Household Air Pollution: An Update from Latin America

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Tyler Laureate 2012
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Pan American Health Organization
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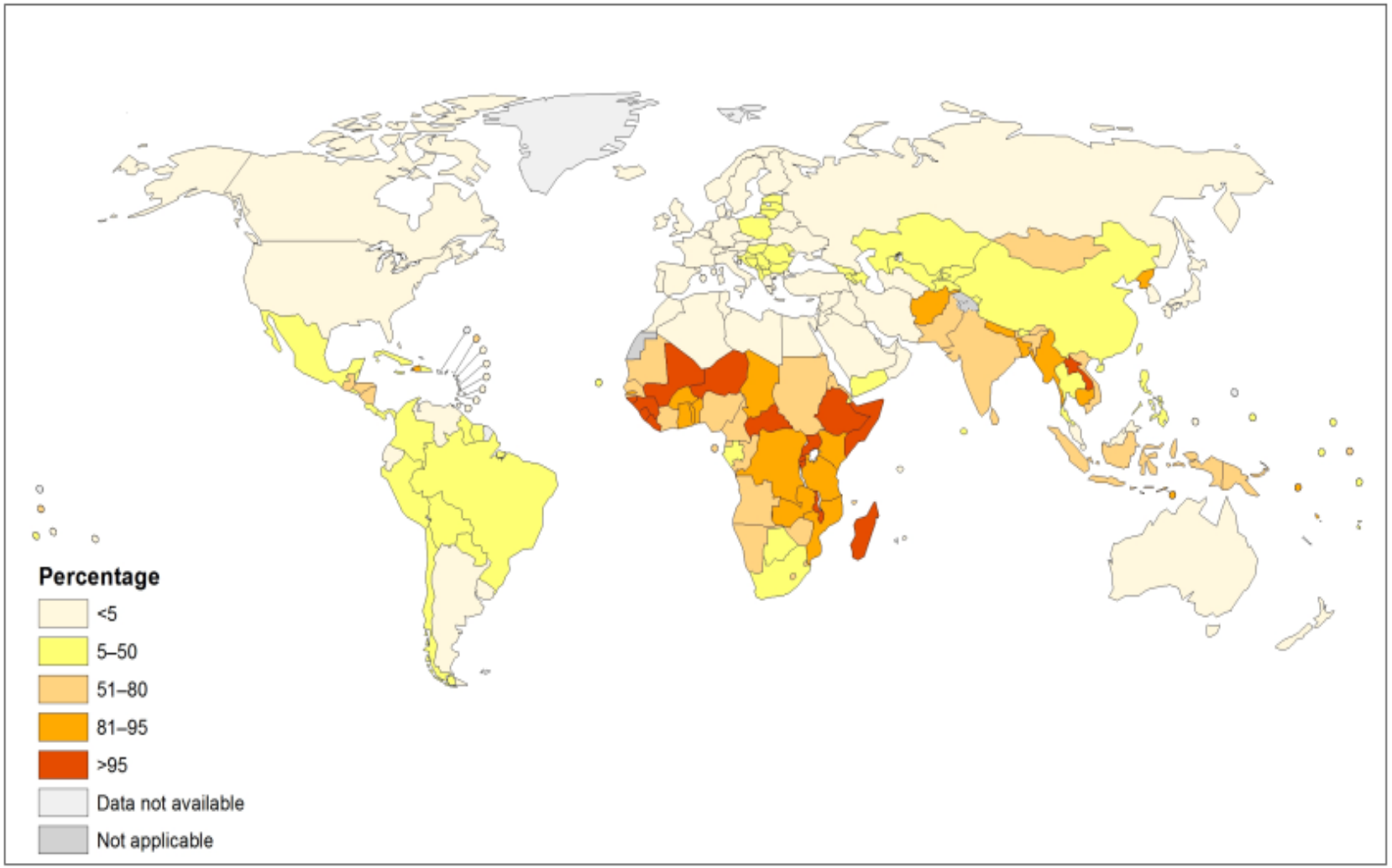
The three major solid fuels

Population using solid fuels (%), 2010
Total



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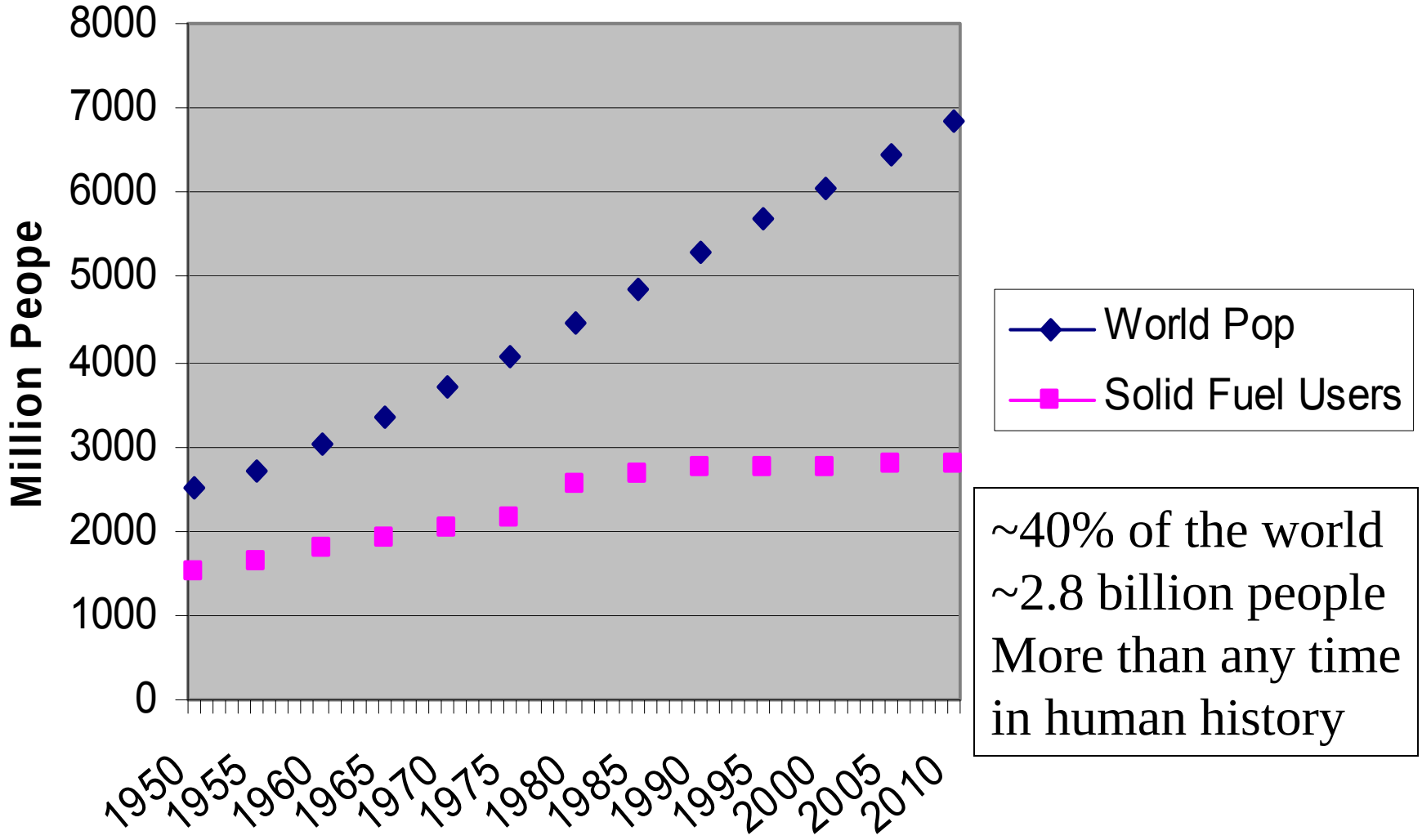
Data Source: World Health Organization
Map Production: Public Health Information and Geographic Information Systems (GIS)
World Health Organization

World Health Organization

2010 Biomass Use in Latin America

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

World Population Using Solid Fuels



~40% of the world
~2.8 billion people
More than any time in human history

Woodsmoke is natural – how can it hurt you?

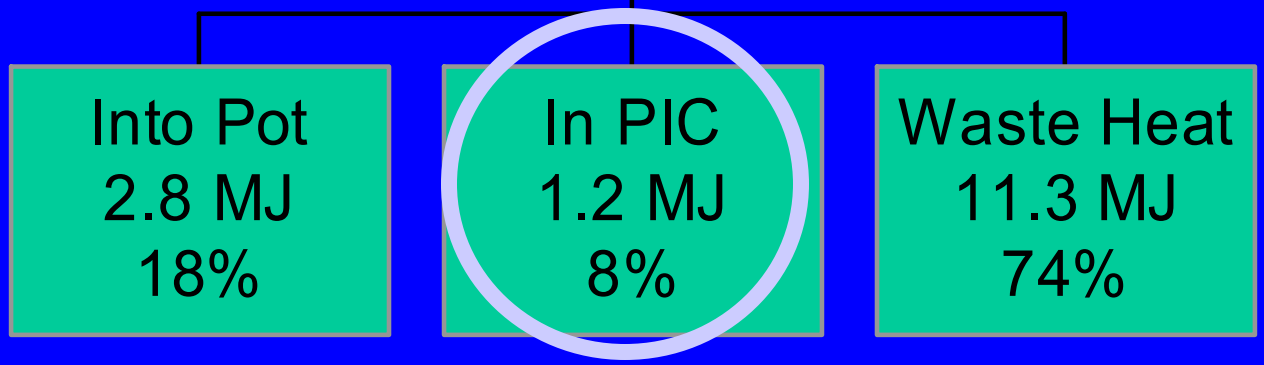
Or, since wood is mainly just carbon, hydrogen, and oxygen, doesn't it just change to CO_2 and H_2O when it is combined with oxygen (burned)?

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



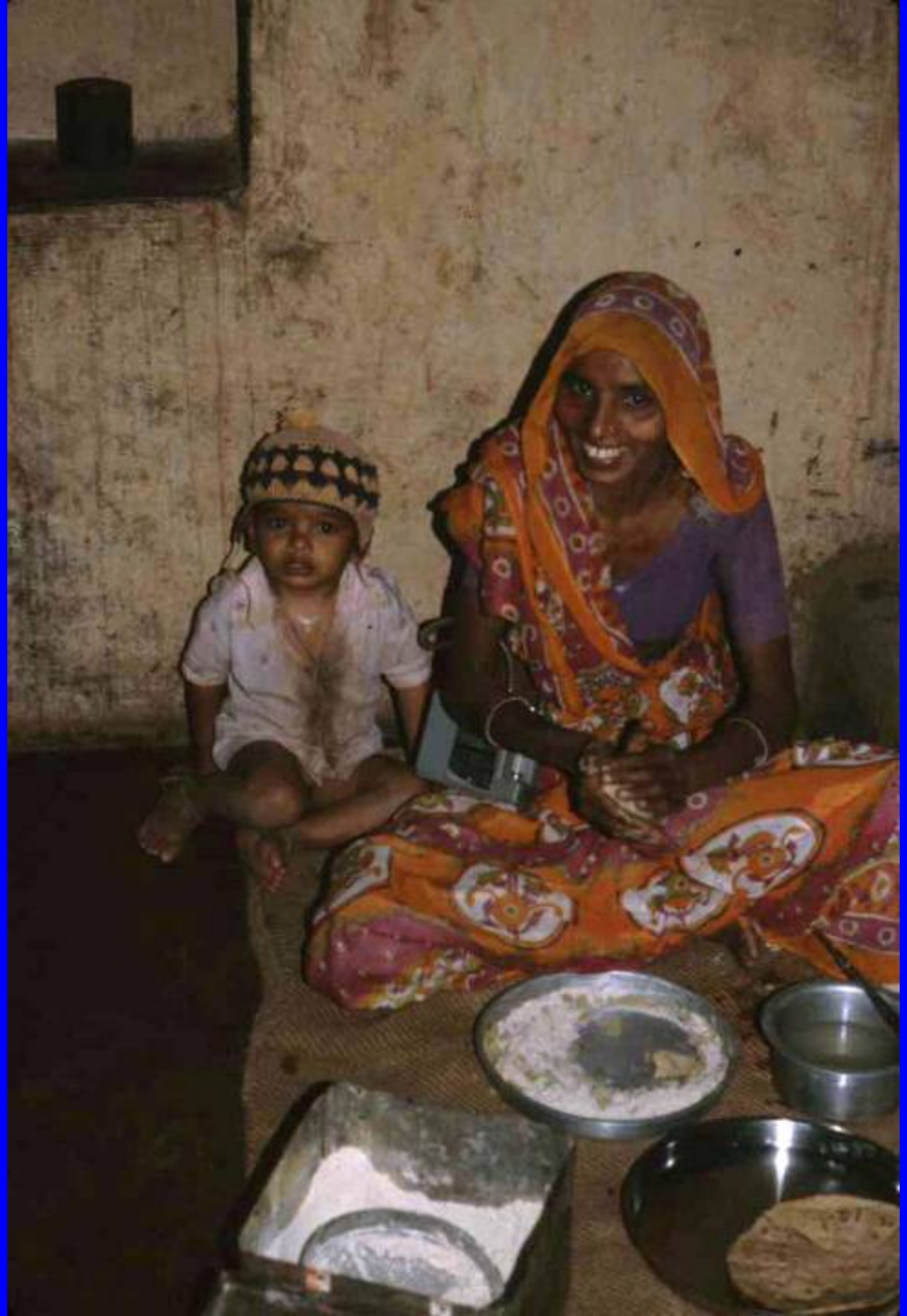
PIC = products of incomplete combustion = CO, HC, C, etc.

