Clean Cooking in the PAHO Region: Why do we Care?

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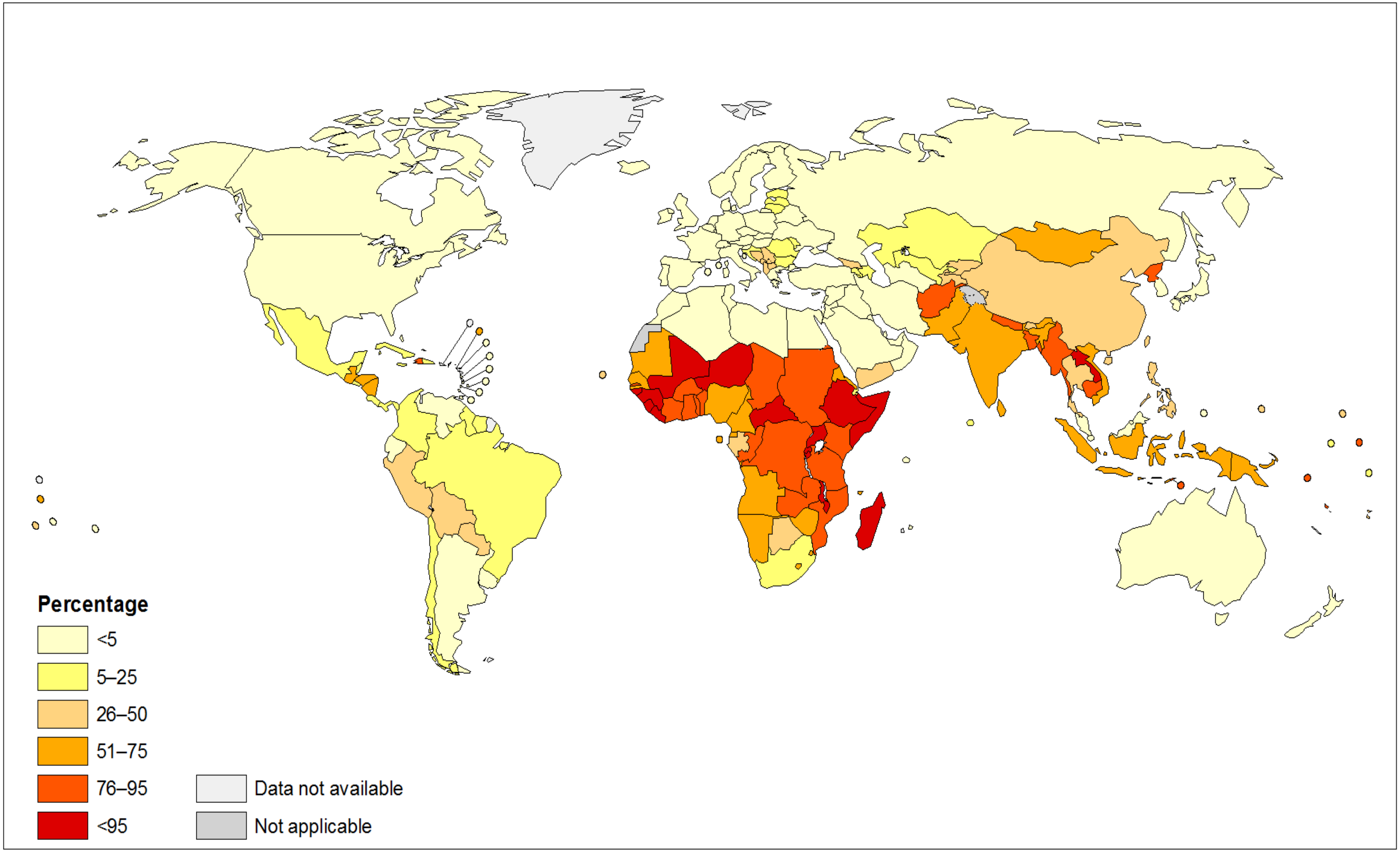
The Environmental Health Pathway


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.

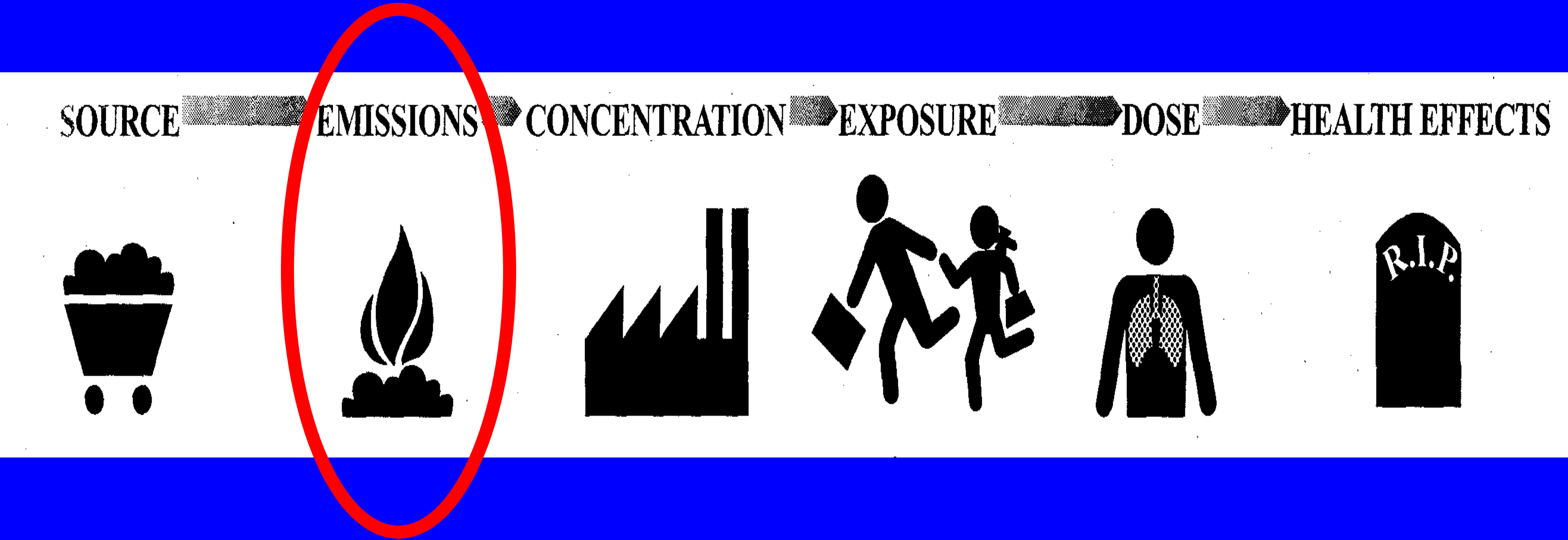
Data Source: World Health Organization
Map Production: Public Health Information and Geographic Information Systems (GIS)
World Health Organization

World Health Organization

2010 Biomass Use for Cooking in Latin America

Argentina	0 (0, 12)
<u>Belize</u>	12 (0, 25)
<u>Bolivia</u>	29 (32, 58)
Brazil	6 (0, 19)
Chile	6 (0, 19)
<u>Colombia</u>	14 (1, 27)
Costa Rica	6 (0, 19)
Cuba	0 (0, 22)
Dominica	1 (0, 14)
Domin Repub	7 (0, 20)
Ecuador	2 (0, 15)
<u>El Salvador</u>	22 (9, 35)
Grenada	0 (0, 0)
<u>Guatemala</u>	57 (44, 70)
Guyana	7 (0, 20)
<u>Haiti</u>	91 (78, 100)
<u>Honduras</u>	51 (38, 64)
<u>Jamaica</u>	11 (0, 24)
<u>Mexico</u>	14 (1, 27)
<u>Nicaragua</u>	54 (41, 67)
Panama	18 (5, 31)
<u>Paraguay</u>	49 (36, 62)
<u>Peru</u>	36 (24, 50)
St Vinc/Grenad	3 (0, 16)
<u>Suriname</u>	12 (0, 25)
Uruguay	0 (0, 13)
Venezuela	0 (0, 8)

The Environmental Health Pathway



Woodsmoke is natural – how can it hurt you?

Or, since wood is mainly just carbon, hydrogen, and oxygen, doesn't it just change to CO_2 and H_2O when it is combined with oxygen (burned)?

Reason: the combustion efficiency is far less than 100%

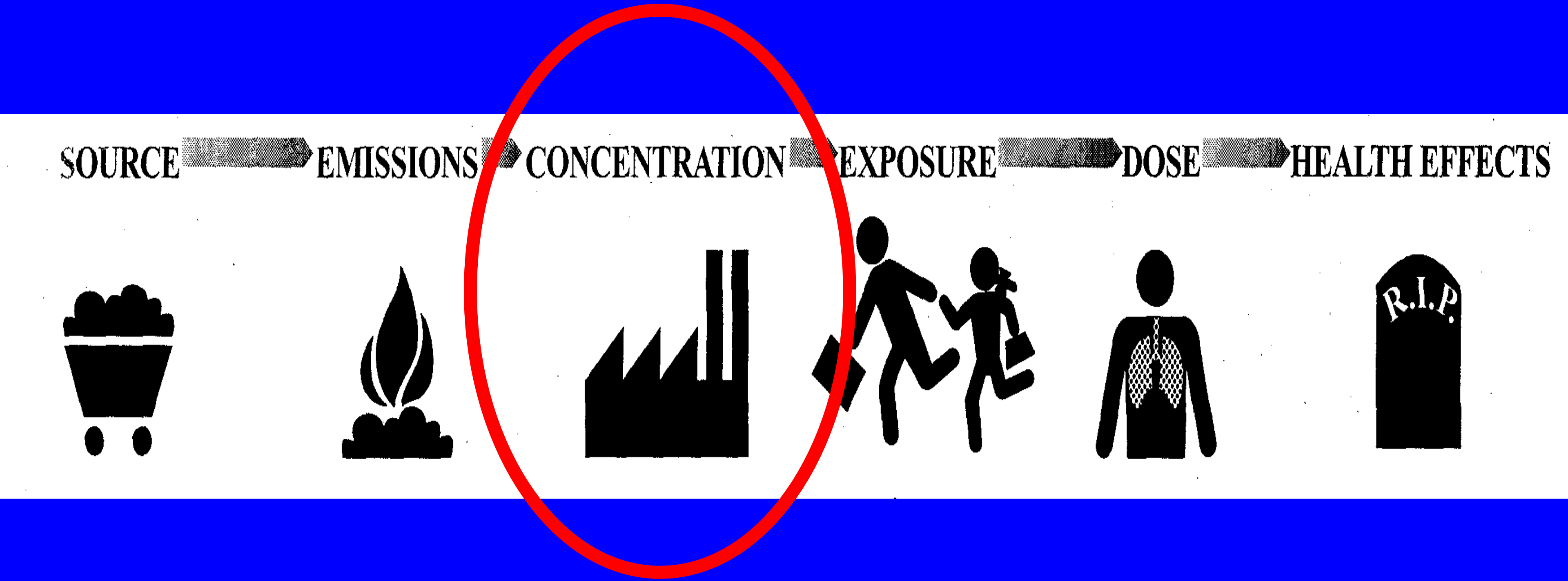
Toxic Pollutants in Wood Smoke from Simple (poor) Combustion

- Small particles, CO, NO_2
- Hydrocarbons
  - 2 … *e*
  - 4 … *tadiene*
  - 2 … *ene*
  - 2 … *rene*
- Oxy…
  - 2 … *rolein*
  - 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*

