Household Air Pollution

New Evidence of Health Impacts from Guatemala and Elsewhere

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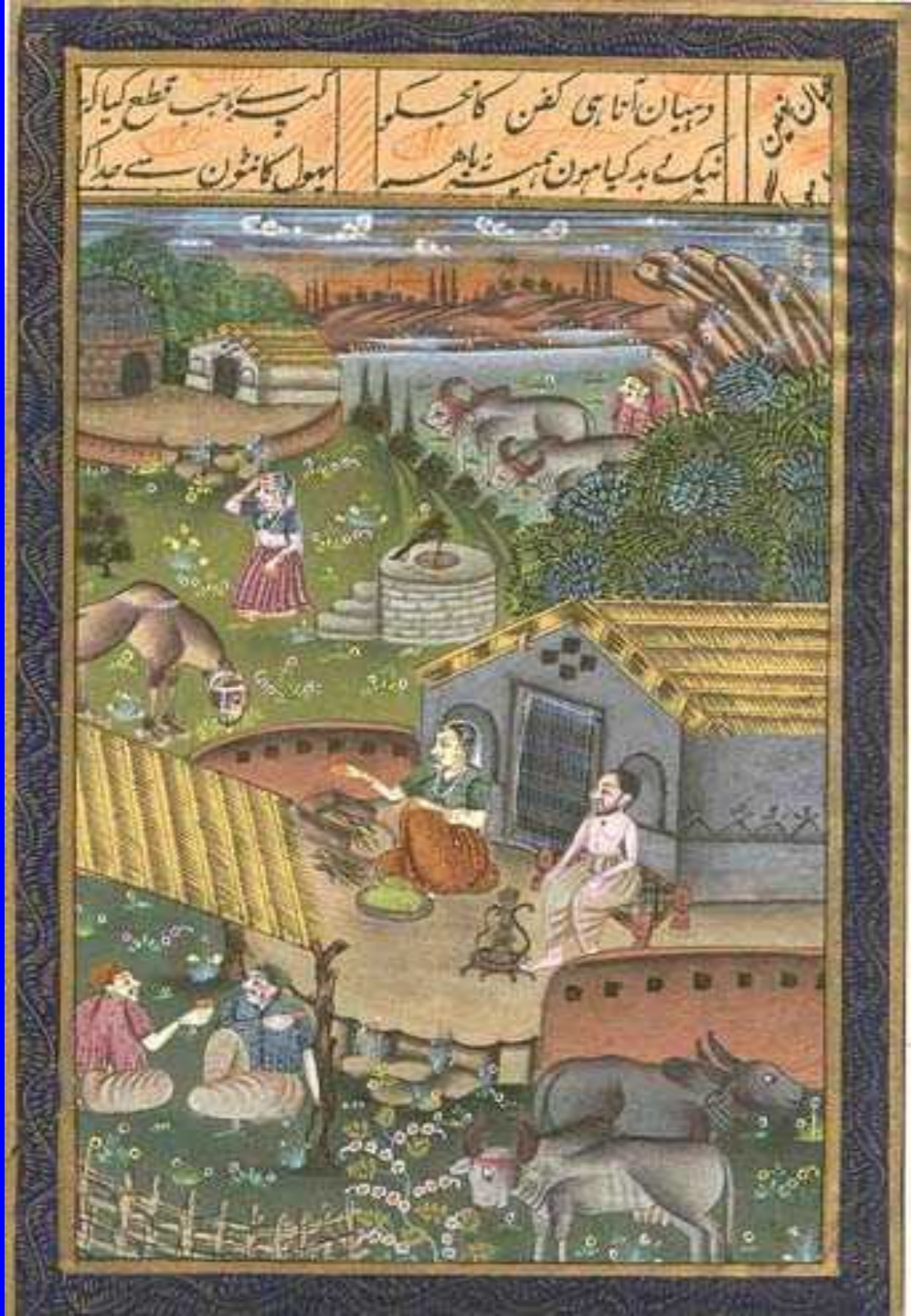
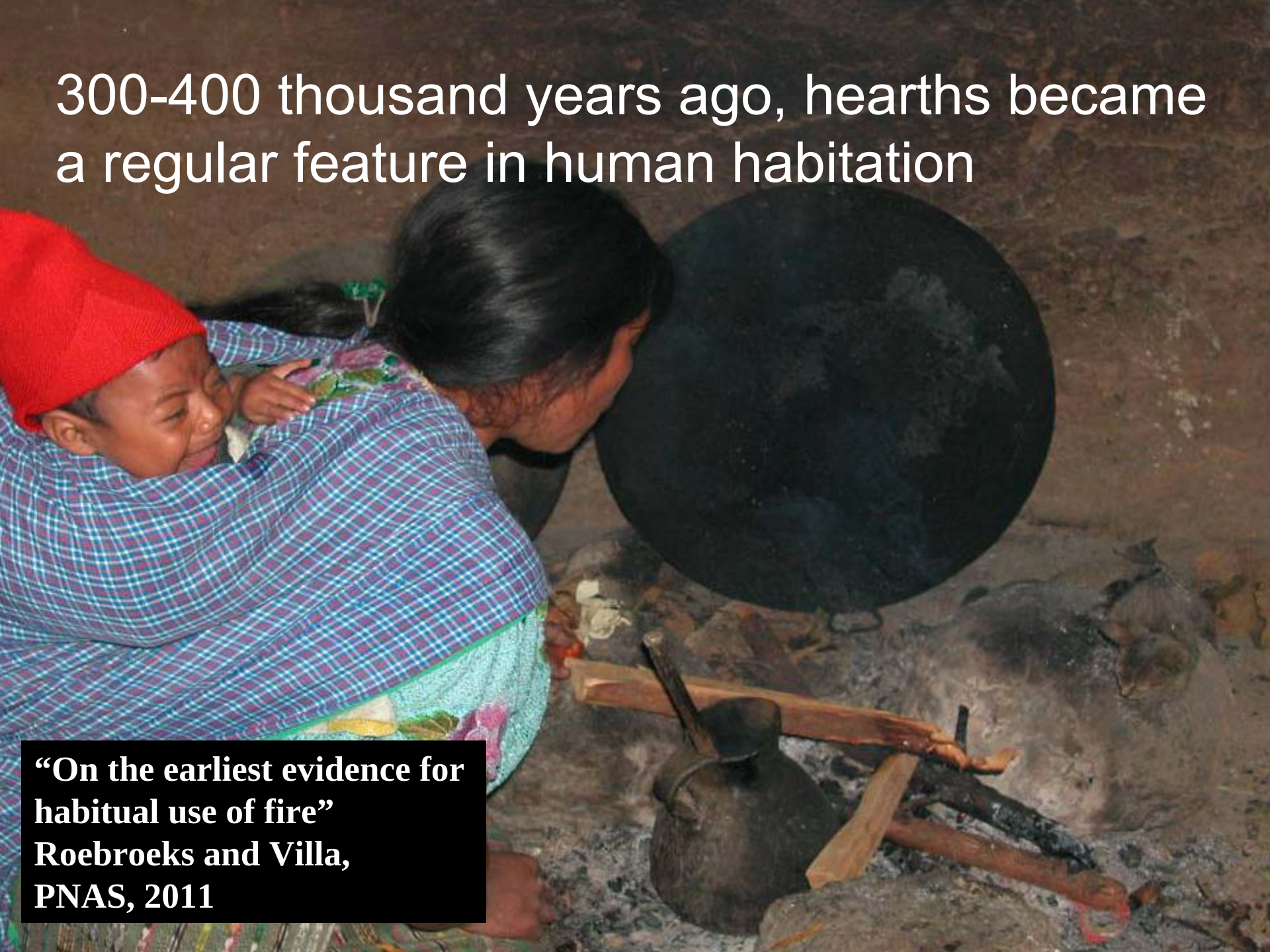


300-400 thousand years ago, hearths became a regular feature in human habitation

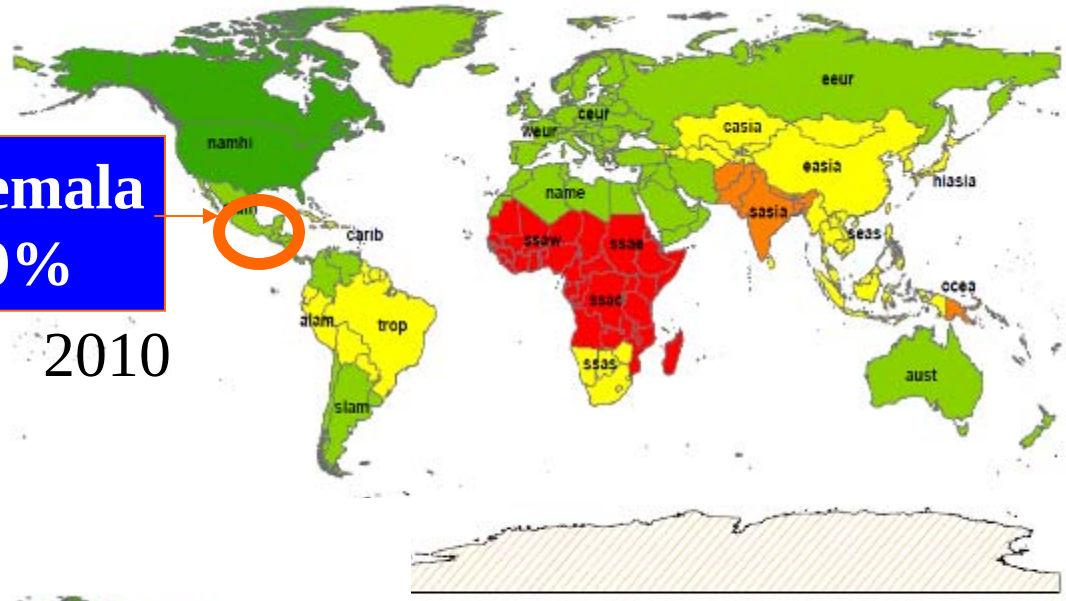


“On the earliest evidence for habitual use of fire”
Roebroeks and Villa,
PNAS, 2011