Source: Smith, et al., 2000

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

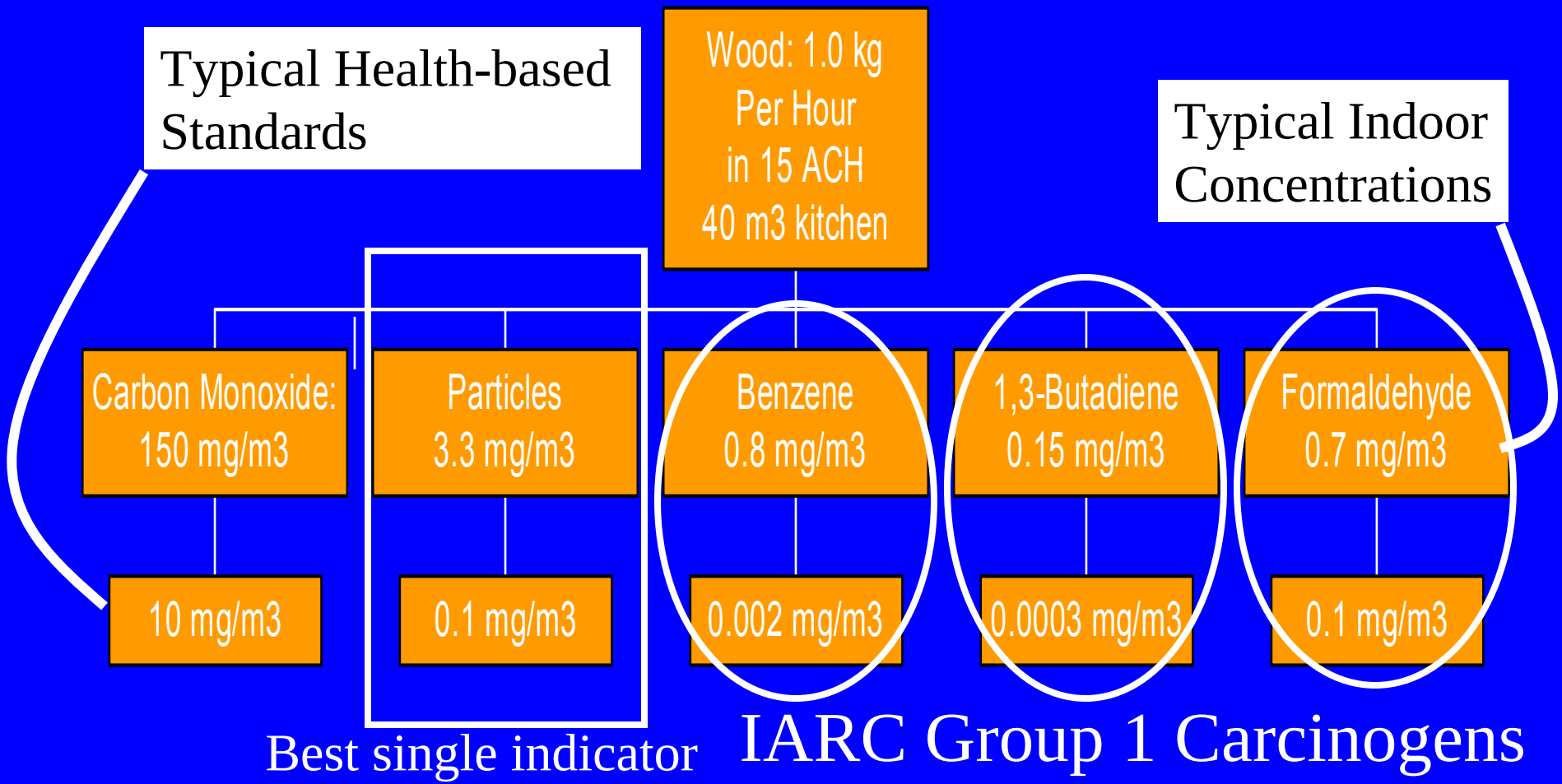
- Small particles, CO, NO_2
- Hydrocarbons
  - 25+ saturated hydrocarbons such as *n-hexane*
  - 40+ unsaturated hydrocarbons such as *1,3 butadiene*
  - 28+ mono-aromatics such as *benzene & styrene*
  - 20+ polycyclic aromatics such as *benzo(α)pyrene*
- Oxygenated organics
  - 20+ aldehydes including *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



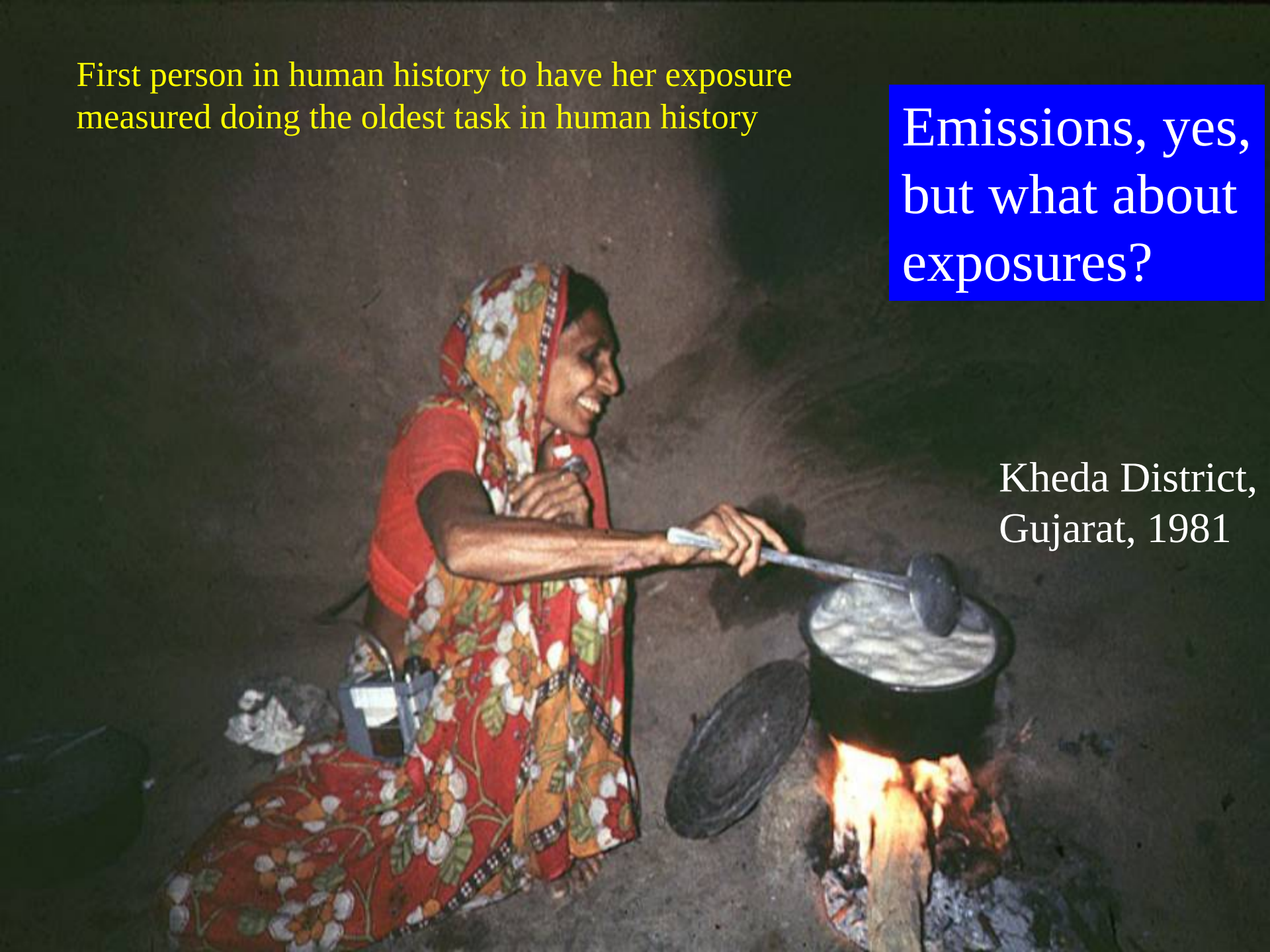
How much Ill-health?

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

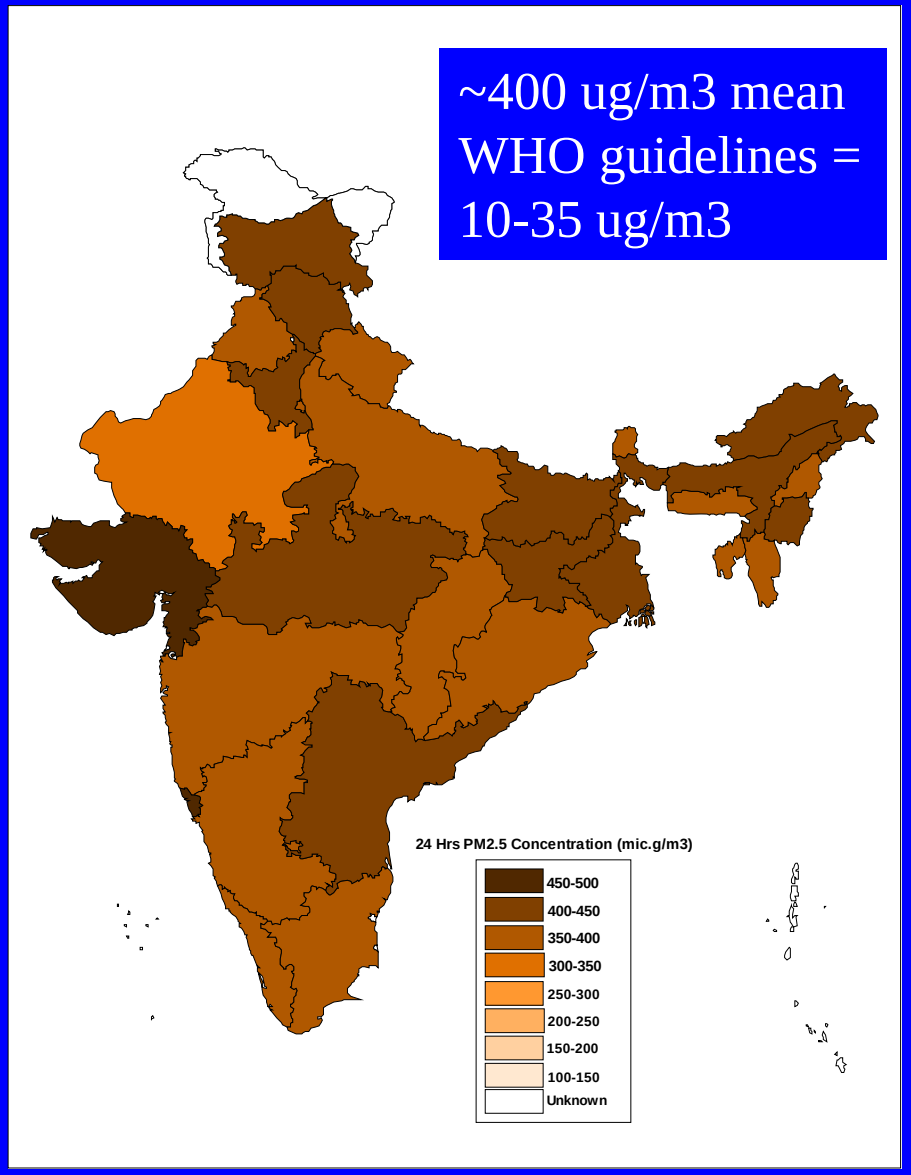
Emissions, yes, but what about exposures?



