Smoke, health, and climate: the unfinished global agenda of poor combustion

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Tyler Laureate 2012
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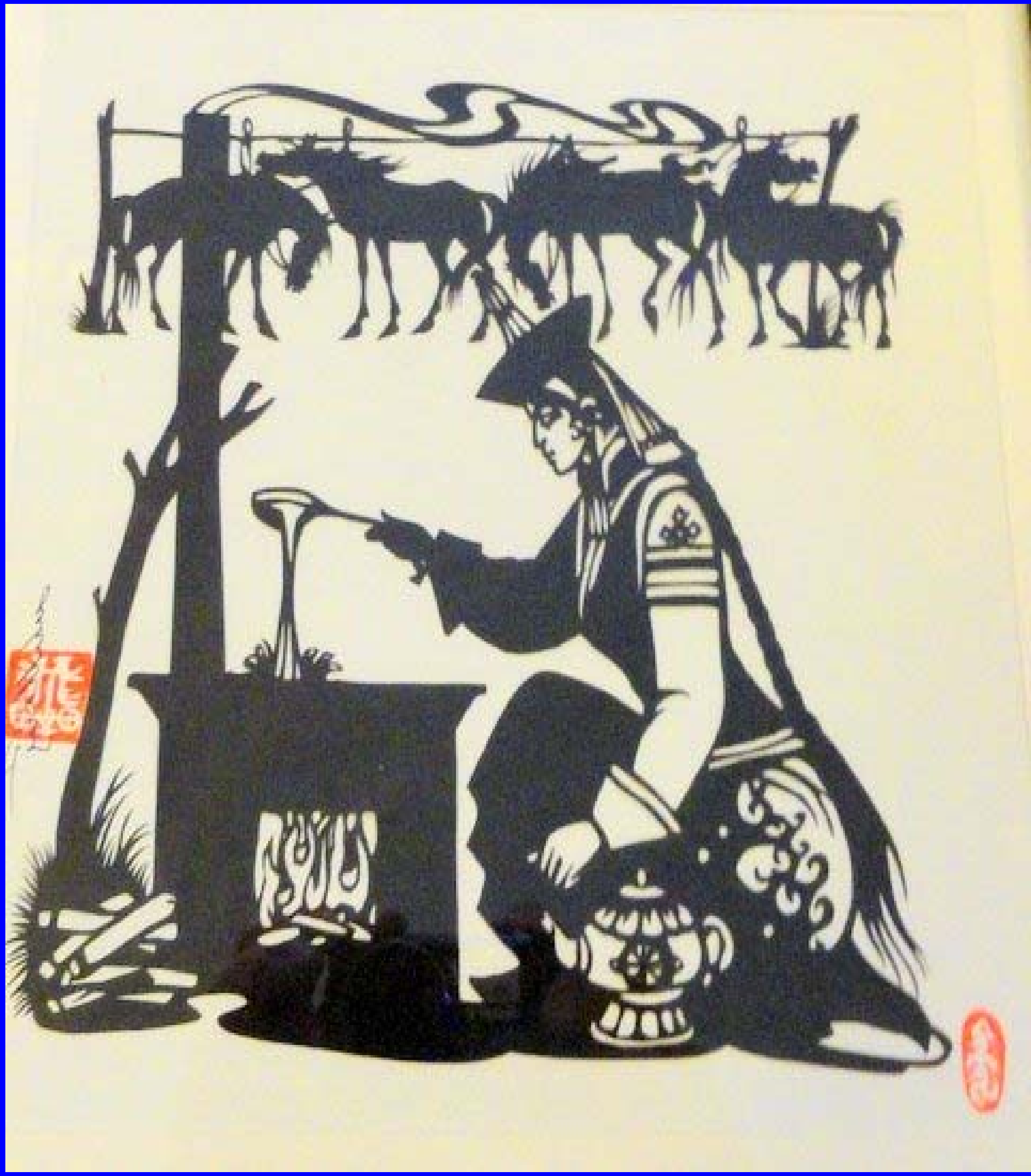
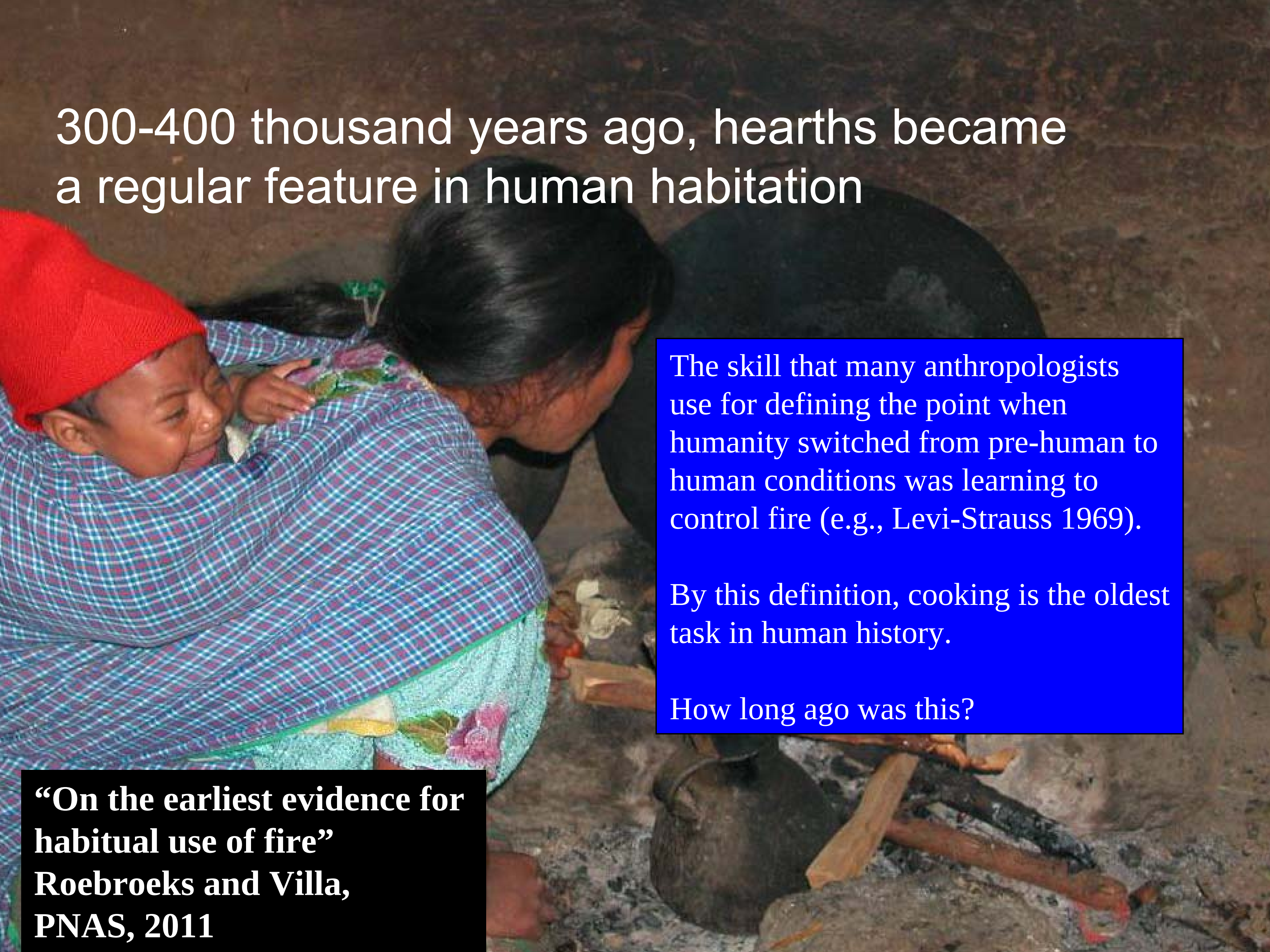




300-400 thousand years ago, hearths became a regular feature in human habitation

The skill that many anthropologists use for defining the point when humanity switched from pre-human to human conditions was learning to control fire (e.g., Levi-Strauss 1969).

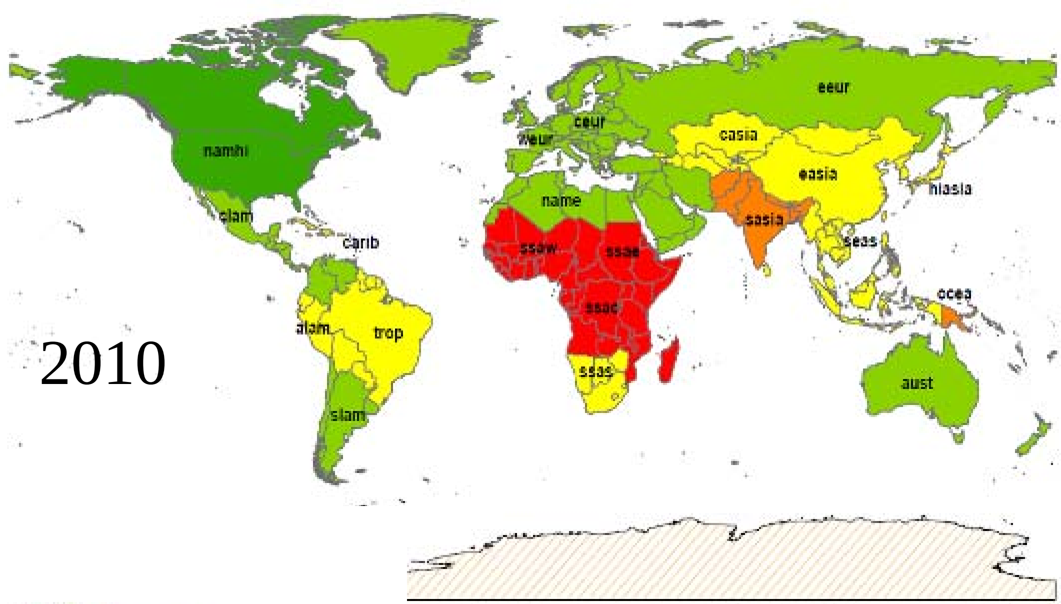
By this definition, cooking is the oldest task in human history.

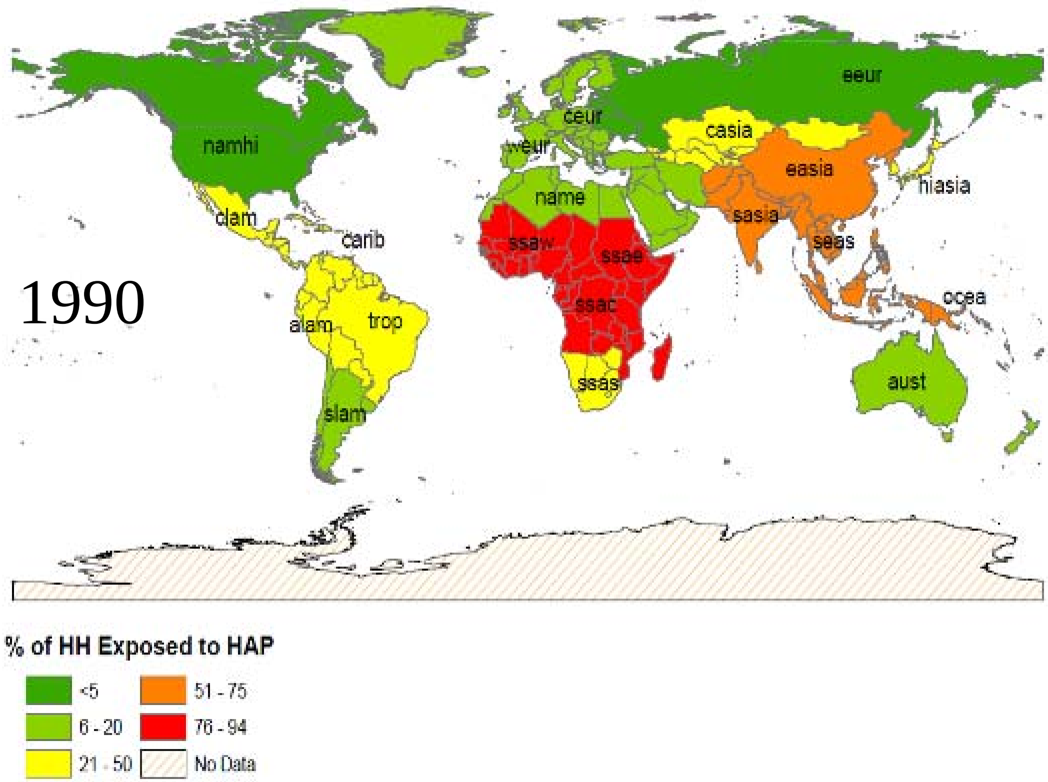
How long ago was this?

“On the earliest evidence for habitual use of fire”
Roebroeks and Villa, PNAS, 2011


The three major solid fuels

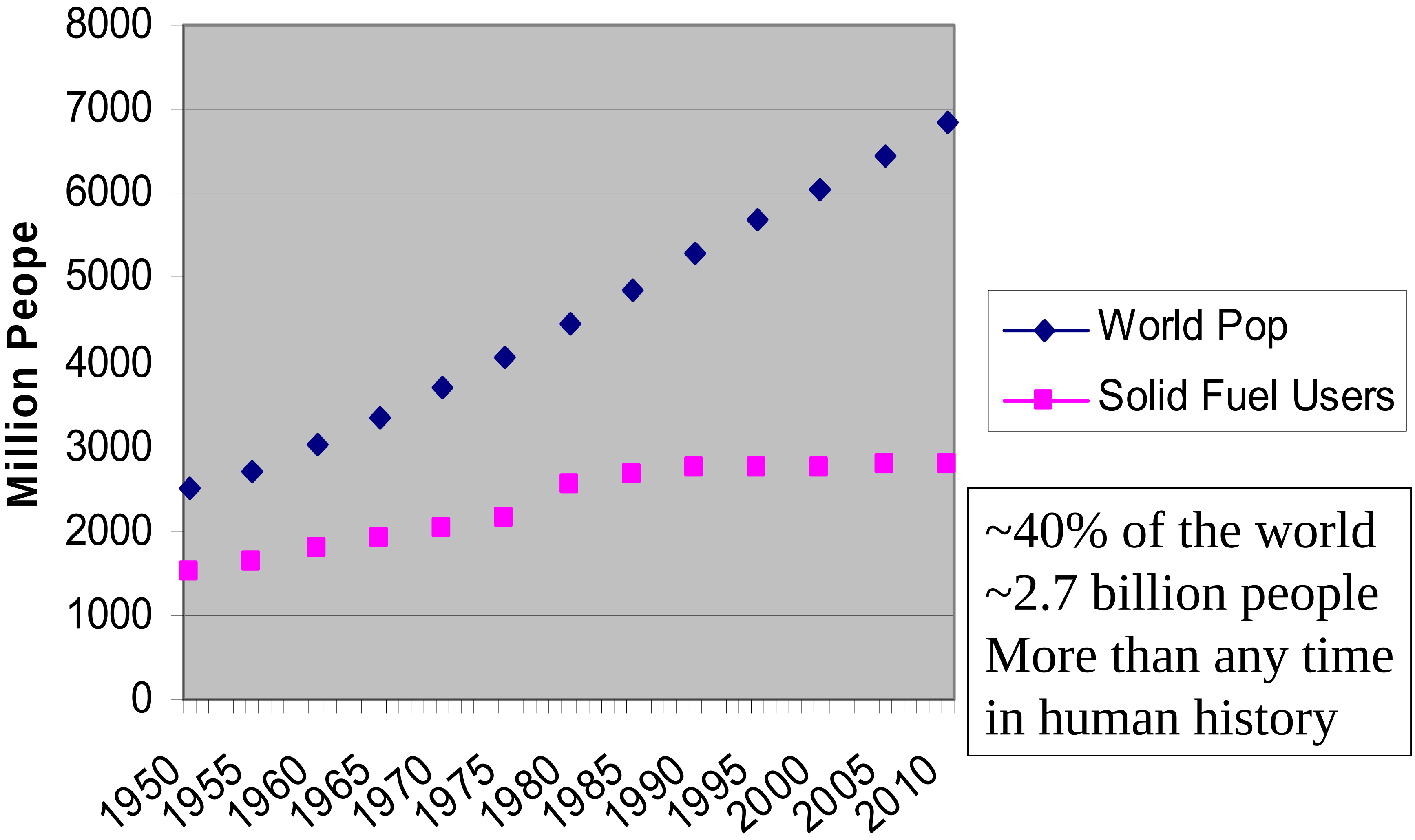
Households using biomass or coal to cook





Comparative Risk Assessment (CRA) 2011- preliminary, Adair, et al.