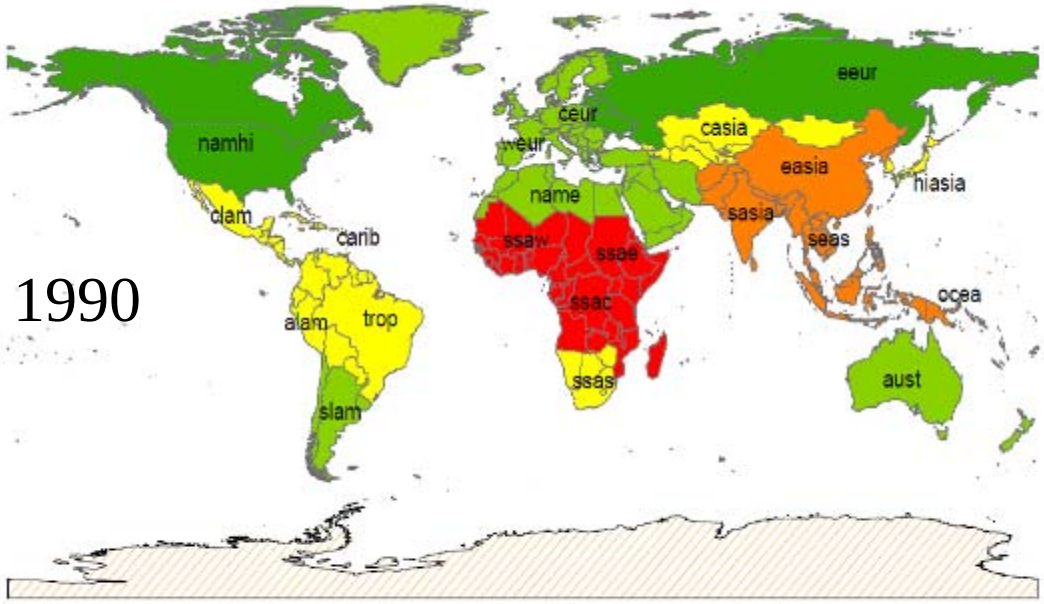
Households using biomass or coal to cook

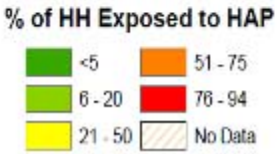
Guatemala ~50%

2010



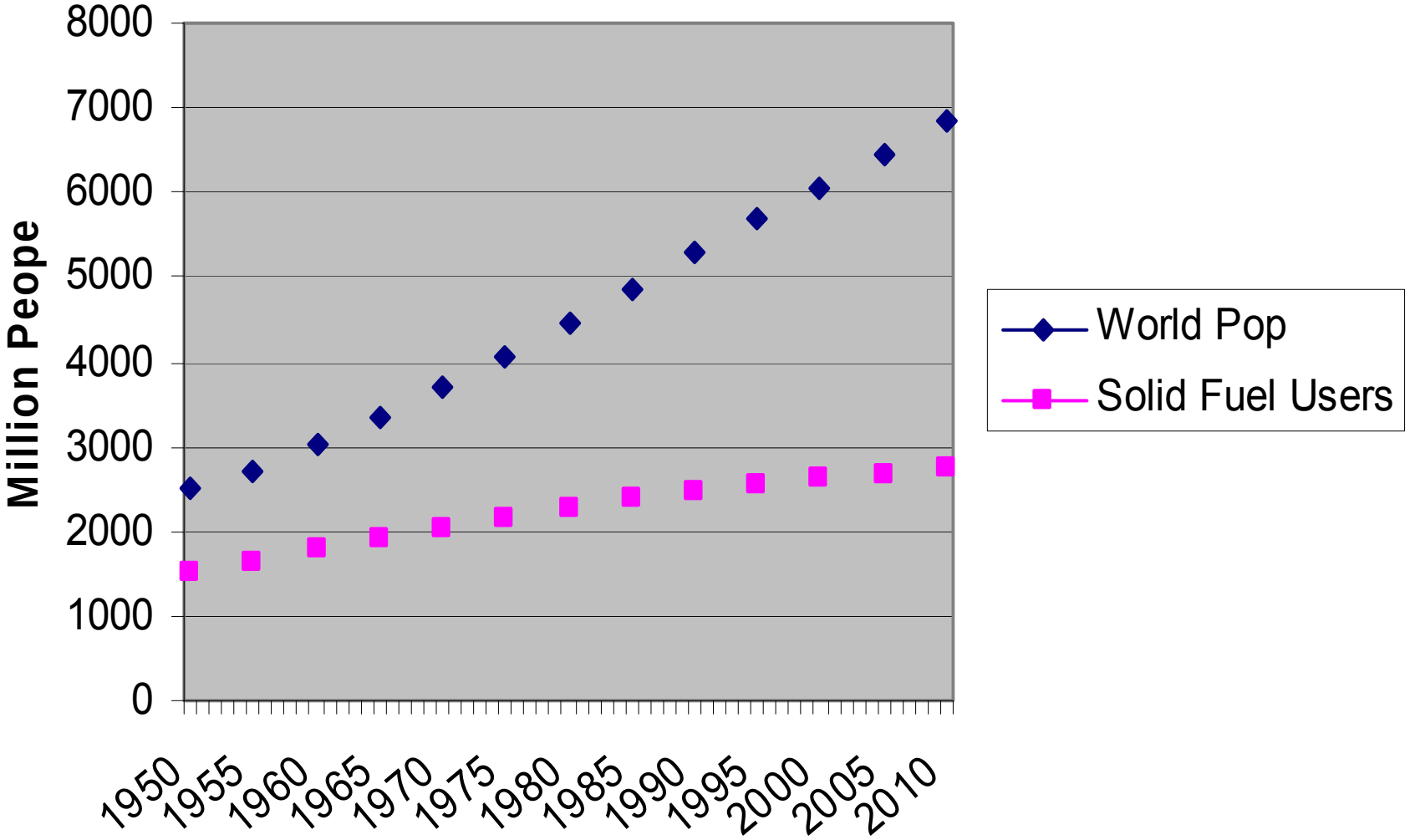
1990





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

World Population Using Solid Fuels



Biomass Cooking in History

- **Today, ~40% use solid fuels, about 2.7 billion people**
- **Although the percentage is dropping, the absolute number is still rising.**
- **Indeed, there are more people using solid fuels today for cooking than the total world population in 1950**
- **Or any year previously**

A problem that has lasted one-third of a million years and is showing no sign of quickly going away by itself.


The three major solid fuels

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-fire 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 Air Pollutants From Typical Woodfired Cookstove

Typical Health-based Standards

Wood: 1.0 kg
Per Hour
in 15 ACH
40 m3 kitchen

Typical Indoor Concentrations

Carbon Monoxide: 150 mg/m3	Particles 3.3 mg/m3	Benzene 0.8 mg/m3	1,3-Butadiene 0.15 mg/m3	Formaldehyde 0.7 mg/m3
10 mg/m3	0.1 mg/m3	0.002 mg/m3	0.0003 mg/m3	0.1 mg/m3

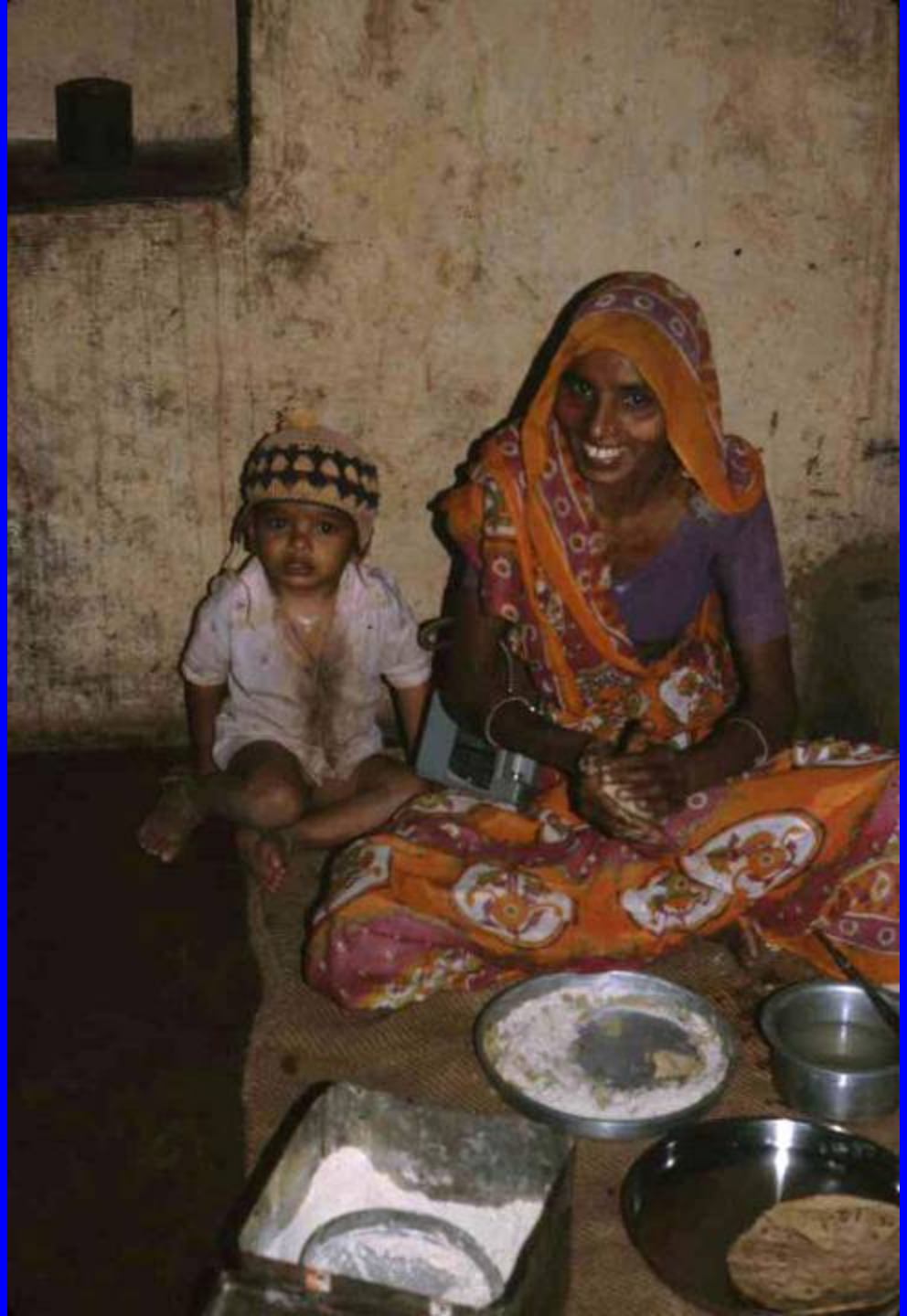
Best single indicator

IARC Group 1 Carcinogens

First person in human history to have her exposure measured doing the oldest task in human history

How much exposure?