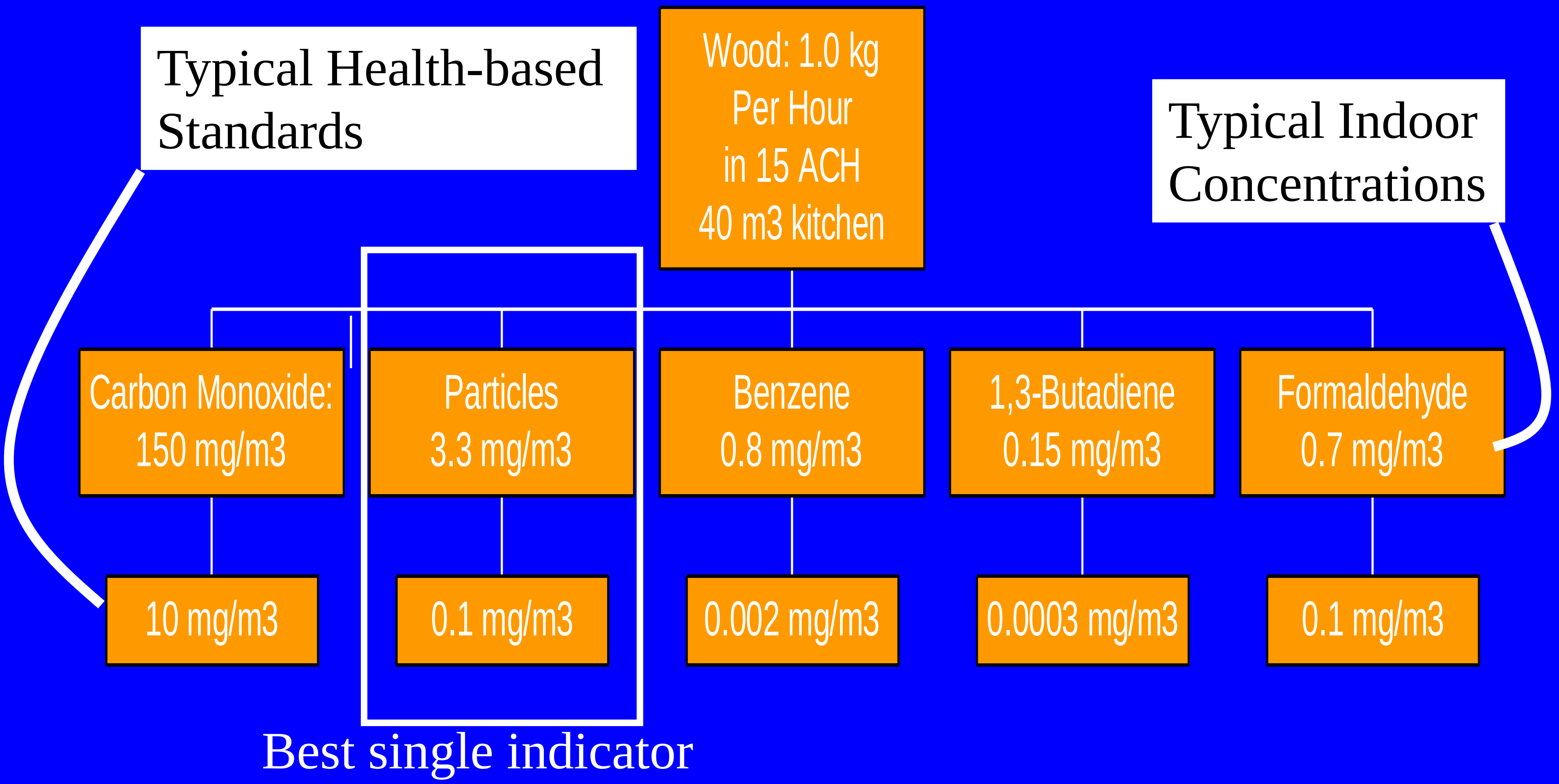
Typical wood cookfire releases 400 cigarettes per hour worth of smoke

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

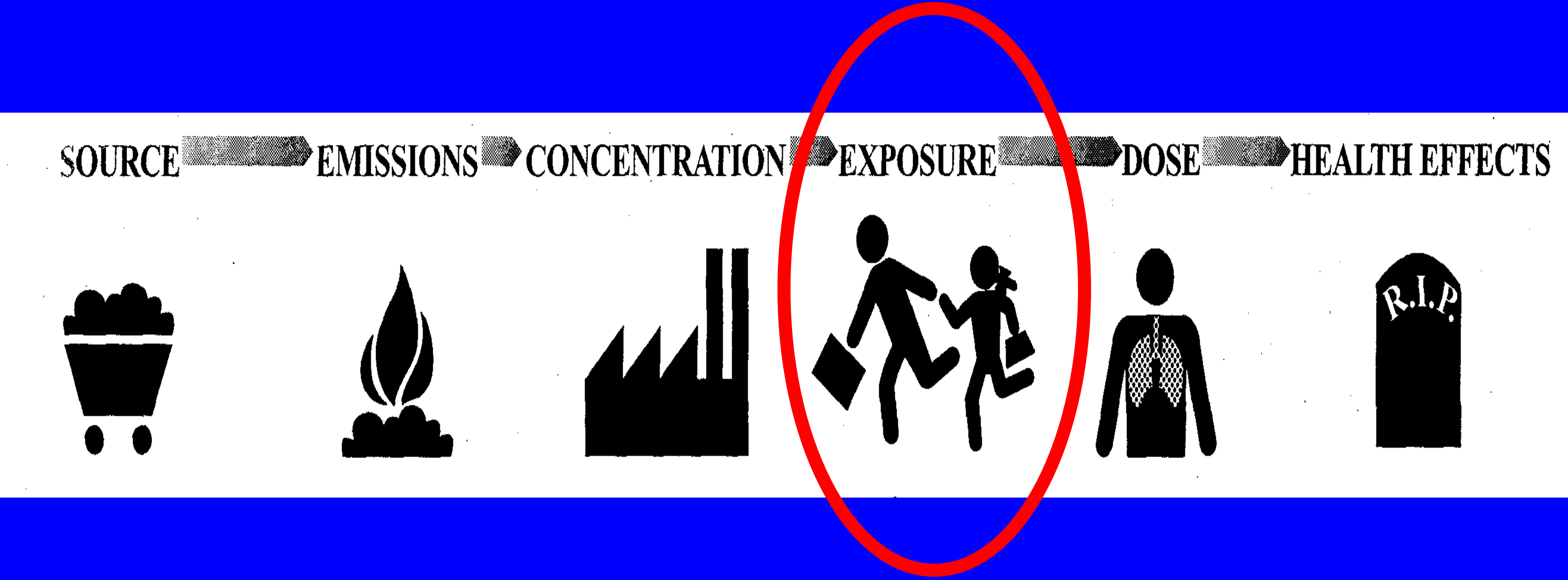
The Environmental Health Pathway

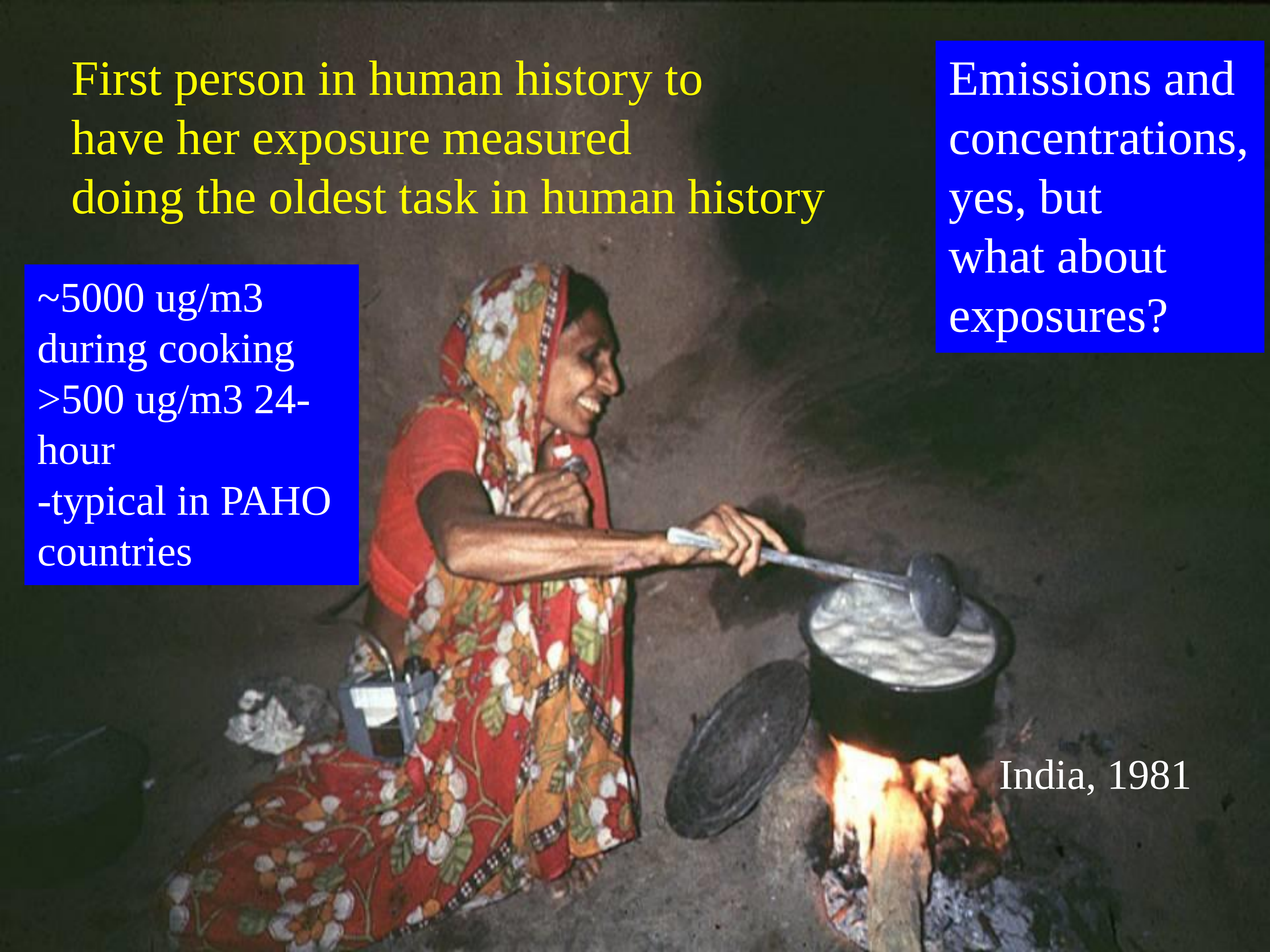


Health-Damaging Air Pollutants From Typical Wood-fired Cookstove.



The Environmental Health Pathway




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

The Environmental Health Pathway

How much $PM_{2.5}$ is unhealthy?

- WHO Air Quality Guidelines
  - 10 ug/m^3 annual average
  - No public microenvironment, indoor or outdoor, should be more than 35 ug/m^3
- USEPA
  - Was 15 ug/m^3 until 2012: annual outdoors
  - Now 12 ug/m^3
  - 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 on Dec 14, 2012
in *The Lancet*

The framing

- Household air pollution from use of solid fuels for cooking
- Not called “indoor” because stove smoke goes outdoors to exposure people in other locations around the household and village.
- And enters atmosphere to become part of general outdoor air pollution (OAP)

Framing, cont.

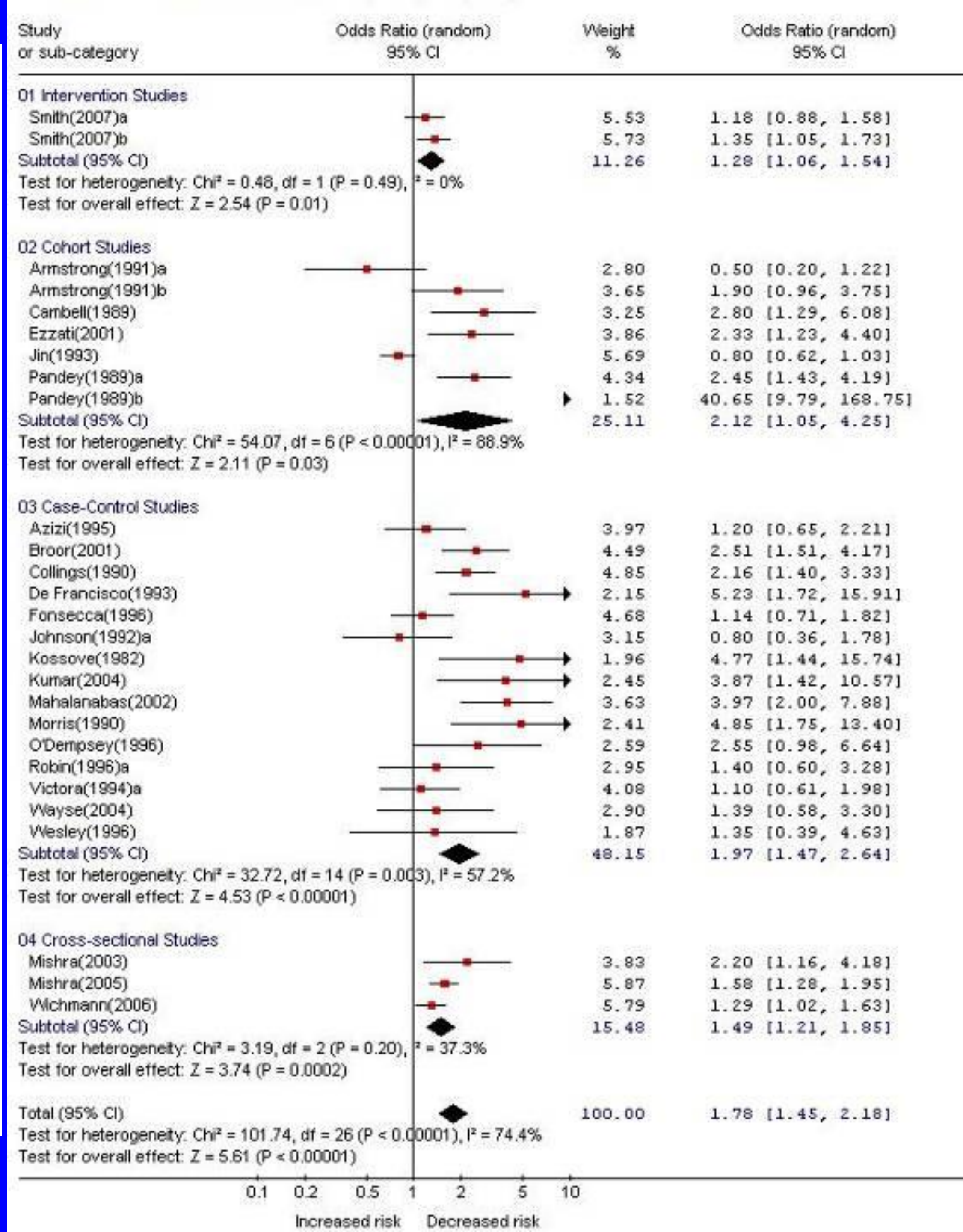
- Much effort made to make estimates consistent across the four combustion particle groups in the new GBD/CRA
- Active tobacco smoking, household air pollution, secondhand tobacco smoking, and outdoor air pollution
- HAP risks are determined in comparisons with a vented gas stove or electric cooking

Four types of direct evidence

- Hundreds of epi studies comparing health effects in households using clean fuels versus polluting fuels or various other binary exposure metrics
- Integrated Exposure-Response Curves for 5 diseases – link across 4 air pollution types
- For ALRI – based on RESPIRE in Guatemala – only ones yet published
  - Randomized controlled trial
  - Exposure-response study

Study design	N*	OR	95% CI
Intervention	2	1.28	1.06, 1.54
Cohort	7	2.12	1.06, 4.25
Case-control	15	1.97	1.47, 2.64
Cross-sectional	3	1.49	1.21, 1.85
All	26	1.78	1.45, 2.18

Dherani et al Bull WHO (2008)



Growing indirect evidence

- Biomarkers of effect
  - Blood pressure
  - Heart function
  - Lung function
  - Urinary toxin levels
  - Etc.