Kheda District, Gujarat, 1981

Preliminary results from the Household Air Pollution Comparative Risk Assessment for the year 2010

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



ALRI/
Pneumonia

Diseases for which we have epidemiological studies

COPD

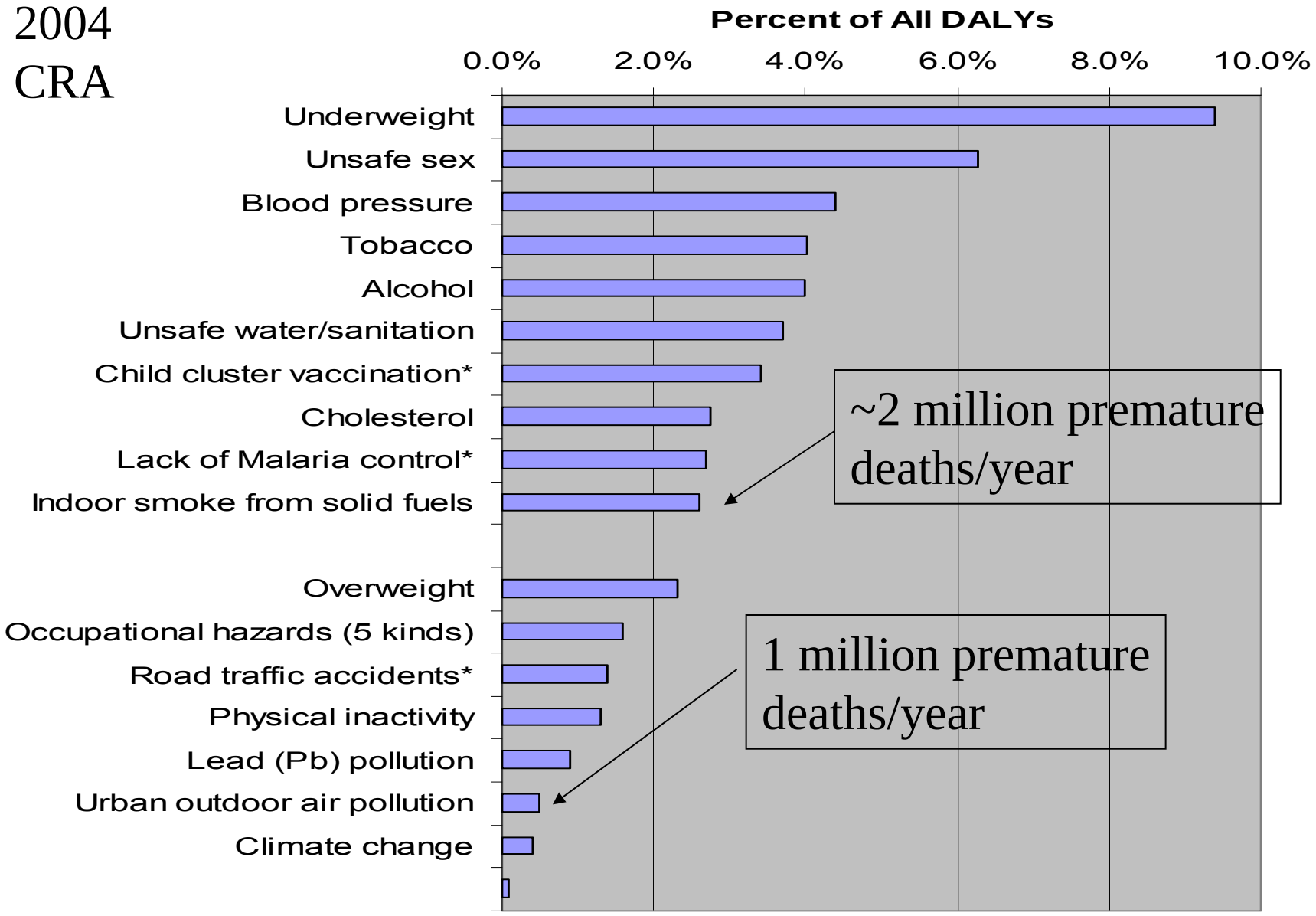
Lung cancer
(coal)

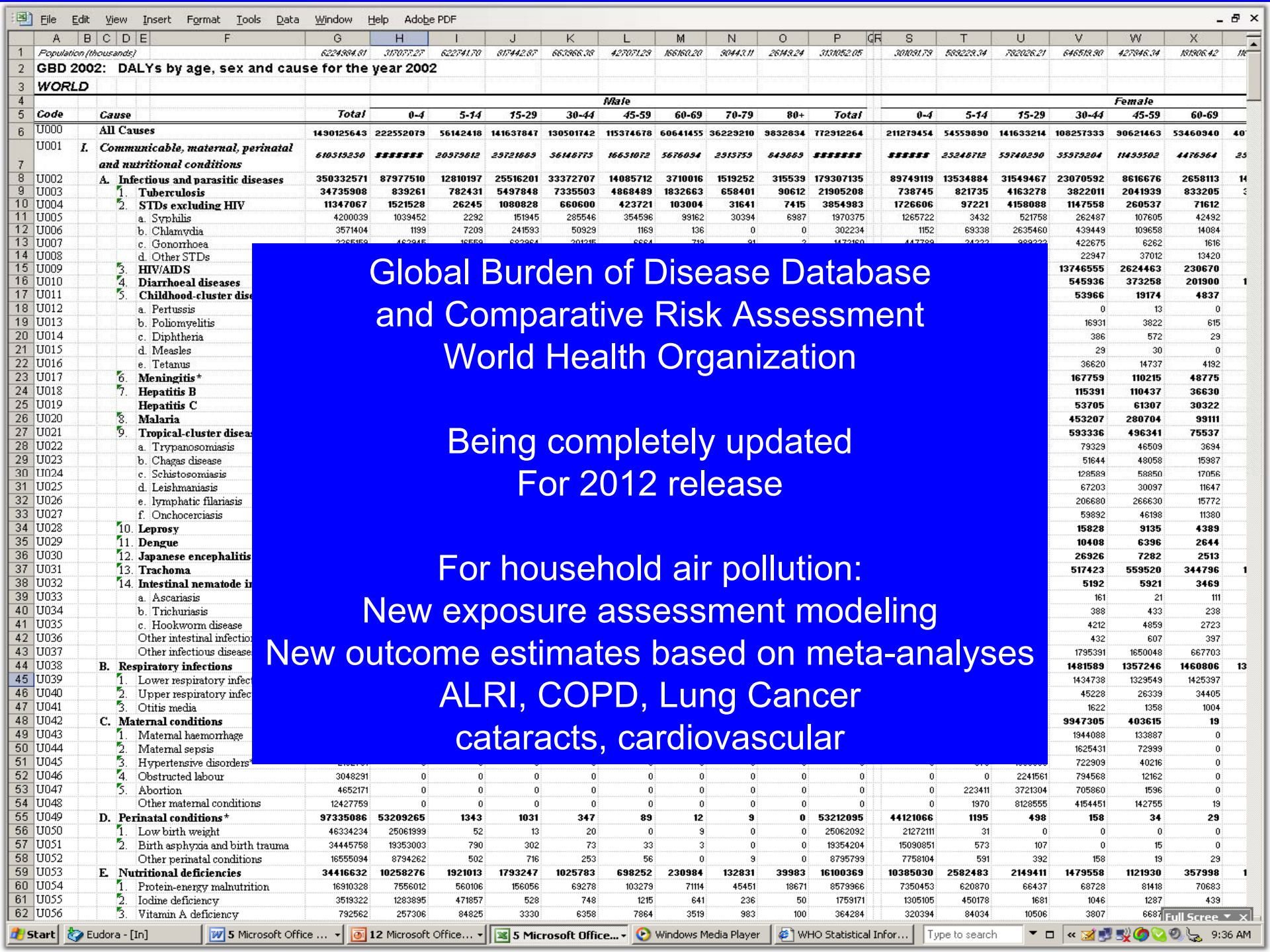
These three diseases were included in the 2004 Comparative Risk Assessment Managed and published by WHO

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




Global Burden of Disease Database
and Comparative Risk Assessment
World Health Organization
Being completely updated
For 2012 release
For household air pollution:
New exposure assessment modeling
New outcome estimates based on meta-analyses
ALRI, COPD, Lung Cancer
cataracts, cardiovascular

ALRI/
Pneumonia

Low birth
weight

Stillbirth

Diseases for which we have epidemiological studies

COPD

Lung cancer
(coal)

Lung cancer
(biomass)

Blindness
(cataracts, opacity)

Heart disease
Blood pressure
ST-segment

These additional diseases will be included in the 2010 Comparative Risk Assessment (to be released in 2012)

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 2010 Comparative Risk Assessment

Burns and the health/safety impacts of fuel gathering

Cognitive Impairment

Birth defects

Asthma?

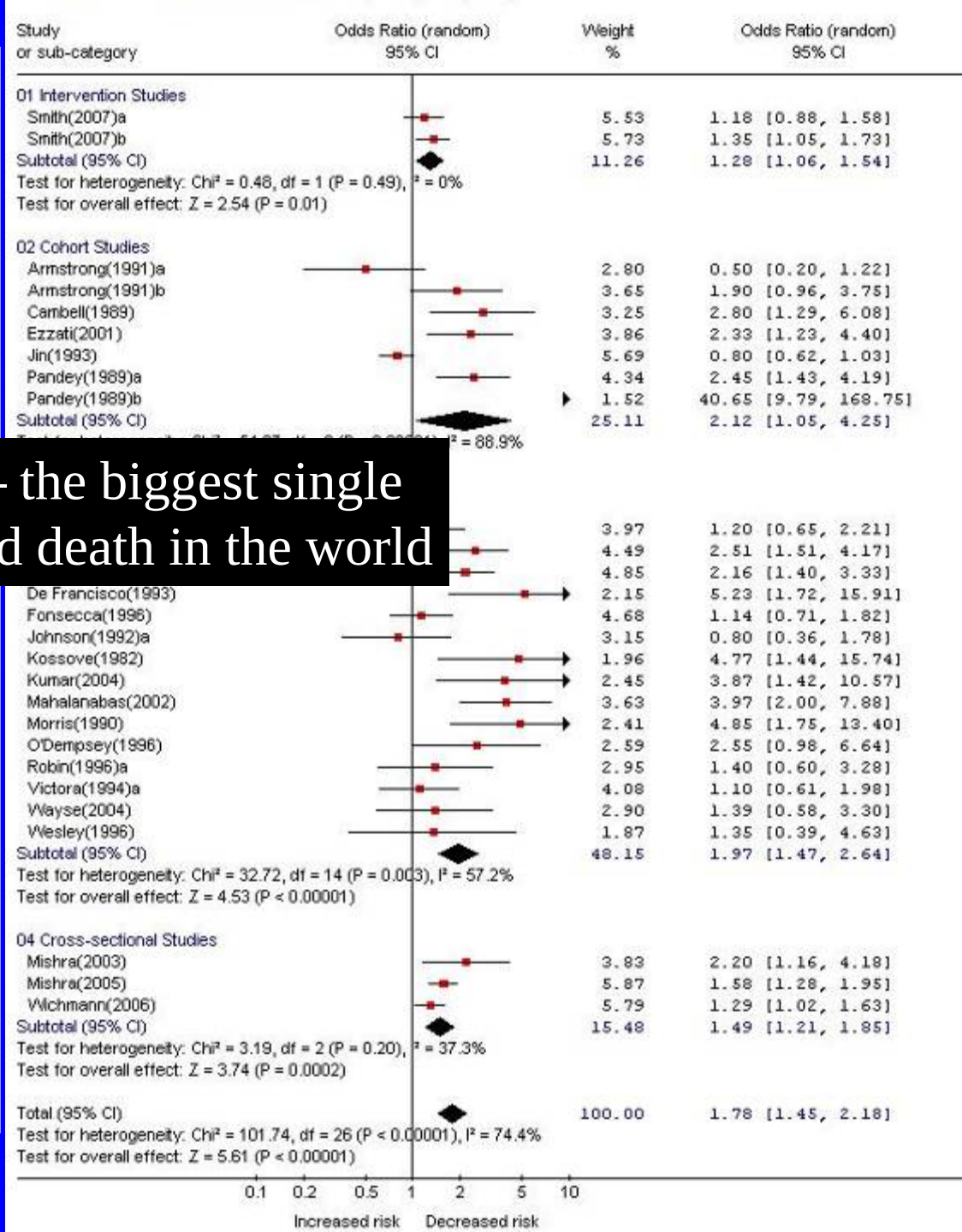
Tuberculosis

ALRI

Other cancers (cervical, NP, upper airway)

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

Dherani et al Bull WHO (2008)



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

Story of Two Conferences

- Air pollution conference
  - High exposures to large vulnerable population
  - We know there are health effects at 20x lower levels
  - No more health effects work needed
- International health conference
  - Extreme scarcity of resources
  - Need to know exact benefit to be expected
  - Still some doubt about causality
  - Where are your randomized controlled trials?