World Population Using Solid Fuels

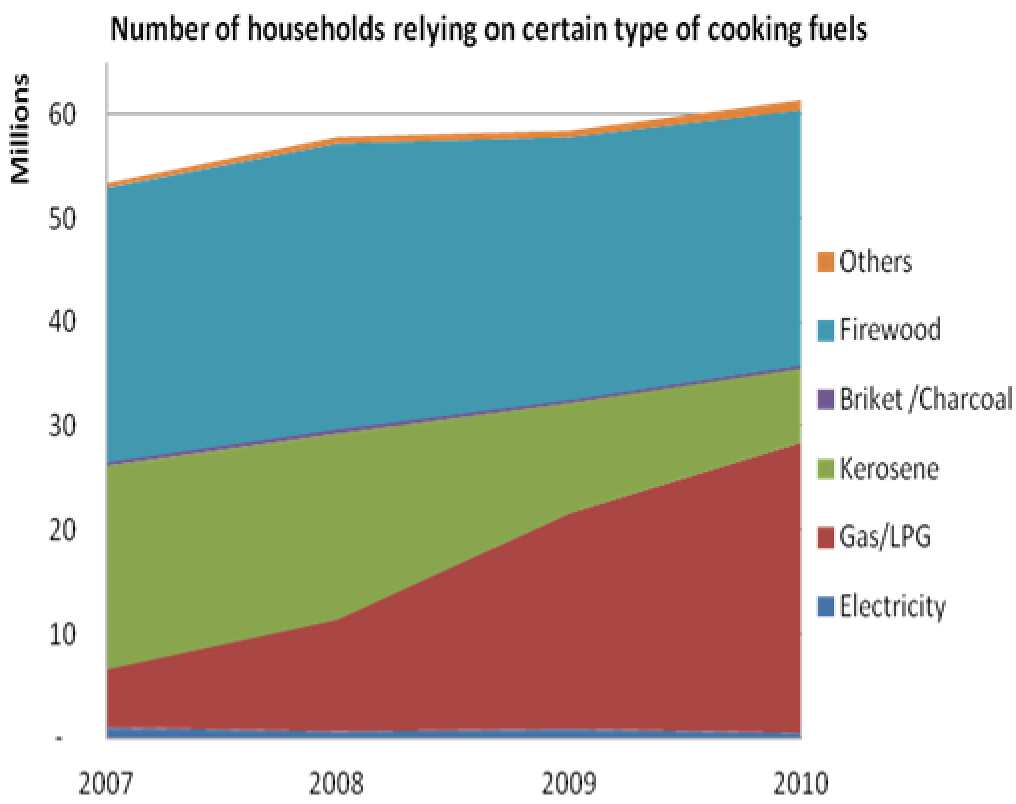


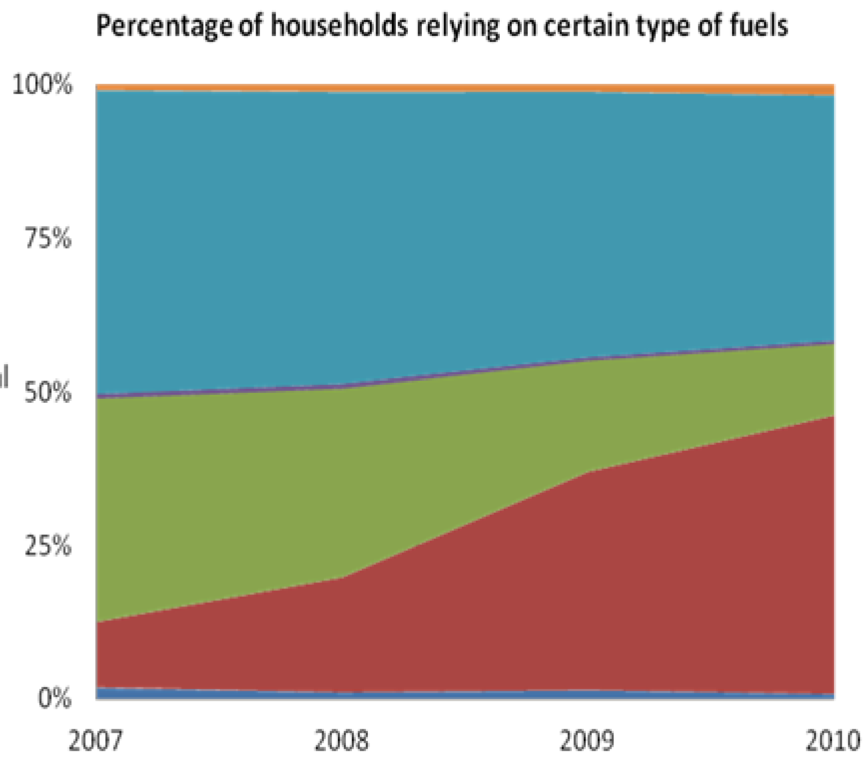
~40% of the world
~2.7 billion people
More than any time
in human history

Indonesia Cooking Fuel Situation 2007-2010

YDD, 2012

- Number of wood users remains large and not much affected by the LPG conversion program and will still become the the dominant cooking fuel in the future;
  - 49.4% to 40.1% (26.3 million to 24.5 million)
- LPG users rapidly increase after 2007, in replacement of the kerosene users
  - 10.6% to 45.6% (5.6 million to 27.6 million)
- Kerosene users decrease significantly, accounting for only 11.7% of all households in 2010. : 36.6% to 11.7% (19.5 million to 7.1 million)





Source: National Socio-Economic Survey, BPS 2008-2011

Wood Users in 2010: 40% nationally

Number of households relying on wood for cooking in 2010

Source: BPS 2011

Percentage of households relying on wood for cooking in 2010

Source: BPS 2011

- **Wood still dominates more than half of all provinces in Indonesia and these provinces are mainly distributed in the Islands of Papua, Sulawesi, and Nusa Tenggara.**
- **Wood continues to be the mostly used cooking fuel in 18 provinces out of 33. These provinces scatter all over the country, stretching from the west to the east.**
- **East Java, Central Java, and West Java remain the provinces with the largest number of wood-dependent households.**
- **Rate is increasing in Papua**

YDD, 2012

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%

Energy flows in a well-operating traditional wood-fired cookstove

A Toxic Waste Factory!!

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

Into Pot	In PIC	Waste Heat
2.8 MJ	1.2 MJ	11.3 MJ
18%	8%	74%

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

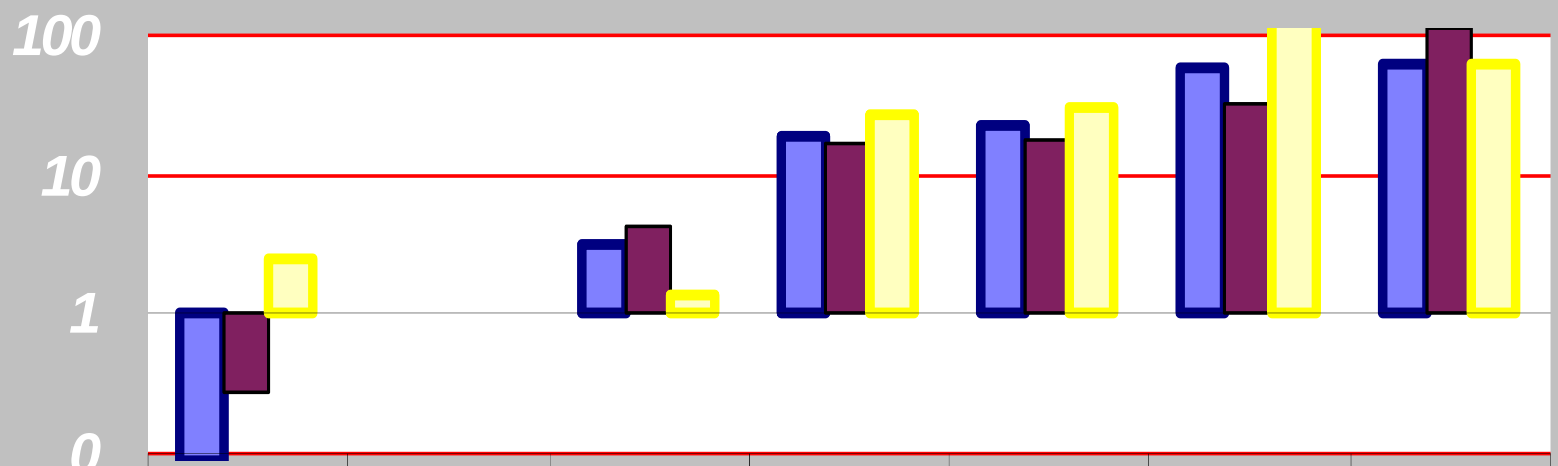
Source: Smith, et al., 2000

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

- Small particles, CO, NO_2
- Hydrocarbons
  - 25+ saturated hydrocarbons such as *n-hexane*
  - 40+ unsaturated hydrocarbons such as *1,3 butadiene*
  - 28+ mono-aromatics such as *benzene & styrene*
  - 20+ polycyclic aromatics such as *benzo(α)pyrene*
- Oxygenated organics
  - 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 Pollutants per Unit Energy Delivered
Ratio of Emissions to LPG



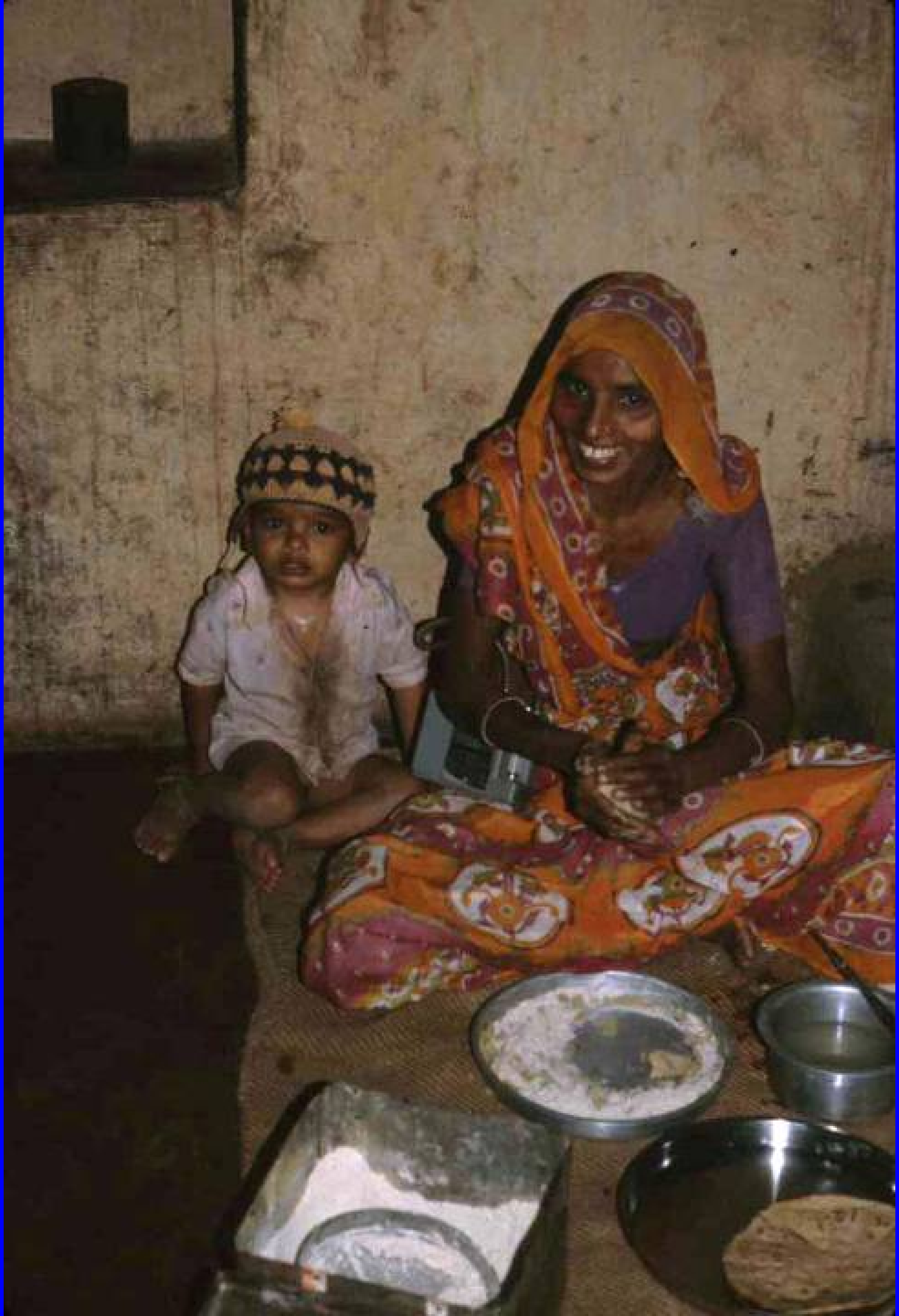
	Biogas	LPG	Kerosene	Wood	Roots	Crop Residues	Dung
CO	0.1	1.0	3	19	22	60	64
Hydrocarbons	0.3	1.0	4.2	17	18	32	115
PM	2.5	1.0	1.3	26	30	124	63

CO Hydrocarbons PM

Smith, et al., 2005

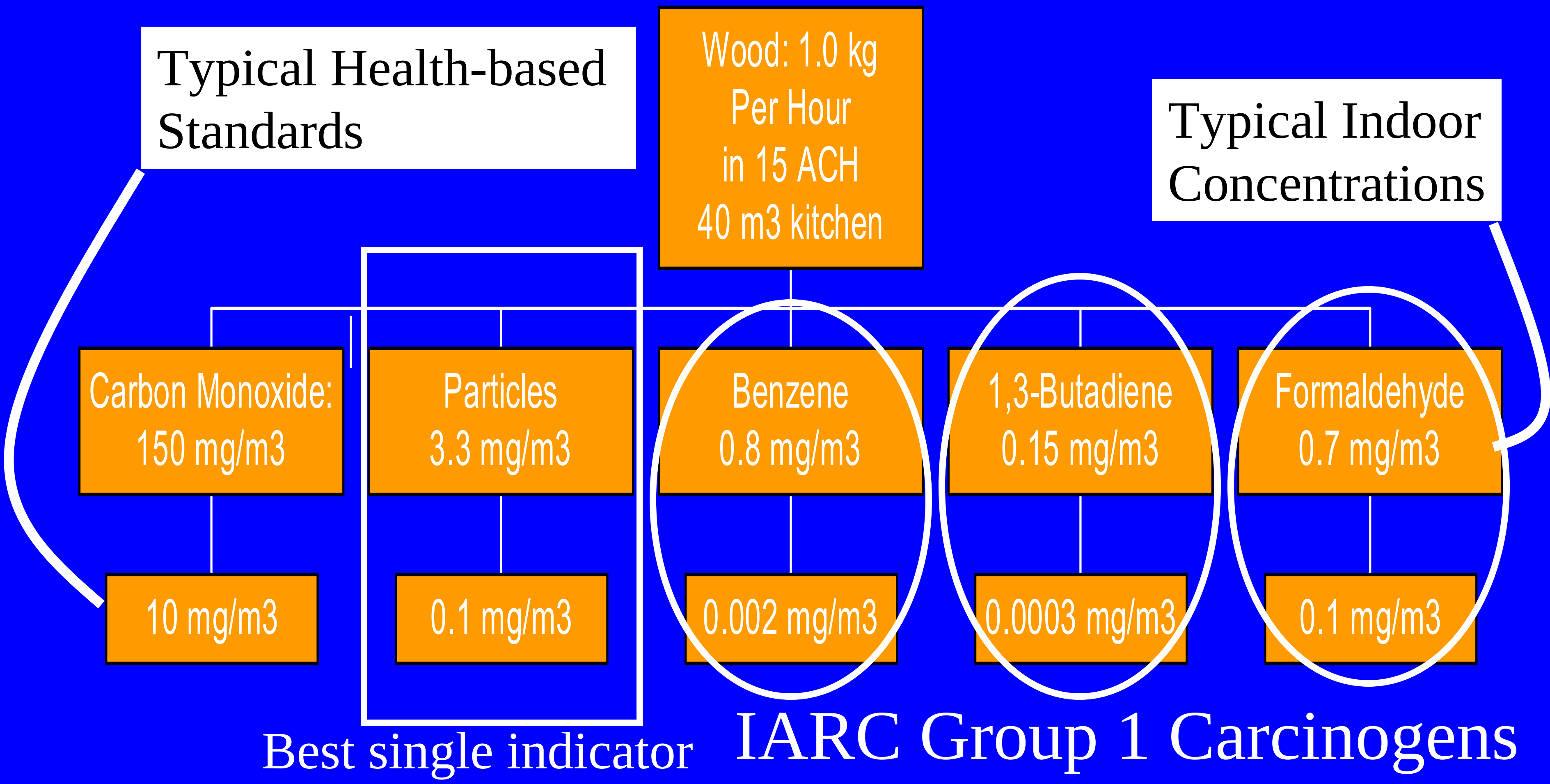
Perfect Storm for Health Impacts

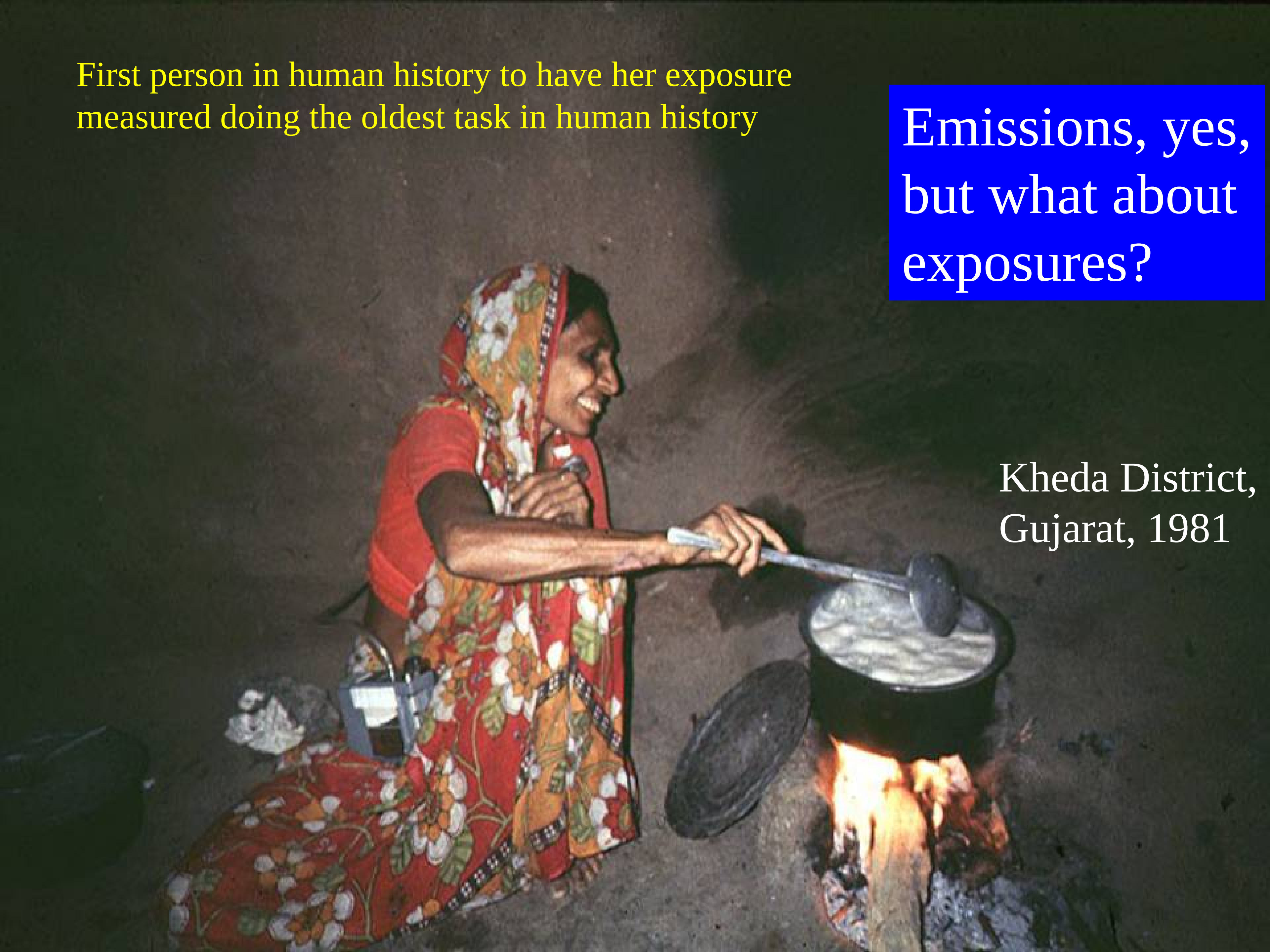
- Highly polluting activity
- Half of world households
- Several times a day
- Just when people are present
- Most vulnerable (women and young children) most likely to be there