Diseases from HAP with Strong Evidence

ALRI/
Pneumonia

Cataracts

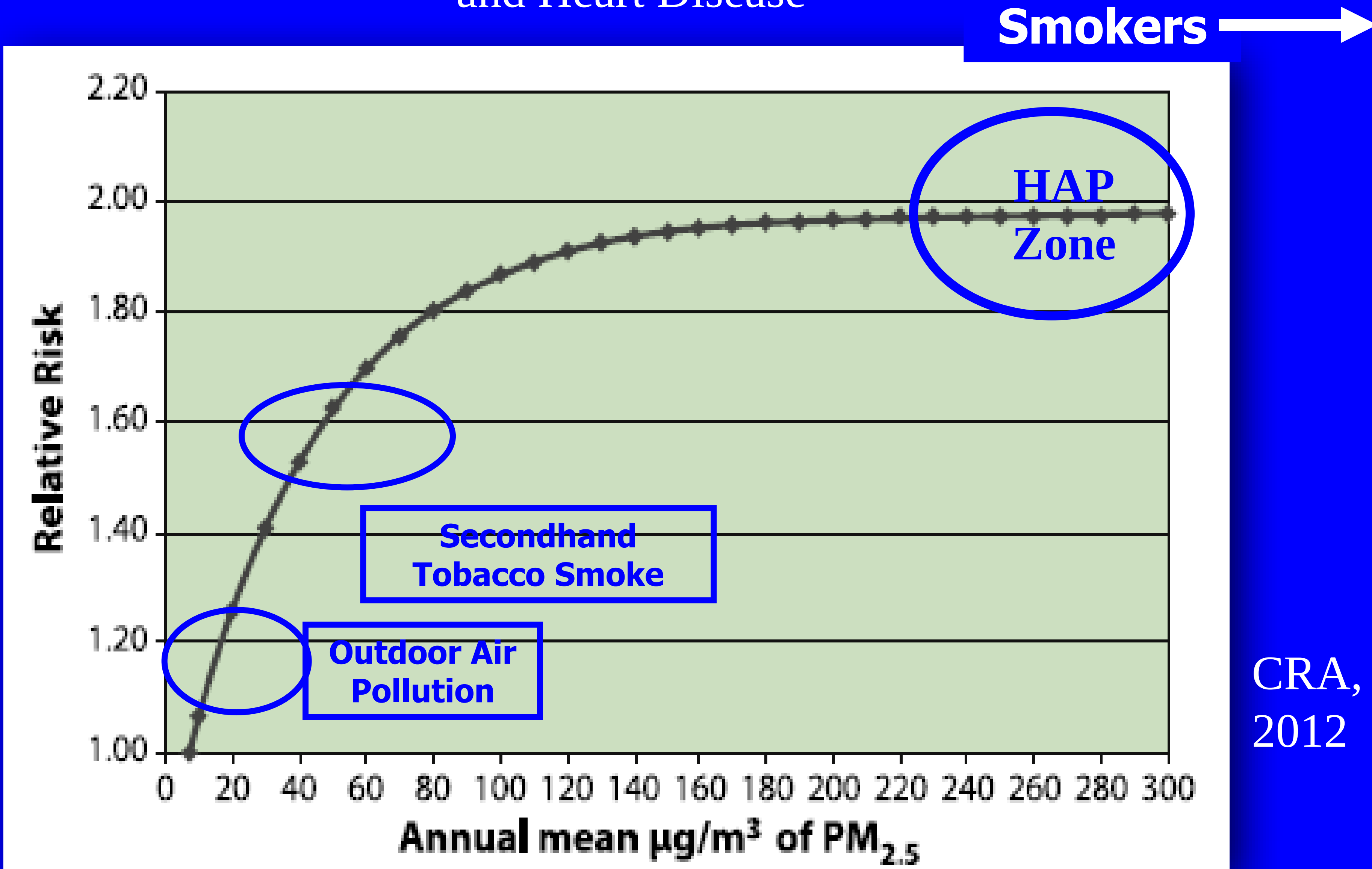
Heart disease
and stroke

COPD

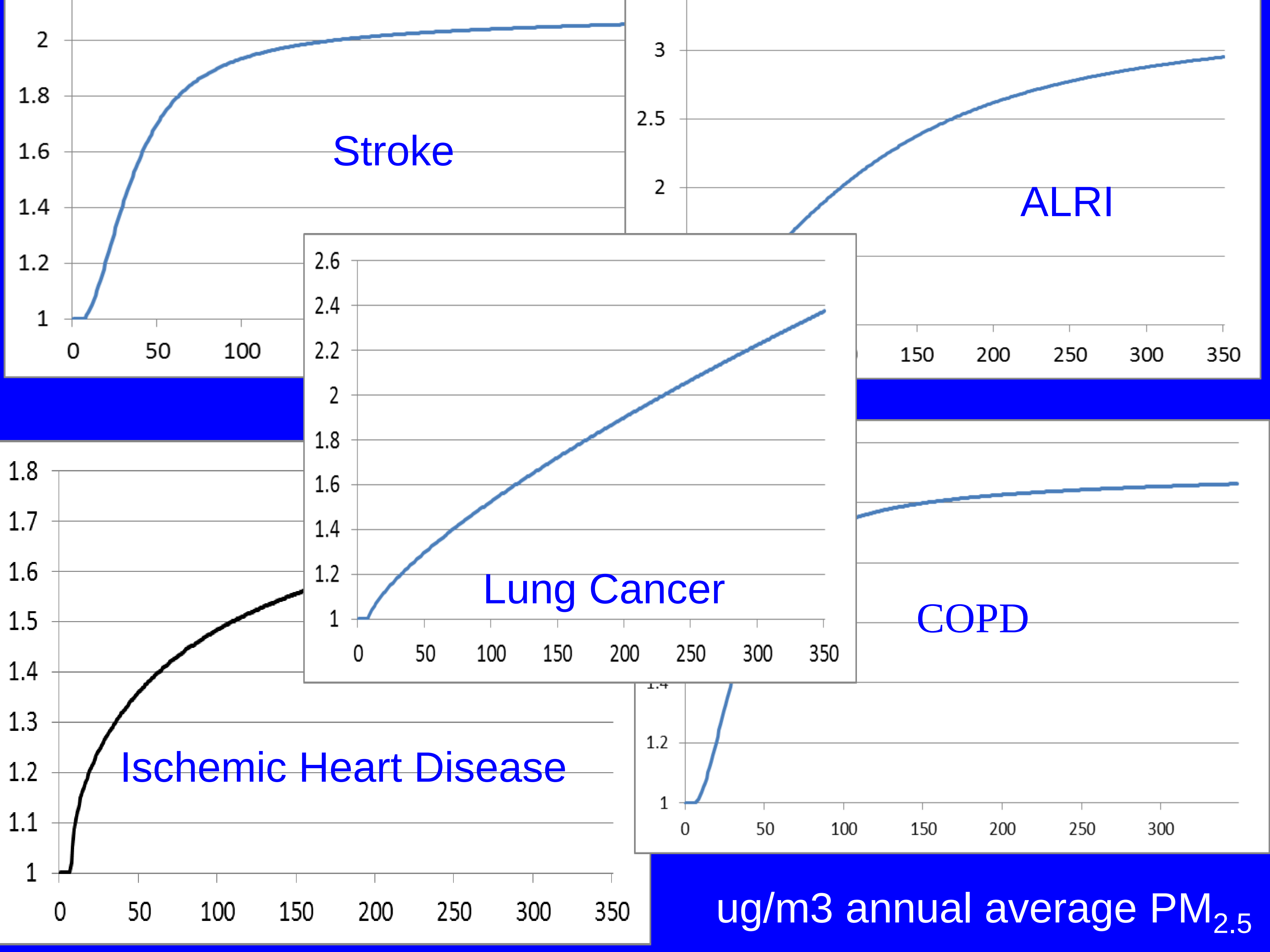
Lung cancer

These diseases are included in the Comparative Risk Assessment of the Global Burden of Disease