History of an RCT

- ~1980: Case reports of health effects in South Asia
- 1981: First measurements of pollution levels in India
- 1984: International meeting to decide on needed research
  - Chose randomized controlled trial (RCT) of ALRI
- 1986-89: Unfunded proposals to do RCT in Nepal
- 1990: WHO establishes committee to find best sites
- 1990-1992: Criteria established and site visits made
- 1992: Highland Guatemala chosen
- 1991-1999: Pilot studies to establish data needed for proposal – does stove work and do people use it?
- 1996-1999: Unfunded proposals
- 2001: NIEHS funding secured
- 2002-2006: Fieldwork completed
- 2011: Main results published
- 25+ years from deciding to conduct RCT to results!

Criteria for Choosing RCT Site

- High child mortality
- Lots of ALRI
- Lots of smoke
- Locally available intervention that reduces exposure
- Intervention popular in local population
- Good local partners for running field studies
- 3 sites each in Asia, Africa, and Latin America were considered – including site visits

Partners in Guatemala

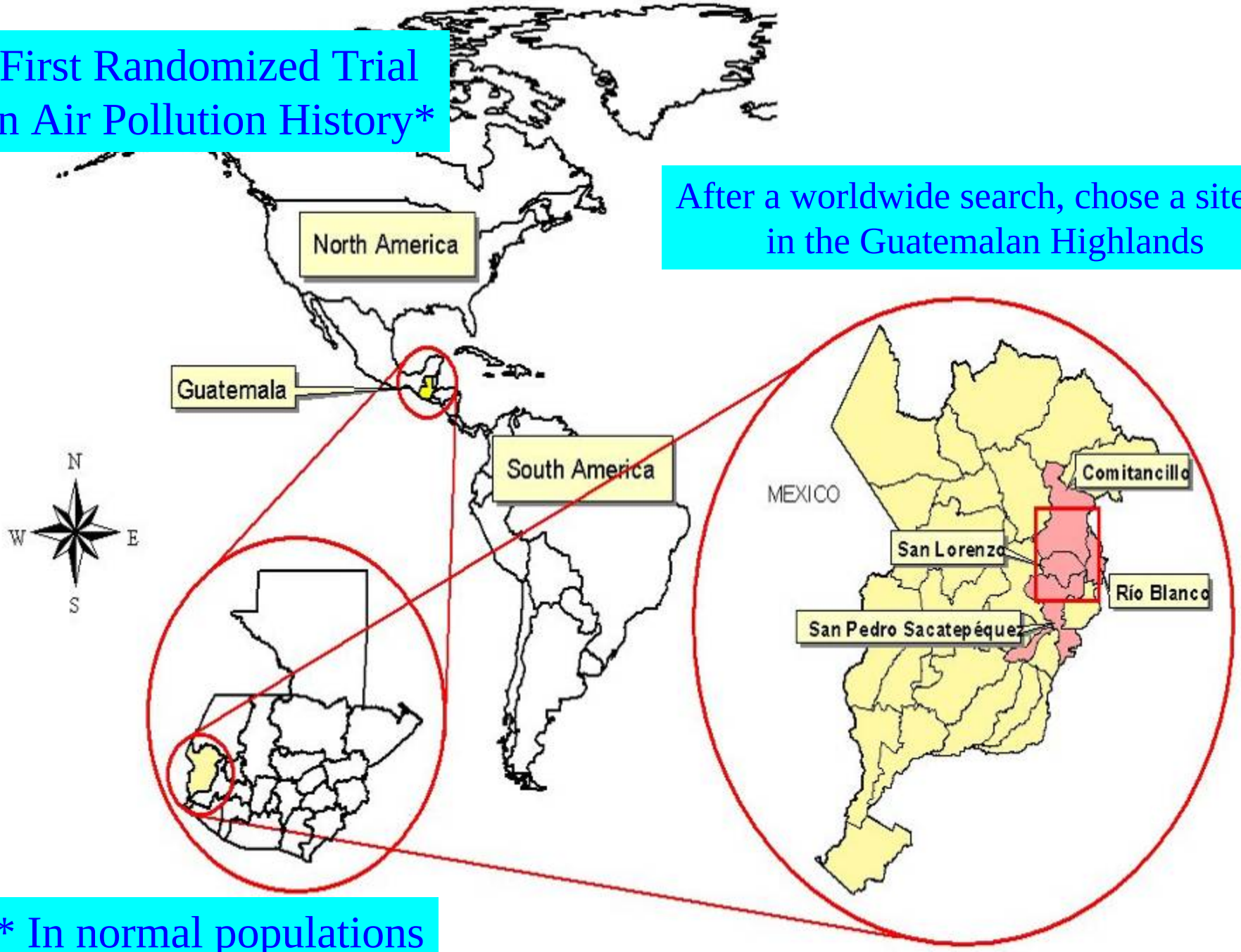
- For pilot studies 1992-1999, partner was INCAP
- Since 2000, partner has been Centro de Estudios en Salud (CES) of the Universidad del Valle de Guatemala
- Much non-financial support has come from the Ministry of Health, San Marcos Municipality

International Partners

- University of Liverpool
- WHO, Geneva – RSV studies
- University of Bergen, Norway – adult respiratory health studies
- Harvard University – heart studies

First Randomized Trial In Air Pollution History*

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



* In normal populations

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):

- Objectives: impact of household air pollution reduction on pneumonia incidence in children ≤18 months
  - Primary: intention to treat (ITT) analysis
  - Secondary: exposure-response analysis
- Rural, highland Guatemala, alt. 2200 – 3000 m
- Poor indigenous (Mayan) rural population using open woodfires for cooking
- 518 homes (pregnant woman, child <4 months) using open fire
- Randomized (blocks) to (i) keep open fire or (ii) use chimney wood stove
- Children followed to 18 months: 30,000 child-weeks
- Home-based active surveillance for pneumonia cases
- MD-diagnosis in community centers, blind to stove status
- Repeated individual exposure measurement

RESPIRE

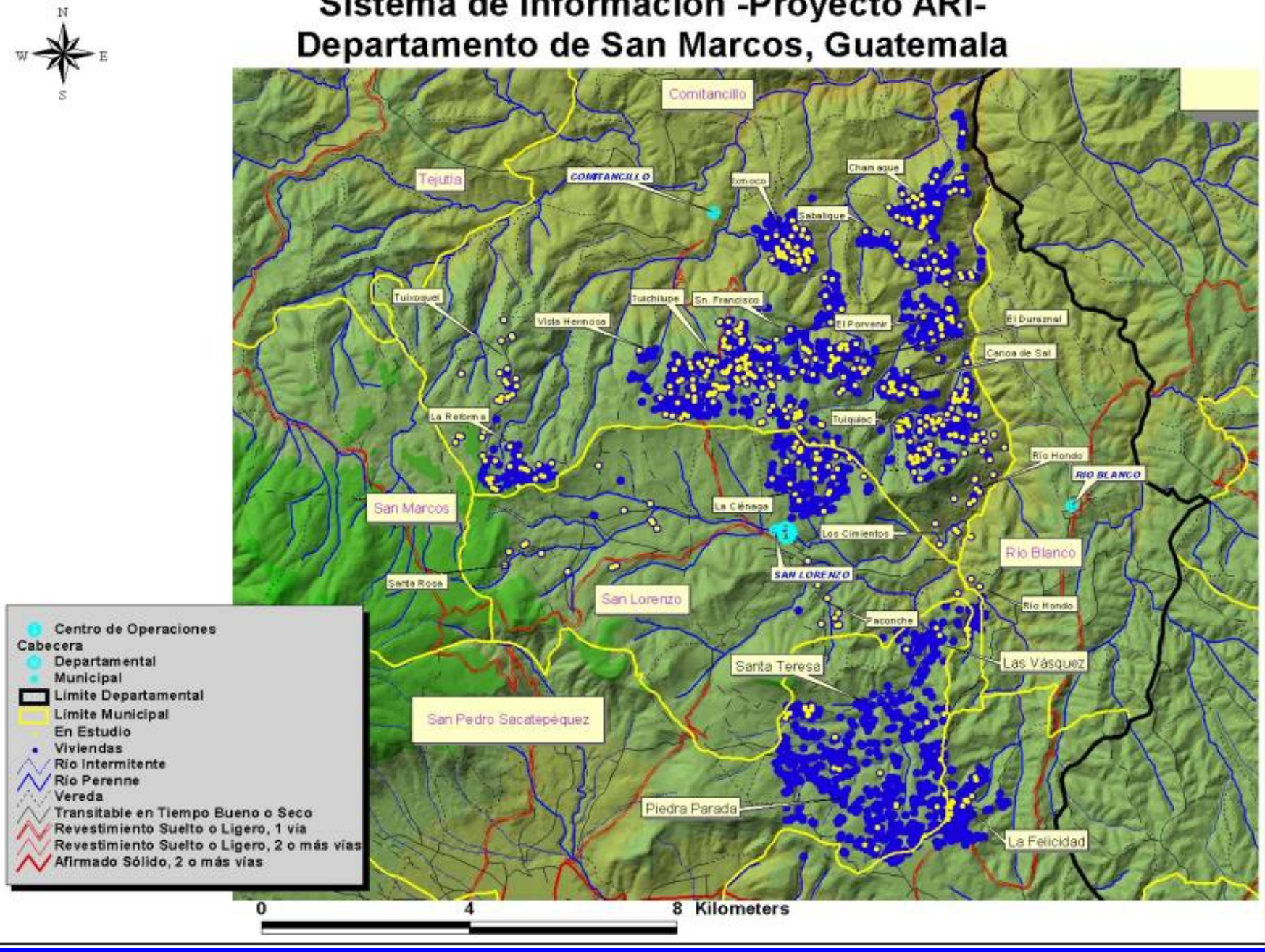
Impact on pneumonia up to 18 months of age

Traditional open 3-stone fire: kitchen 48-hour $PM_{2.5}$ levels of 600 - 1000 µg/m^3