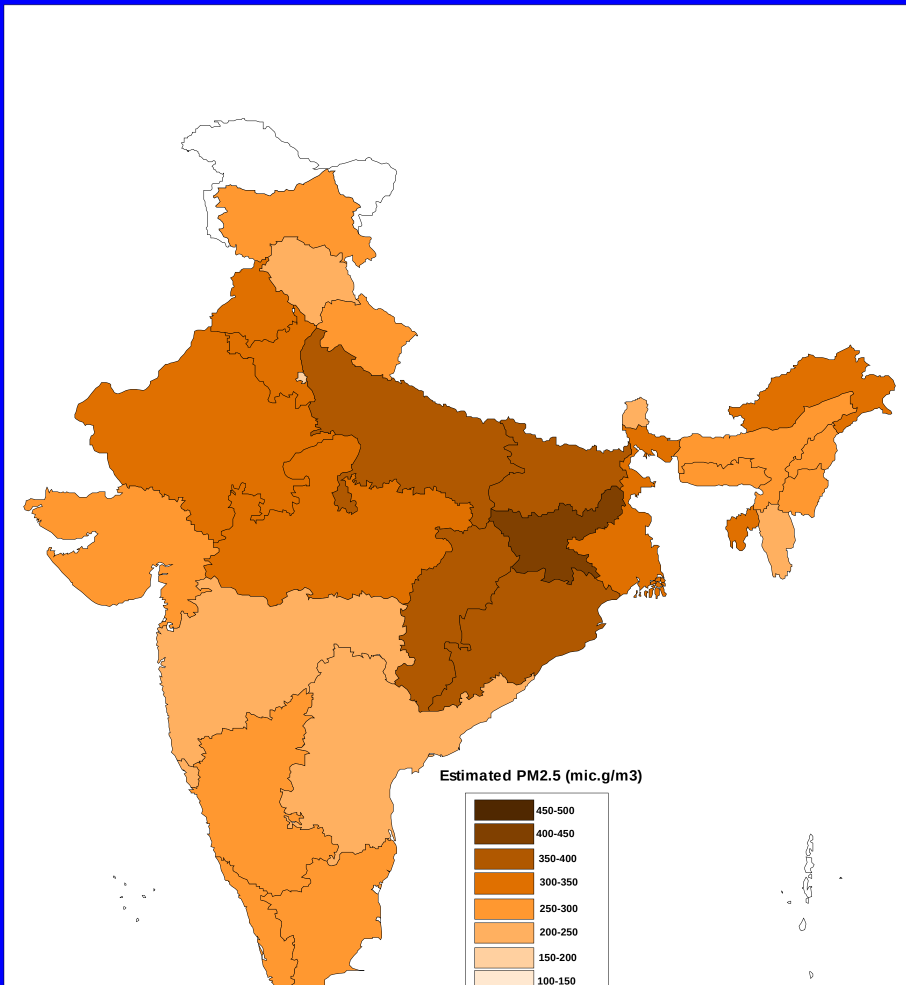
How much
Ill-health?

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




First person in human history to have her exposure measured doing the oldest task in human history
Emissions, yes, but what about exposures?
Kheda District, Gujarat, 1981

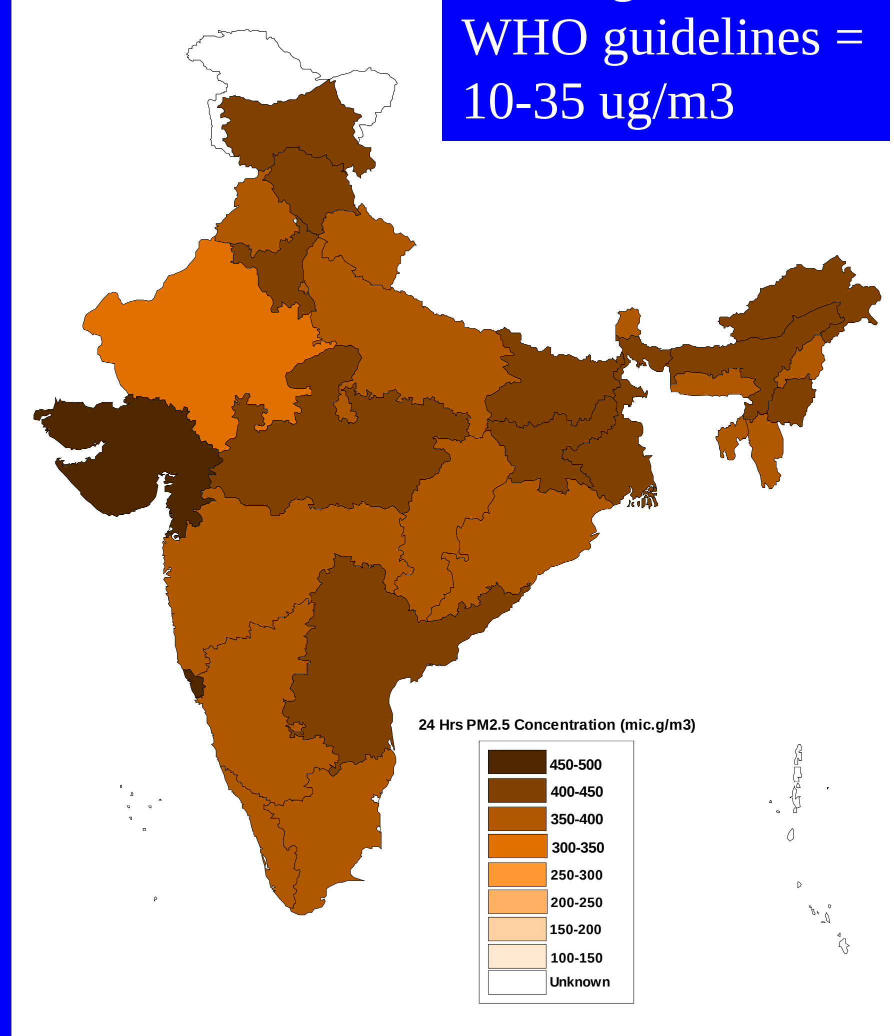
Estimated PM2.5 indoors for all households



Preliminary results from the Household Air Pollution Comparative Risk Assessment, 2011

Estimated PM2.5 for only solid-fuel-using households

~400 ug/m3 mean
WHO guidelines = 10-35 ug/m3

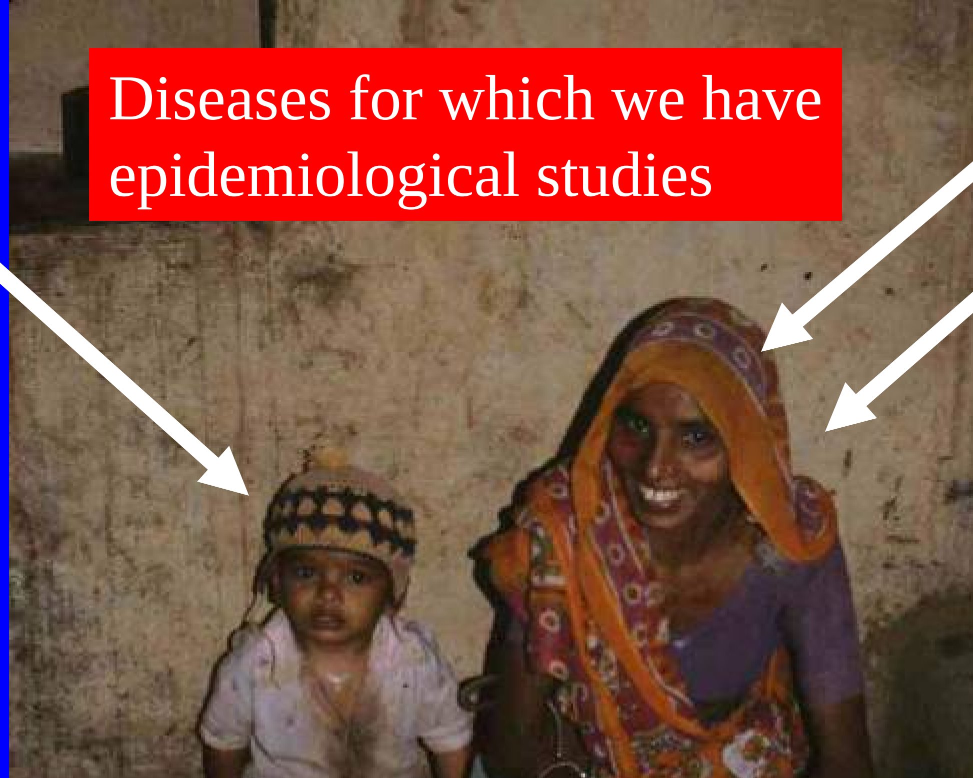


ALRI/
Pneumonia

Diseases for which we have epidemiological studies

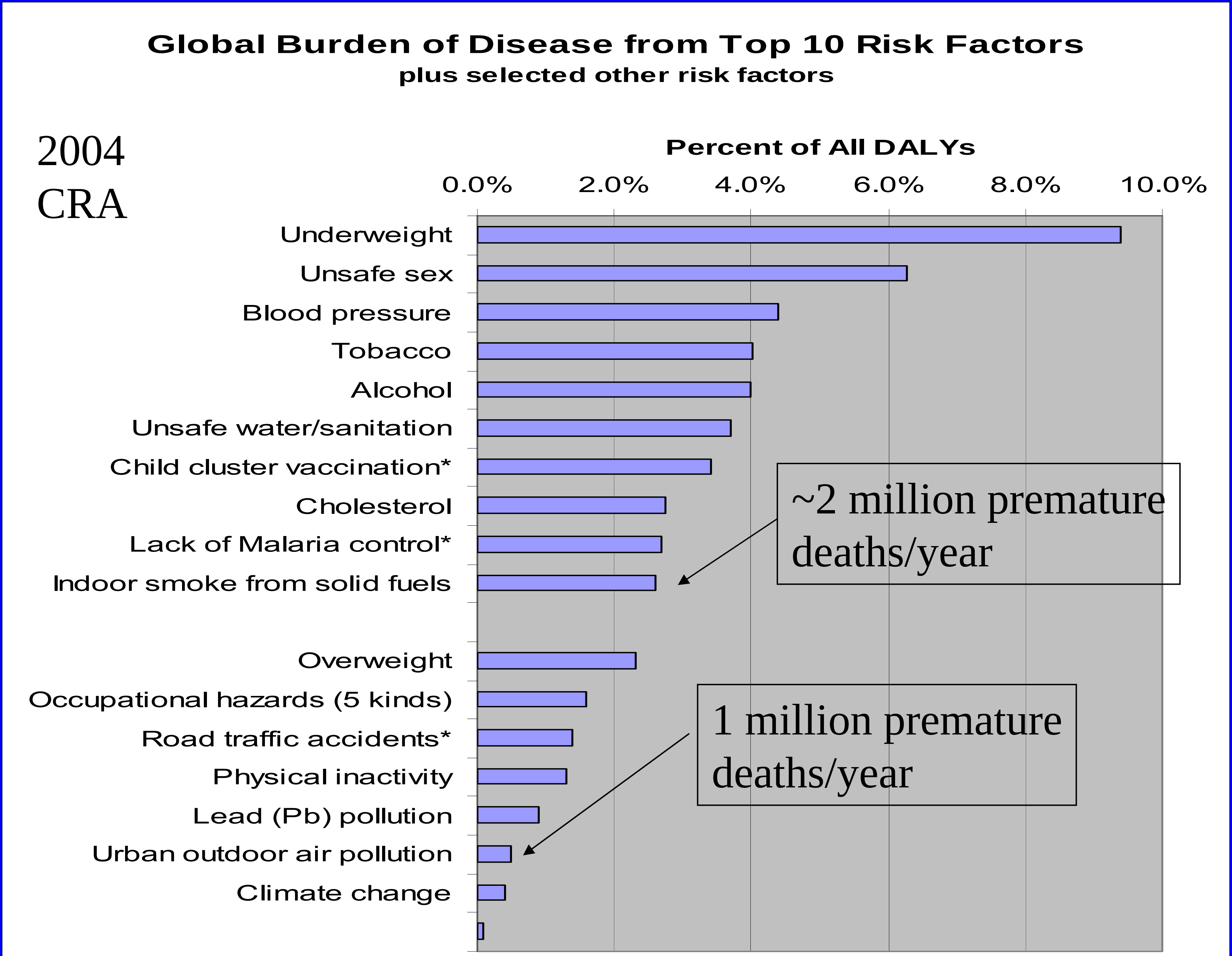
COPD

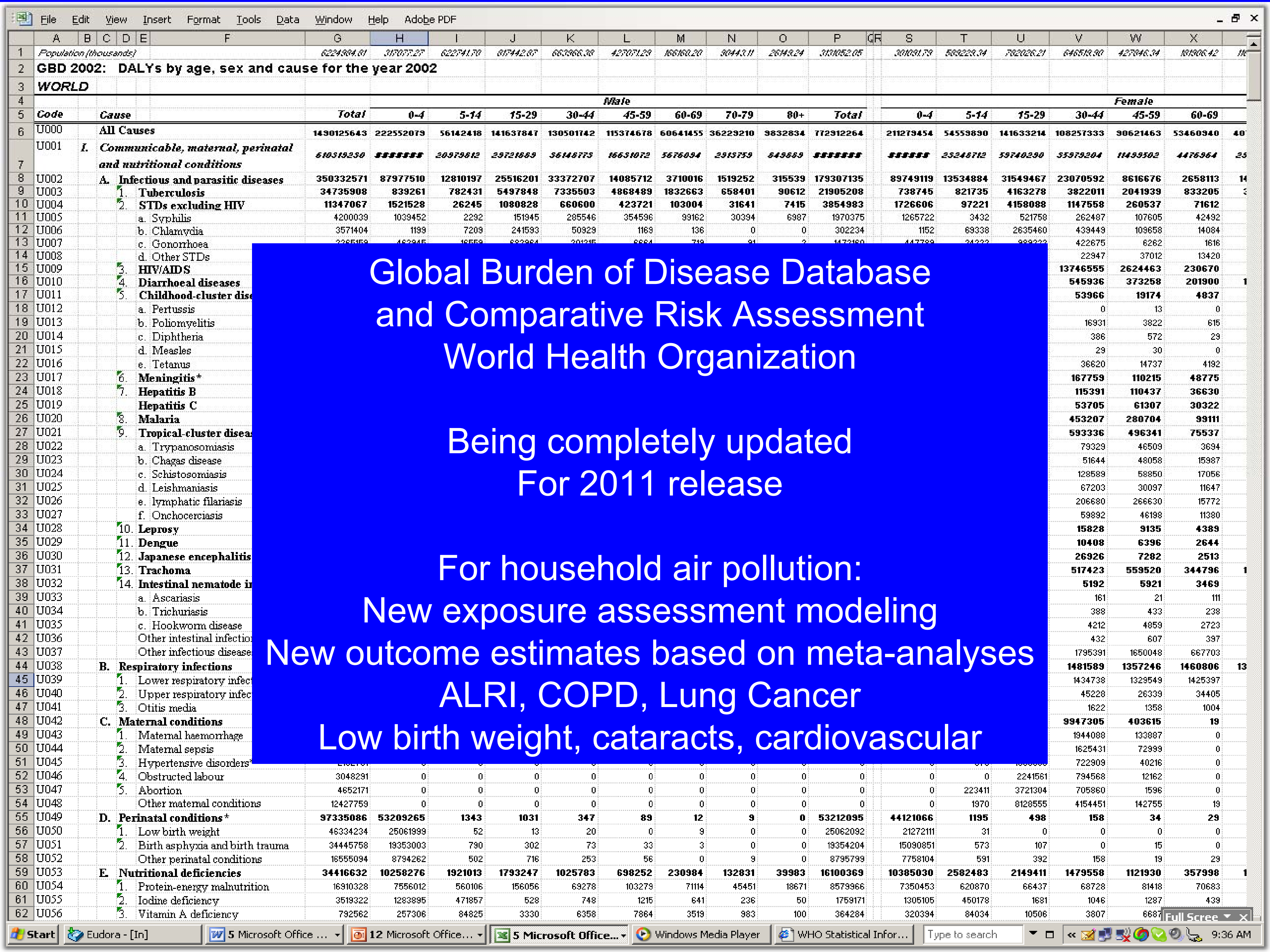
Lung cancer
(coal)



These three diseases were included in the
2004 Comparative Risk Assessment
Managed and published by WHO

First ever comprehensive risk assessment
with consistent rules of evidence
and common databases

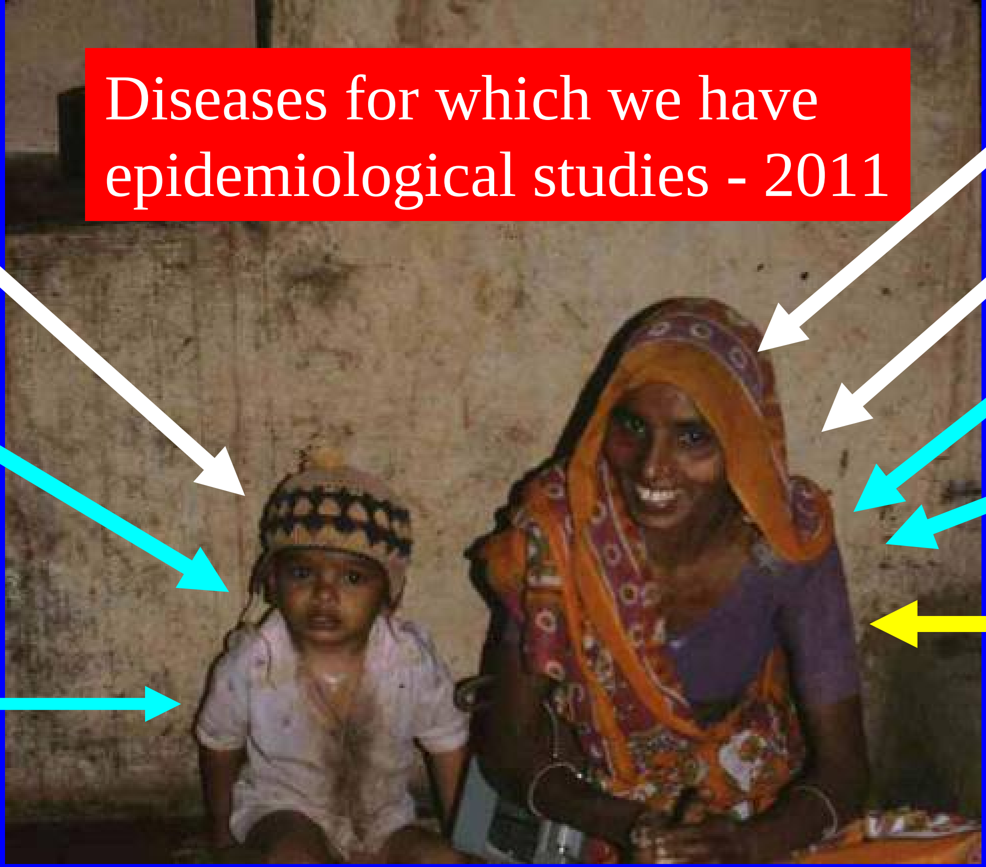

Global Burden of Disease from Top 10 Risk Factors
plus selected other risk factors
2004
CRA
Percent of All DALYs
0.0%
2.0%
4.0%
6.0%
8.0%
10.0%
Underweight
Unsafe sex
Blood pressure
Tobacco
Alcohol
Unsafe water/sanitation
Child cluster vaccination*
Cholesterol
Lack of Malaria control*
Indoor smoke from solid fuels
Overweight
Occupational hazards (5 kinds)
Road traffic accidents*
Physical inactivity
Lead (Pb) pollution
Urban outdoor air pollution
Climate change
~2 million premature deaths/year
1 million premature deaths/year



Global Burden of Disease Database
and Comparative Risk Assessment
World Health Organization

Being completely updated
For 2011 release

For household air pollution:
New exposure assessment modeling
New outcome estimates based on meta-analyses
ALRI, COPD, Lung Cancer
Low birth weight, cataracts, cardiovascular



ALRI/
Pneumonia

Low birth
weight

Stillbirth

COPD

Lung cancer
(coal)

Lung cancer
(biomass)

Blindness
(cataracts, opacity)

Heart disease
Blood pressure
ST-segment

These additional diseases will be included in the
2011 Comparative Risk Assessment

In addition, using evidence from other
exposure sources, heart will be included

There is epi evidence for these other diseases, but considered insufficient to include in the 2011 Comparative Risk Assessment

Cognitive Impairment

Birth defects

Asthma?