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



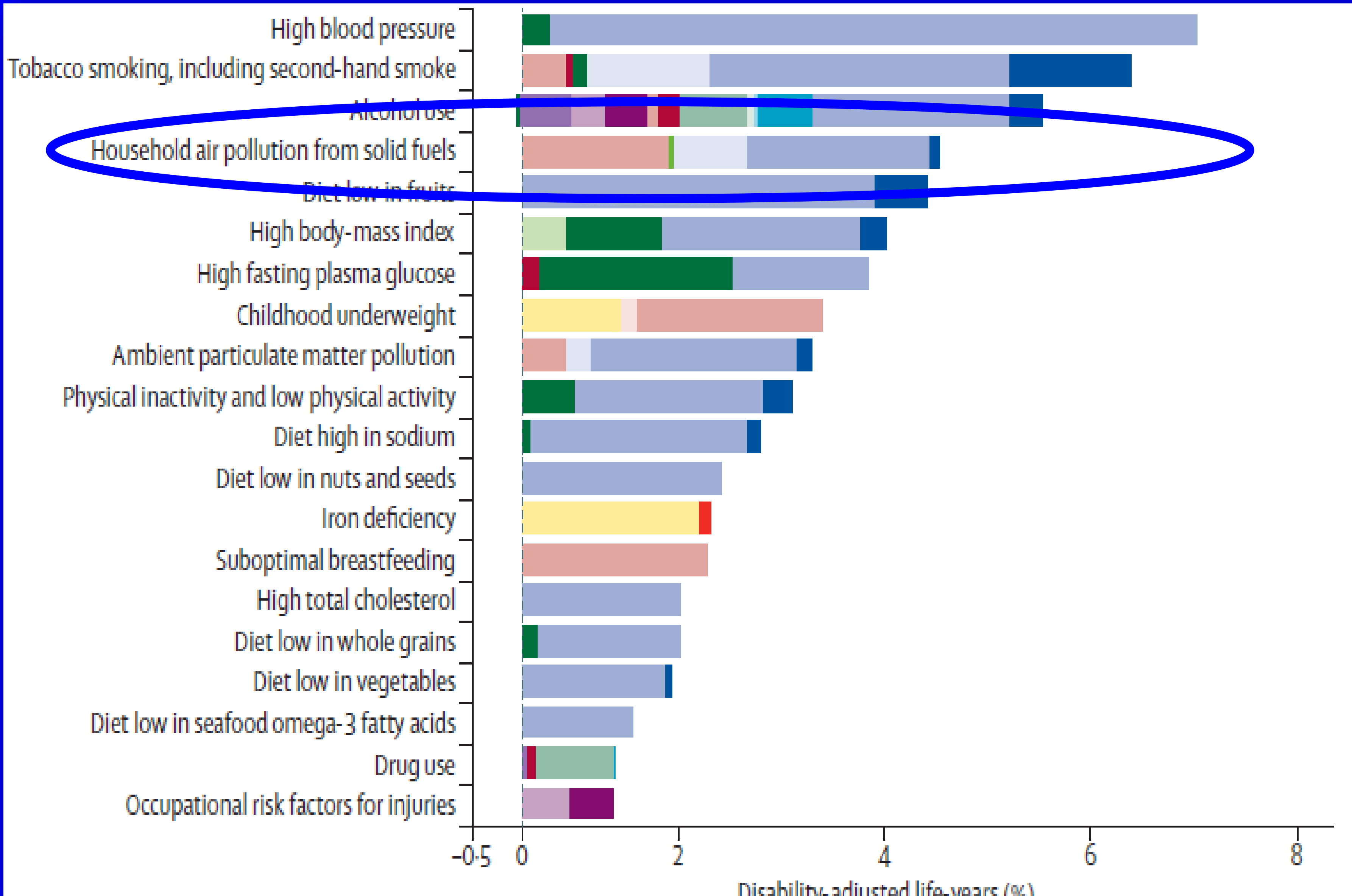
CRA, 2012


Stroke
ALRI
Lung Cancer
COPD
Ischemic Heart Disease
ug/m3 annual average PM2.5

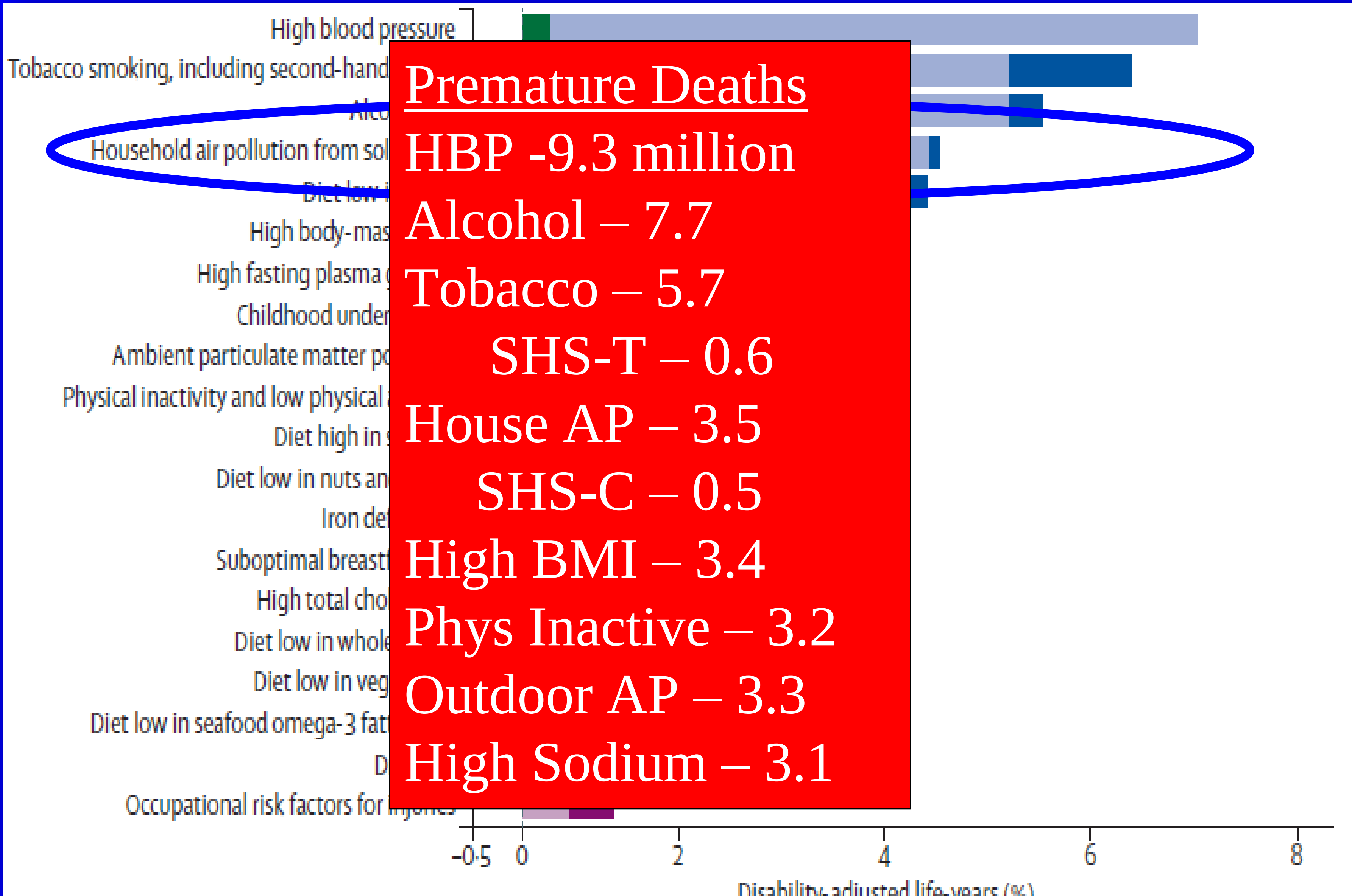
Metrics

- 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

Global DALYs 2010: Top 20 Risk Factors



Global DALYs 2010: Top 20 Risk Factors



<u>Premature Deaths</u>

HBP -9.3 million

Alcohol – 7.7

Tobacco – 5.7

SHS-T – 0.6

House AP – 3.5

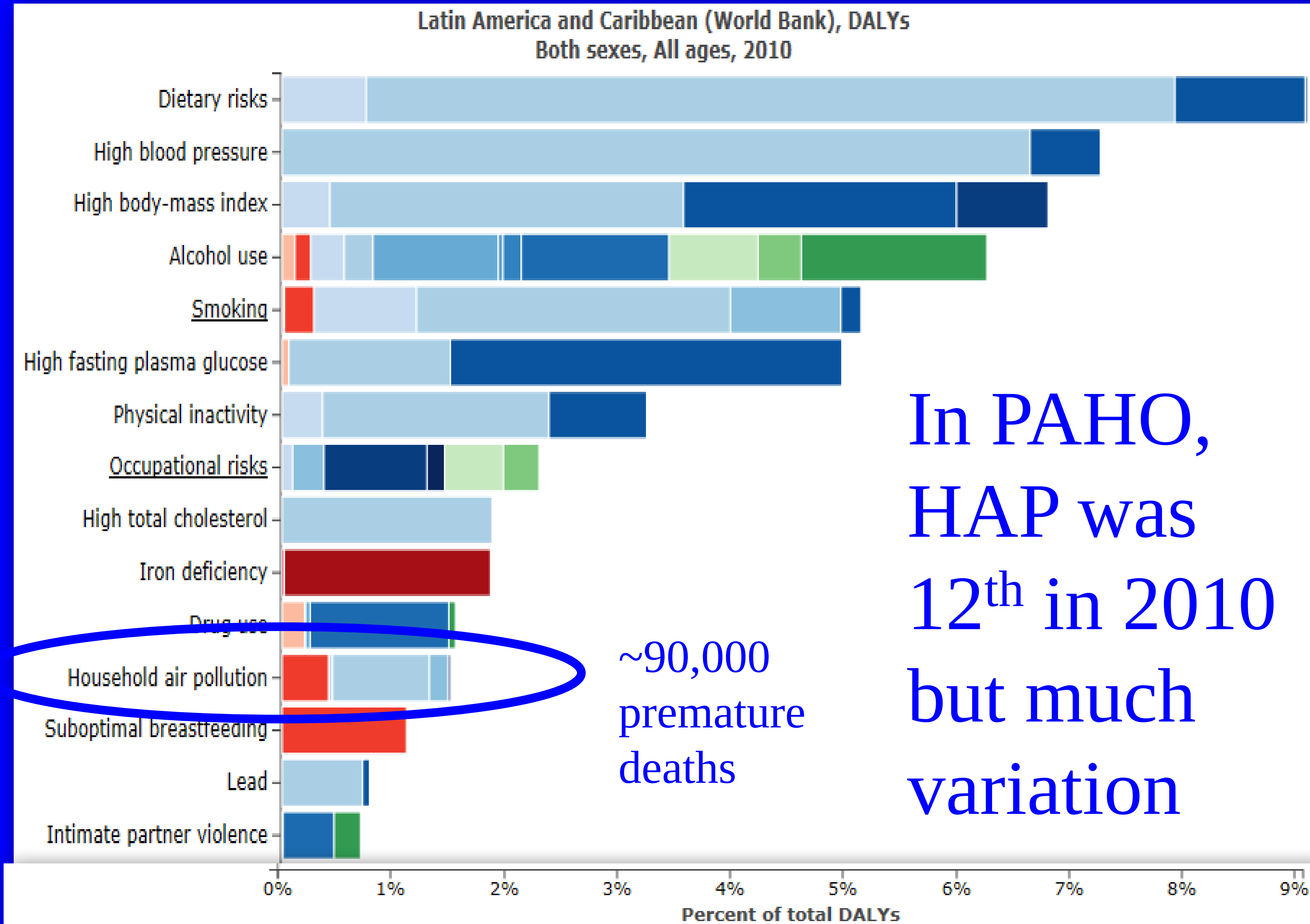
SHS-C – 0.5

High BMI – 3.4

Phys Inactive – 3.2

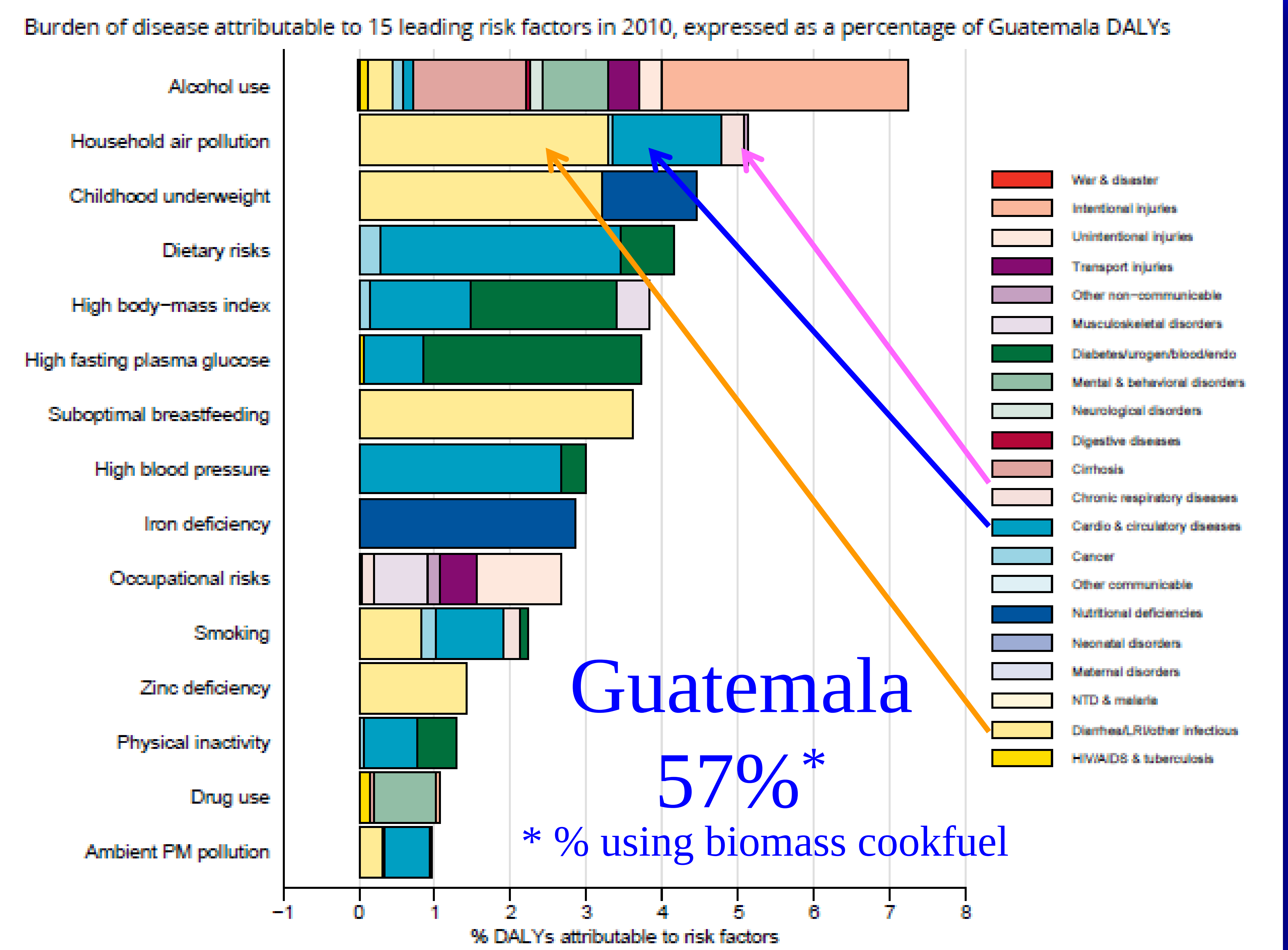
Outdoor AP – 3.3

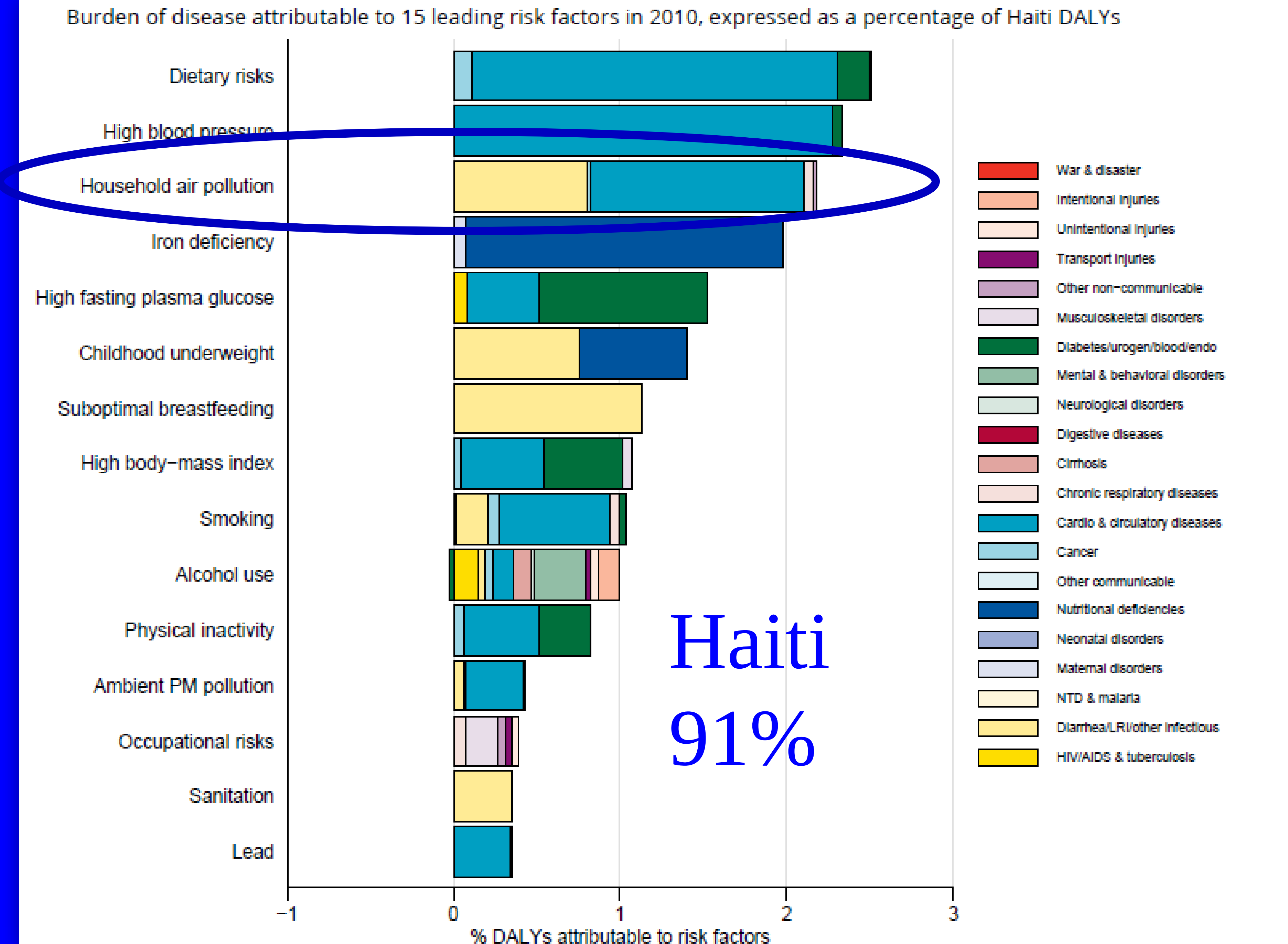
High Sodium – 3.1

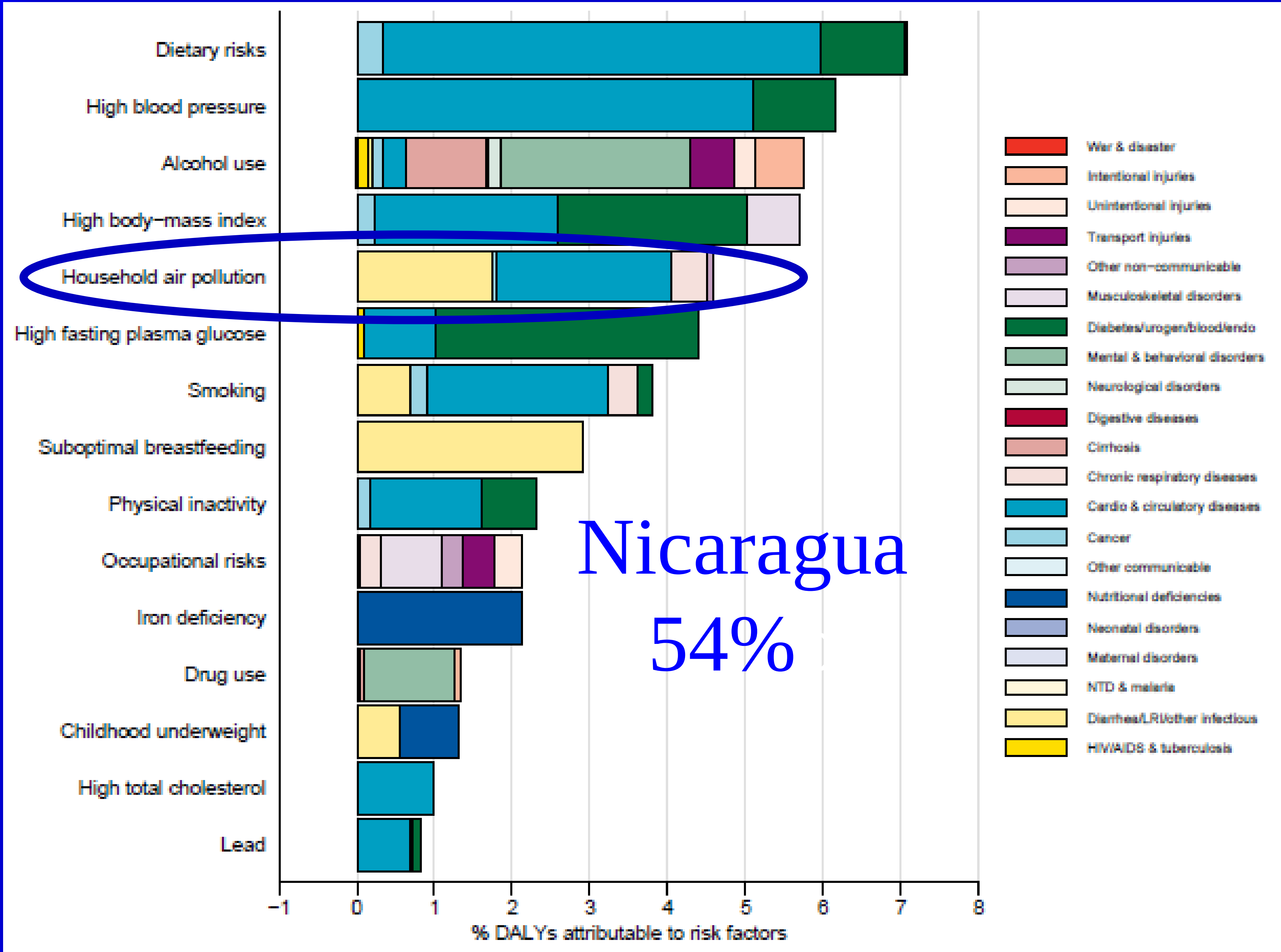


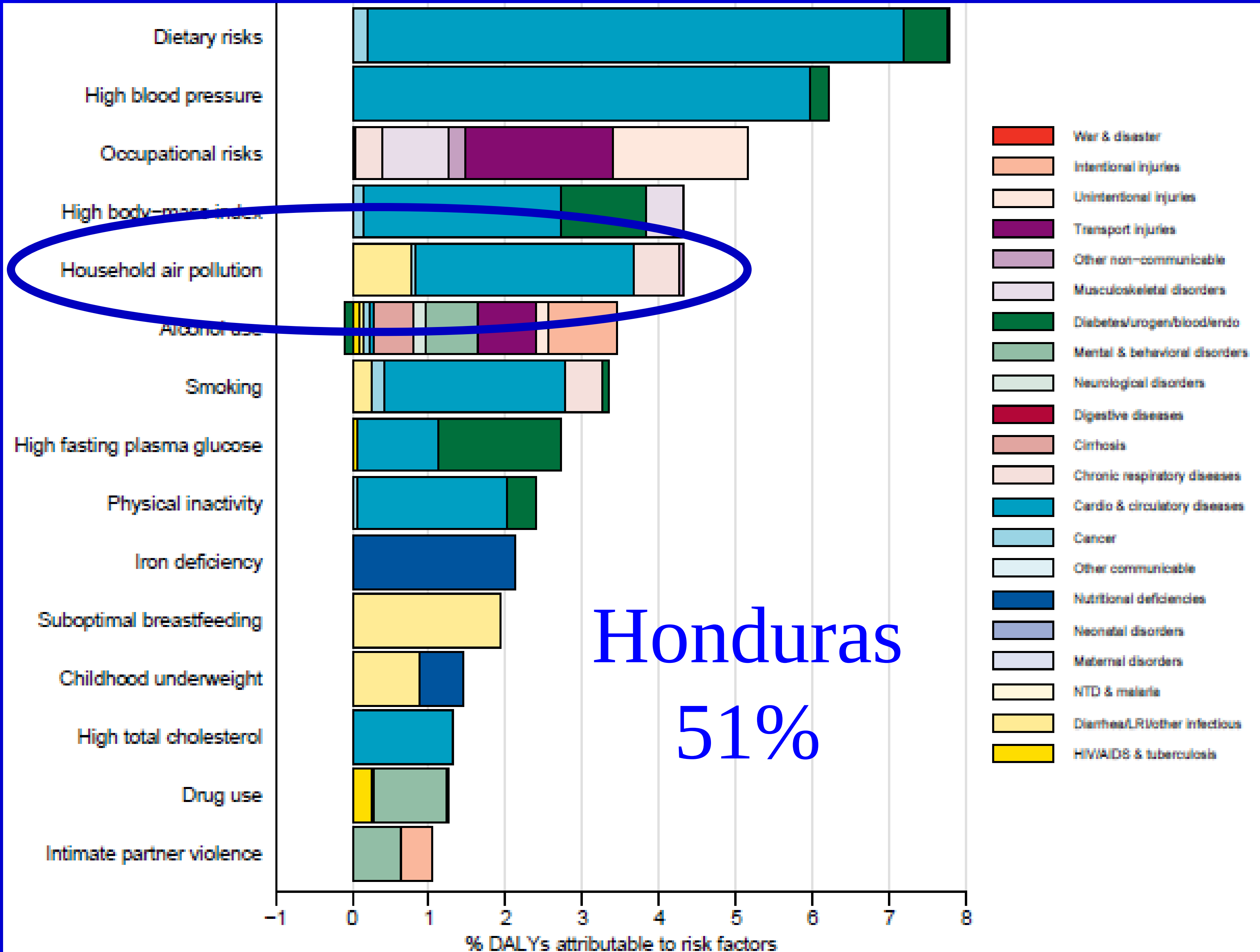
~90,000 premature deaths

In PAHO, HAP was 12th in 2010 but much variation


Burden of disease attributable to 15 leading risk factors in 2010, expressed as a percentage of Guatemala DALYs
Alcohol use
Household air pollution
Childhood underweight
Dietary risks
High body−mass index
High fasting plasma glucose
Suboptimal breastfeeding
High blood pressure
Iron deficiency
Occupational risks
Smoking
Zinc deficiency
Physical inactivity
Drug use
Ambient PM pollution
−1
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
Guatemala
57%*
* % using biomass cookfuel


Burden of disease attributable to 15 leading risk factors in 2010, expressed as a percentage of Haiti DALYs
Dietary risks
High blood pressure
Household air pollution