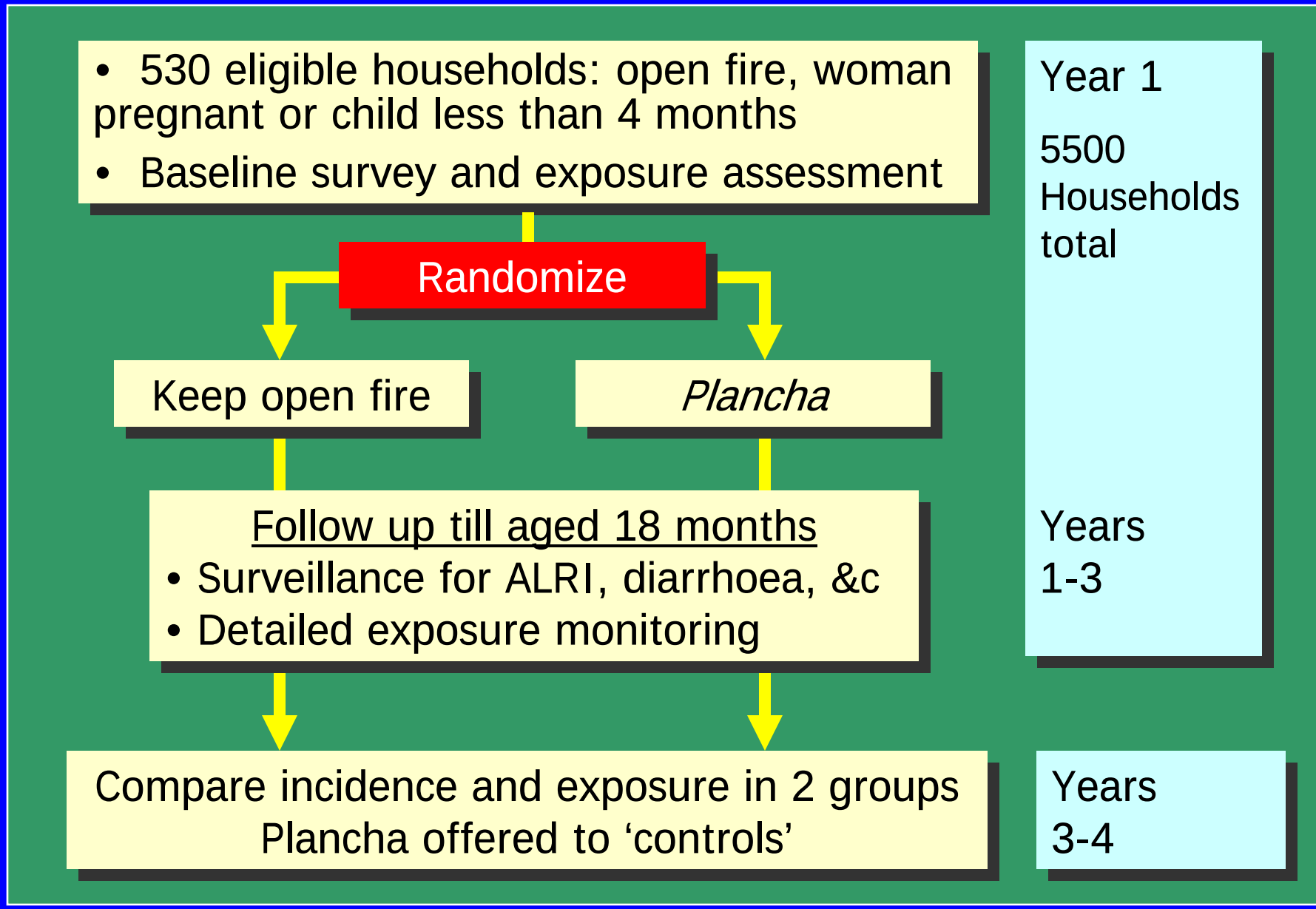
WHO AQG = 10-35 ug/m3

Chimney woodstove, locally made and popular with households

Sistema de Información -Proyecto ARI-
Departamento de San Marcos, Guatemala



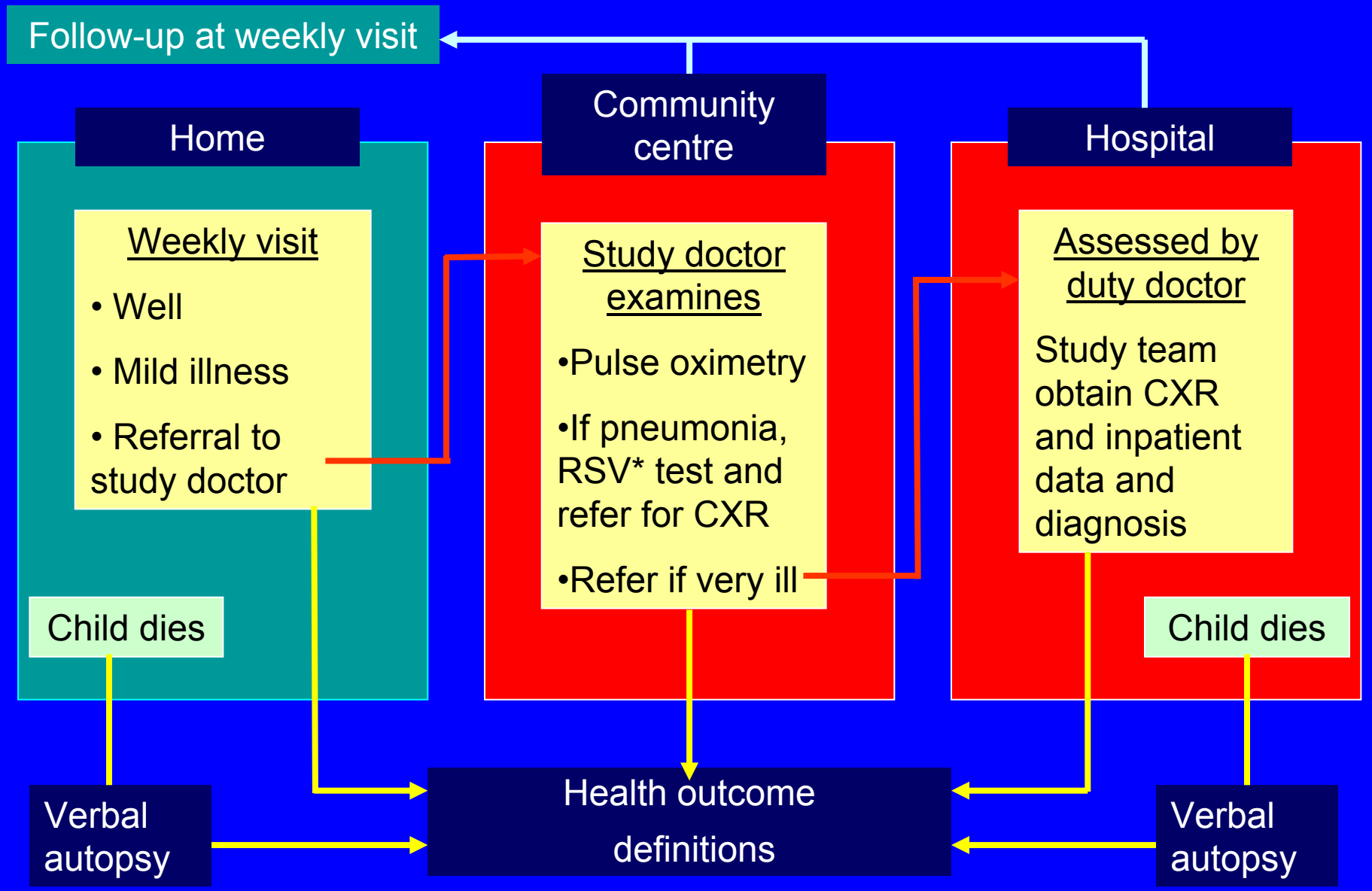
Overview of RESPIRE study design



Randomisation: balance of groups at baseline

Variable	Control	Intervention
Socio-demographic factors		
Mother's Age (years)	27.0	26.4
Pregnant at recruitment (%)	48.3	51.3
Own home (%)	92.8	94.1
Migrates part of year (%)	17.7	17.1
House structure		
Separate enclosed cooking area (%)	76.2	74.3
Completely open eaves (%)	42.7	40.6
Walls – adobe (mud) (%)	88.7	90.7
Roof – metal (%)	77.4	74.3
Floor – earth (%)	92.5	88.8
Leaks in roof (water) (%)	24.5	33.3
Electricity (%)	70.8	69.3
Other sources of smoke		
Other fire near house (%)	14.6	14.4
Smoking (tobacco) indoors (%)	26.8	20.4
Use traditional sauna bath (%)	84.5	87.8
Geographic		
Mean altitude (metres)	2613	2601

Overview of child health outcomes assessment



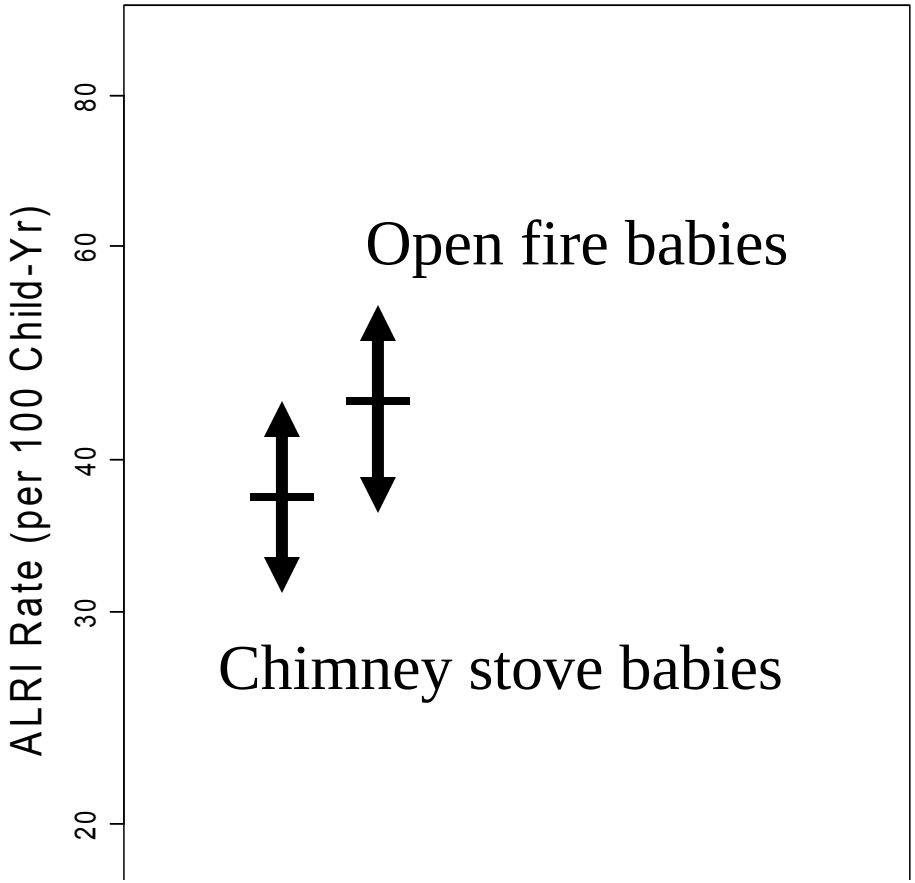
* Respiratory syncitial virus

Overview of weekly visits

		Plancha	Control
Number of children		265	253
Weekly visits	Total possible in follow up period	16,446	15,664
	Completed	14,756	14,369
% of possible weekly visits completed		89.7%	91.7%*
Mean (SD, range) visits per child		55.7 (17.8; 1 to 80)	56.8 (17.3; 2 to 81)
Number (%) children - no missed visit		17 (6.4%)	19 (7.5%)
Withdrawals		19 (7.2%)	14 (5.5%)

* $P < 0.001$

MD-diagnosed Acute Lower Respiratory Infection



RESPIRE-
Guatemala

0.78 (0.59, 1.06)	0.095

Fieldworker assessed outcomes:
ITT: 50% mean reduction in child exposure

Upper Respiratory	RR	95% CI	P-value
Cases	1.01	0.87, 1.17	0.88
Number of weeks	0.99	0.87, 1.12	0.87
ALRI ('WHO Pneumonia')	RR	95% CI	P-value
New cases: all	0.91	0.74, 1.13	0.39
New cases: severe**	**0.56**	**0.32, 0.97**	**0.04**