Tuberculosis

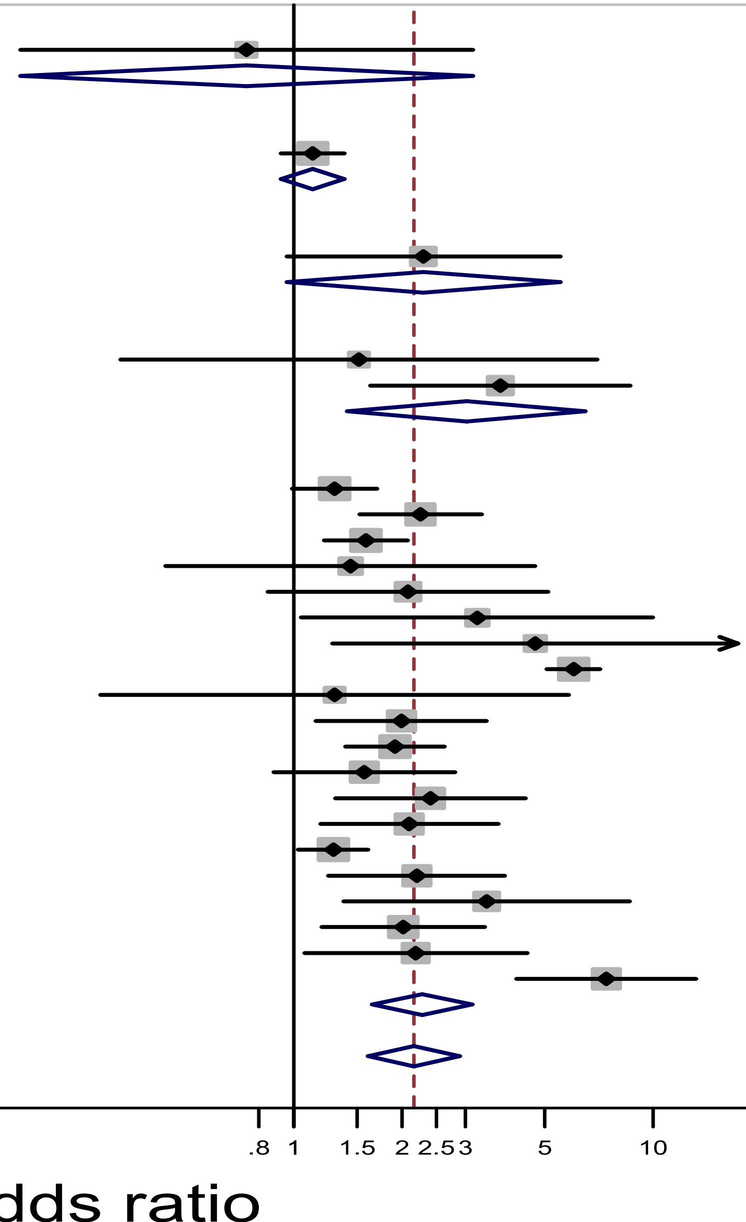
ALRI

Other cancers
(cervical, NP, upper airway)

Burns and the health/safety impacts of fuel gathering

Summary risk estimates of lung cancer associated with in-home coal use for heating and cooking by geographic region

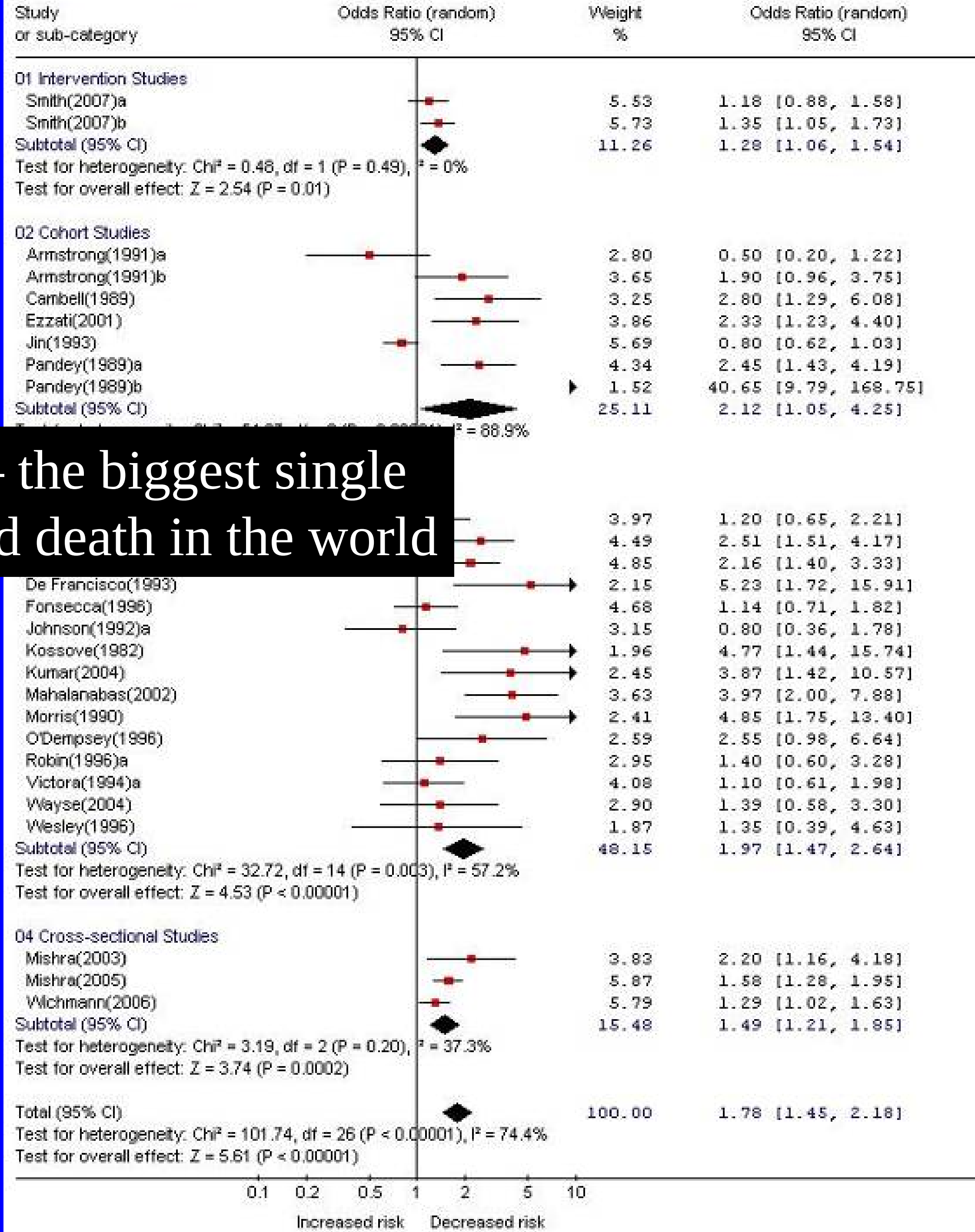
study	studyyear	casenum	contnum	ES (95% CI)
Africa				
Sasco(2002)	1996-1998	118	235	0.74 (0.17, 3.14)
Subtotal (I-squared = .%, p = .)				0.74 (0.17, 3.14)
.				
Europe				
Lissowska(2005)	1998-2001	2861	3118	1.13 (0.93, 1.38)
Subtotal (I-squared = .%, p = .)				1.13 (0.93, 1.38)
.				
North America				
Wu(1985)	1981-1982	220	220	2.30 (0.96, 5.50)
Subtotal (I-squared = .%, p = .)				2.30 (0.96, 5.50)
.				
India				
Gupta(2001)	1995-1997	265	525	1.52 (0.33, 6.98)
Sapkota(2008)	2001-2004	793	718	3.76 (1.64, 8.63)
Subtotal (I-squared = 4.4%, p = 0.307)				3.02 (1.42, 6.46)
.				
Mainland China and Taiwan				
Wu-Williams(1990)	1985-1987	965	959	1.30 (0.99, 1.70)
Sun(1991)	1985-1987	418	398	2.26 (1.53, 3.33)
Chengyu(1992)	1990-1991	135	135	1.59 (1.22, 2.07)
Ger(1993)	1990-1991	131	524	1.44 (0.44, 4.69)
Li(1993)	1986-1992	161	161	2.08 (0.85, 5.08)
Lin(1996)	1985-1990	122	122	3.24 (1.05, 9.94)
Dai(1996)	1992-1993	120	120	4.70 (1.29, 17.18)
Luo(1996)	1990-1991	102	306	6.00 (5.07, 7.10)
Ko(1997)	1992-1993	117	117	1.30 (0.29, 5.80)
Hao(1998)	1981-1986	220	440	1.99 (1.16, 3.43)
Huang(1999)	1993-1996	122	244	1.92 (1.40, 2.62)
Wu(1999)	1997	258	258	1.58 (0.89, 2.80)
Lan(2000)	1995-1996	122	122	2.40 (1.31, 4.40)
Lee(2001)	1993-1999	527	805	2.10 (1.19, 3.70)
Kleinerman(2002)	1994-1998	832	1724	1.29 (1.03, 1.61)
Sun(2002)	1996-1999	206	618	2.20 (1.25, 3.86)
Lu(2003)	1998-2001	445	445	3.44 (1.38, 8.57)
Liang(2004)	2001-2002	152	152	2.02 (1.20, 3.39)
Galeone(2008)	1987-1990	218	436	2.19 (1.08, 4.46)
Lan(2008)	1985-1990	498	498	7.40 (4.18, 13.10)
Subtotal (I-squared = 90.3%, p = 0.000)				2.28 (1.66, 3.13)
.				
Overall (I-squared = 90.4%, p = 0.000)				2.16 (1.62, 2.90)



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[illegible]	[illegible]
Cross-sectional	3	1.49	1.21, 1.85
All	26	1.78	1.45, 2.18

Pneumonia – the biggest single cause of child death in the world

Dherani et al Bull WHO (2008)



THELANCET-D-09-06268R3

S0140-6736(11)60921-5

Embargo: [add date when known]

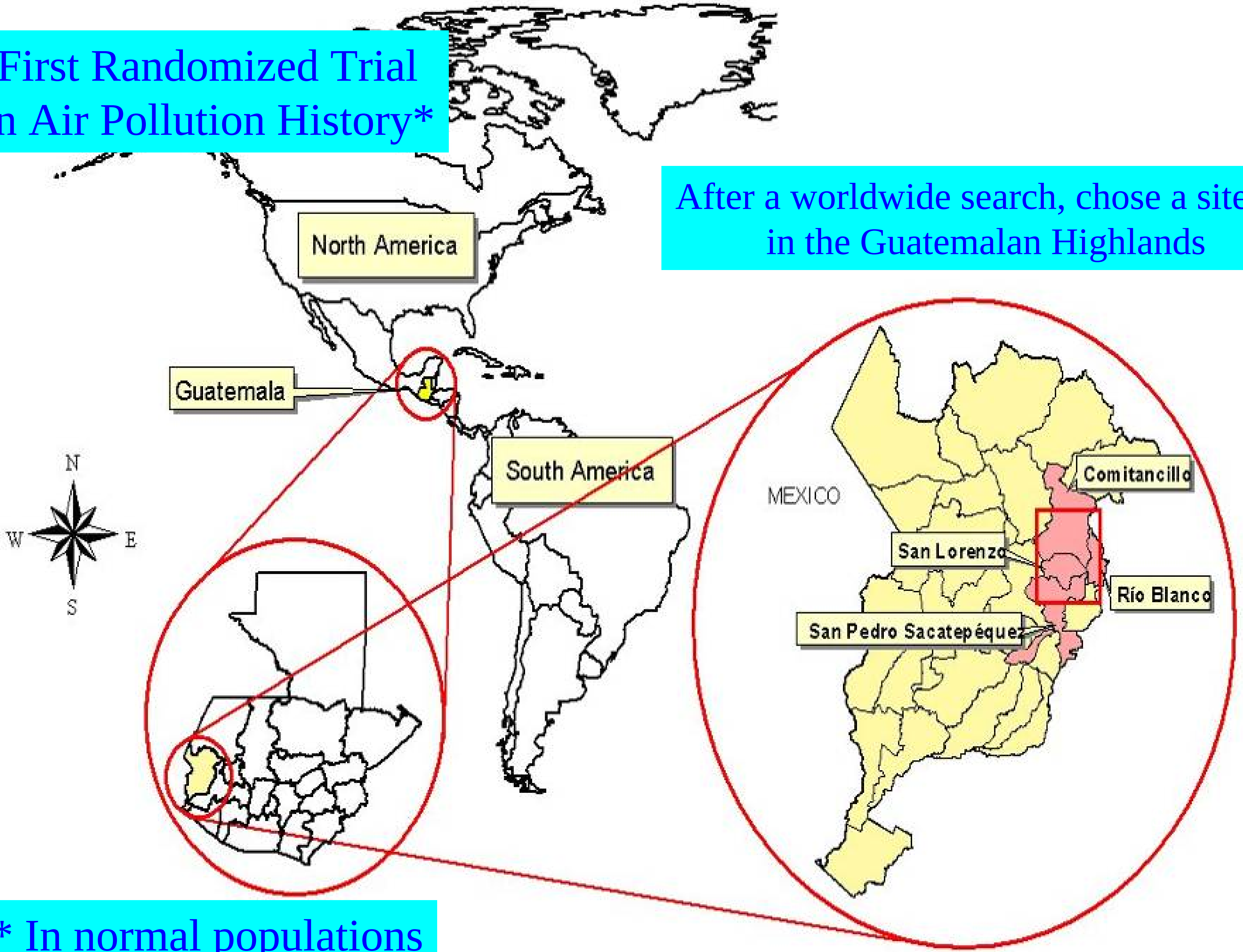
Effect of reduction in household air pollution on childhood pneumonia in Guatemala (RESPIRE): a randomised controlled trial

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

First Randomized Trial In Air Pollution History*

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



* In normal populations

RESPIRE – Randomized trial (n=518)

Impact on pneumonia up to 18 months of age

Traditional open 3-stone fire: kitchen 48-hour $PM_{2.5}$ levels of 600 - 1200 μg/m^3

Chimney wood stove, locally made and popular with households

Overview of RESPIRE study design

- 530 eligible households: open fire, woman pregnant or child less than 4 months
- Baseline survey and exposure assessment