Iron deficiency
High fasting plasma glucose
Childhood underweight
Suboptimal breastfeeding
High body−mass index
Smoking
Alcohol use
Physical inactivity
Ambient PM pollution
Occupational risks
Sanitation
Lead
−1
0
1
2
3
% 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
Haiti
91%


Dietary risks
High blood pressure
Alcohol use
High body−mass index
Household air pollution
High fasting plasma glucose
Smoking
Suboptimal breastfeeding
Physical inactivity
Occupational risks
Iron deficiency
Drug use
Childhood underweight
High total cholesterol
Lead
−1
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
Nicaragua
54%



Dietary risks
High blood pressure
Occupational risks
High body-mass index
Household air pollution
Alcohol use
Smoking
High fasting plasma glucose
Physical inactivity
Iron deficiency
Suboptimal breastfeeding
Childhood underweight
High total cholesterol
Drug use
Intimate partner violence
−1
0
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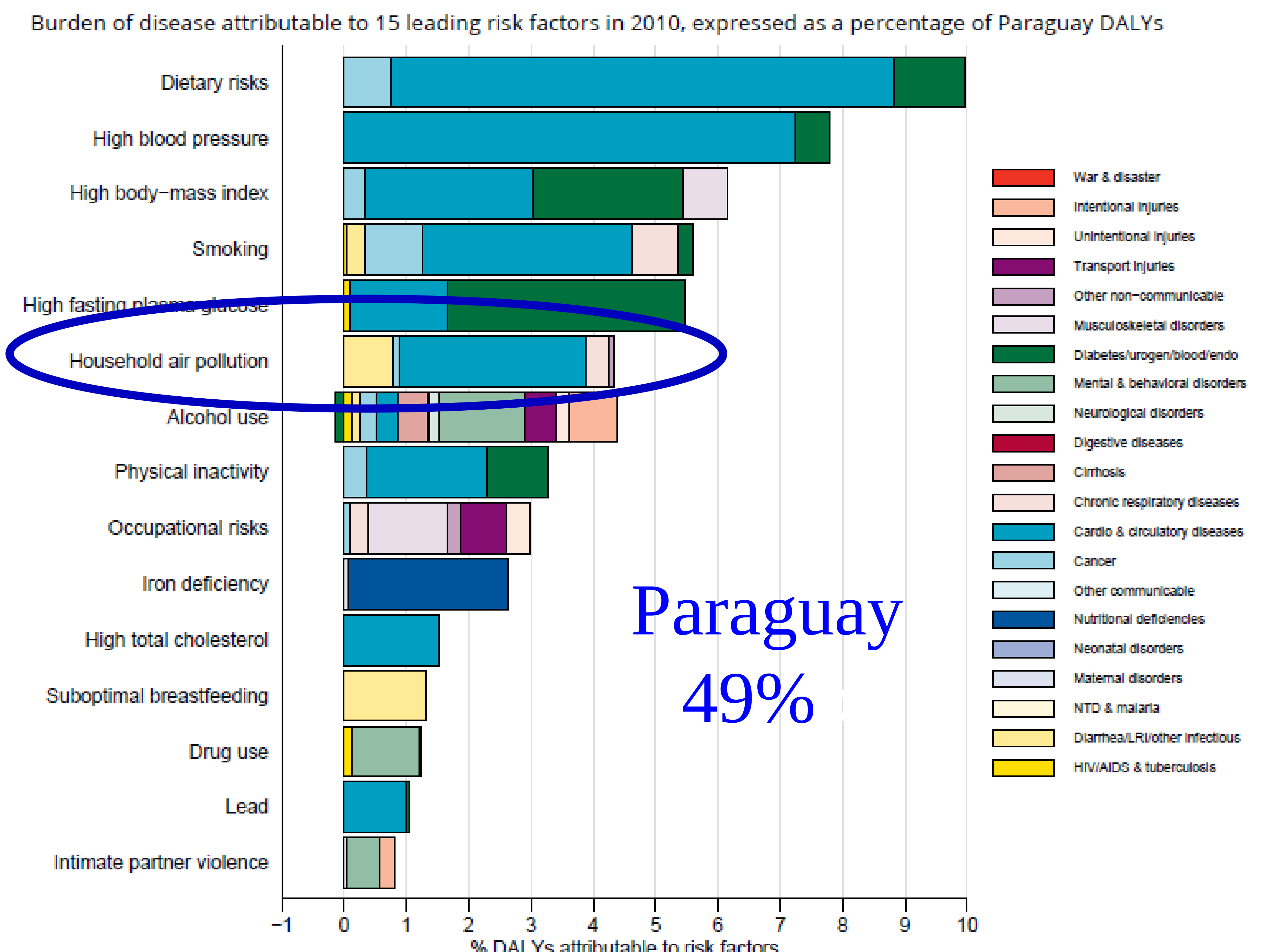
8
% DALYs attributable to risk factors
War & disaster
Intentional injuries
Unintentional injuries
Transport injuries
Other non-communicable
Musculoskeletal disorders
Diabetes/urogen/blood/endo
Mental & behavioral disorders
Neurological disorders
Digestive diseases
Cirrhosis
Chronic respiratory diseases
Cardio & circulatory diseases
Cancer
Other communicable
Nutritional deficiencies
Neonatal disorders
Maternal disorders
NTD & malaria
Diarrhea/LRI/other infectious
HIV/AIDS & tuberculosis
Honduras
51%