Kheda District, Gujarat, 1981



How much
Ill-health?

ALRI/
Pneumonia

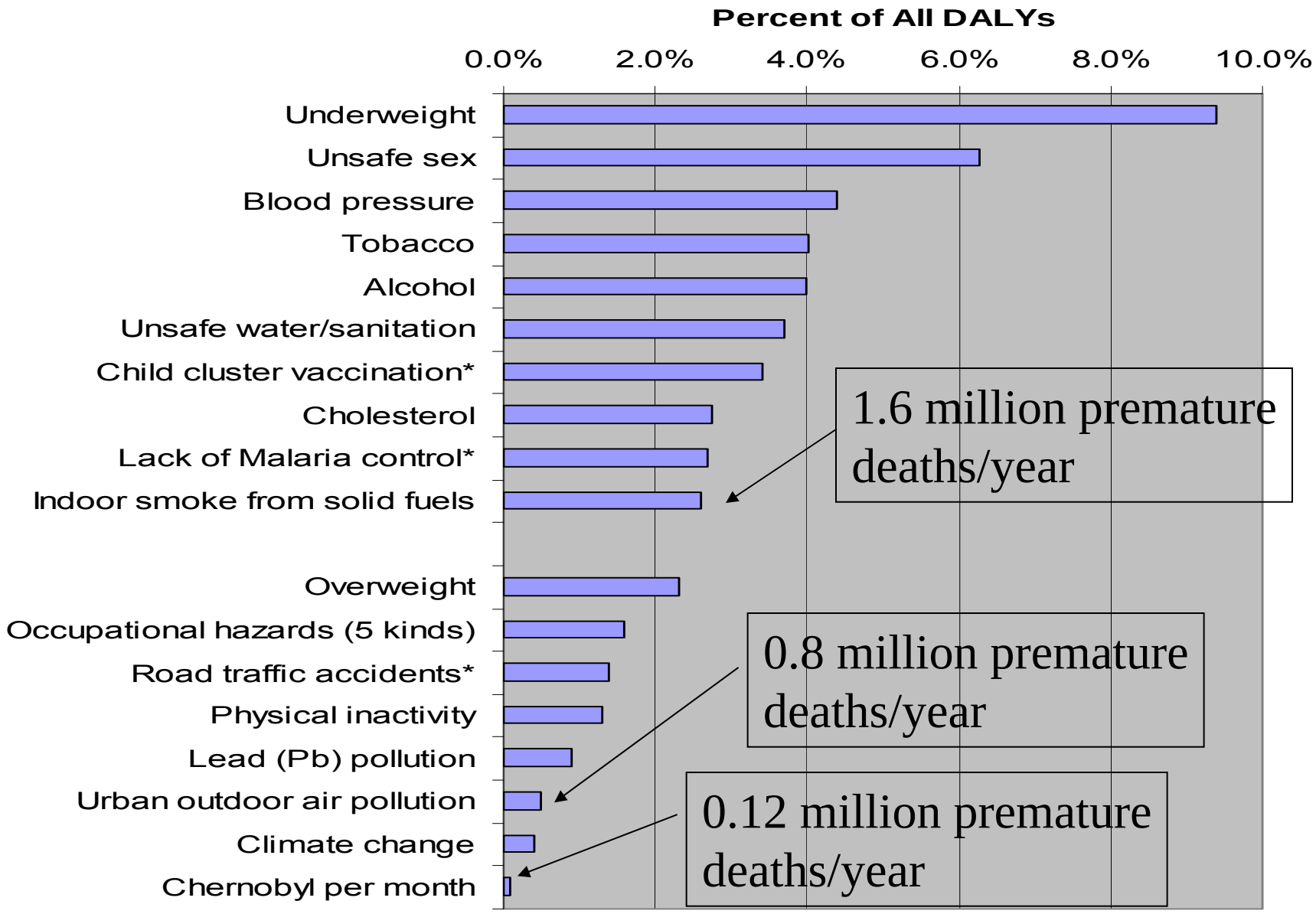
COPD

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



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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1	*Population (thousands)*						*6224984.81*	*317077.27*	*622741.70*	*817442.87*	*663966.38*	*427071.29*	*166160.20*	*30443.11*	*26143.24*	*3130052.05*			*301091.79*	*589229.34*	*782026.21*	*646518.90*	*427846.34*	*181906.42*
2	**GBD 2002: DALYs by age, sex and cause for the year 2002**																							
3	***WORLD***																							
4								*Male*											*Female*					
5	*Code*					*Cause*	*Total*	*0-4*	*5-14*	*15-29*	*30-44*	*45-59*	*60-69*	*70-79*	*80+*	*Total*			*0-4*	*5-14*	*15-29*	*30-44*	*45-59*	*60-69*
6	U000					**All Causes**	**1430125643**	**222552079**	**56142418**	**141637847**	**130501742**	**115374678**	**60641455**	**36229210**	**9832834**	**772912264**			**211279454**	**54559890**	**141633214**	**108257333**	**90621463**	**53460940**
7	U001		*I.*			***Communicable, maternal, perinatal and nutritional conditions***	*610319230*	***$$$$$$$***	*20979812*	*29721689*	*36148775*	*16631072*	*5676094*	*2913759*	*649689*	***$$$$$$$***			***$$$$$$***	*23248712*	*59740250*	*35979204*	*11499502*	*4476964*
8	U002					**A. Infectious and parasitic diseases**	**350332571**	**87977510**	**12810197**	**25516201**	**33372707**	**14085712**	**3710016**	**1519252**	**315539**	**179307135**			**89749119**	**13534884**	**31549467**	**23070592**	**8616676**	**2658113**
9	U003					**1. Tuberculosis**	**34735908**	**839261**	**782431**	**5497848**	**7335503**	**4868489**	**1832663**	**658401**	**90612**	**21905208**			**738745**	**821735**	**4163278**	**3822011**	**2041939**	**833205**
10	U004					**2. STDs excluding HIV**	**11347067**	**1521528**	**26245**	**1080828**	**660600**	**423721**	**103004**	**31641**	**7415**	**3854983**			**1726606**	**97221**	**4158088**	**1147558**	**260537**	**71612**
11	U005					a. Syphilis	4200039	1039452	2292	151945	285546	354596	99162	30394	6987	1970375			1265722	3432	521758	262487	107605	42492
12	U006					b. Chlamydia	3571404	1199	7209	241593	50929	1169	136	0	0	302234			1152	69338	2635460	439449	109658	14084
13	U007					c. Gonorrhoea	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	422675	6262	1616
14	U008					d. Other STDs																22947	37012	13420
15	U009					**3. HIV/AIDS**																**13746555**	**2624463**	**230670**
16	U010					**4. Diarrhoeal diseases**																**545936**	**373258**	**201900**
17	U011					**5. Childhood-cluster dis**																**53966**	**19174**	**4837**
18	U012					a. Pertussis																0	13	0
19	U013					b. Poliomyelitis																16931	3822	615
20	U014					c. Diphtheria																386	572	29
21	U015					d. Measles																29	30	0
22	U016					e. Tetanus																36620	14737	4192
23	U017					**6. Meningitis***																**167759**	**110215**	**48775**
24	U018					**7. Hepatitis B**																**115391**	**110437**	**36630**
25	U019					**Hepatitis C**																**53705**	**61307**	**30322**
26	U020					**8. Malaria**																**453207**	**280704**	**99111**
27	U021					**9. Tropical-cluster disea**																**593336**	**496341**	**75537**
28	U022					a. Trypanosomiasis																79329	46509	3694
29	U023					b. Chagas disease																51644	48058	15987
30	U024					c. Schistosomiasis																128589	58850	17056
31	U025					d. Leishmaniasis																67203	30097	11647
32	U026					e. lymphatic filariasis																206680	266630	15772
33	U027					f. Onchocerciasis																59892	46198	11380
34	U028					**10. Leprosy**																**15828**	**9135**	**4389**
35	U029					**11. Dengue**																**10408**	**6396**	**2644**
36	U030					**12. Japanese encephalitis**																**26926**	**7282**	**2513**
37	U031					**13. Trachoma**																**517423**	**559520**	**344796**
38	U032					**14. Intestinal nematode i**																**5192**	**5921**	**3469**
39	U033					a. Ascariasis																161	21	111
40	U034					b. Trichuriasis																388	433	238
41	U035					c. Hookworm disease																4212	4859	2723
42	U036					Other intestinal infectio																432	607	397
43	U037					Other infectious disease																1795391	1650048	667703
44	U038					**B. Respiratory infections**																**1481589**	**1357246**	**1460806**
45	U039					1. Lower respiratory infec																1434738	1329549	1425397
46	U040					2. Upper respiratory infec																45228	26339	34405
47	U041					3. Otitis media																1622	1358	1004
48	U042					**C. Maternal conditions**																**9947305**	**403615**	**19**
49	U043					1. Maternal haemorrhage																1944088	133887	0
50	U044					2. Maternal sepsis																1625431	72999	0
51	U045					3. Hypertensive disorders*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	722909	40216	0
52	U046					4. Obstructed labour	3048291	0	0	0	0	0	0	0	0	0			0	0	2241561	794568	12162	0
53	U047					5. Abortion	4652171	0	0	0	0	0	0	0	0	0			0	223411	3721304	705860	1596	0
54	U048					Other maternal conditions	12427759	0	0	0	0	0	0	0	0	0			0	1970	8128555	4154451	142755	19
55	U049					**D. Perinatal conditions***	**97335086**	**53209265**	**1343**	**1031**	**347**	**89**	**12**	**9**	**0**	**53212095**			**44121066**	**1195**	**498**	**158**	**34**	**29**
56	U050					1. Low birth weight	46334234	25061999	52	13	20	0	9	0	0	25062092			21272111	31	0	0	0	0
57	U051					2. Birth asphyxia and birth trauma	34445758	19353003	790	302	73	33	3	0	0	19354204			15090851	573	107	0	15	0
58	U052					Other perinatal conditions	16555094	8794262	502	716	253	56	0	9	0	8795799			7758104	591	392	158	19	29
59	U053					**E. Nutritional deficiencies**	**34416632**	**10258276**	**1921013**	**1793247**	**1025783**	**698252**	**230984**	**132831**	**39983**	**16100369**			**10385030**	**2582483**	**2149411**	**1479558**	**1121930**	**357998**
60	U054					1. Protein-energy malnutrition	16910328	7556012	560106	156056	69278	103279	71114	45451	18671	8579966			7350453	620870	66437	68728	81418	70683
61	U055					2. Iodine deficiency	3519322	1283895	471857	528	748	1215	641	236	50	1759171			1305105	450178	1681	1046	1287	439
62	U056					3. Vitamin A deficiency	792562	257306	84825	3330	6358	7864	3519	983	100	364284			320394	84034	10506	3807	6687	