* Excludes evidence of pneumonia based on FW and physician assessment

** Severe: ill with cough or difficulty breathing and chest wall indrawing and/or unable to drink / breast feed

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**

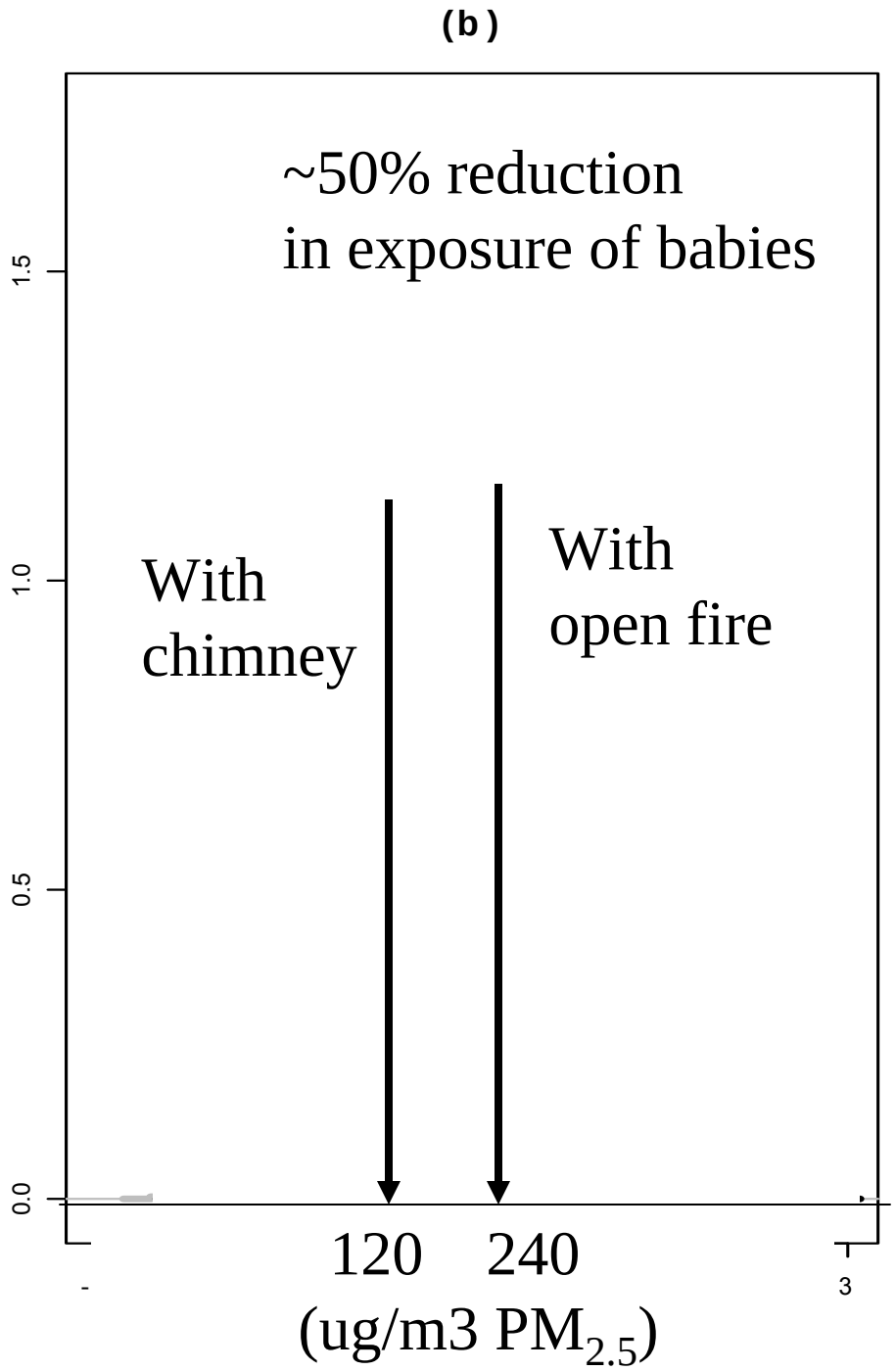
*Likely bacterial pneumonia


CO monitor
CO monitor

Unpublished results from RESPIRE have been removed

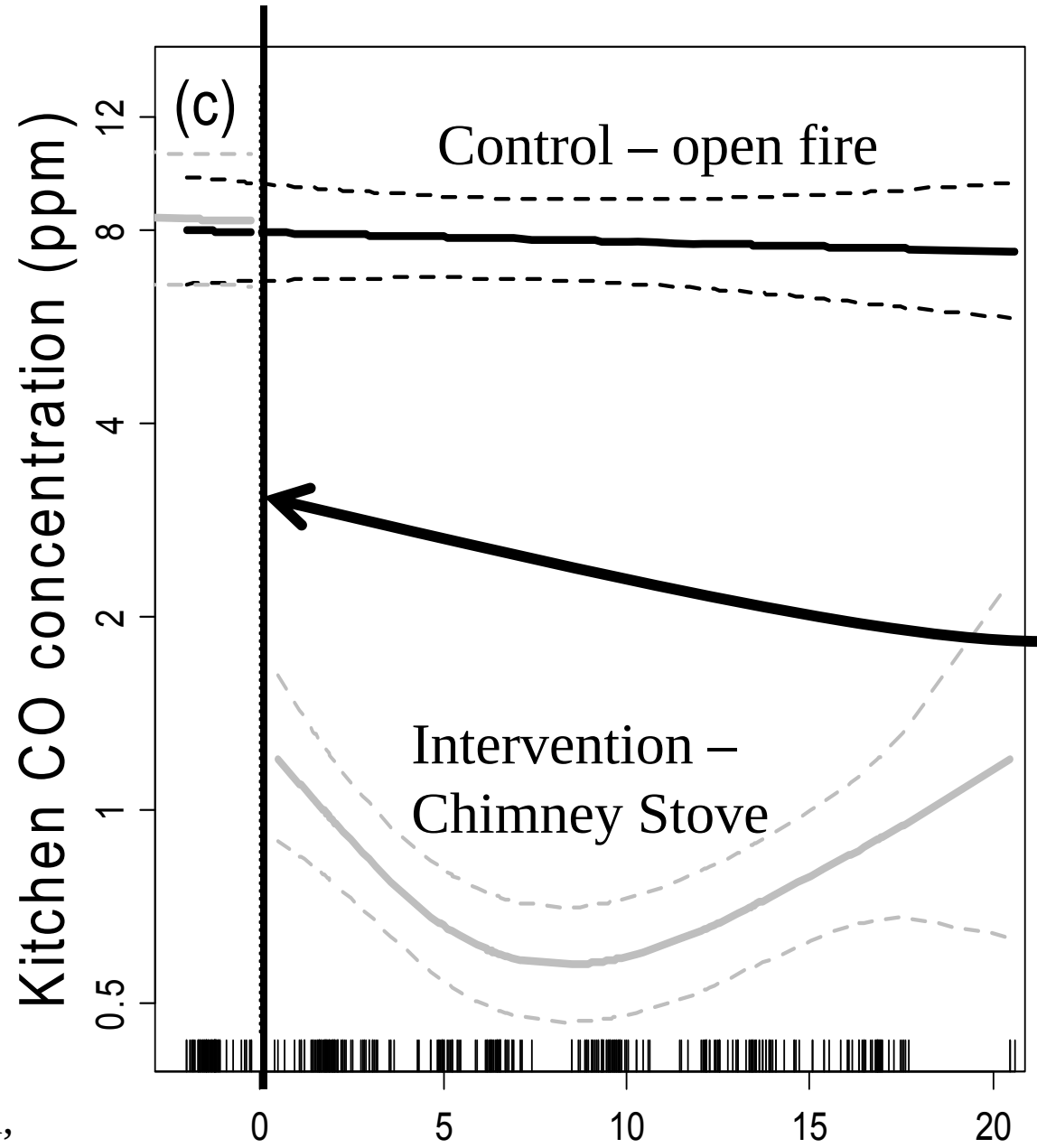
Watch the website below where they will be posted as soon as they are published.

http://ehs.sph.berkeley.edu/krsmith



Chimney stove did not protect all babies

Guatemala RCT: Kitchen Concentrations



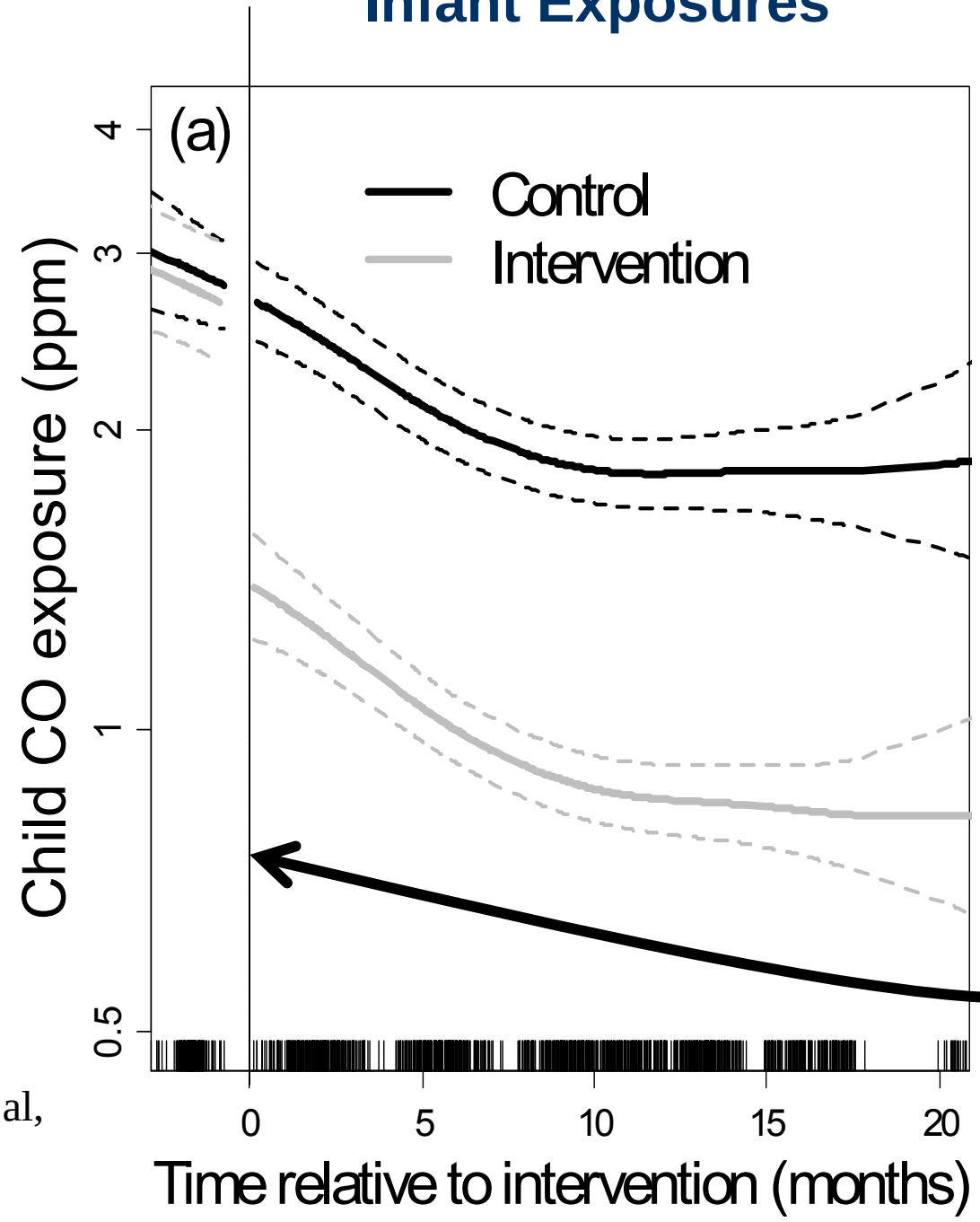
Effect of Chimney Stove On Kitchen CO Levels