Burden of disease attributable to 15 leading risk factors in 2010, expressed as a percentage of Paraguay DALYs
Dietary risks
High blood pressure
High body−mass index
Smoking
High fasting plasma glucose
Household air pollution
Alcohol use
Physical inactivity
Occupational risks
Iron deficiency
High total cholesterol
Suboptimal breastfeeding
Drug use
Lead
Intimate partner violence
−1
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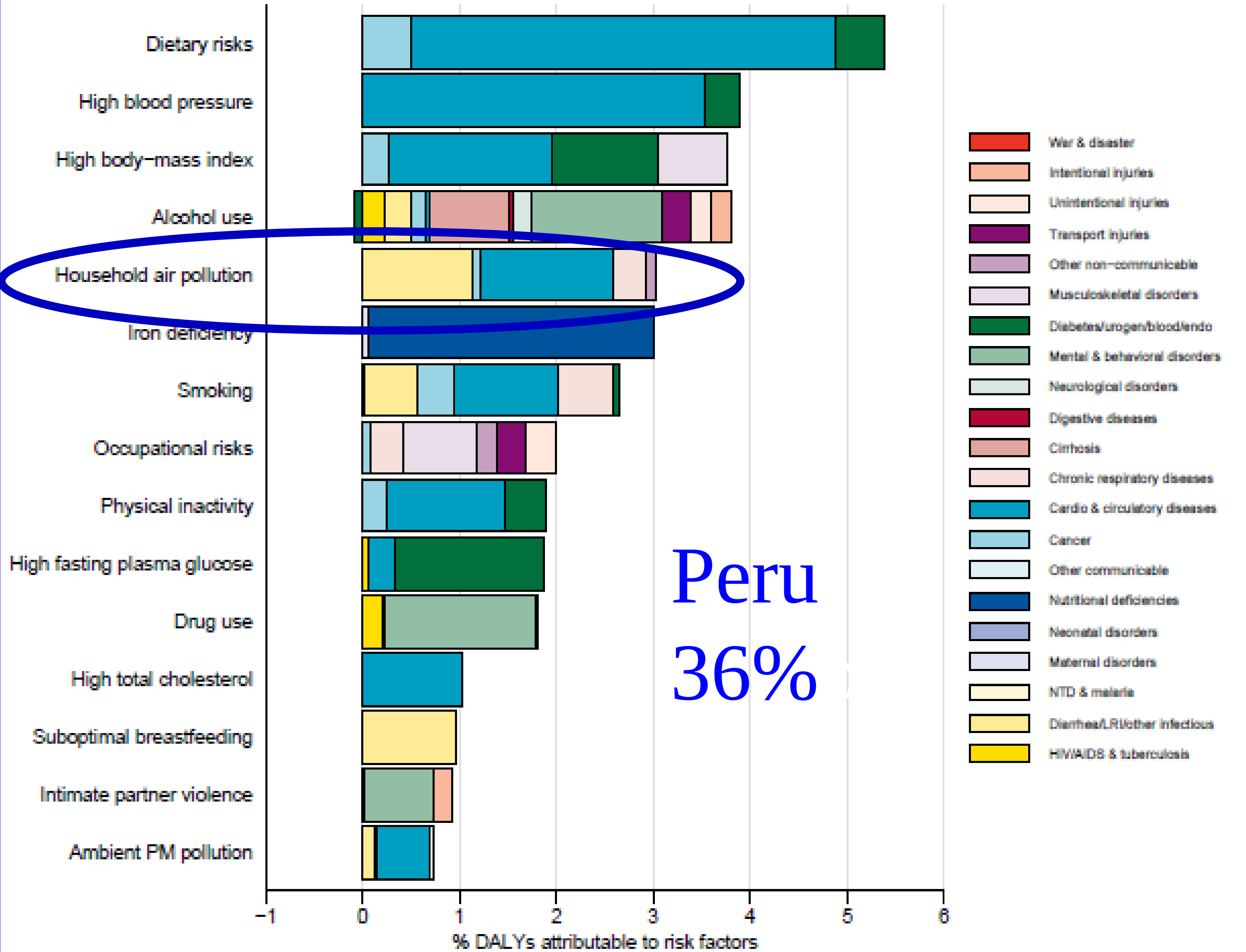
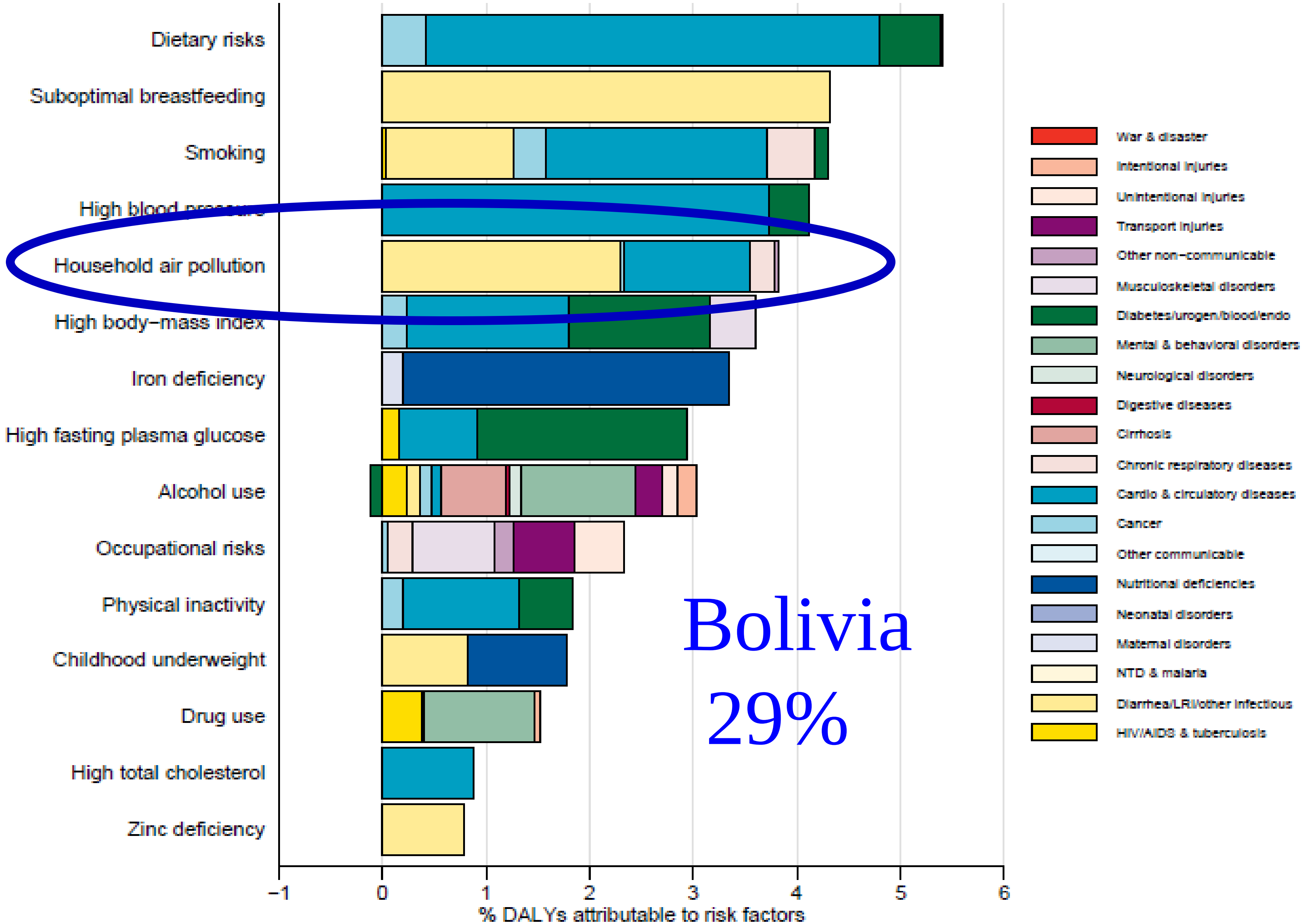
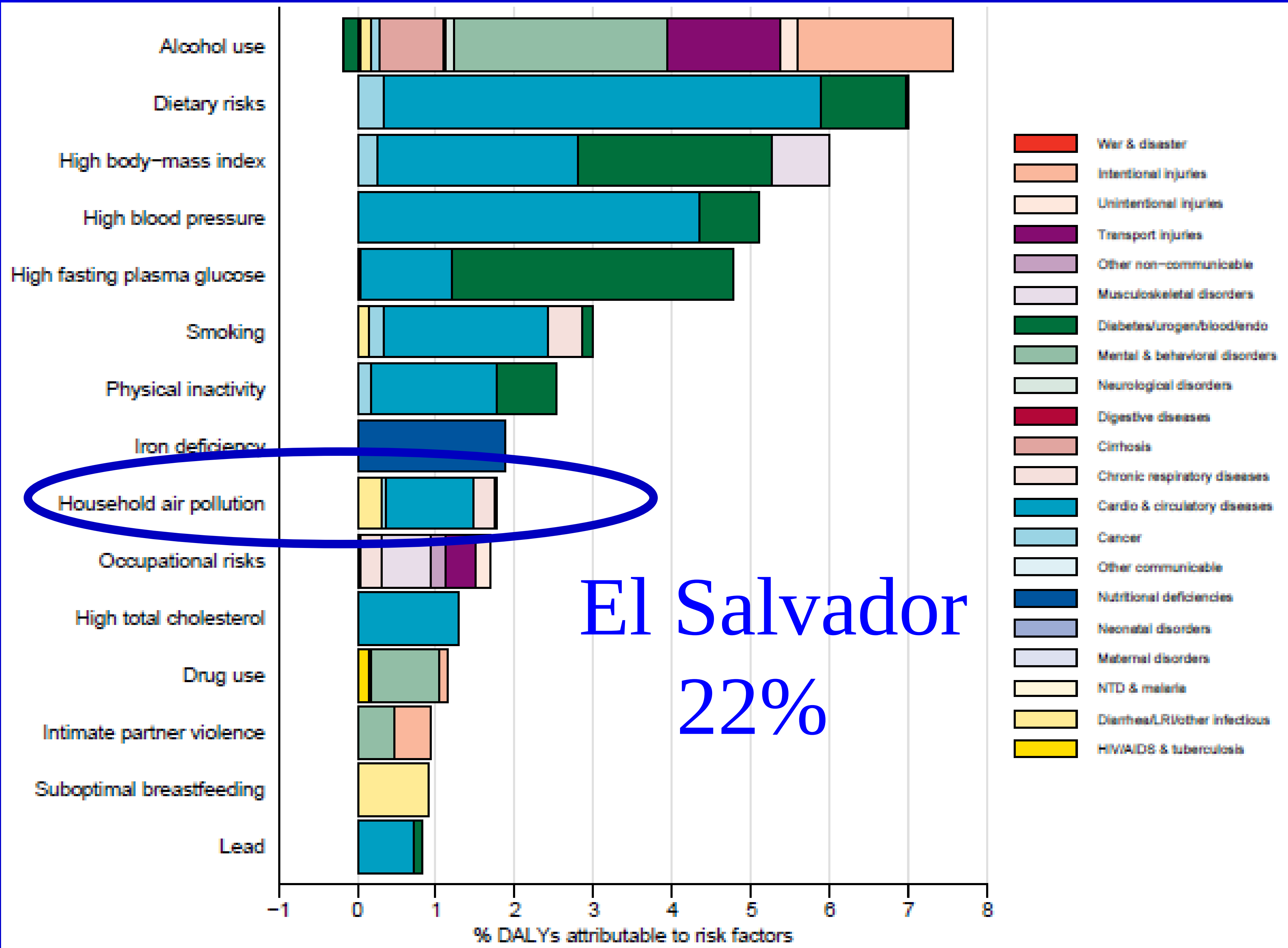
7
8
9
10
% DALYs attributable to risk factors
War & disaster
Intentional injuries
Unintentional injuries
Transport injuries
Other non−communicable
Musculoskeletal disorders
Diabetes/urogen/blood/endo
Mental & behavioral disorders
Neurological disorders
Digestive diseases
Cirrhosis
Chronic respiratory diseases
Cardio & circulatory diseases
Cancer
Other communicable
Nutritional deficiencies
Neonatal disorders
Maternal disorders
NTD & malaria
Diarrhea/LRI/other infectious
HIV/AIDS & tuberculosis
Paraguay
49%