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

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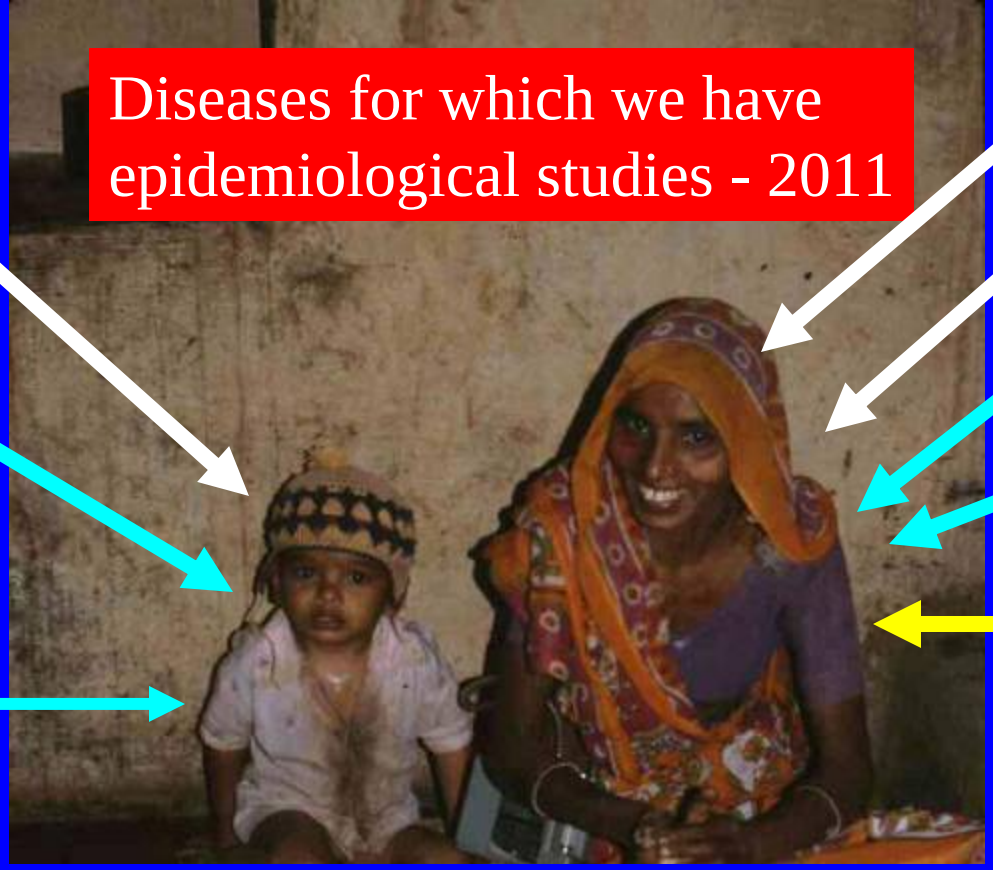
Diseases for which we have epidemiological studies - 2011



ALRI/ Pneumonia

Low birth weight

Stillbirth

COPD

Lung cancer (coal)

Lung cancer (biomass)

Blindness (cataracts, opacity)

CV 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, CVD will be included

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

Burns and the health/safety impacts of fuel gathering

Cognitive Impairment

Birth defects

Asthma?

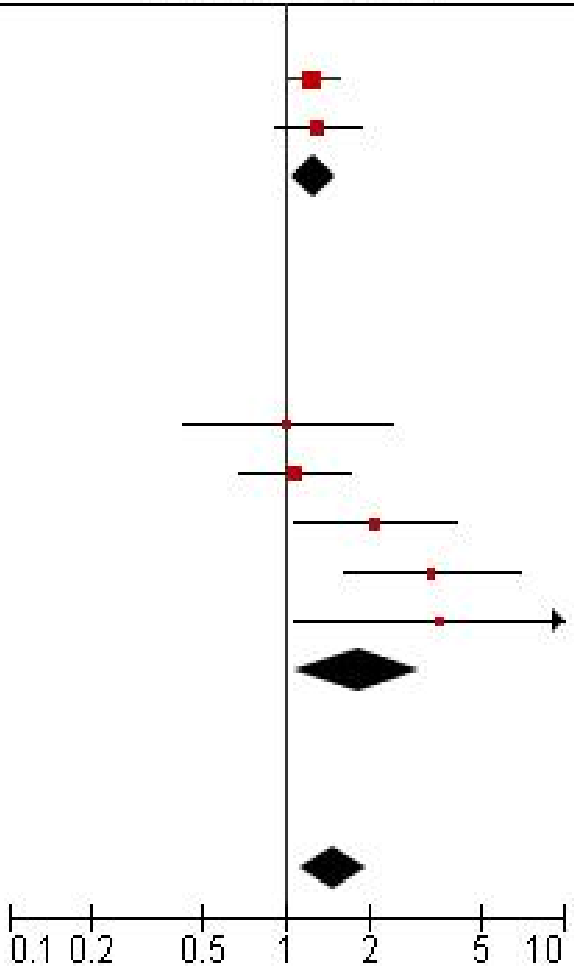
Tuberculosis

ALRI

Other cancers (cervical, NP, upper airway)

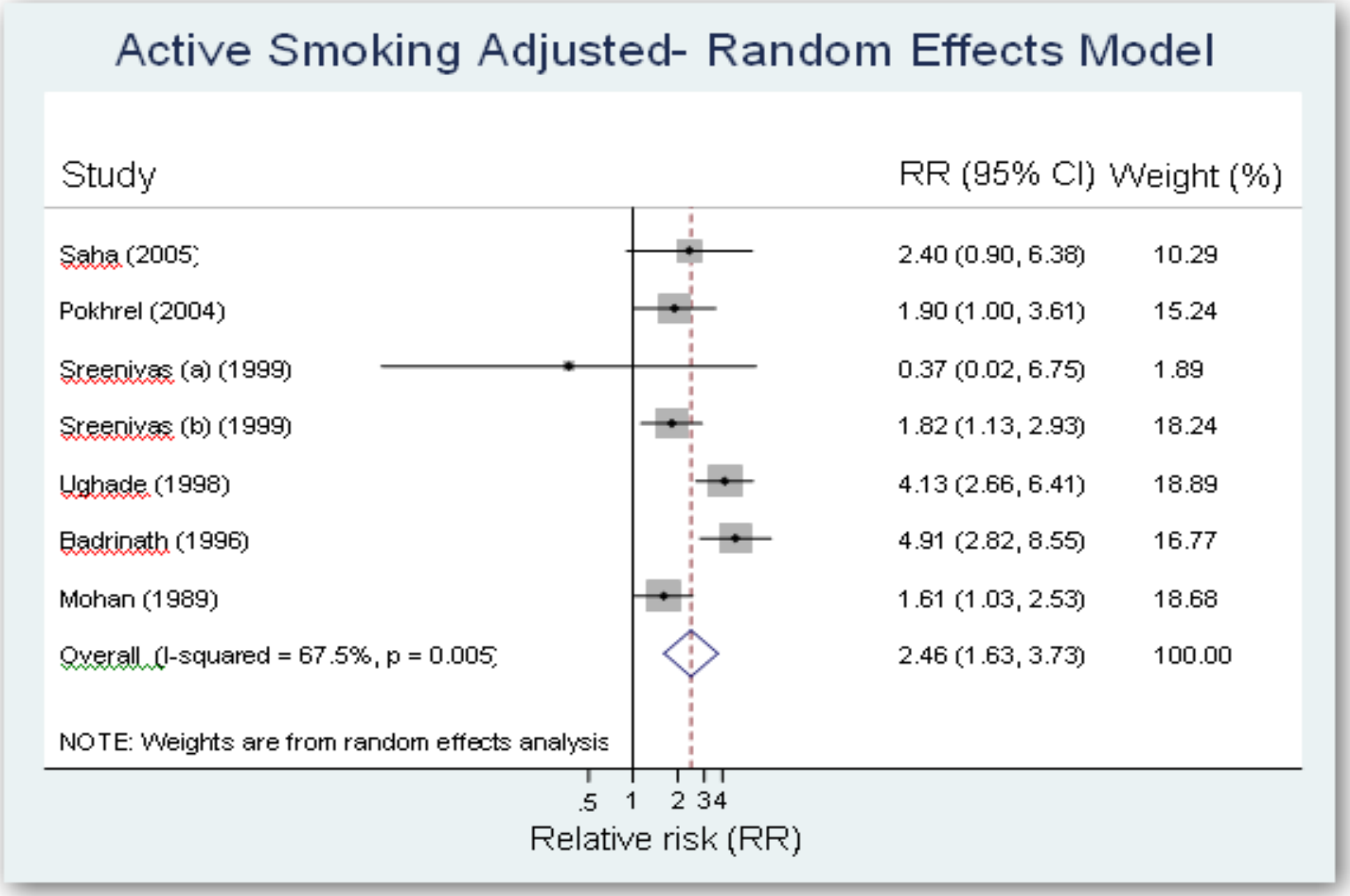
Lung Cancer: Biomass vs. clean fuel

Study or Subgroup	IV, Random, 95% CI
2.7.1 Male	
Lissowska2005	1.24 [1.00, 1.54]
Sapkota2008	1.30 [0.90, 1.87]
Subtotal (95% CI)	**1.26 [1.04, 1.52]**
Heterogeneity: Tau² = 0.00; Chi² = 0.05, df = 1 (P = 0.83); I² = 0%	
Test for overall effect: Z = 2.37 (P = 0.02)	
2.7.2 Female	
Sapkota2008	1.01 [0.42, 2.41]
Lissowska2005	1.07 [0.67, 1.71]
Ko1997	2.08 [1.06, 4.07]
Lee2001	3.36 [1.62, 6.96]
Behera 2005	3.59 [1.08, 11.97]
Subtotal (95% CI)	**1.81 [1.07, 3.06]**
Heterogeneity: Tau² = 0.21; Chi² = 10.21, df = 4 (P = 0.04); I² = 61%	
Test for overall effect: Z = 2.20 (P = 0.03)	
Total (95% CI)	**1.48 [1.12, 1.97]**
Heterogeneity: Tau² = 0.06; Chi² = 12.14, df = 6 (P = 0.06); I² = 51%	
Test for overall effect: Z = 2.75 (P = 0.006)	
Test for subgroup differences: Chi² = 1.89, df = 1 (P = 0.17), I² = 47.1%	



CRA, Imran et al. preliminary

Cataracts and Biomass Cooking Smoke*



CRA Preliminary, Adair et al.