Factor of ~10 less

285 48-h measurements

Smith, et al, 2010

Infant Exposures



1888 48-h measurements

Effect of Chimney Stove On Infant Exposures - 2x less

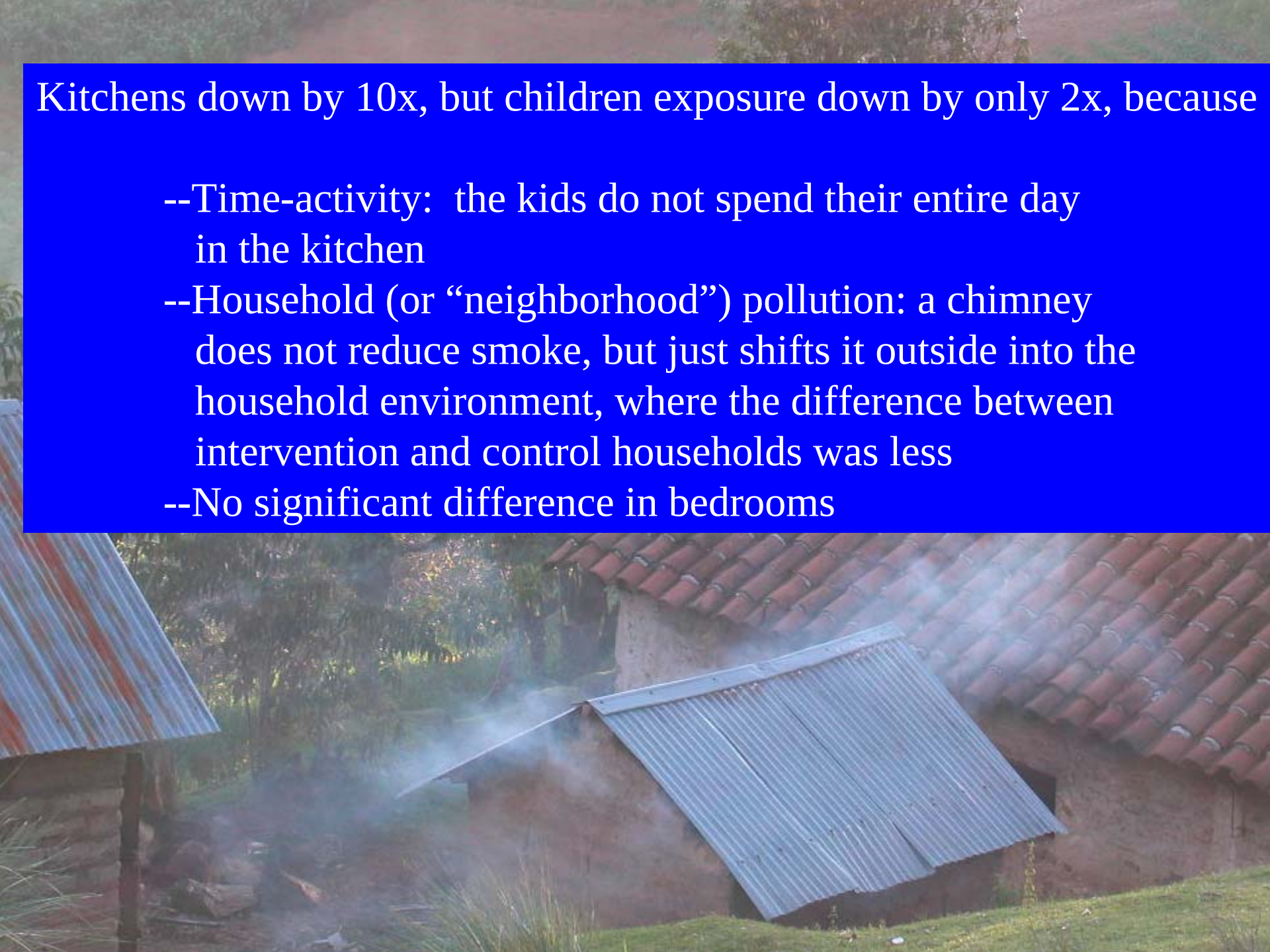
Smith, et al, 2010

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



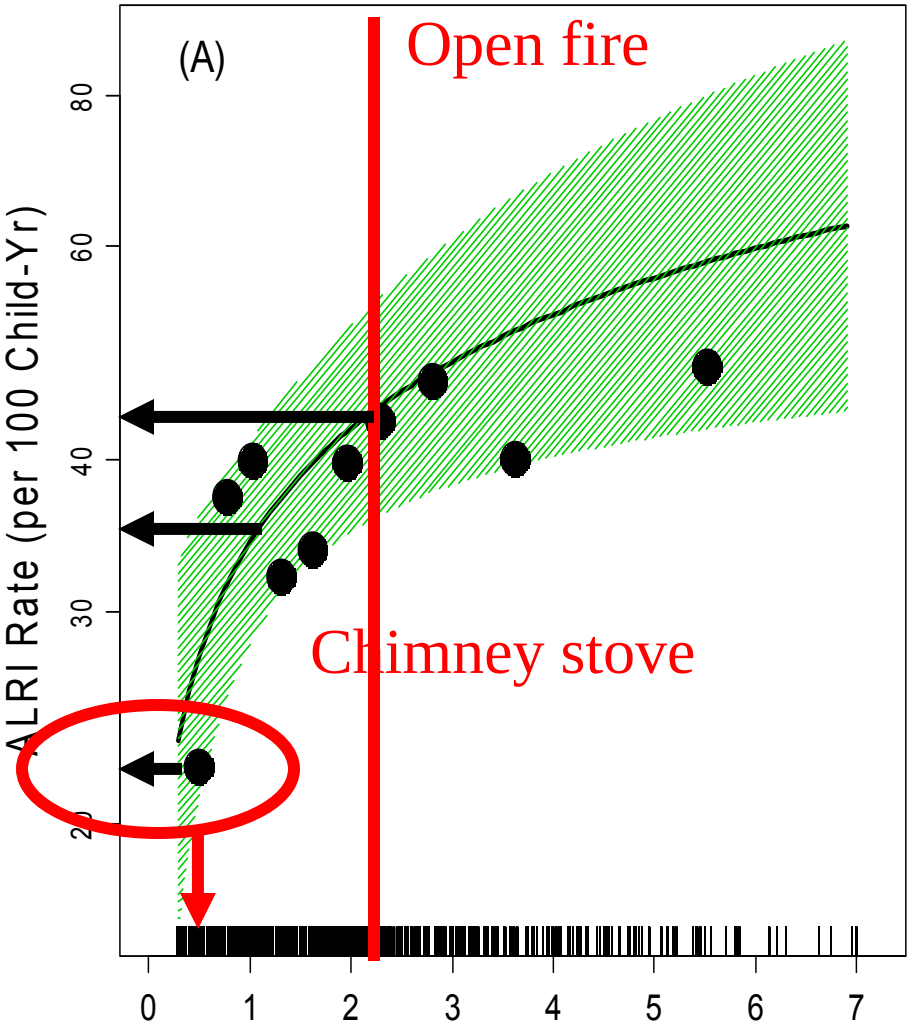
RESPIRE Summary

- Results - ITT
  - Chimney stove did not reduce all MD pneumonia,
  - But did reduce severe MD pneumonia and
  - RSV-negative (bacterial pneumonia)
  - Even though well operating, chimney was not capable of sufficient exposure reduction by itself
- Results – Exposure-response
  - All major outcome showed significant results (still not RSV pneumonia)
  - Partial exposure reduction brings some benefit, but exposure-response curve highly non-linear
  - Large reductions needed for substantial health benefits – levels not possible with chimneys

Bottom lines

- Chimney stove did not protect against MD-diagnosed pneumonia – strict RCT interpretation
- But did protect against severe pnuemonia
- Smoke is a major risk factor for child pneumonia, probably mostly for the bacterial form
- Reasons for apparent difference:
  - RSV cases showed no effect, sample size effectively reduced
  - Effect is mostly in severe cases
  - Intervention status left much exposure misclassification

MD-diagnosed Acute Lower Respiratory Infection



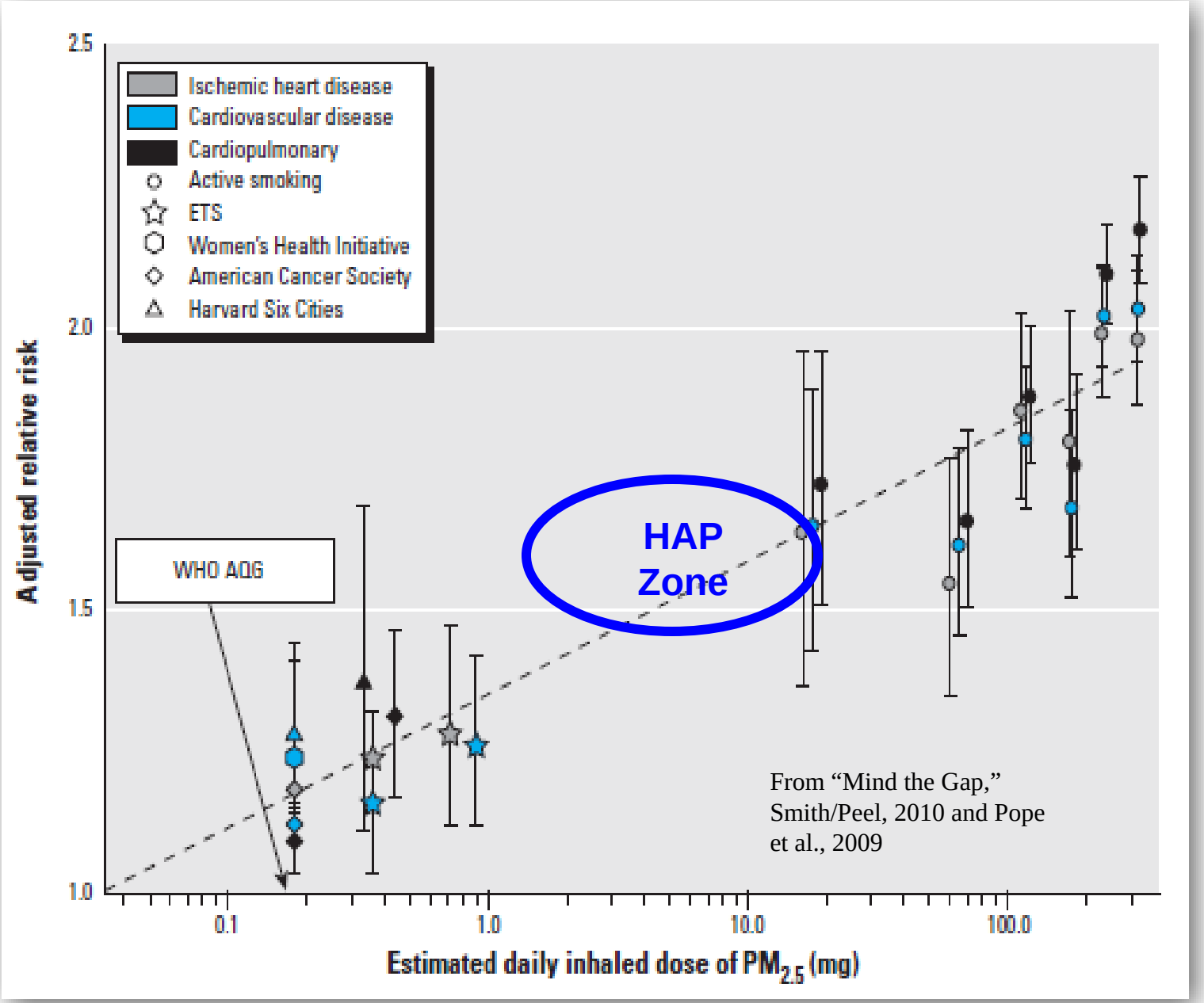
Where we Want to Be!

RESPIRE-Guatemala

Combustion Particles

The Generalized Exposure Response (GER)

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

Table 3. Crude and adjusted between-group differences in SBP and DBP (mm Hg) associated with *plancha* compared with open fire use during the trial period.

	No. of subjects (measures)		Crude mean difference			Adjusted mean difference[a]		
	Control group	Intervention group	Estimate	95% CI	*p*-Value	Estimate	95% CI	*p*-Value
SBP	71 (111)	49 (115)	–2.3	–6.6 to 2.0	0.30	–3.7	–8.1 to 0.6	0.10
DBP	71 (111)	49 (115)	–2.2	–4.7 to 0.3	0.09	–3.0	–5.7 to –0.4	0.02

Between group analysis

Table 4. Crude and adjusted within-subject differences in SBP and DBP (mm Hg) after the *plancha* echo-intervention compared with before.

	No. of subjects (measures)		Crude mean difference			Adjusted mean difference[a]		
	Trial period	Echo-intervention	Estimate	95% CI	*p*-Value	Estimate	95% CI	*p*-Value
SBP	55 (88)	55 (65)	–3.7	–6.0 to –1.4	0.002	–3.1	–5.3 to –0.8	0.01
DBP	55 (88)	55 (65)	–2.3	–3.8 to 0.9	0.003	–1.9	–3.5 to –0.4	0.01

Before and after analysis

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

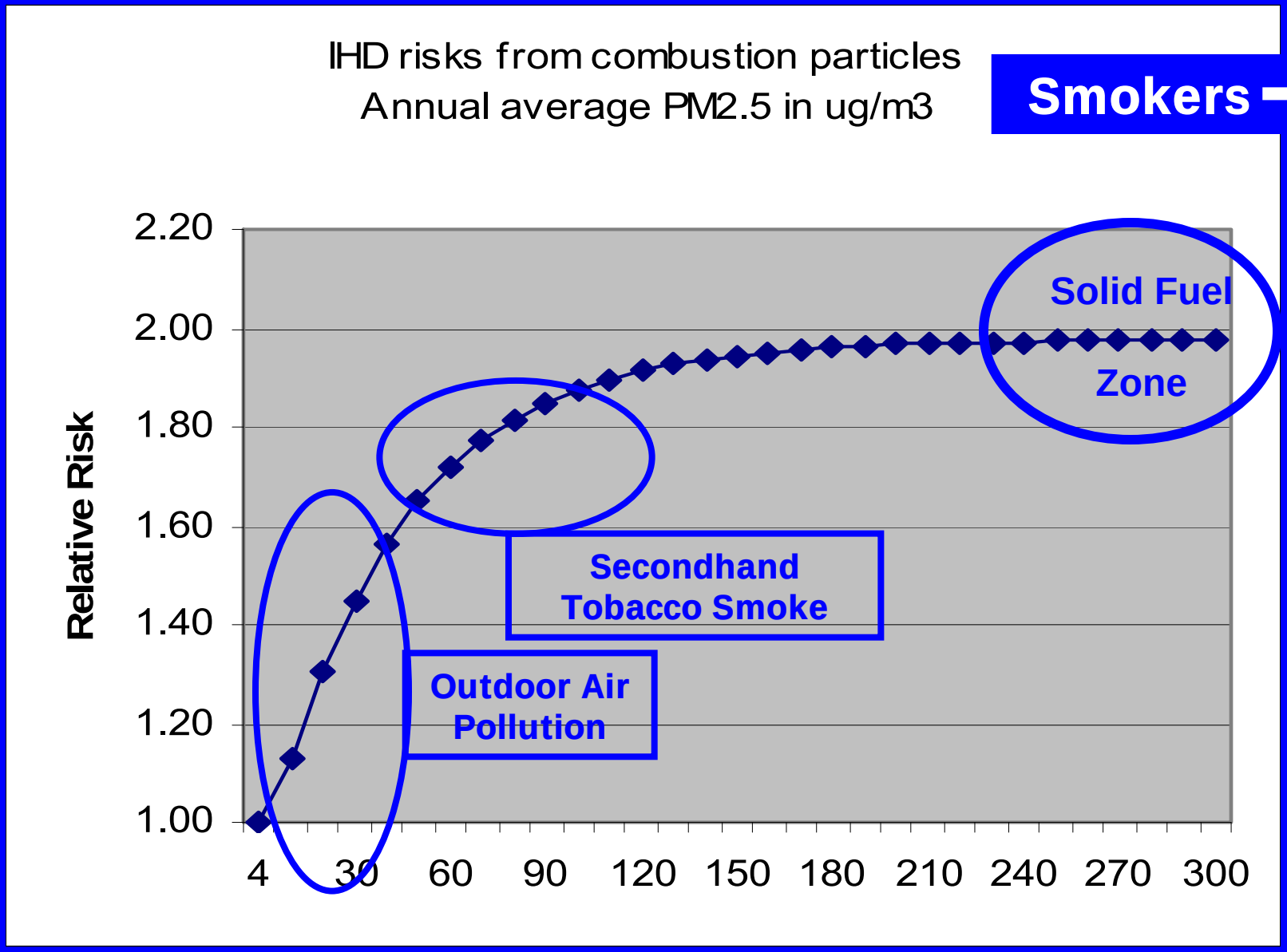
[a]Adjusted for age (quadratic), BMI (quadratic), asset index category, ever smoking, SHS, owning a wood-fired sauna, recent use of wood-fired sauna, and time of day (natural spline with 5 degrees of freedom). [b]Adjusted for age (quadratic), day of week, season (wet/dry), daily average temperature and 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 $\mu g/m^3$ ambient $PM_{2.5}$	-----	-----	-----	1.31(1.17-1.46)	0.44
ACS-air pol. extend.	10 $\mu g/m^3$ 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 $\mu g/m^3$ ambient $PM_{2.5}$	-----	-----	-----	1.37(1.11-1.68)	0.33
HSC-air pol. extend.	10 $\mu g/m^3$ ambient $PM_{2.5}$	1.21(0.92-1.69)	-----	1.28(1.13-1.44)	-----	0.18
WHI-air pol.	10 $\mu g/m^3$ 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