Year 1

5500 Households total

Randomize

Keep open fire

Plancha

<u>Follow up till aged 18 months</u>

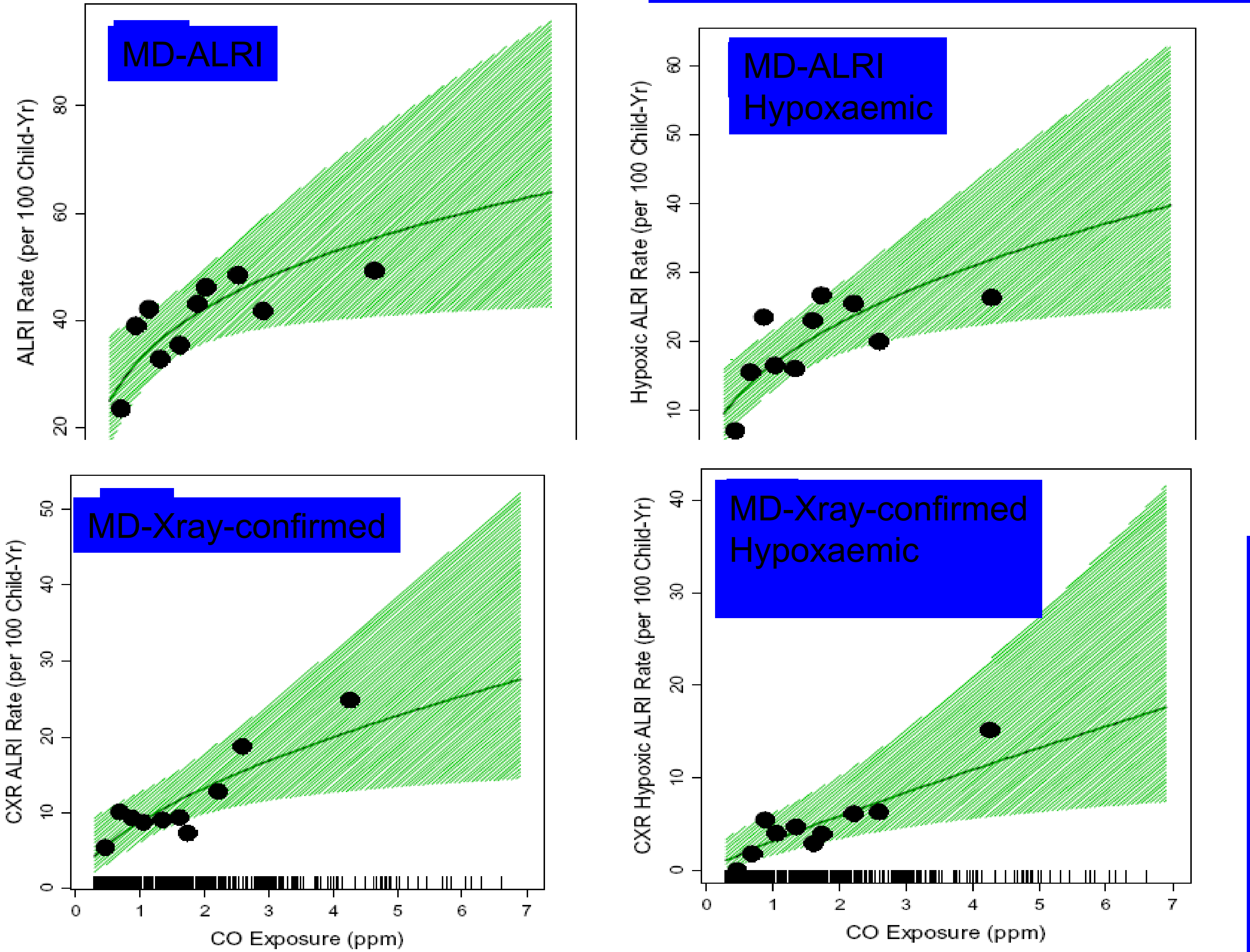
- Surveillance for ALRI, diarrhoea, &c
- Detailed exposure monitoring

Years 1-3

Compare incidence and exposure in 2 groups
Plancha offered to ‘controls’

Years 3-4


CO monitor
CO monitor



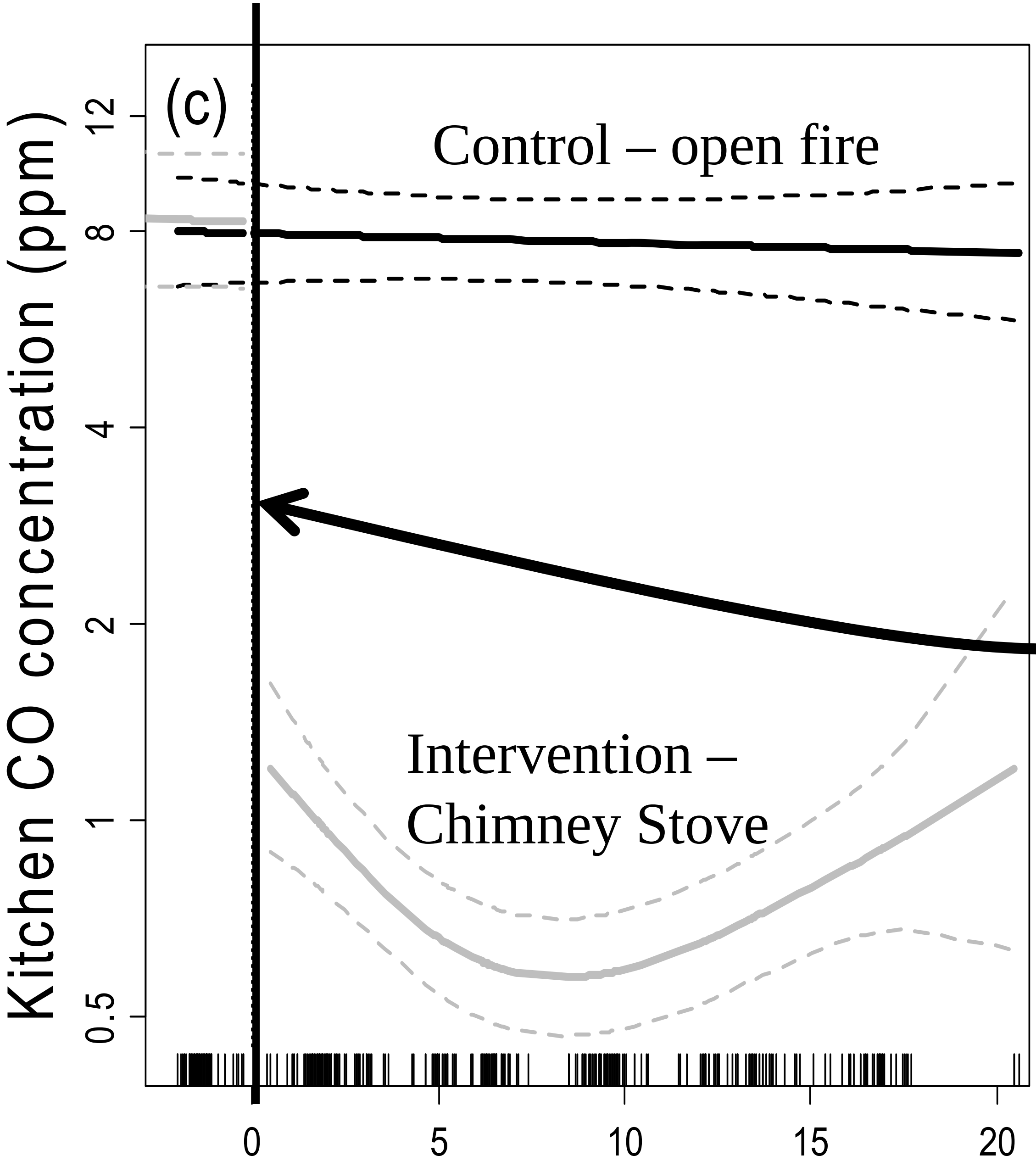
RESPIRE - Guatemala

RESPIRE: Pneumonia Reductions with Exposure Reduction
Preliminary Results

Exposure reduction	Overall MD-pneumonia	Severe (hypoxic) MD-pneumonia	CXR pneumonia	Severe (hypoxic) CXR pneumonia
25%	0.92 (0.86, 0.99)	0.88 (0.80, 0.97)	0.84 (0.74, 0.96)	0.79 (0.69, 0.95)
50%	0.82 (0.70, 0.98)	0.73 (0.59, 0.92)	0.66 (0.49, 0.91)	0.56 (0.40, 0.88)
75%	0.67 (0.50, 0.96)	0.53 (0.35, 0.84)	0.44 (0.24, 0.83)	0.31 (0.16, 0.78)
90%	0.51 (0.31, 0.93)	0.35 (0.17, 0.76)	0.26 (0.09, 0.74)	0.15 (0.05, 0.67)

RESPIRE - Guatemala

Guatemala RCT: Kitchen Concentrations



Effect of Chimney Stove On Kitchen CO Levels

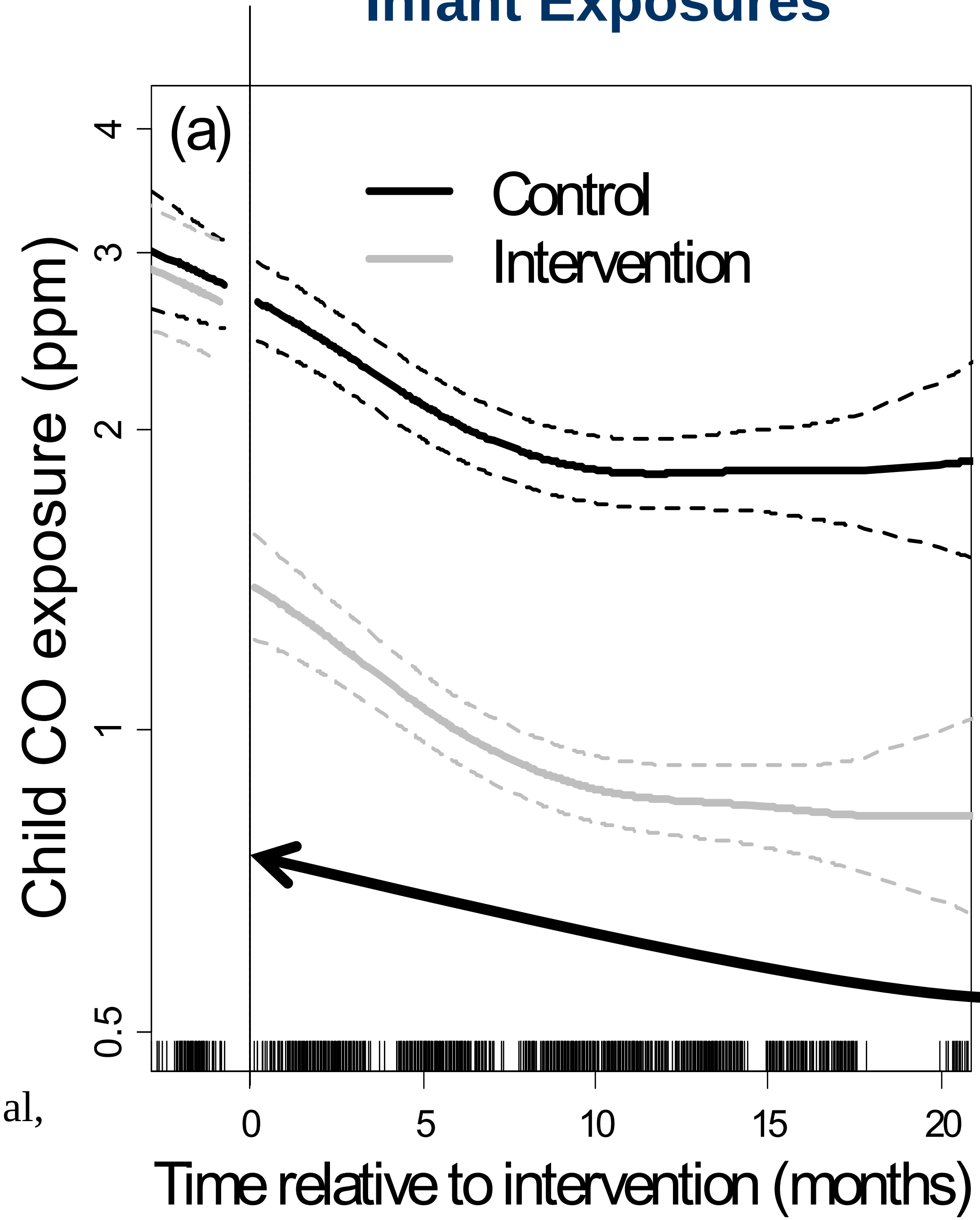
Factor of ~10 less

285 48-h measurements

Months

Smith, et al, 2010

Infant Exposures



1888 48-h measurements

Effect of Chimney Stove On Infant Exposures - 2x less

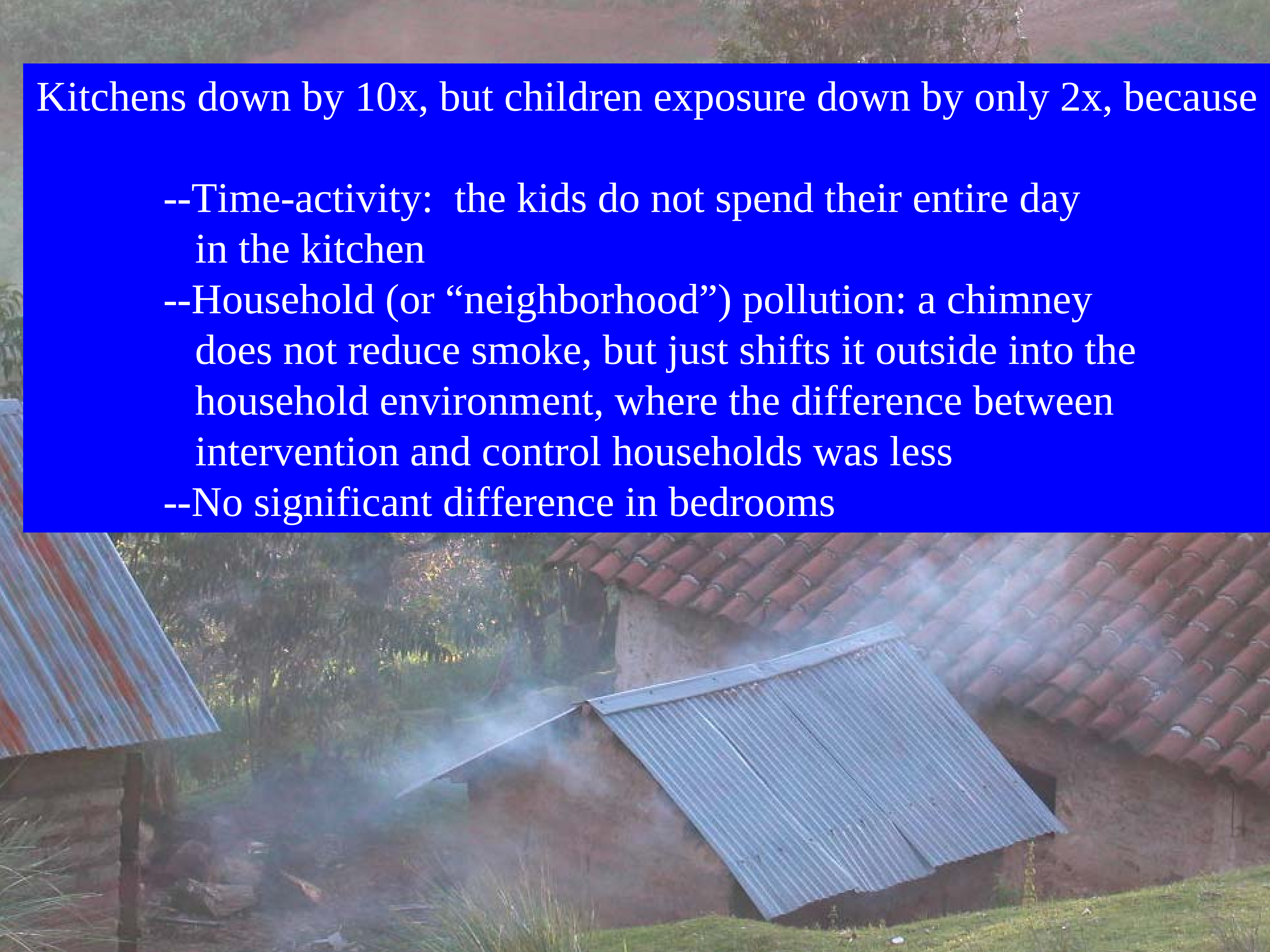
Smith, et al, 2010

Kitchens down by 10x, but children exposure down by only 2x, because

--Time-activity: the kids do not spend their entire day in the kitchen

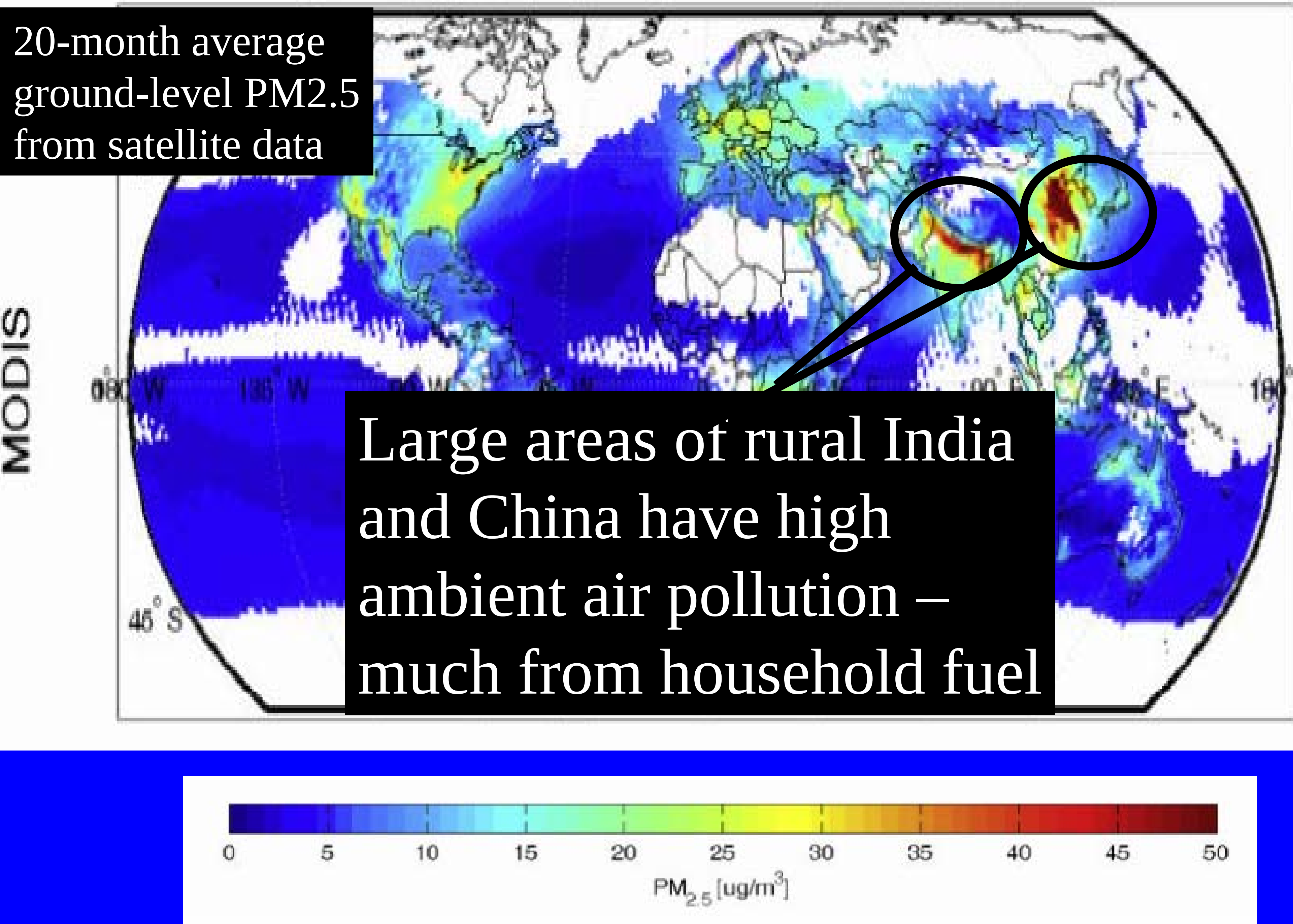
--Household (or "neighborhood") pollution: a chimney does not reduce smoke, but just shifts it outside into the household environment, where the difference between intervention and control households was less