Dietary risks
High blood pressure
High body−mass index
Alcohol use
Household air pollution
Iron deficiency
Smoking
Occupational risks
Physical inactivity
High fasting plasma glucose
Drug use
High total cholesterol
Suboptimal breastfeeding
Intimate partner violence
Ambient PM pollution
−1
0
1
2
3
4
5
6
% DALYs attributable to risk factors
Peru
36%
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

Burden of disease attributable to 15 leading risk factors in 2010, expressed as a percentage of Bolivia DALYs




Alcohol use
Dietary risks
High body−mass index
High blood pressure
High fasting plasma glucose
Smoking
Physical inactivity
Iron deficiency
Household air pollution
Occupational risks
High total cholesterol
Drug use
Intimate partner violence
Suboptimal breastfeeding
Lead
−1
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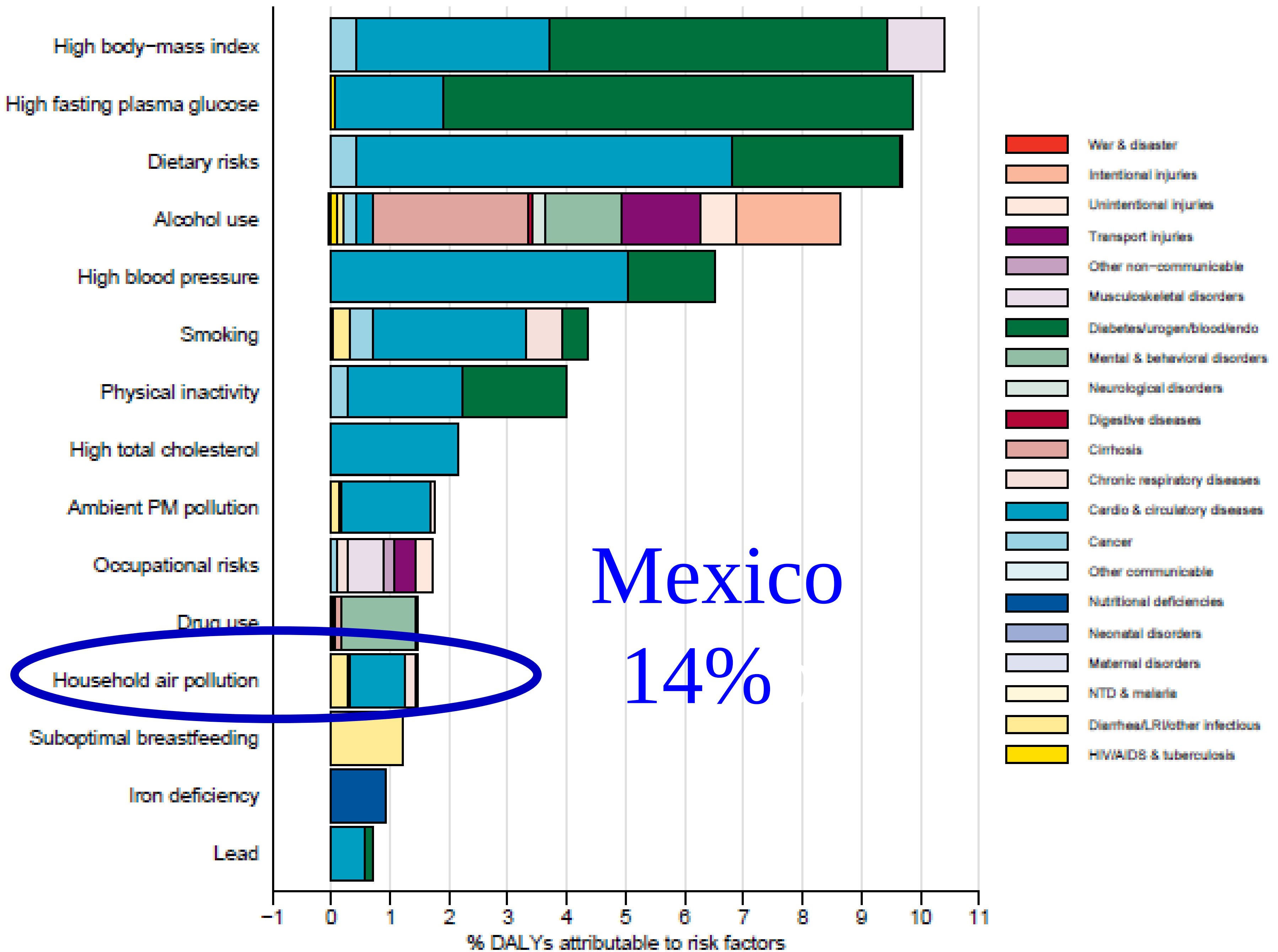
Digestive diseases
Cirrhosis
Chronic respiratory diseases
Cardio & circulatory diseases
Cancer
Other communicable
Nutritional deficiencies
Neonatal disorders
Maternal disorders
NTD & malaria
Diarrhea/LRI/other infectious
HIV/AIDS & tuberculosis
El Salvador
22%



High body−mass index
High fasting plasma glucose
Dietary risks
Alcohol use
High blood pressure
Smoking
Physical inactivity
High total cholesterol
Ambient PM pollution
Occupational risks
Drug use
Household air pollution
Suboptimal breastfeeding
Iron deficiency
Lead
−1
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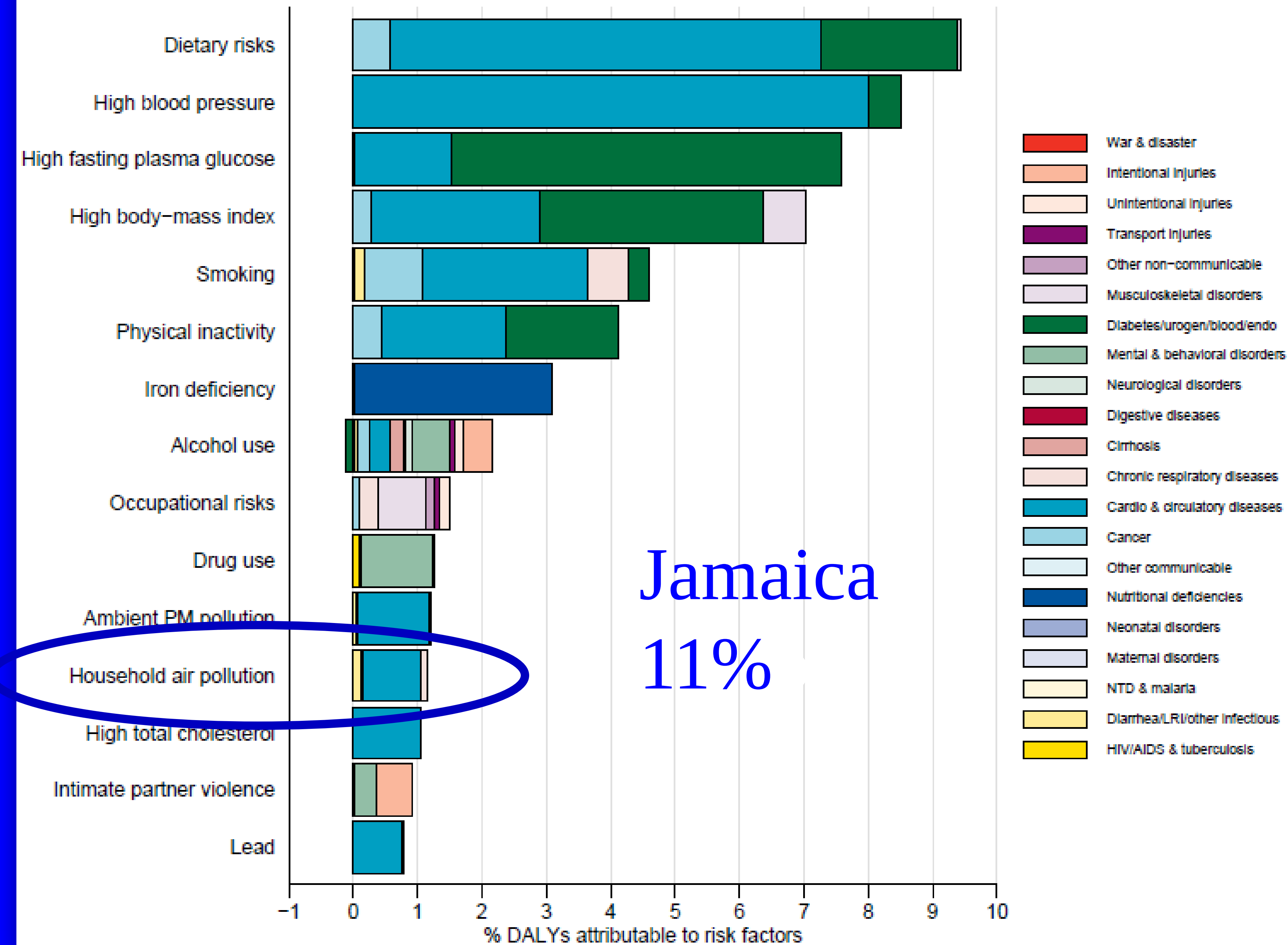
10
11
% DALYs attributable to risk factors
War & disaster
Intentional injuries
Unintentional injuries
Transport injuries
Other non−communicable
Musculoskeletal disorders
Diabetes/urogen/blood/endo
Mental & behavioral disorders
Neurological disorders
Digestive diseases
Cirrhosis
Chronic respiratory diseases
Cardio & circulatory diseases
Cancer
Other communicable
Nutritional deficiencies
Neonatal disorders
Maternal disorders
NTD & malaria
Diarrhea/LRI/other infectious
HIV/AIDS & tuberculosis
Mexico
14%

Burden of disease attributable to 15 leading risk factors in 2010, expressed as a percentage of Jamaica DALYs



Summary of CRA

- 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

Not all diseases included

- Many with some evidence not included yet
  - Low birth weight and prematurity
  - 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

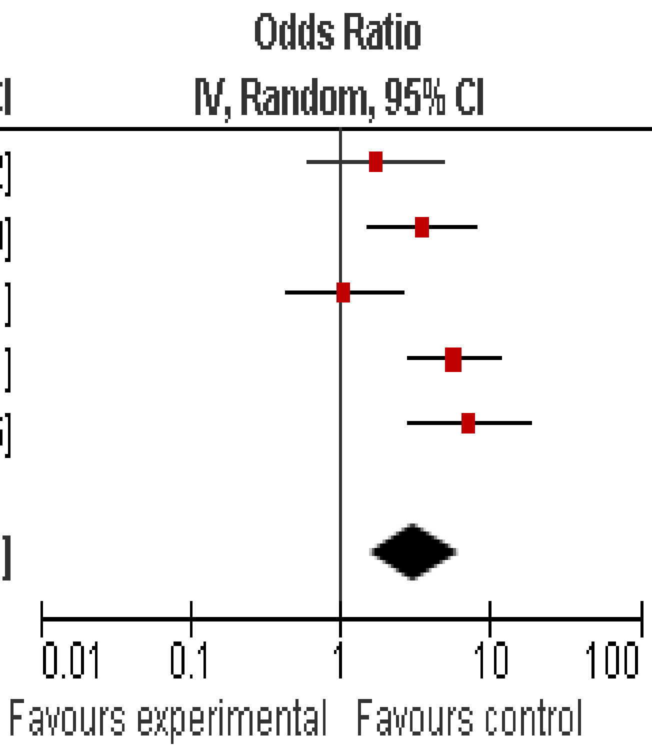
Evidence from Latin America

- Oldest and most productive HAP research site in the world – RESPIRE in Guatemala
  - Pneumonia in children
  - Low birth weight
  - Impaired cognitive ability
  - Chronic lung disease in women
  - 50+ scientific publications
- Several studies of cervical cancer in Honduras and Columbia

Cervical Cancer and Household Air Pollution

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Ferrera 2000(a)	0.54232429	0.53624989	17.6%	1.72 [0.60, 4.92]
Ferrera 2000(b)	1.24990174	0.41614175	20.9%	3.49 [1.54, 7.89]
Velema 2002(a)	0.06765865	0.45514155	19.8%	1.07 [0.44, 2.61]
Velema 2002(b)	1.75093748	0.36626585	22.4%	5.76 [2.81, 11.81]
Sierra Torres 2006	1.98787435	0.47618897	19.2%	7.30 [2.87, 18.56]
Total (95% CI)			**100.0%**	**3.14 [1.57, 6.30]**