* Adjusted for UV

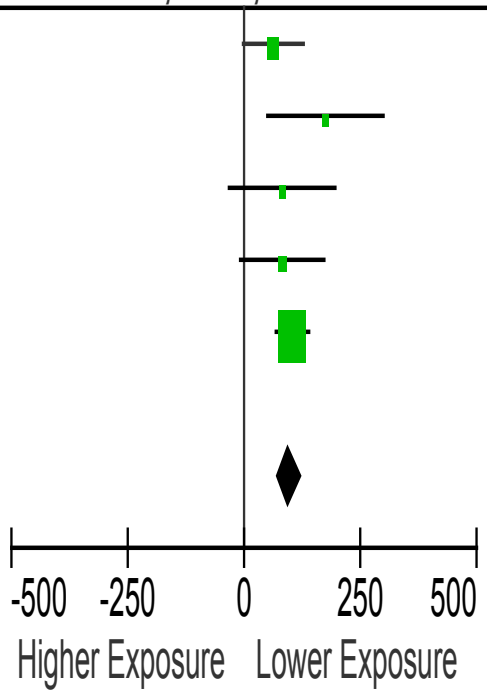
Pooled birth weight difference (low minus high exposure):

Adjusted estimates (Boy and Tielsch have GA)

Study or Subgroup	Lower Exposure Mean	Lower Exposure SD	Lower Exposure Total	Higher Exposure Mean	Higher Exposure SD	Higher Exposure 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)

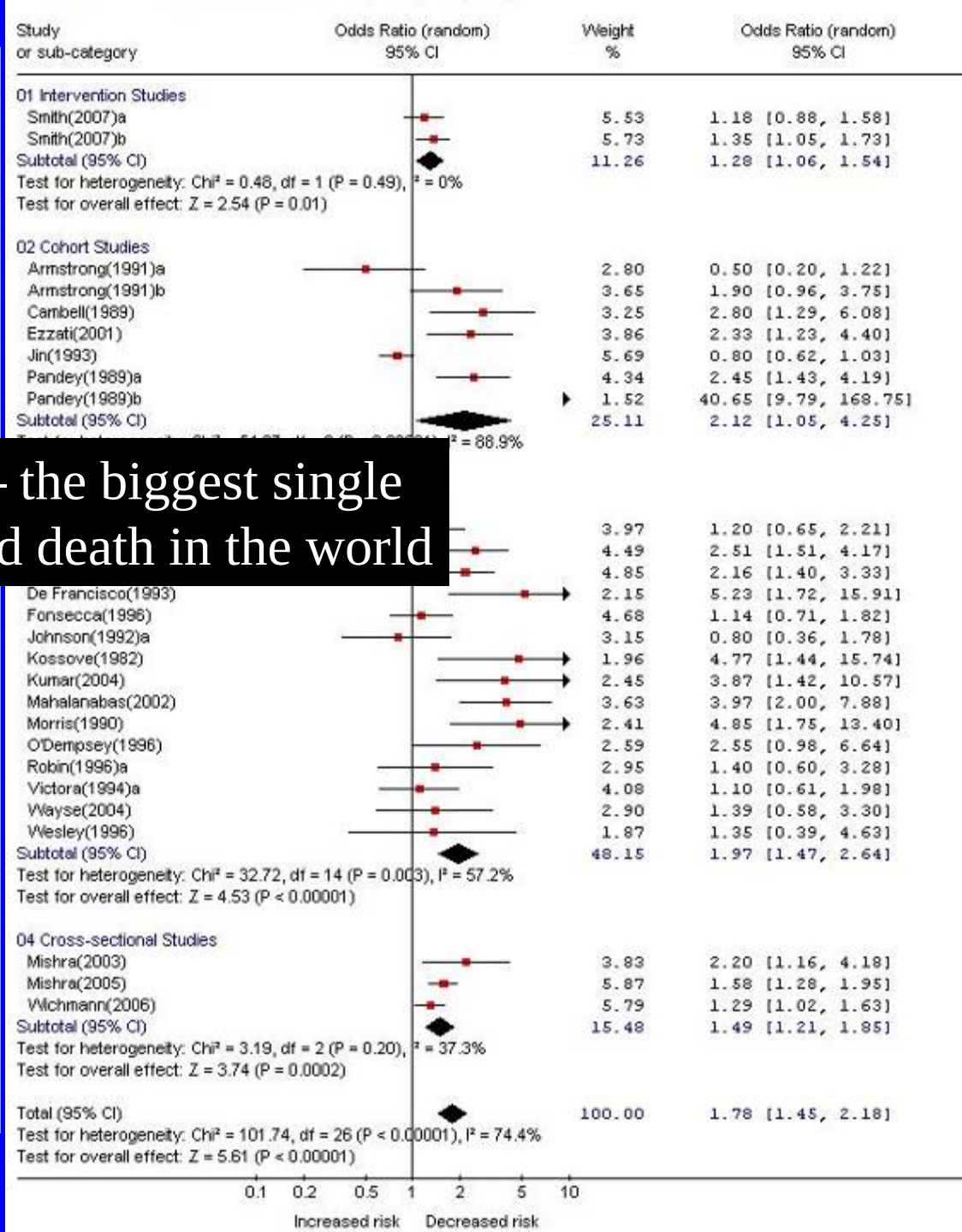
CRA: Pope et al., 2010

Preliminary CRA Effect Estimates

Health Outcome	Sex	Age	Level of Outcome	Risk Estimate
ALRI	M & F	< 60 mo	Ia	1.78 (1.45 to 2.18)
ALRI: exposure/response	M&F	< 60 mo	Ib	2.3 (95% CI ?)
COPD	F	>15 yr	Ia	2.7 (1.95 to 3.75)
COPD	M	>15 yo	Ia	1.9 (1.15 to 3.13)
Lung Cancer (coal)	F	> 15 yr	Ia	1.98 (1.16 to 3.36)
Lung Cancer (coal)	M	> 15 yr	Ia*	1.38
Cataract	F	> 30 yr	Ia	2.45 (1.61 to 3.73)
Cataract	M	> 30 yr	Ia	?
LBW (OR)	M & F	Perinatal	Ia	1.52 (1.25 to 1.80)
LBW (mean weight)	M & F	Perinatal	Ia	93.1g (64.6, 121.6)
Lung Cancer (biomass)	F	> 15 yr	Ia	1.81 (1.07 to 3.06)
Lung Cancer (biomass)	M	> 15 yr	Ia	1.26 (1.04 to 1.52)
CVD	F	> 30 yr	Ib	1.3 to 1.4 (95% CI)
CVD	M	> 30 yr	Ib*	1.16

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

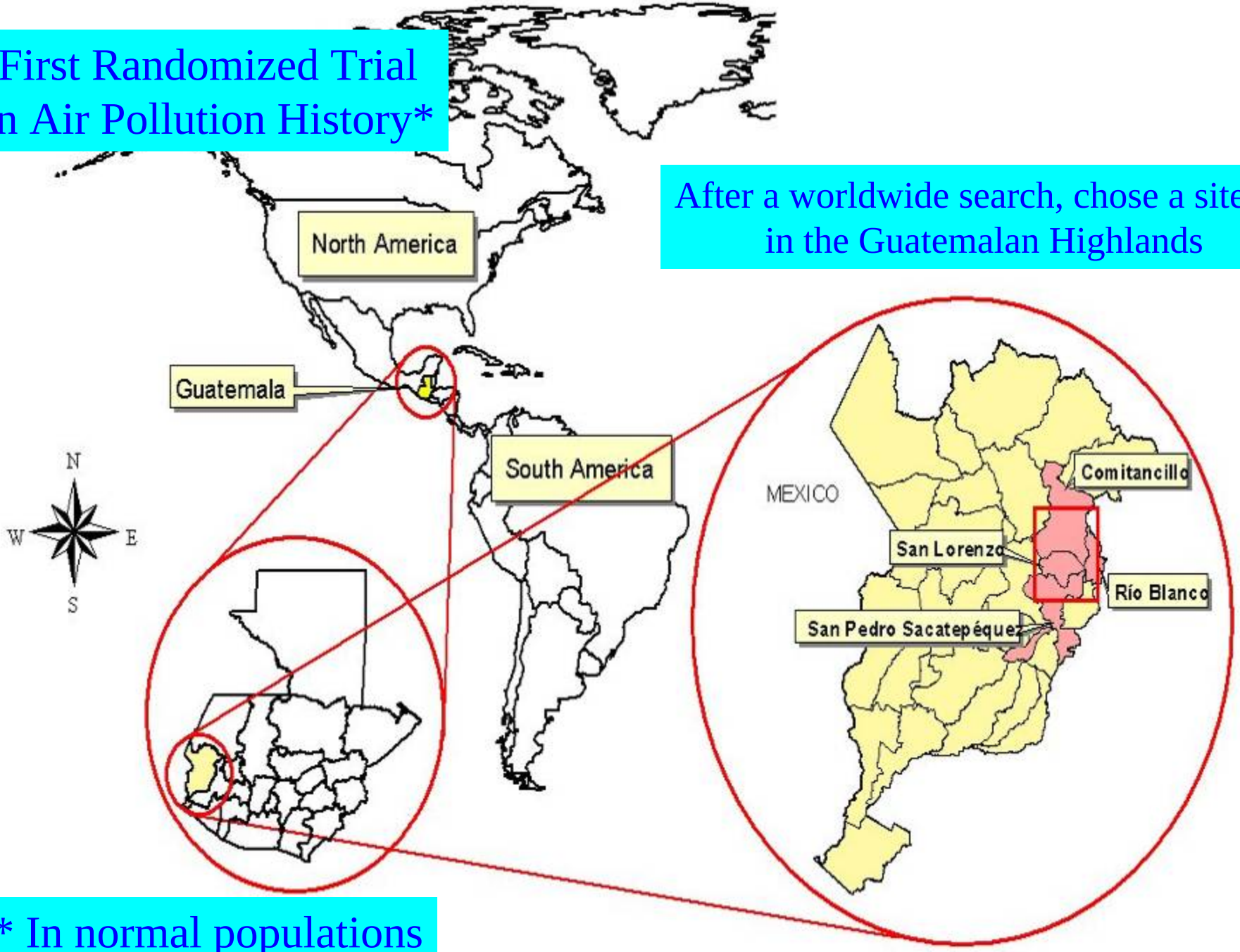
- Air pollution conference
  - High exposures to large vulnerable population
  - No more health effects work needed
- International health conference
  - Still doubt about causality
  - Need to know exact benefit to be expected
- Where are your randomized controlled trials?