--No significant difference in bedrooms



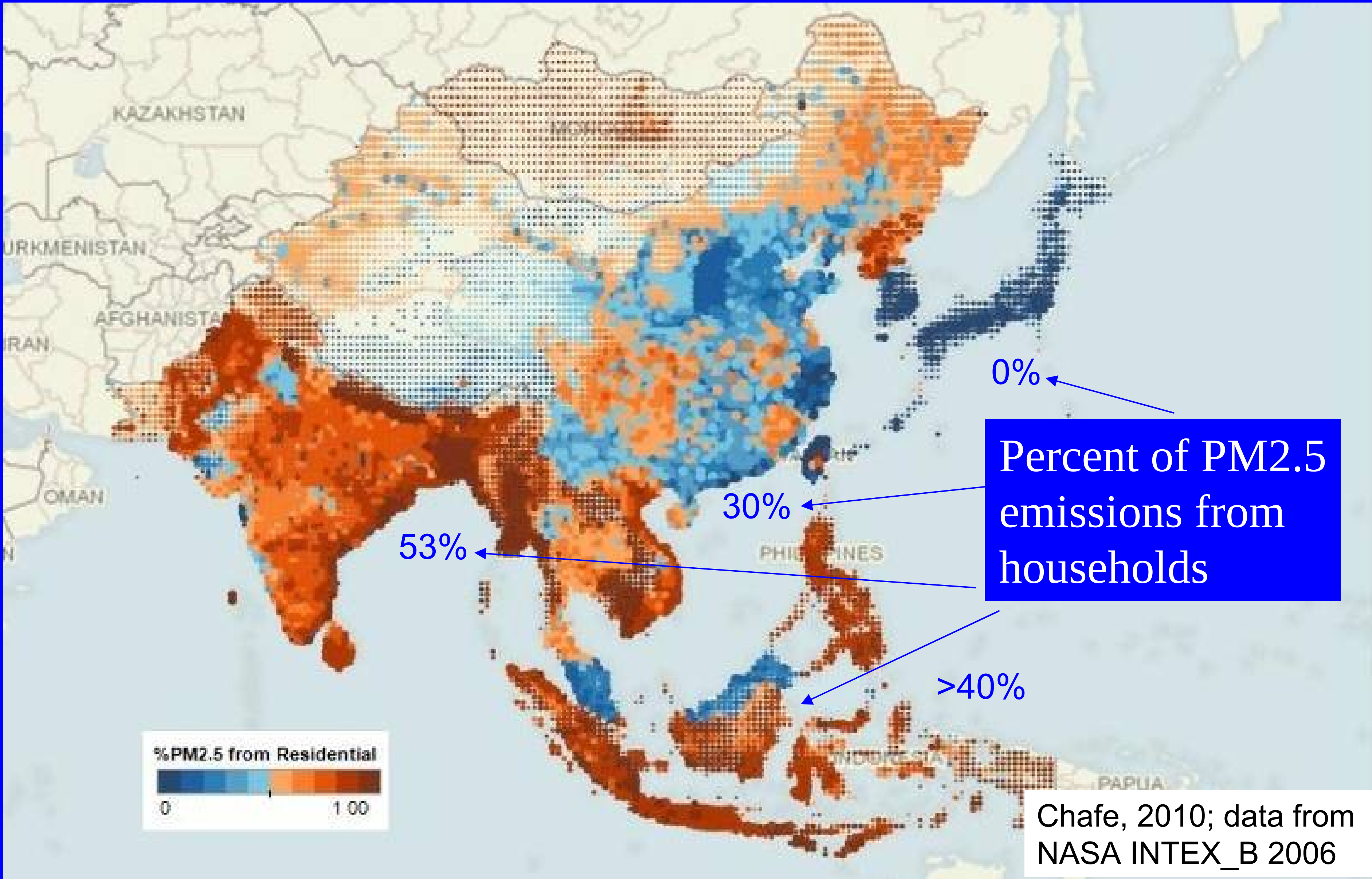
You have heard of secondhand smoke – from tobacco burning

But there is another kind – from cookfires



20-month average ground-level PM2.5 from satellite data
Large areas of rural India and China have high ambient air pollution – much from household fuel
MODIS
45° S
0
5
10
15
20
25
30
35
40
45
50
PM2.5 [ug/m3]

NASA INTEX_B Database
Percent $PM_{2.5}$ emissions from households



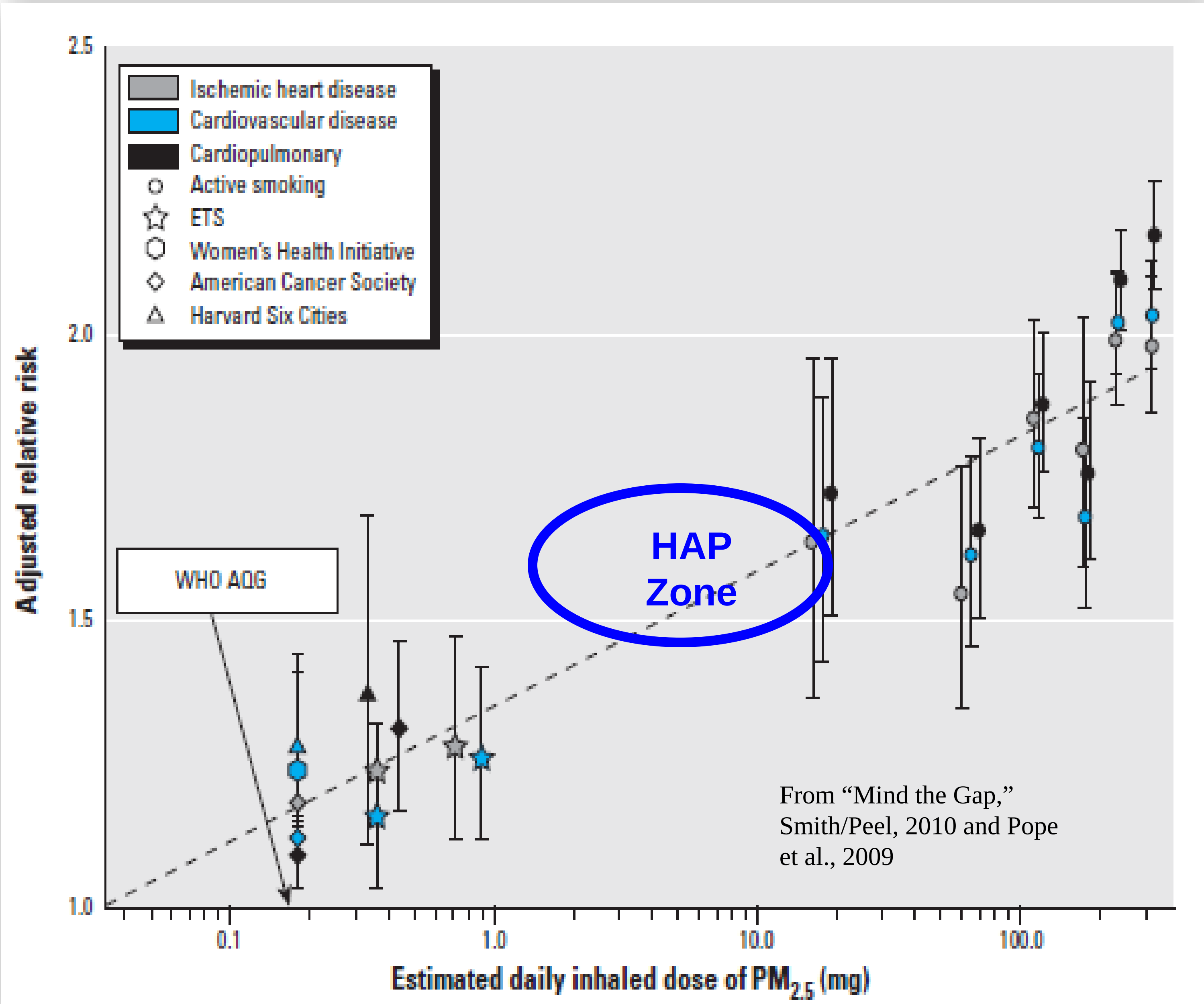
Chafe, 2010; data from NASA INTEX_B 2006

Combustion Particles

The Generalized Exposure Response

(GER)

Heart Disease and Combustion Particle Doses



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]

[1]Department of Environmental Health, Harvard School of Public Health, Boston, Massachusetts, USA; [2]Environmental Sciences Division, University of California, Berkeley, California, USA; [3]Brigham and Women's Hospital, Boston, Massachusetts, USA; [4]Center for Health Studies, Universidad del Valle, Guatemala City, Guatemala

EHP Nov, 2011

Table 3. Odds ratios (ORs) for nonspecific ST-segment depression (30-min average ≤ –1 mm, regardless of slope) associated with chimney-stove intervention compared with open fire from two study designs: between-groups and before-and-after analyses.

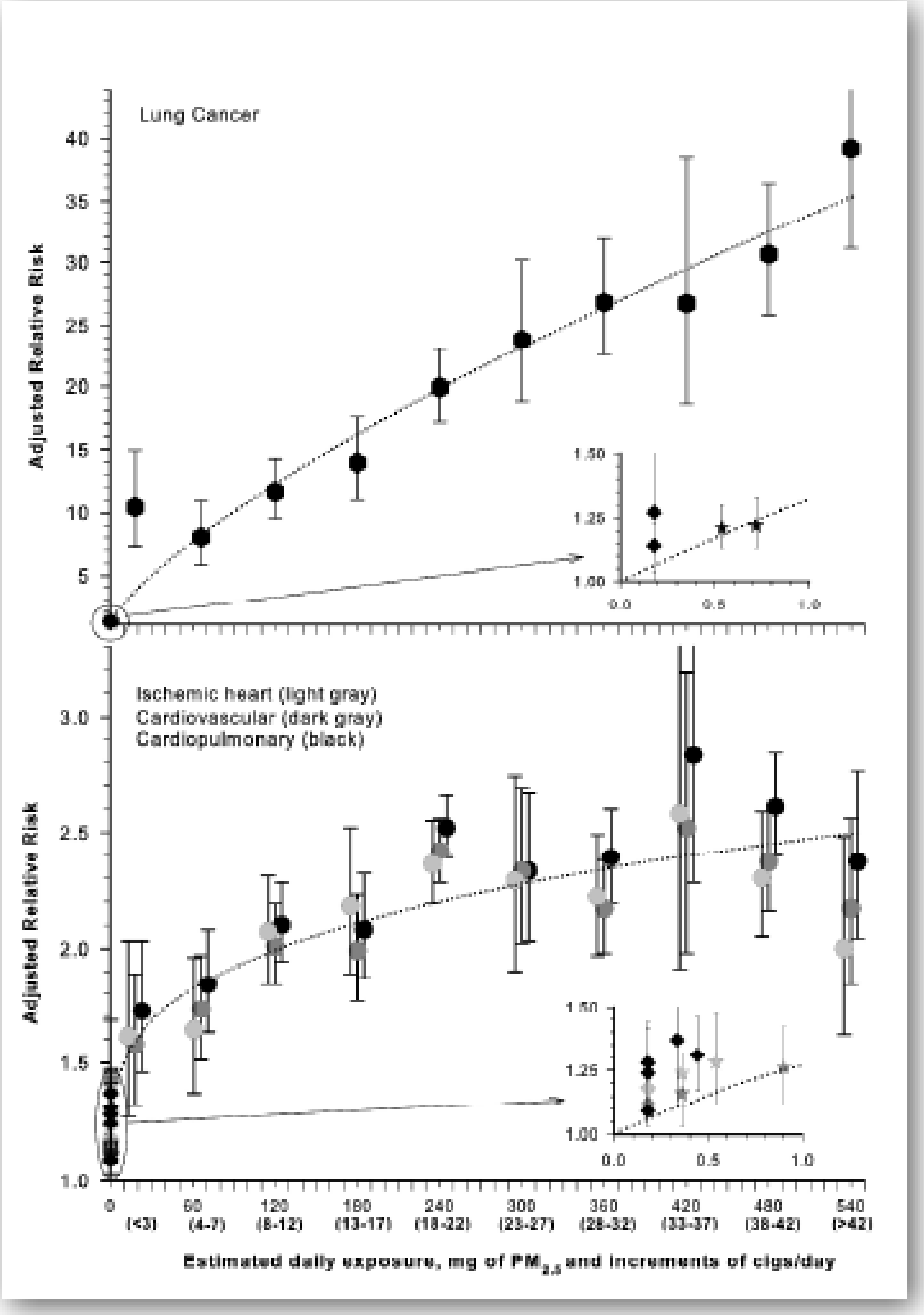
	Crude		Adjusted	
Comparison	OR (95% CI)	*p*-Value	OR (95% CI)	*p*-Value
Between-groups	0.34 (0.15, 0.81)	0.015	0.26 (0.08, 0.90)[a]	0.033
Before-and-after (only control group)	0.41 (0.24, 0.70)	0.001	0.28 (0.12, 0.63)[b]	0.002

[a]Adjusted for age (quadratic), BMI (quadratic), asset index category, ever smoking, SHS, owning a wood-fired sauna, recent use of wood-fired sauna, and time of day (natural spline with 5 degrees of freedom). [b]Adjusted for age (quadratic), day of week, season (wet/dry), daily average temperature and relative humidity, daily rainfall, interactions of weather variables with season, recent use of wood-fired sauna, and time of day (natural spline with 5 degrees of freedom).

Table 2. Adjusted relative risk estimates[a] for various increments of exposure from cigarette smoking (versus never smokers), second hand cigarette smoke, and ambient air pollution from the present analysis and selected comparison studies.

Source of risk estimate	Increments of Exposure	Adjusted RR (95% CI)				Estimated Daily Dose $PM_{2.5}$ (mg)[b]
		Lung Cancer	IHD	CVD	CPD	
ACS- present analysis	≤3 (1.5) cigs/day	10.44 (7.30-14.94)	1.61 (1.27-2.03)	1.58 (1.32-1.89)	1.72 (1.46-2.03)	18
ACS- present analysis	4-7 (5.5) cigs/day	8.03 (5.89-10.96)	1.64 (1.37-1.96)	1.73 (1.51-1.97)	1.84 (1.63-2.08)	66
ACS- present analysis	8-12 (10) cigs/day	11.63 (9.51-14.24)	2.07 (1.84-2.31)	2.01 (1.84-2.19)	2.10 (1.94-2.28)	120
ACS- present analysis	13-17 (15) cigs/day	13.93 (11.04-17.58)	2.18 (1.89-2.52)	1.99 (1.77-2.23)	2.08 (1.87-2.32)	180
ACS- present analysis	18-22 (20) cigs/day	19.88 (17.14-23.06)	2.36 (2.19-2.55)	2.42 (2.28-2.56)	2.52 (2.39-2.66)	240
ACS- present analysis	23-27 (25) cigs/day	23.82 (18.80-30.18)	2.29 (1.91-2.75)	2.33 (2.02-2.69)	2.33 (2.03-2.67)	300
ACS- present analysis	28-32 (30) cigs/day	26.82 (22.54-31.91)	2.22 (1.97-2.49)	2.17 (1.98-2.38)	2.39 (2.19-2.60)	360
ACS- present analysis	33-37 (35) cigs/day	26.72 (18.58-38.44)	2.58 (1.91-3.47)	2.52 (1.98-3.19)	2.83 (2.28-3.52)	420
ACS- present analysis	38-42 (40) cigs/day	30.63 (25.79-36.38)	2.30 (2.05-2.59)	2.37 (2.16-2.59)	2.61 (2.40-2.84)	480
ACS- present analysis	43+ (45) cigs/day	39.16 (31.13-49.26)	2.00 (1.62-2.48)	2.17 (1.84-2.56)	2.37 (2.04-2.76)	540
ACS-air pol. original	24.5 μg/m³ ambient $PM_{2.5}$	-----	-----	-----	1.31(1.17-1.46)	0.44
ACS-air pol. extend.	10 μg/m³ ambient $PM_{2.5}$	1.14(1.04-1.23)	1.18(1.14-1.23)	1.12(1.08-1.15)	1.09(1.03-1.16)	0.18
HSC-air pol. original	18.6 μg/m³ ambient $PM_{2.5}$	-----	-----	-----	1.37(1.11-1.68)	0.33
HSC-air pol. extend.	10 μg/m³ ambient $PM_{2.5}$	1.21(0.92-1.69)	-----	1.28(1.13-1.44)	-----	0.18
WHI-air pol.	10 μg/m³ ambient $PM_{2.5}$	-----	-----	1.24(1.09-1.41)[c]	-----	0.18
SGR-SHS	Low- moderate SHS exp.	-----	-----	1.16(1.03-1.32)	-----	0.36
SGR-SHS	Moderate-high SHS exp	-----	-----	1.26(1.12-1.42)	-----	0.90
SGR-SHS	Live with smoking spouse	1.21(1.13-1.30)	-----	-----	-----	0.54
SGR-SHS	Work with SHS exposure	1.22(1.13-1.33)	-----	-----	-----	0.72
INTERHEART	1-7 hrs/wk SHS exp.	-----	1.24(1.17-1.32)[d]	-----	-----	0.36
INTERHEART	Live with smoking spouse	-----	1.28(1.12-1.47)[d]	-----	-----	0.54