Heterogeneity: Tau² = 0.43; Chi² = 12.71, df = 4 (P = 0.01); I² = 69%
Test for overall effect: Z = 3.23 (P = 0.001)



Three papers; two done in Honduras with four groups, one in Columbia

First randomized controlled trial in air pollution history

THELANCET-D-09-06268R3

S0140-6736(11)60921-5

Embargo: [add date when known]

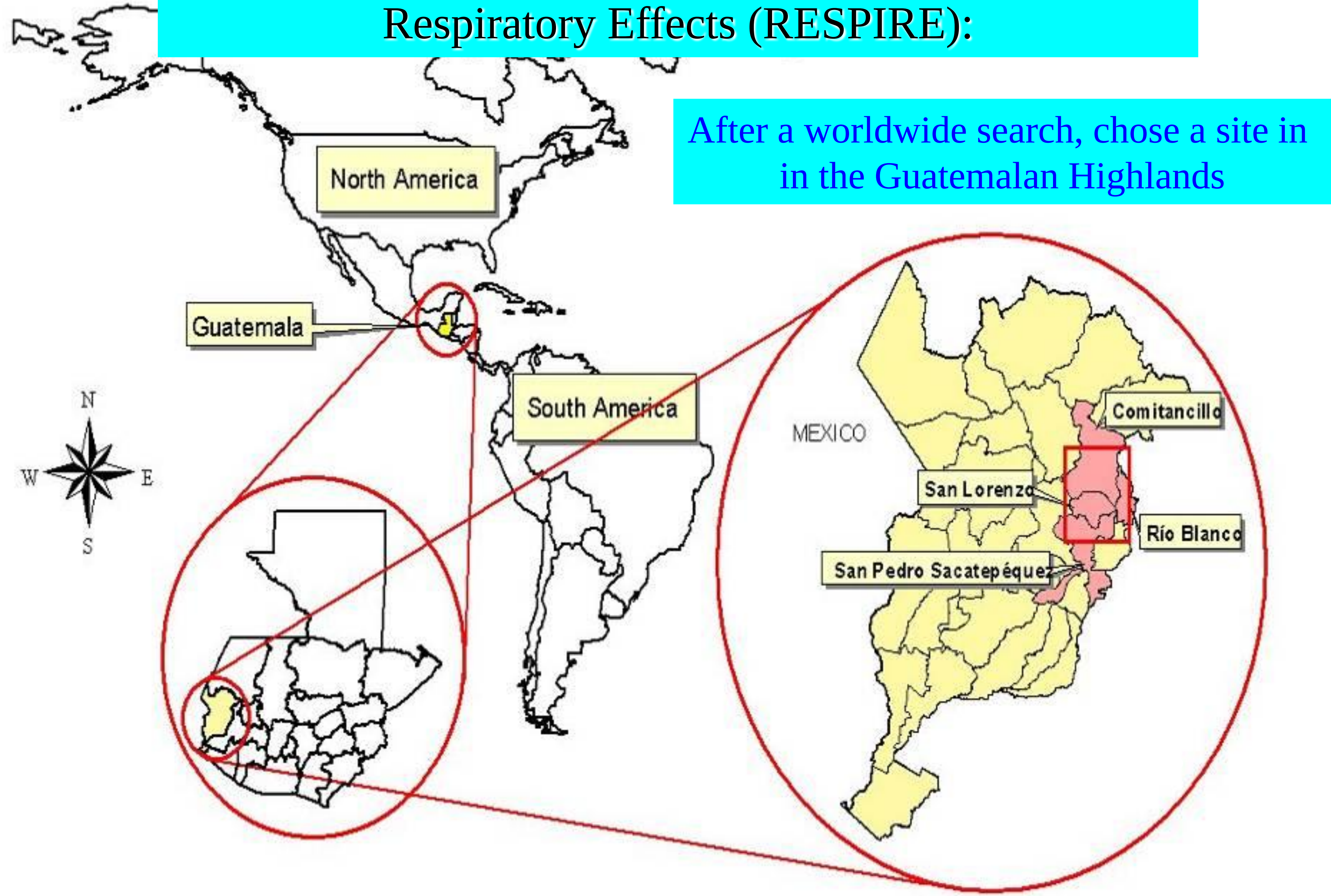
Effect of reduction in household air pollution on childhood pneumonia in Guatemala (RESPIRE): a randomised controlled trial

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

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

After a worldwide search, chose a site in in the Guatemalan Highlands



RESPIRE
Impact on pneumonia up to 18 months of age

Traditional open 3-stone fire:

Chimney woodstove, locally made and popular with households

The Plancha

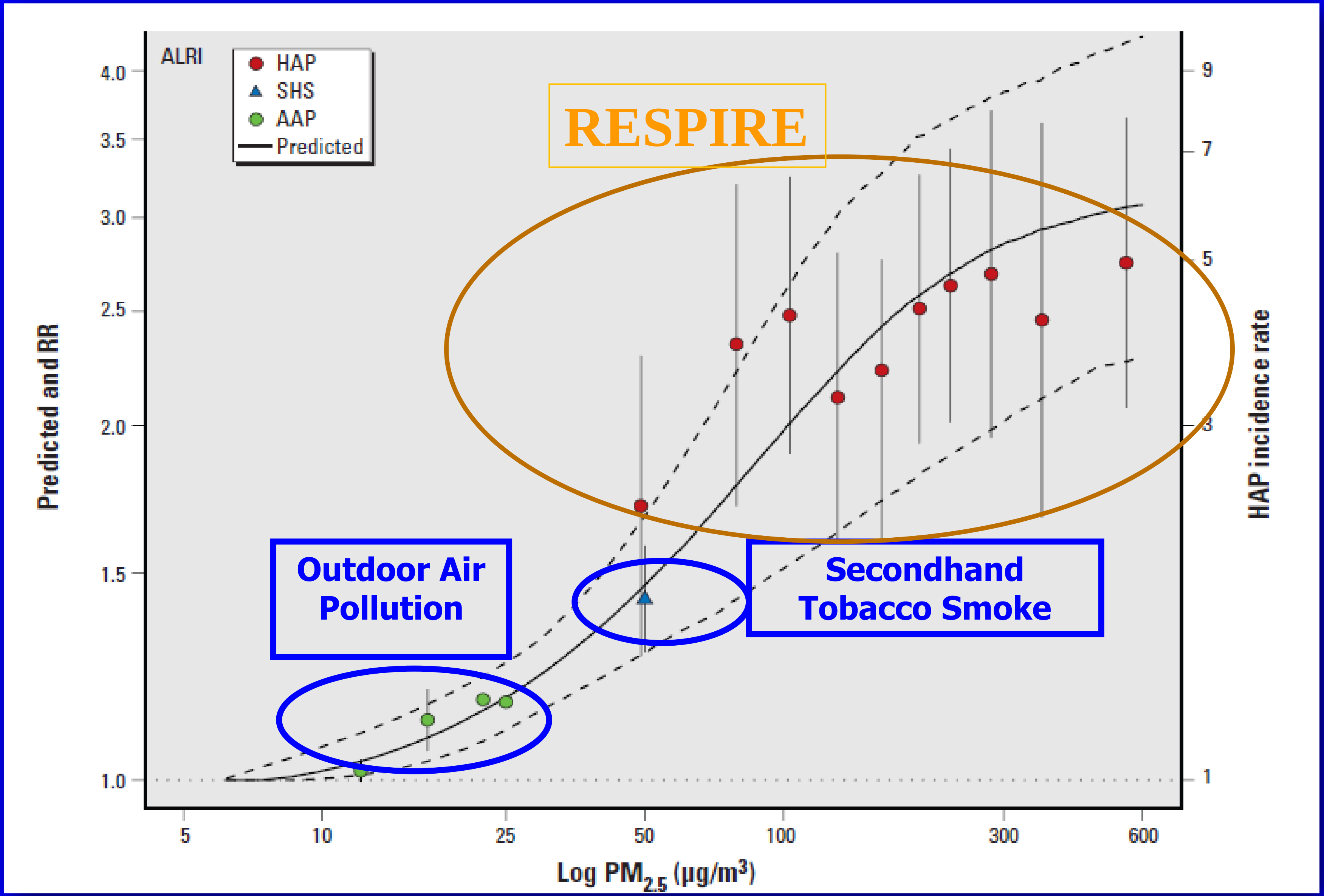
Physician-assessed outcomes (ITT)

(blind to intervention status)

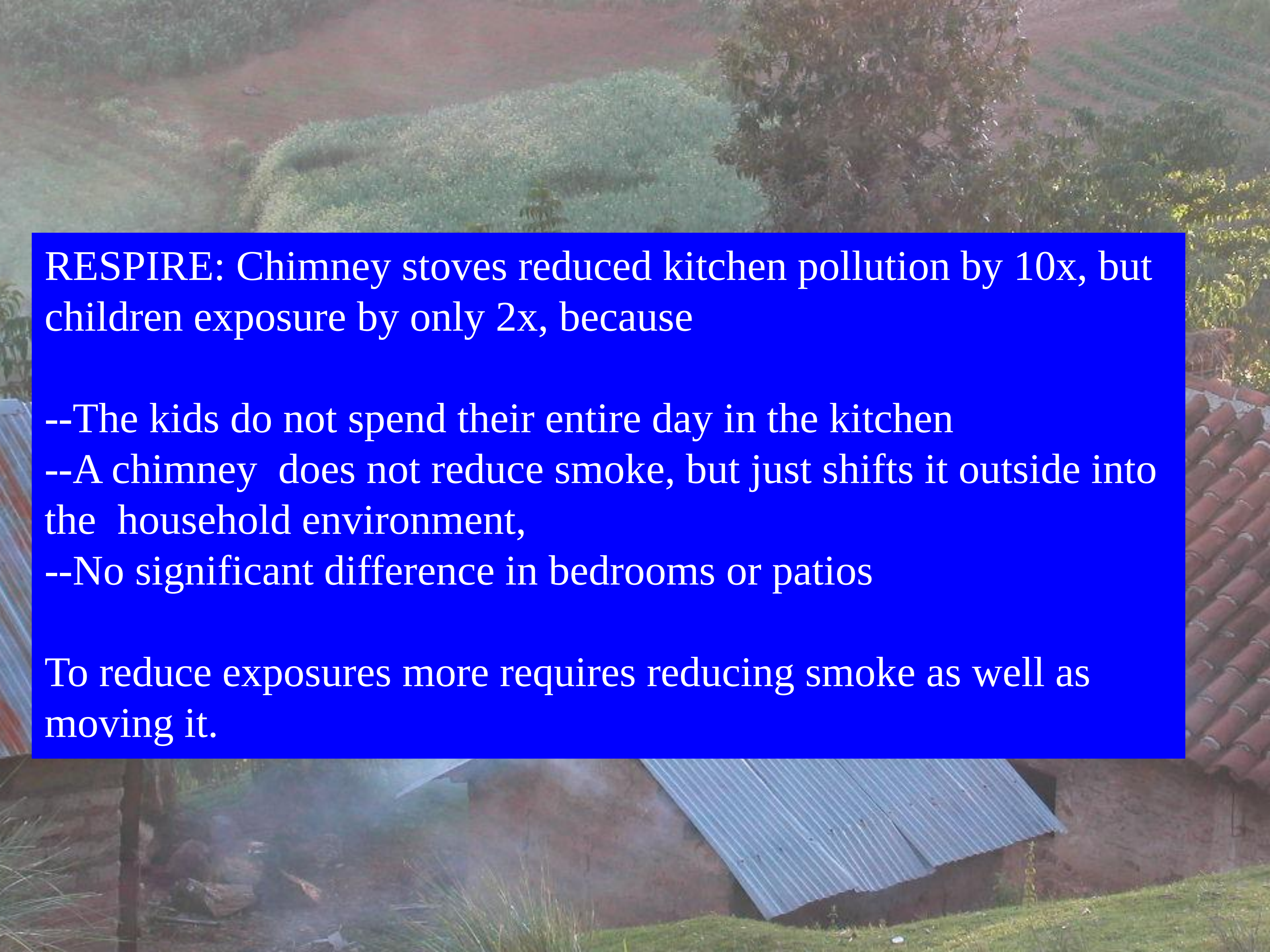
Case finding	Outcome	adj RR (95% CI)	P-value
Physician diagnosed pneumonia	**All**	0.78 (0.59, 1.06)	0.095
	Severe (low oxygen)	**0.67 (0.45, 0.98)**	**0.042**
Investigations: - Pulse oximetry - RSV direct antigen test	**RS Virus**	0.76 (0.42, 1.16)	0.275
	Severe	0.87 (0.46, 1.51)	0.633
	No RSV*	0.79 (0.53, 1.07)	0.192
	Severe	**0.54 (0.31, 0.91)**	**0.026**

*Likely bacterial pneumonia


CO monitor
CO monitor



Burnett et al., EHP. 2014, Integrated Exposure-Response Functions



RESPIRE: Chimney stoves reduced kitchen pollution by 10x, but children exposure by only 2x, because

--The kids do not spend their entire day in the kitchen
--A chimney does not reduce smoke, but just shifts it outside into the household environment,
--No significant difference in bedrooms or patios

To reduce exposures more requires reducing smoke as well as moving it.

Important!

- Implied health benefit from HAP reduction only potentially achieved by shifting to clean cooking – gas & electricity
- Not achievable with a chimney alone
- Must be very clean combustion
- Can we do this with biomass fuels?
- The big question!

Many thanks

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