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 (we hope)
- 25+ years from deciding to conduct RCT to results!

First Randomized Trial In Air Pollution History*

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



* In normal populations

RESPIRE – ALRI in Children under 18

Randomized Exposure Study of Pollution Indoors and Respiratory Effects

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

Plancha, a 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

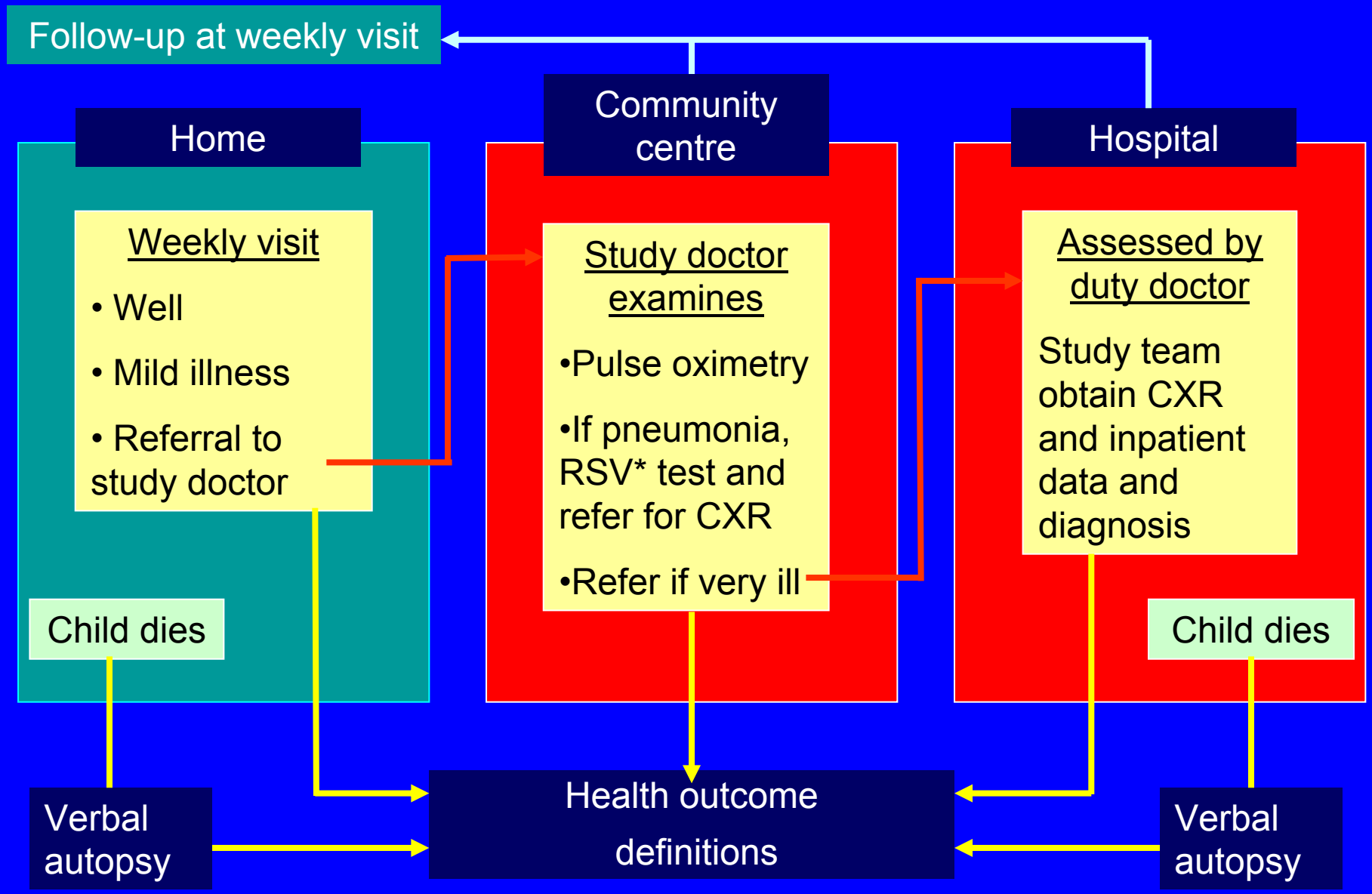
Compare incidence and exposure in 2 groups
Plancha offered to 'controls'

Years 3-4

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%)

* $P < 0.001$

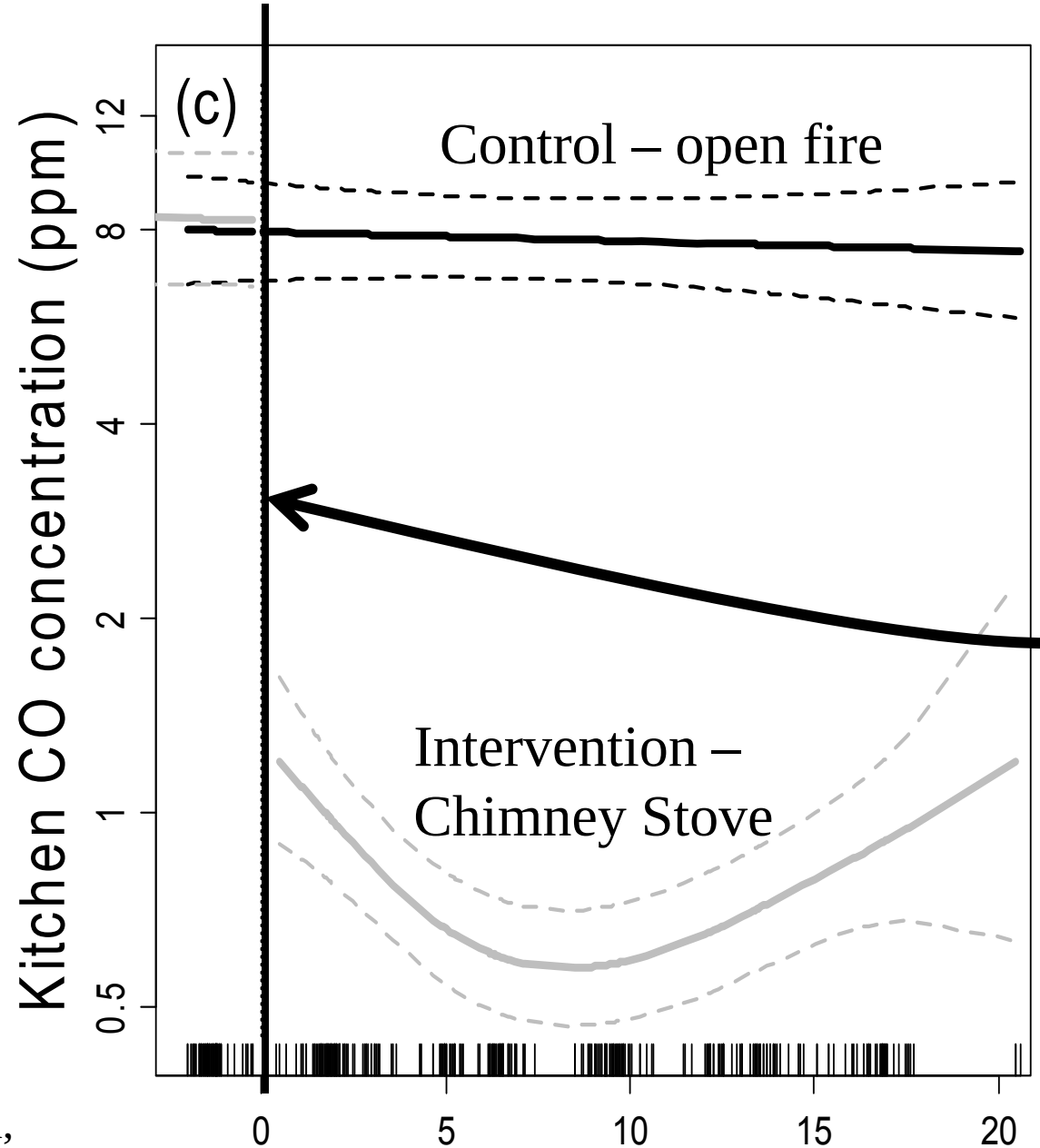
RESPIRE Results

(Randomized Exposure Study of Pollution Indoors and Respiratory Effects)

- Intention-to-Treat analysis of the RCT under journal embargo
- Will present preliminary results of the exposure-response analysis, which is most relevant to this audience


