.
- We no longer refer to it as “indoor” air pollution because the exposures occur not only inside, but around the house, down the street, and indeed regionally – “secondhand cook smoke”
- Cannot solve outdoor air pollution problems in South Asia and other regions without reducing substantially household pollution.

Just because we know it's a risk, does not mean we know how to fix it

- **1964:** Surgeon General's Report but Framework Convention on Tobacco Control was 2005 and not all countries yet signed up and impacts growing
- **~1900**: Mosquito-born disease cause established, but still 1.4 million die of malaria today
- **~1890**: causation of health risk from human waste in drinking water firmly established: still today one-third of world population without adequate sanitation/water

Why is it so hard?

- What we know works, gas and electricity, is not “affordable” by the poor.
- Other technologies difficult and less effective and no drug companies to pay for their advancement
- Particularly difficult because of the high component of behavioral change required
- Yet, the fact that 60% of the world is now protected, gives us reason to think we can protect the other 40%
- Will take a new type of research and development, however, both sophisticated and rigorous, to develop and test the interventions in ways to convince the health community
- And completely different levels of funding, for example the kinds of large intervention trials done for vaccines, water/sanitation, bednets, etc. – $10s of millions each

If it doesn’t take fifty years, it isn’t worth doing.*

- Let us hope, however, that in 2030 we are not like poor water/sanitation today, i.e., 120 years from when causation was accepted by most people, but still killing millions annually.

*Attributed to Albert Einstein

New WHO AQGs Will Play an Important Role in this Future

- By indicating in an authoritative way what is clean enough to protect health.
- For example, it will help the new Indian National Cookstove Initiative to operationalize its far-sighted vision for all Indian households:

- **"Our aim is to achieve the quality of energy services from cookstoves comparable to that from other clean energy sources such as LPG."**

  – **Ministry of New and Renewable Energy, 2009**

HAP Interventions

- Ban coal and kerosene in household use
- Aggressively expand access to LPG and other clean fuels
- Expand and stabilize household electricity access – pick off cooking tasks with electric appliances
- Develop and deploy very clean biomass stoves – none yet available at scale, however

Many thanks

Publications and presentations on website – easiest to just "google" Kirk R. Smith