Pope et al.
Environmental Health Perspectives
2011, in press

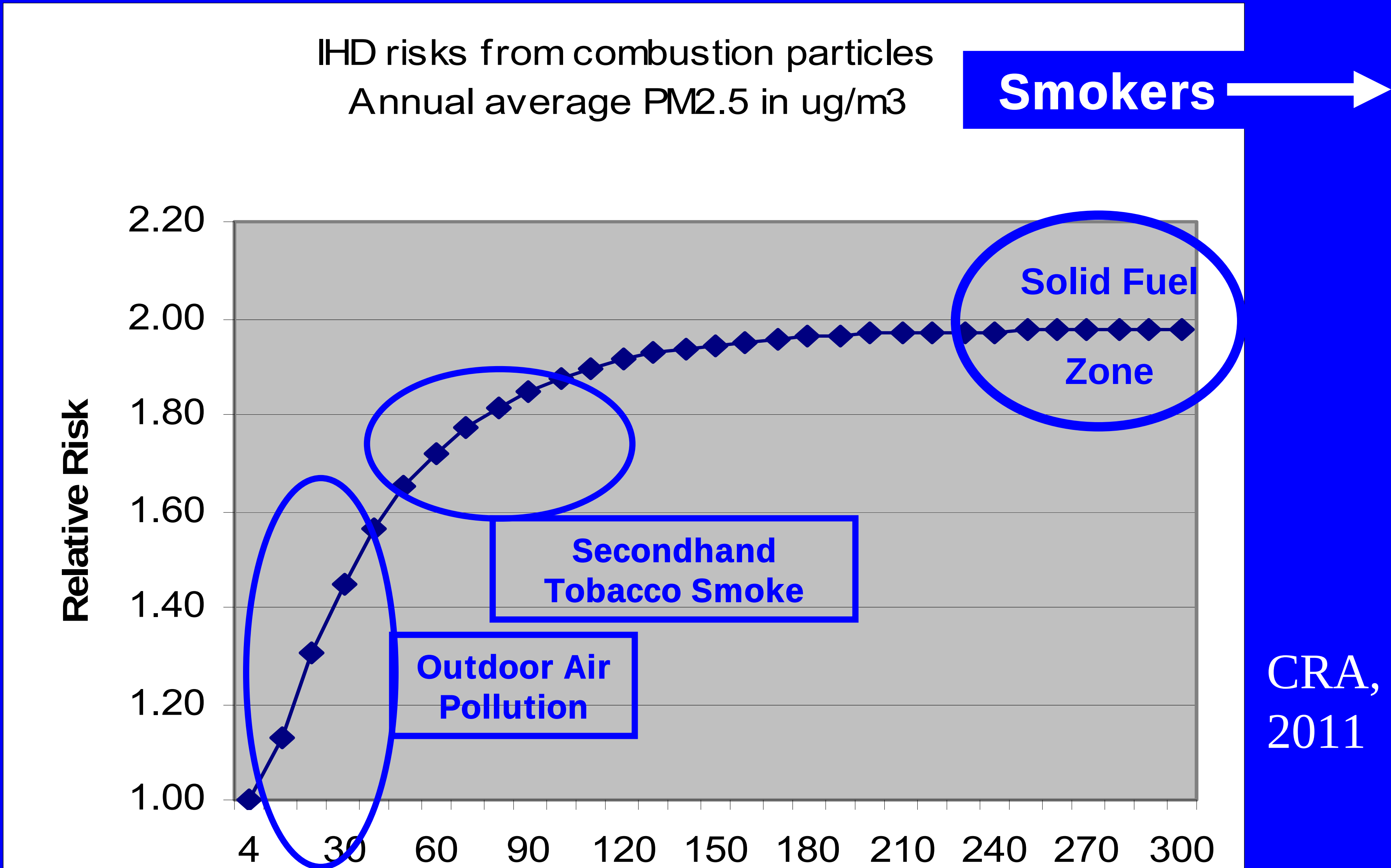


Lung Cancer

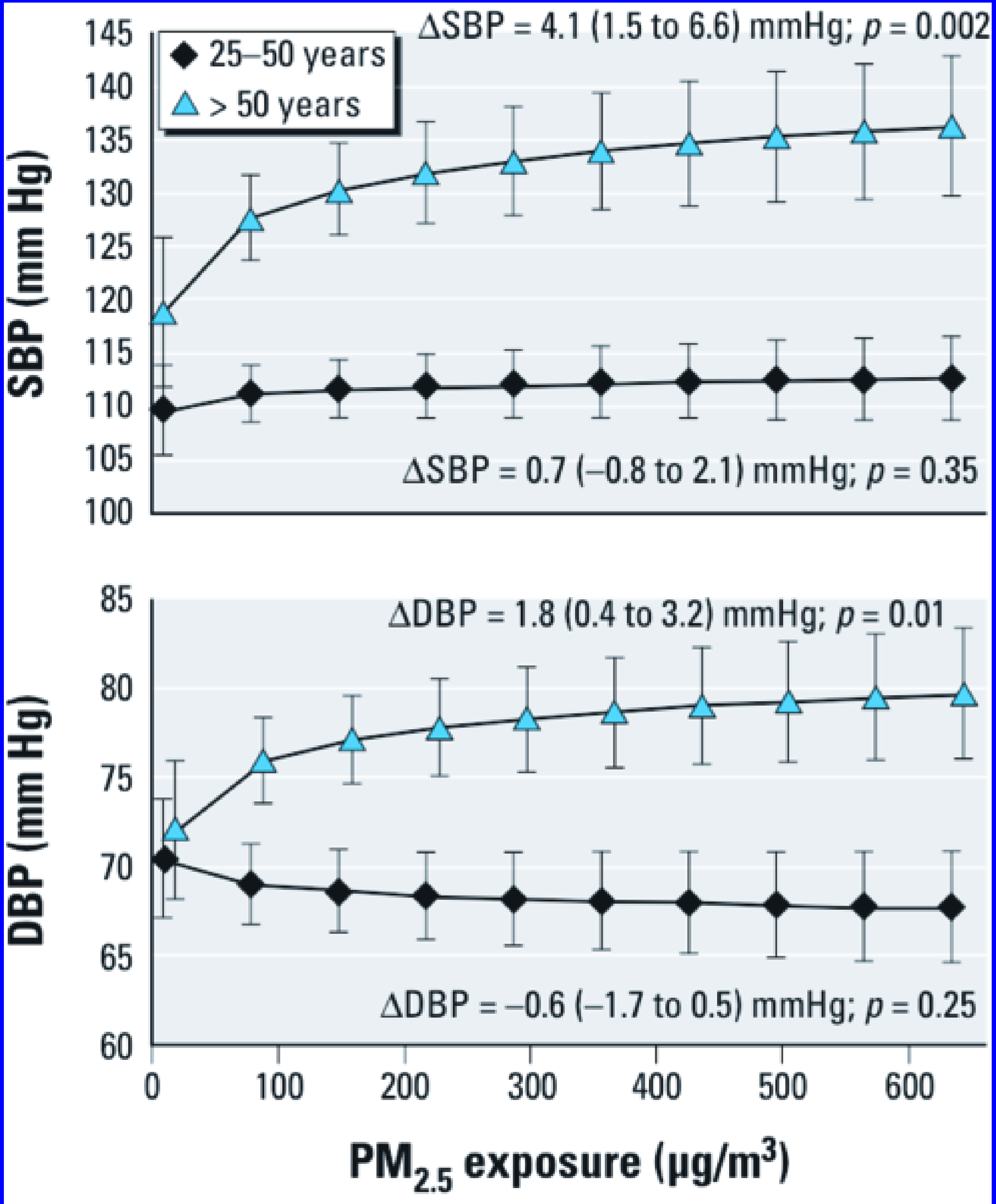
Heart Disease

Pope et al. Environmental Health Perspectives 2011, in press

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



CRA, 2011

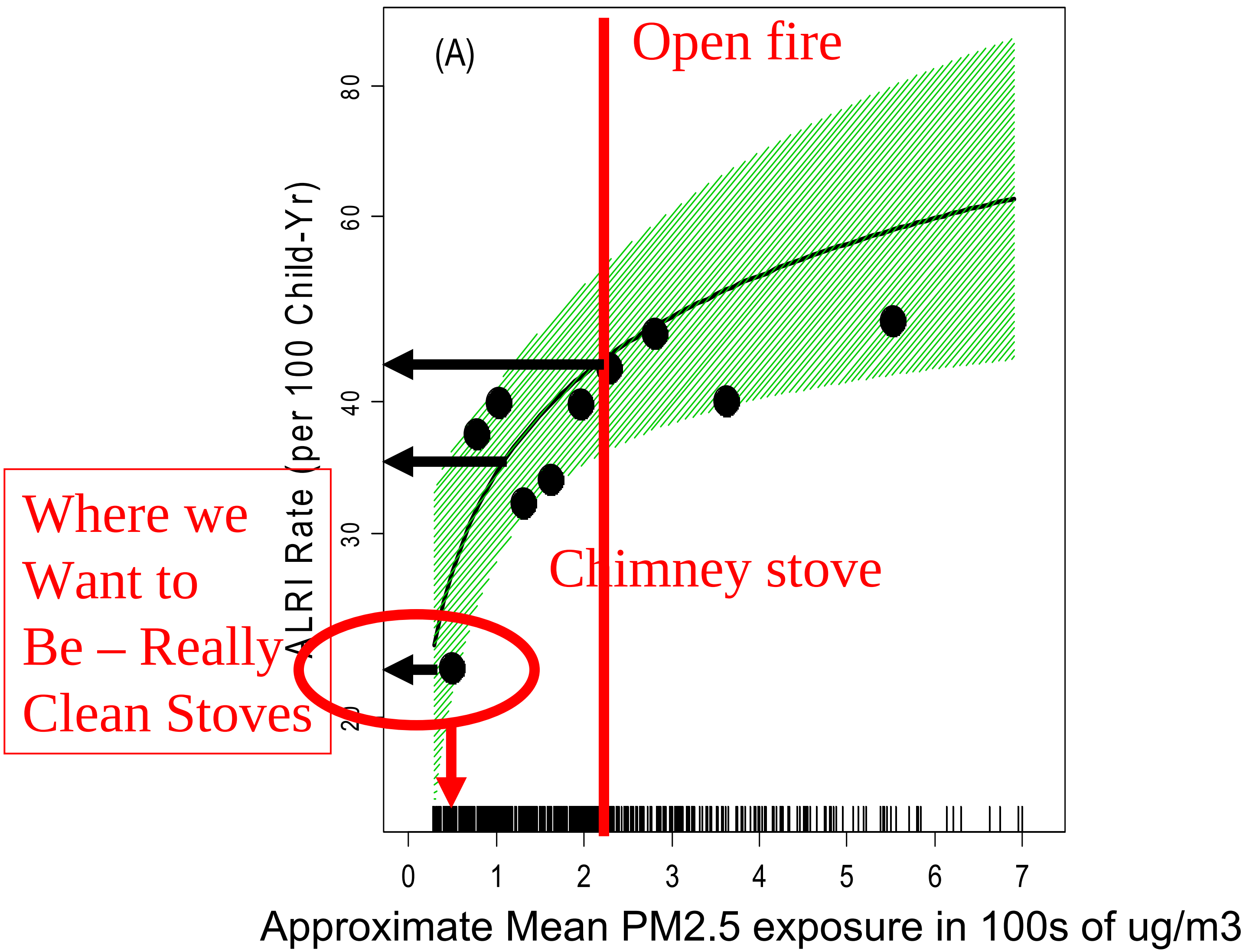


Household
Air
Pollution
and
Blood Pressure

In Yunnan

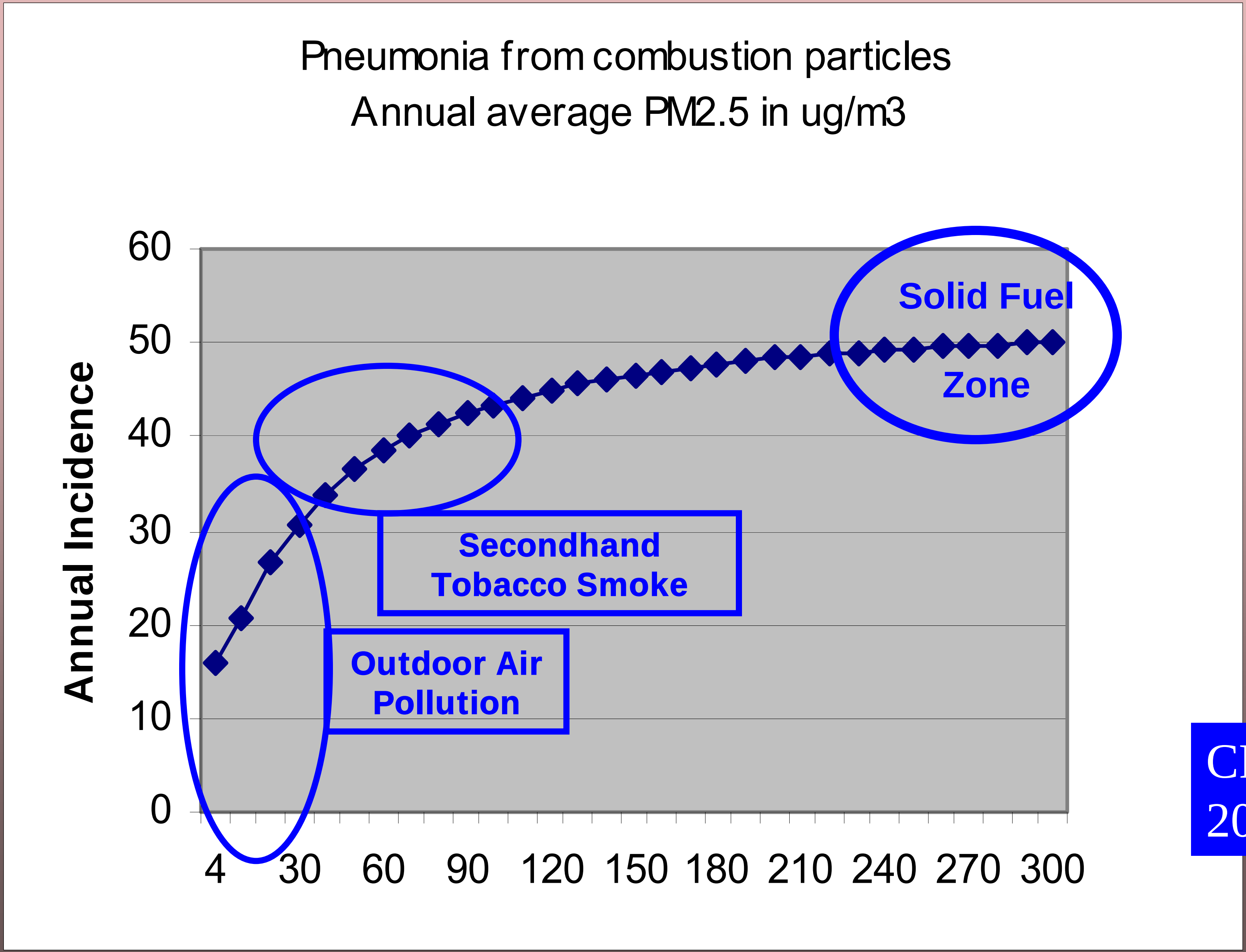
Baumgartner et al. Environmental Health Perspectives 2011, Oct

MD-diagnosed Acute Lower Respiratory Infection



RESPIRE-
Guatemala

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



CRA, 2011

Biggest impacts from smoking

- Chronic obstructive lung disease
- Lung cancer
- Heart disease and stroke

- All not associated with 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

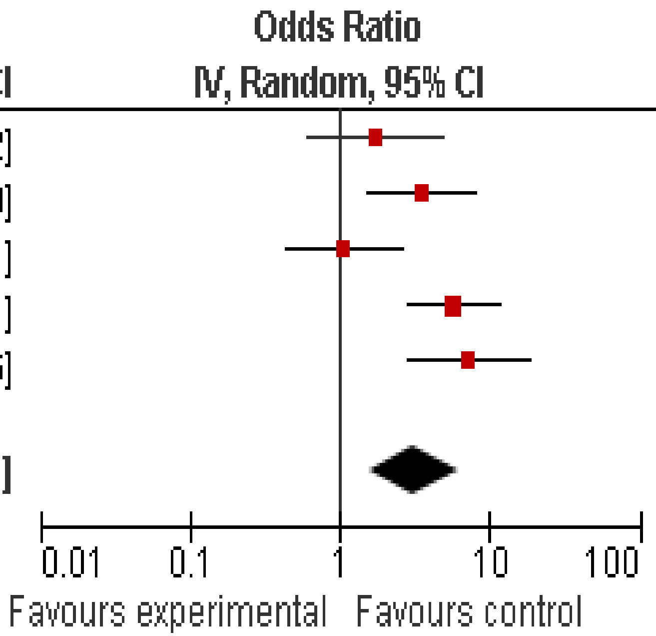
Review of Epi Evidence: Lung Cancer, 2004

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, one in Columbia

Infectious disease and smoking

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

Archives of Internal Medicine, 2004

Tuberculosis and Indoor Biomass and Kerosene Use in Nepal: A Case–Control Study

Amod K. Pokhrel,[1] Michael N. Bates,[1] Sharat C. Verma,[2,3] Hari S. Joshi,[3] Chandrashekhar T. Sreeramareddy,[3**] and Kirk R. Smith[1]*

[1]School of Public Health, University of California–Berkeley, Berkeley, California, USA; [2]Regional Tuberculosis Center, Ram Ghat, Pokhara, Nepal; [3]Department of Community Medicine, Manipal Teaching Hospital, Manipal College of Medical Sciences, Pokhara, Nepal

VOLUME 118 | NUMBER 4 | April 2010 • Environmental Health Perspectives

Risks from fuel use for TB in women in Pokhara

Cookstove	
Gas	1.00
Biomass	1.21 (0.48–3.05)
Kerosene	*3.36 (1.01–11.22)*
Heating fuel	
No heating fuel use or electricity	1.00
Biomass	*3.45 (1.44–8.27)*
Main light source in the house	
Electricity	1.00
Kerosene lamp	*9.43 (1.45–61.32)*

Pokhrel et al., 2010

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

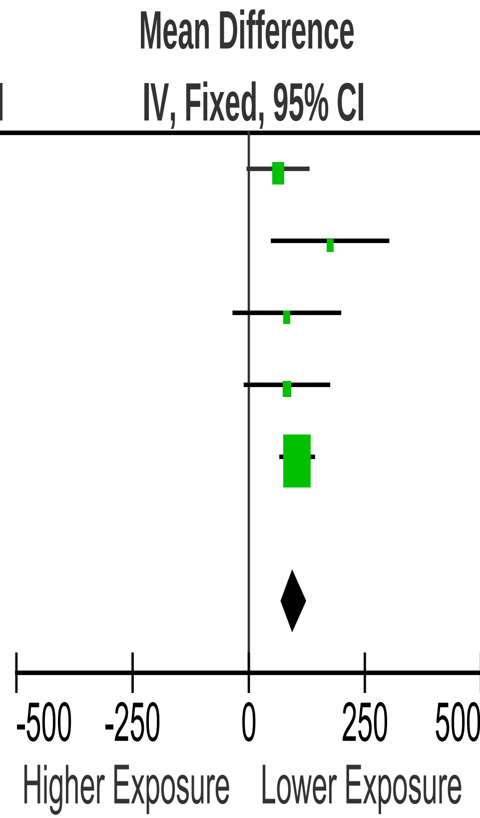
Pooled birth weight difference (low minus high exposure):