Tubito
Tubito

Guatemala RCT: Kitchen Concentrations



Effect of Chimney Stove On Kitchen CO Levels

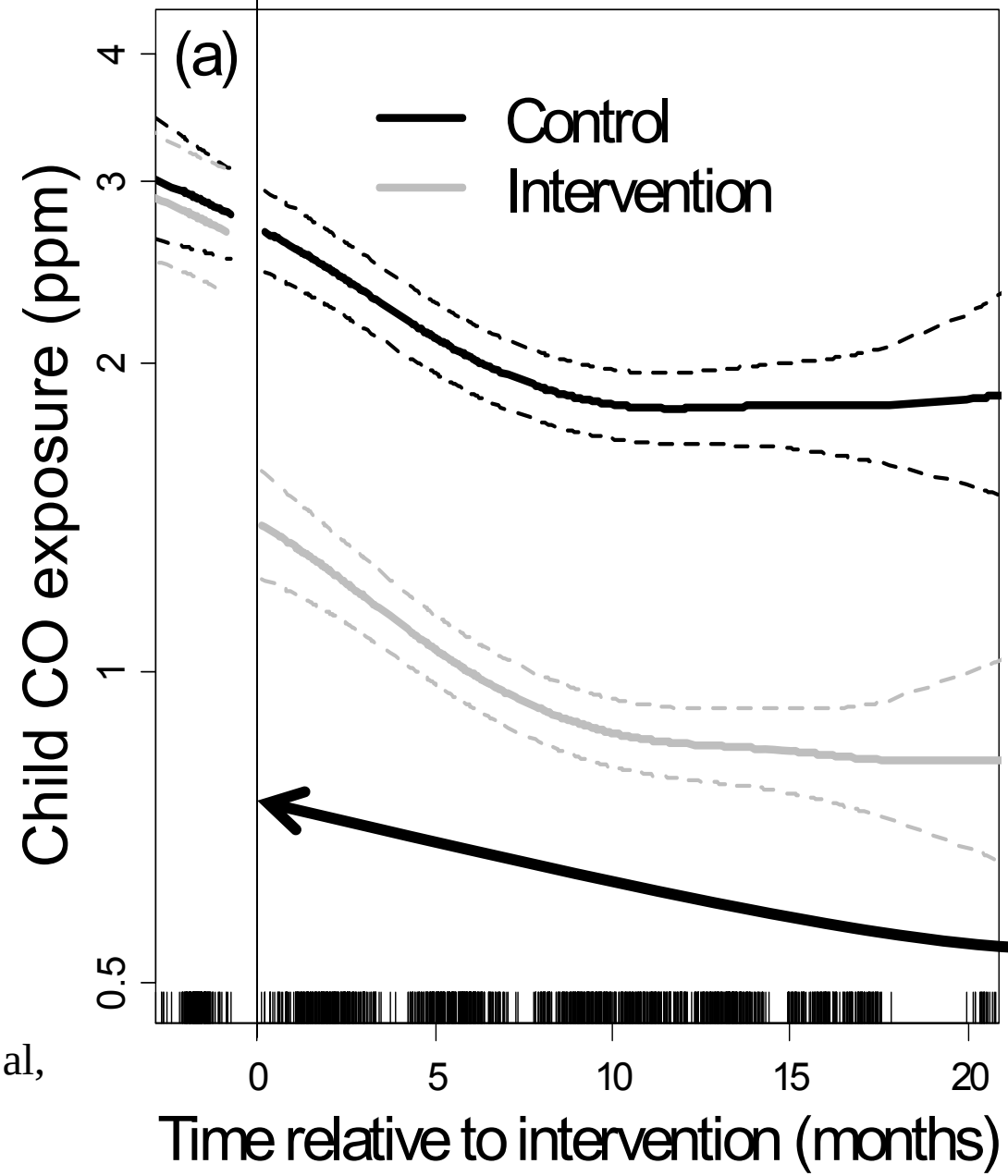
Factor of ~10 less

285 48-h measurements

Months

Smith, et al, 2010

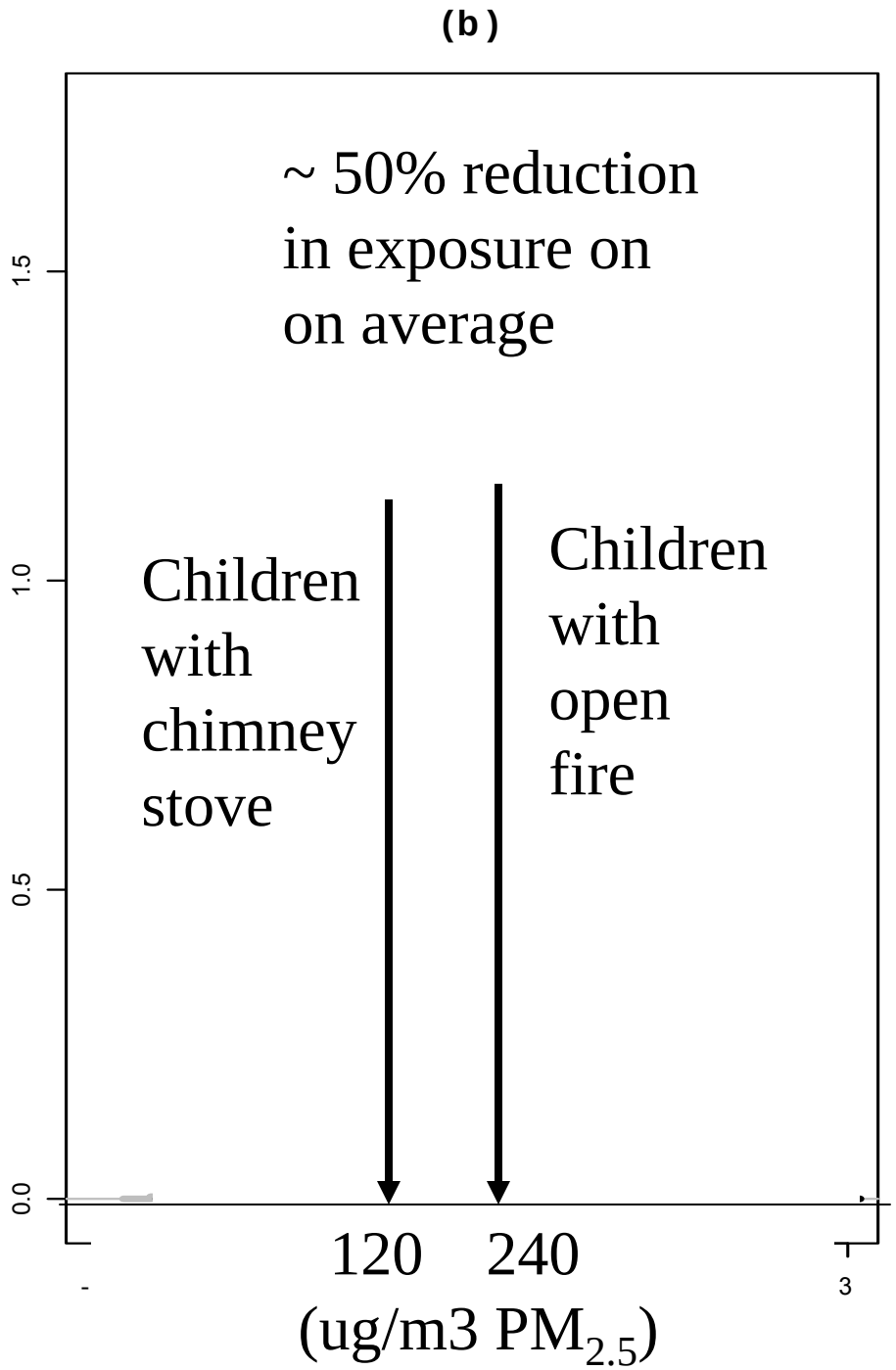
Infant Exposures



1888 48-h measurements

Effect of Chimney Stove On Infant Exposures - 2x less

Smith, et al, 2010



Chimney stove did not protect all children

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

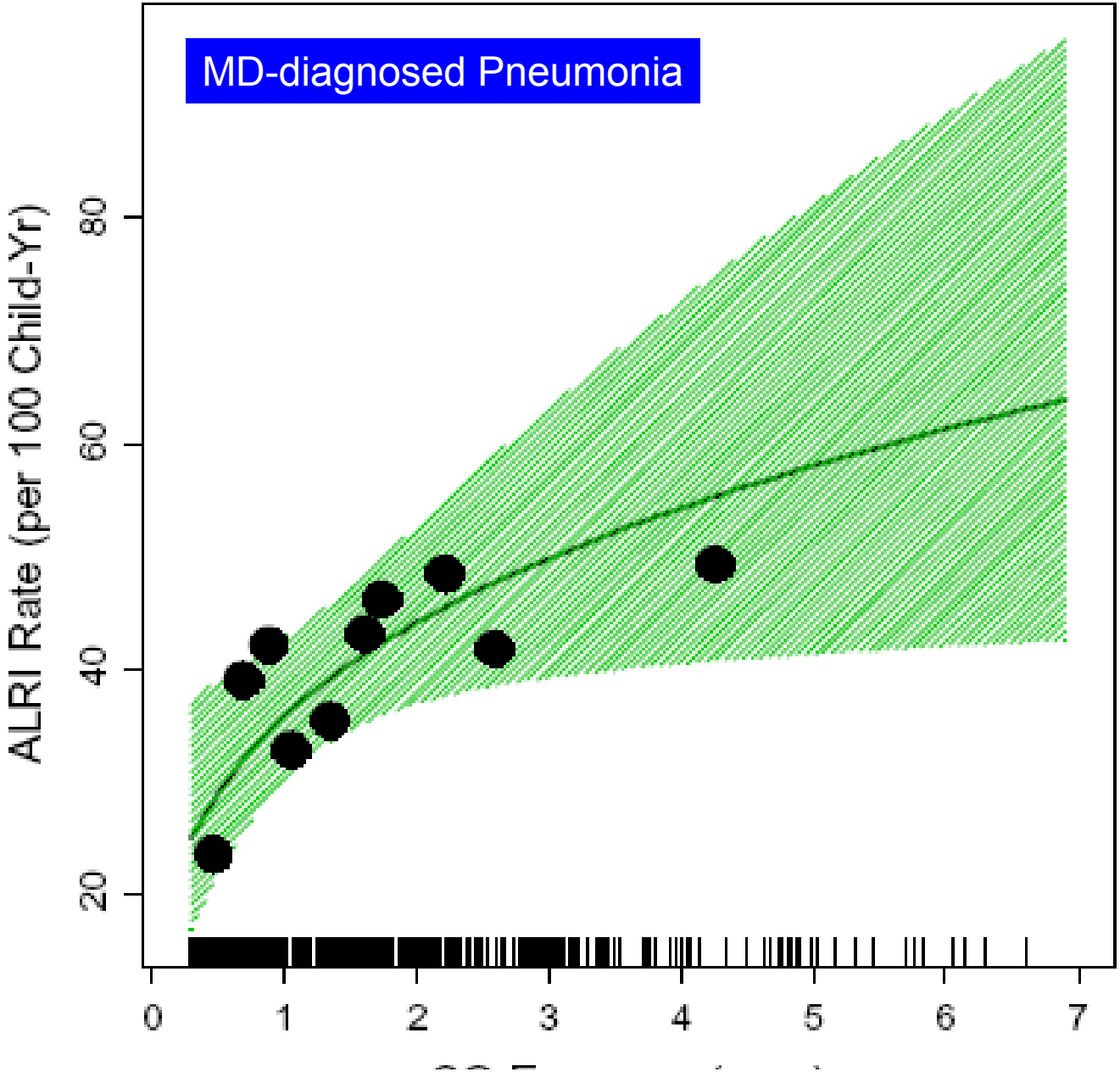
--Household (or “neighborhood”) pollution: a chimney does not reduce smoke, but just shifts it outside into the household environment, where the difference between intervention and control households was less