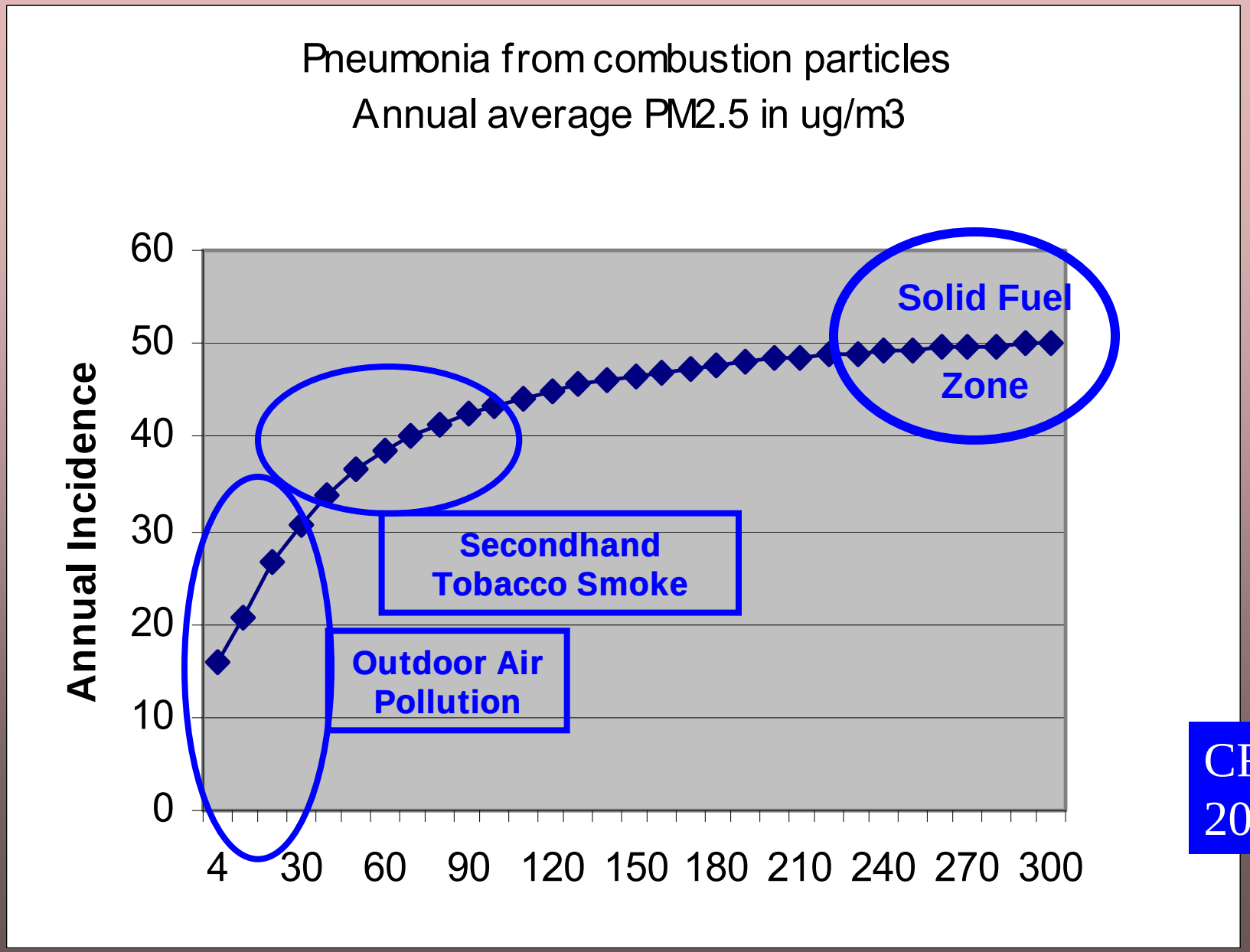
Pope et al.
Environmental Health Perspectives
2011, in press

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



CRA, 2011

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



CRA, 2011

What can we learn from smoking?

- Open wood cookfire equivalent to roughly 400 cigs/hour of emissions
- Not as bad as sticking burning stuff in your mouth (active smoking), but
- Worse than someone doing so near you (passive smoking)
- Thus, diseases from cigarettes can be expected to be found for HAP as well.

Biggest impacts from smoking

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

- All 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

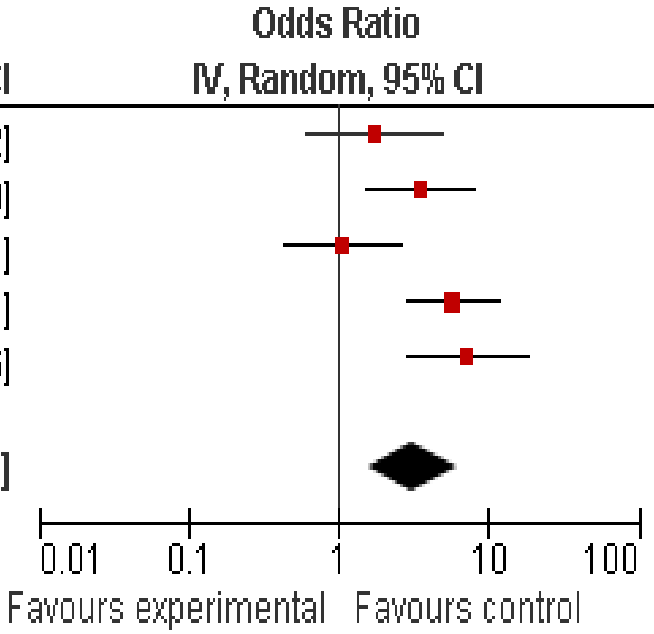
Review of Epi Evidence: Lung Cancer, 2004

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: $Tau^2 = 0.43$; $Chi^2 = 12.71$, $df = 4$ ($P = 0.01$); $I^2 = 69\%$

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

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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

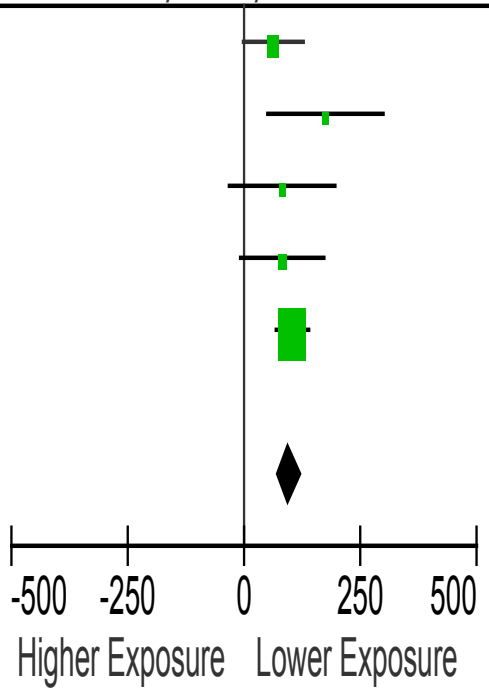
Pooled birth weight difference (low minus high exposure):

Adjusted estimates (Boy and Tielsch have GA)

Study or Subgroup	Lower Exposure Mean	SD	Total	Higher Exposure Mean	SD	Total	Weight	Mean Difference 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,*]

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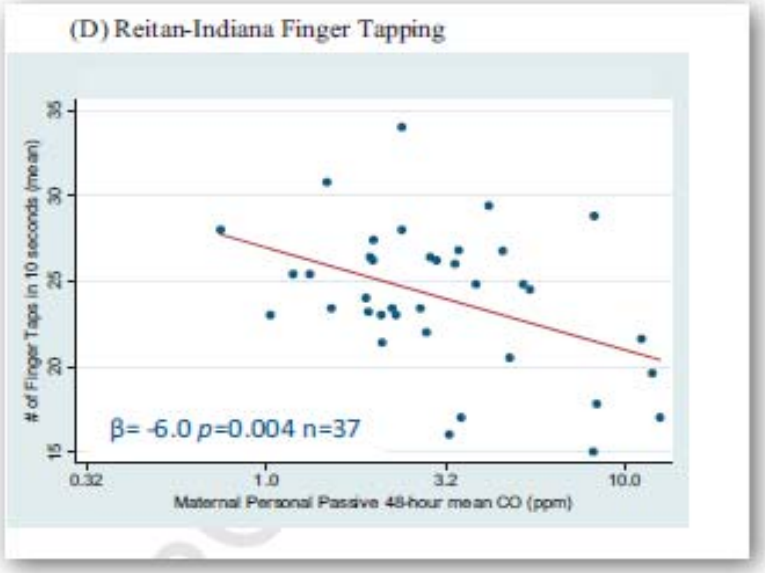
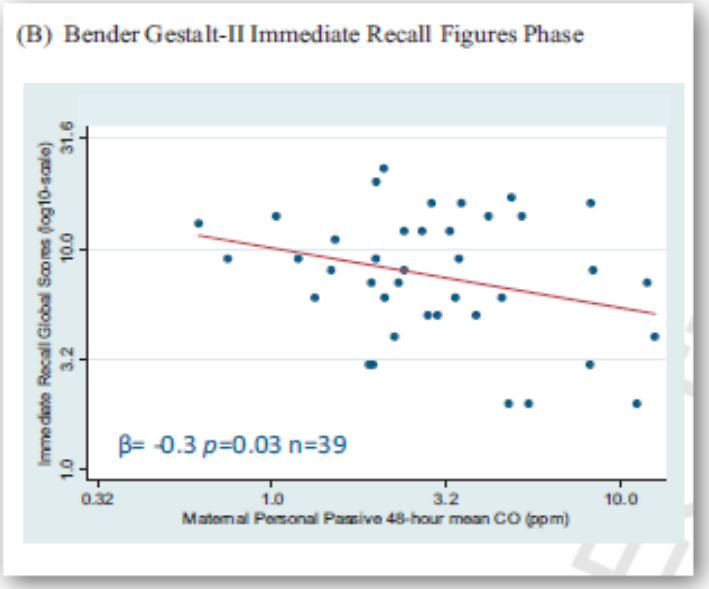
[d] Division of Occupational and Environmental Medicine, Department of Medicine, University of California, San Francisco, CA, USA





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”

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, but gas and electricity (piped water/flush toilets), not “affordable” by the poor.
- Other technologies difficult and less effective and insufficient profits for private sector to enter
- Particularly difficult because of the high component of behavioral change required
- Easy unhealthy alternatives available – gathered biomass (and open defecation)
- Yet, the fact that 60% of the world is now protected, gives us reason to think we can protect the other 40%

What to do

- 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 to

Guatemala Ministry of Health, NIEHS, WHO, Griffin Trust, Daniele Agostino Derossi Foundation

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