Adjusted estimates (Boy and Tielsch have GA)

	Lower Exposure			Higher Exposure				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Boy 2002	2,835	533	357	2,772	525	871	18.5%	63.00 [-2.36, 128.36]
Mishra 2004	3,271	1,448	766	3,096	1,429	1535	5.0%	175.00 [50.00, 300.00]
Siddiqui 2008	2,812	404	80	2,730	385	108	6.0%	82.00 [-32.50, 196.50]
Thompson 2005	2,805	579	366	2,723	573	268	9.6%	82.00 [-8.69, 172.69]
Tielsch 2009	2,819	453	646	2,715	420	8958	60.9%	104.00 [68.00, 140.00]
Total (95% CI)			**2215**			**11740**	**100.0%**	**96.58 [68.49, 124.67]**

Heterogeneity: $Chi^2 = 2.85$, $df = 4$ ($P = 0.58$); $I^2 = 0\%$

Test for overall effect: $Z = 6.74$ ($P < 0.00001$)



All estimates: +96.6g (68.5, 124.7)

Excluding self-reports +93.1g (64.6, 121.6)

CRA: Pope et al., 2010

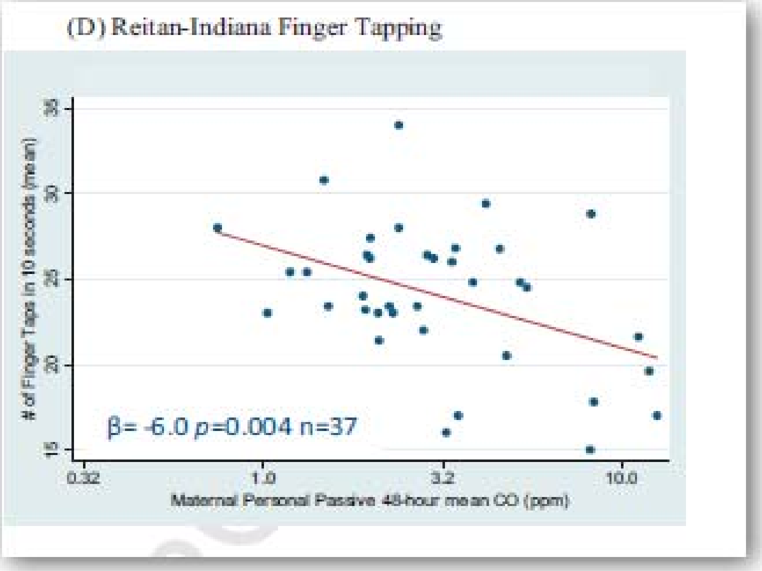
Contents lists available at SciVerse ScienceDirect

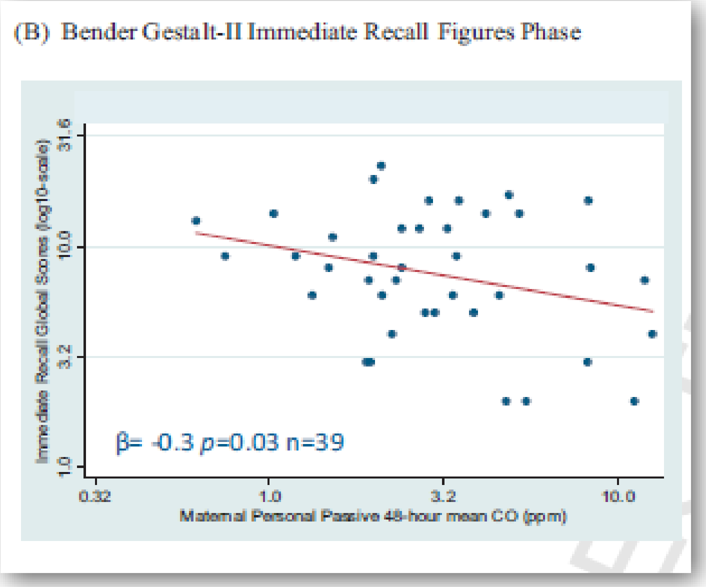
NeuroToxicology

Neurodevelopmental performance among school age children in rural Guatemala is associated with prenatal and postnatal exposure to carbon monoxide, a marker for exposure to woodsmoke

Linda Dix-Cooper[a], Brenda Eskenazi[b], Carolina Romero[c], John Balmes[a,d], Kirk R. Smith[a,*]

[a] Division of Environmental Health Sciences, School of Public Health, University of California, Berkeley, CA 94720-7360, USA
[b] Center for Environmental Research and Children's Health (CERCH), School of Public Health, University of California, Berkeley, CA, USA
[c] Centro de Estudios en Salud Universidad Del Valle, Guatemala
[d] Division of Occupational and Environmental Medicine, Department of Medicine, University of California, San Francisco, CA, USA



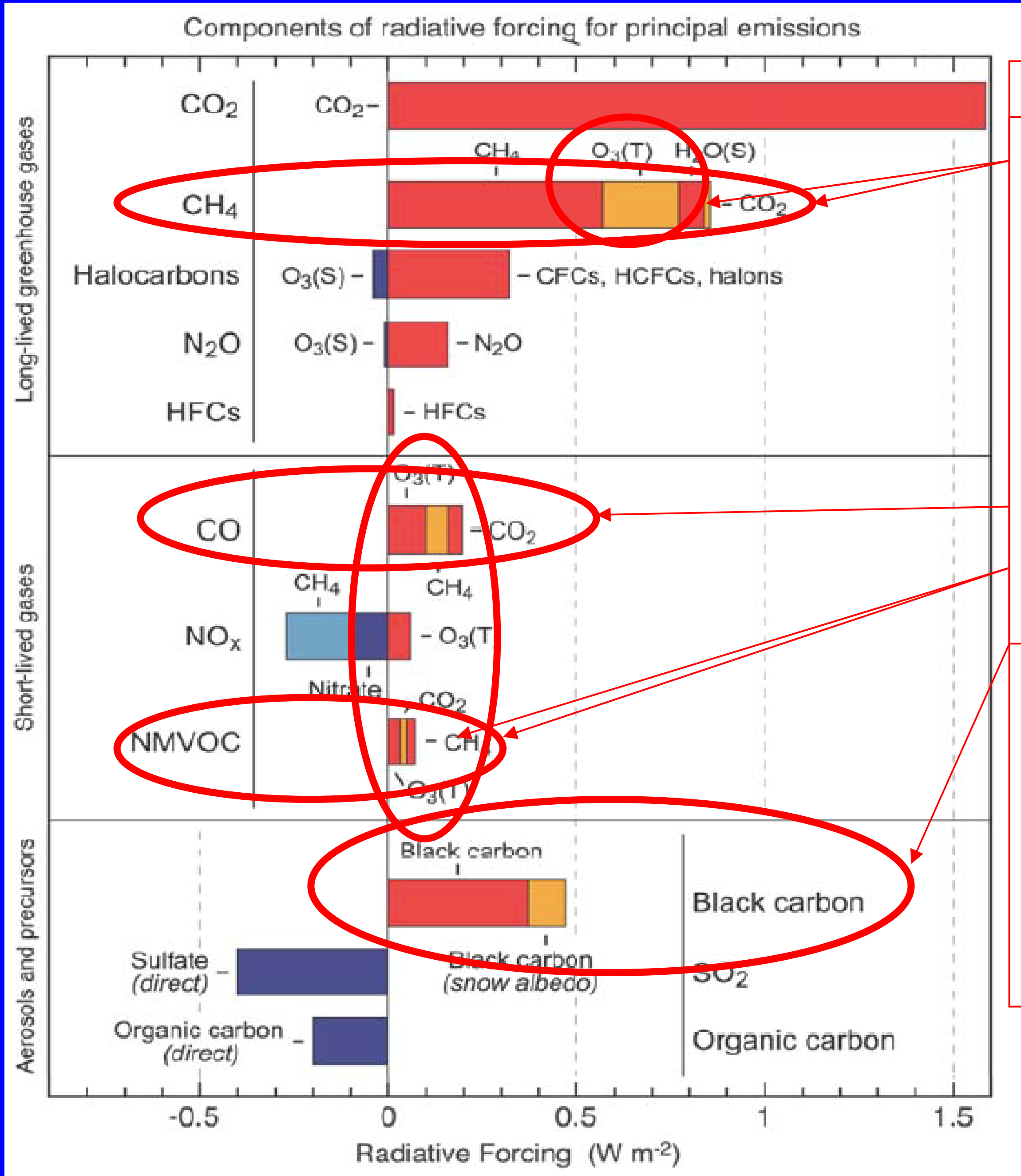


Bottom Lines

- 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.

What is the climate connection?

Global warming in 2005 due to all human emissions since 1750



CO_2 is important for climate,
Several of the non-CO_2,
but so are many other
greenhouse gases create
pollutants, including the ones
a good proportion of both
circled that, unlike CO_2, also
their climate forcing and
have significant health as
health damage through
well as climate impacts
the secondary pollutant,

tropospheric ozone

All come from incomplete combustion in households

IPCC, 2007

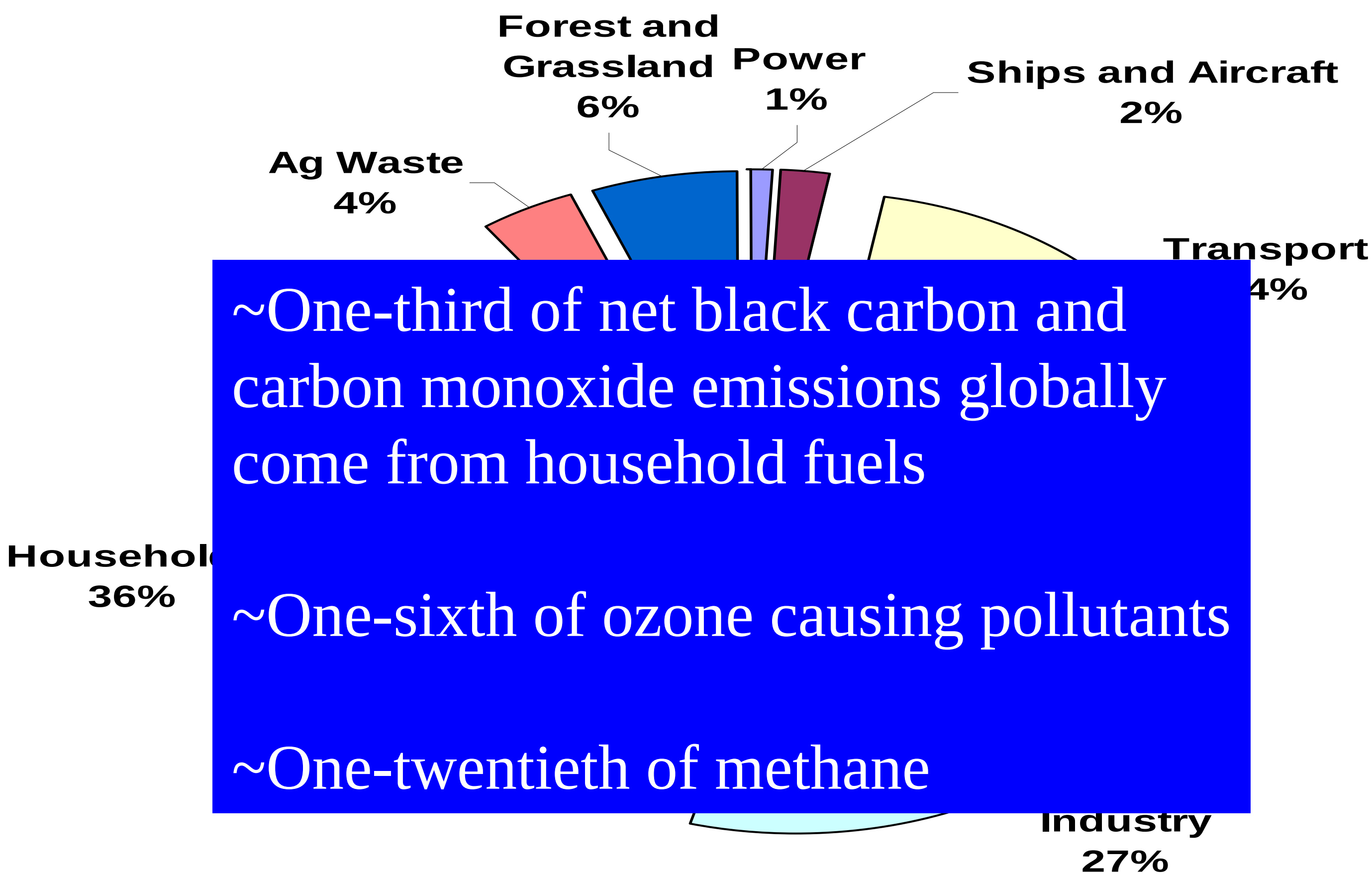
Household Fuels and Climate

- Climate impacts come from non-renewable biomass and coal, i.e., from net CO_2 emissions
- Poor combustion also leads to other emissions such as the relatively well-understood GHGs – methane and nitrous oxide – which are “Kyoto” GHGs
- In addition, a wide range of less well-understood short-lived GH-related emissions are emitted including
  - CO and black carbon – warming agents
  - Ozone precursors – warming But also cooling agents such as sulfates and organic carbon particles
- There are also indirect climate impacts of these pollutants including
  - Reducing carbon capture of forests by ozone damage
  - Darkening of snow/ice by black carbon

Controllable Global Warming from Black Carbon Emissions

Net of OC, Forcings from IPCC, 2007: 0.25 W/m^2

Inventory from T Bond Database, V 7.1.1 Feb 2009

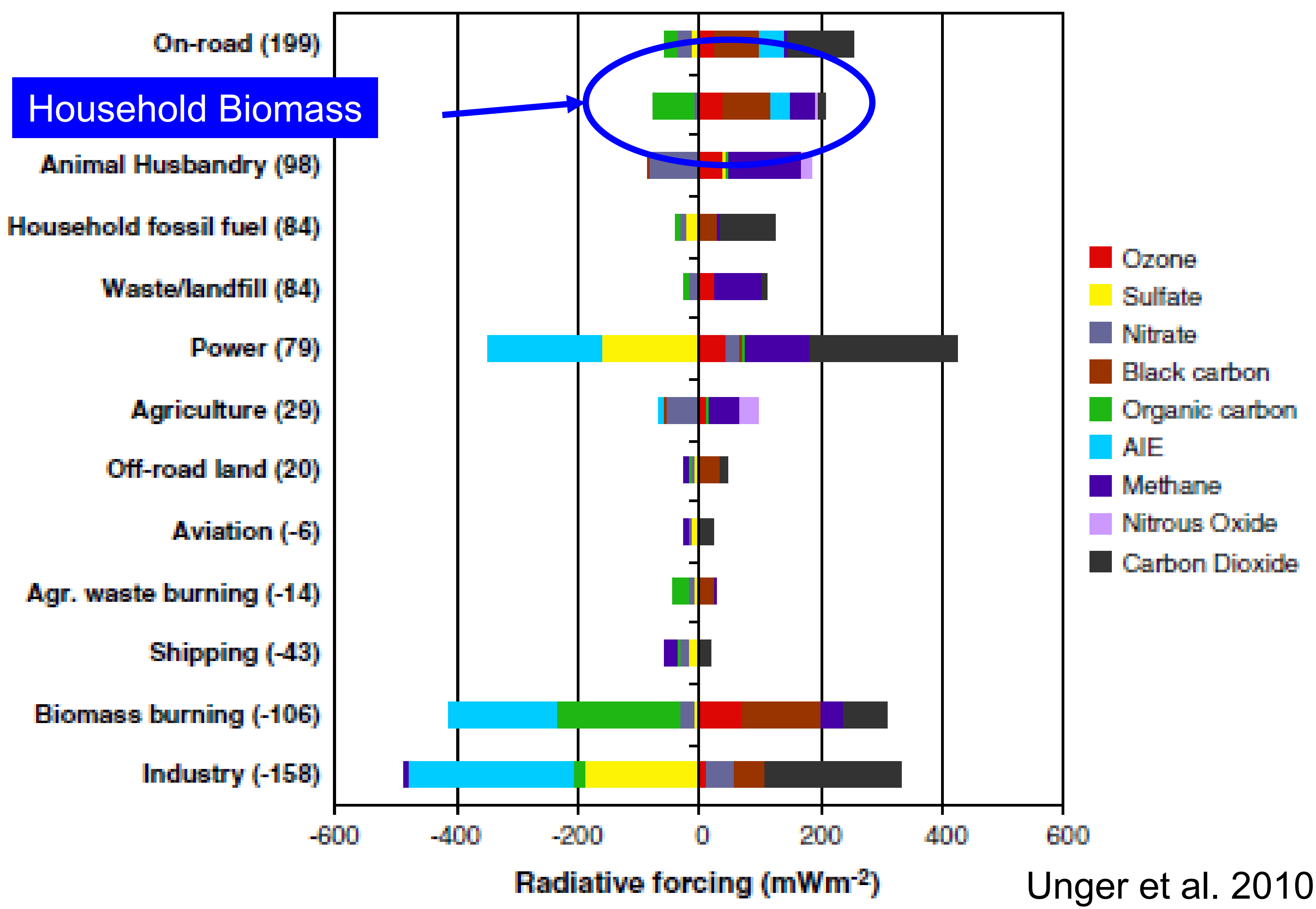


~One-third of net black carbon and carbon monoxide emissions globally come from household fuels

~One-sixth of ozone causing pollutants

~One-twentieth of methane

Climate Warming in 2020 Under Present Trends



Unger et al. 2010

Perfect Storm for Health Impacts

- Highly polluting activity
- Half of world households
- Several times a day
- Just when people are present
- Most vulnerable (women and young children) most likely to be there

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

Summary

- Worst thing to do is stick burning stuff in your mouth – 5+ million premature deaths
- Next worse is burning in your house – 2+ million deaths
- Next worse is having someone else nearby sticking in their mouth – 400k+ deaths
- Even bad to have on your planet – 2+ million deaths from outdoor air pollution
- And climate change risks
- Chimneys do not help the last two– need to stop producing the pollution at all.

Many thanks

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