--No significant difference in bedrooms

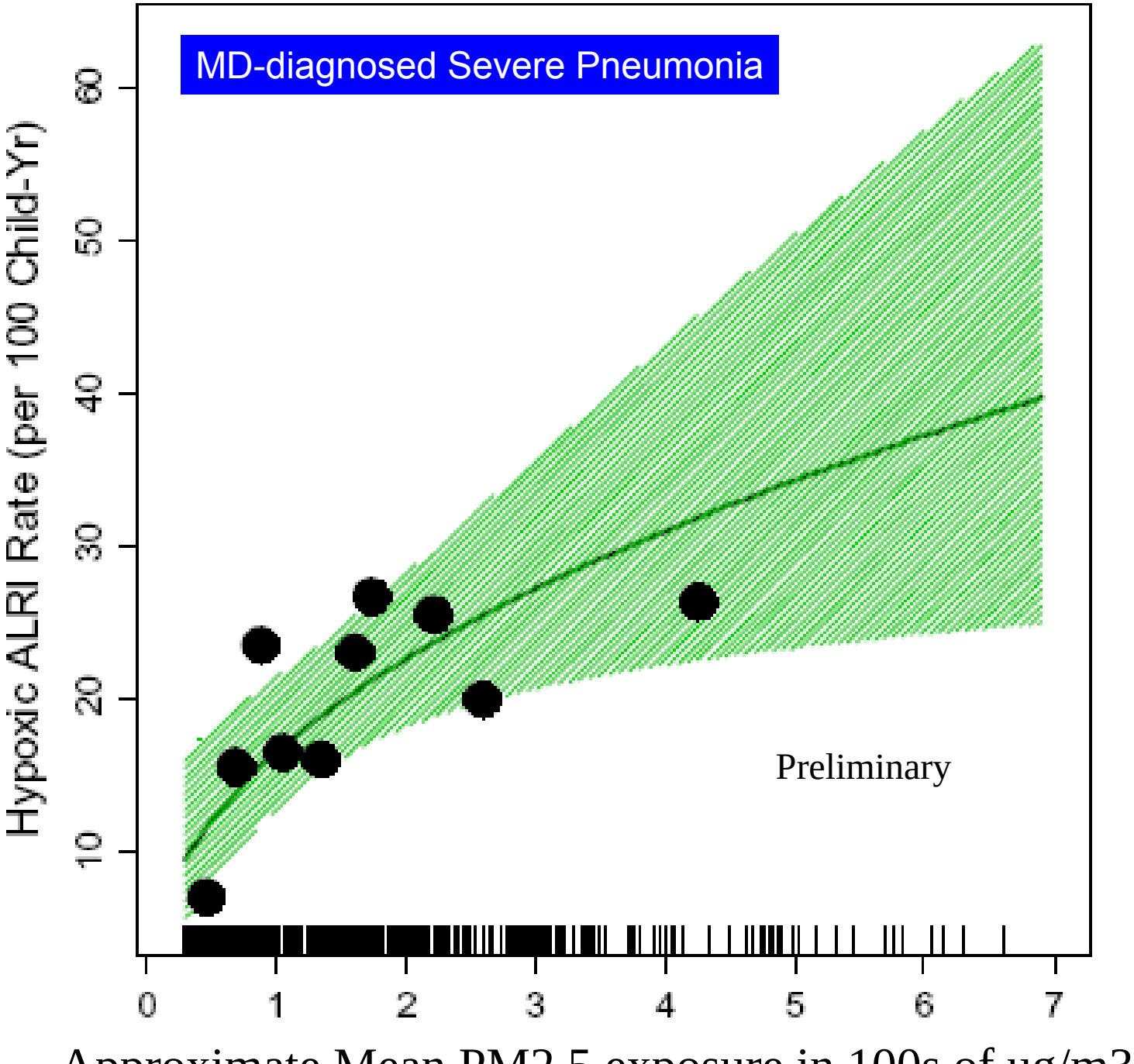
Preliminary Adjustments for Exposure-Response Model

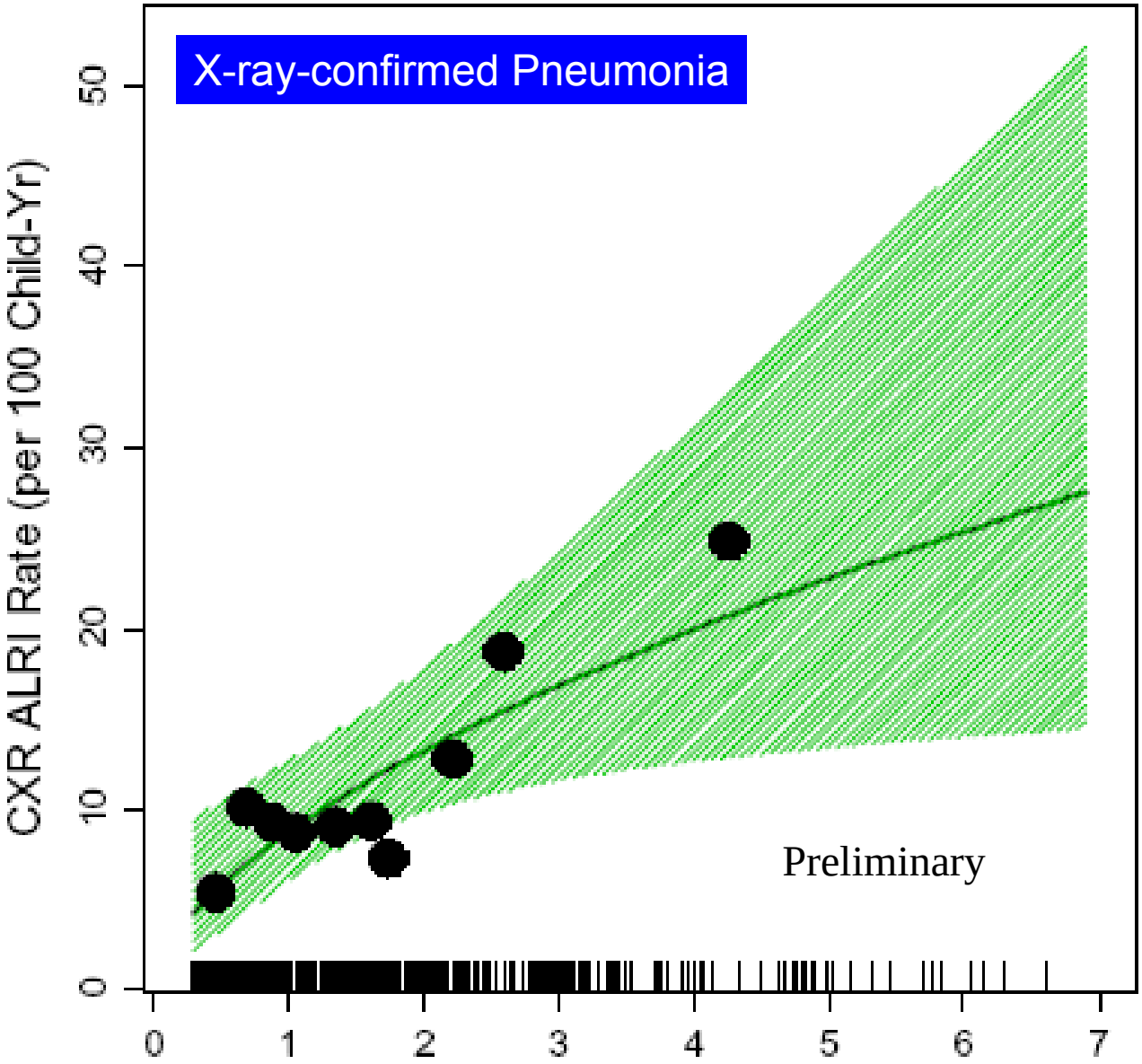
- Adjusted for child's age (quadratic), sex, birth interval less than 2 yr (yes/no), mother's age (quadratic), maternal education and paternal education (none/primary/ secondary), secondhand tobacco smoke exposure (yes/no), latrine (yes/no), piped water (yes/no), electricity (yes/no), kerosene lamp (yes/no), wood-fired sauna (yes/no), bedroom in kitchen (yes/no), roof type (metal sheet/tiles/straw), earth floor (yes/no), asset index (linear over range 0 to 6), animal ownership index (linear over range 0 to 4), crowding index (people per room), altitude (5 categories), occupation (farm other land/farm own land/other), and season (cold dry, warm wet, warm dry).

Preliminary

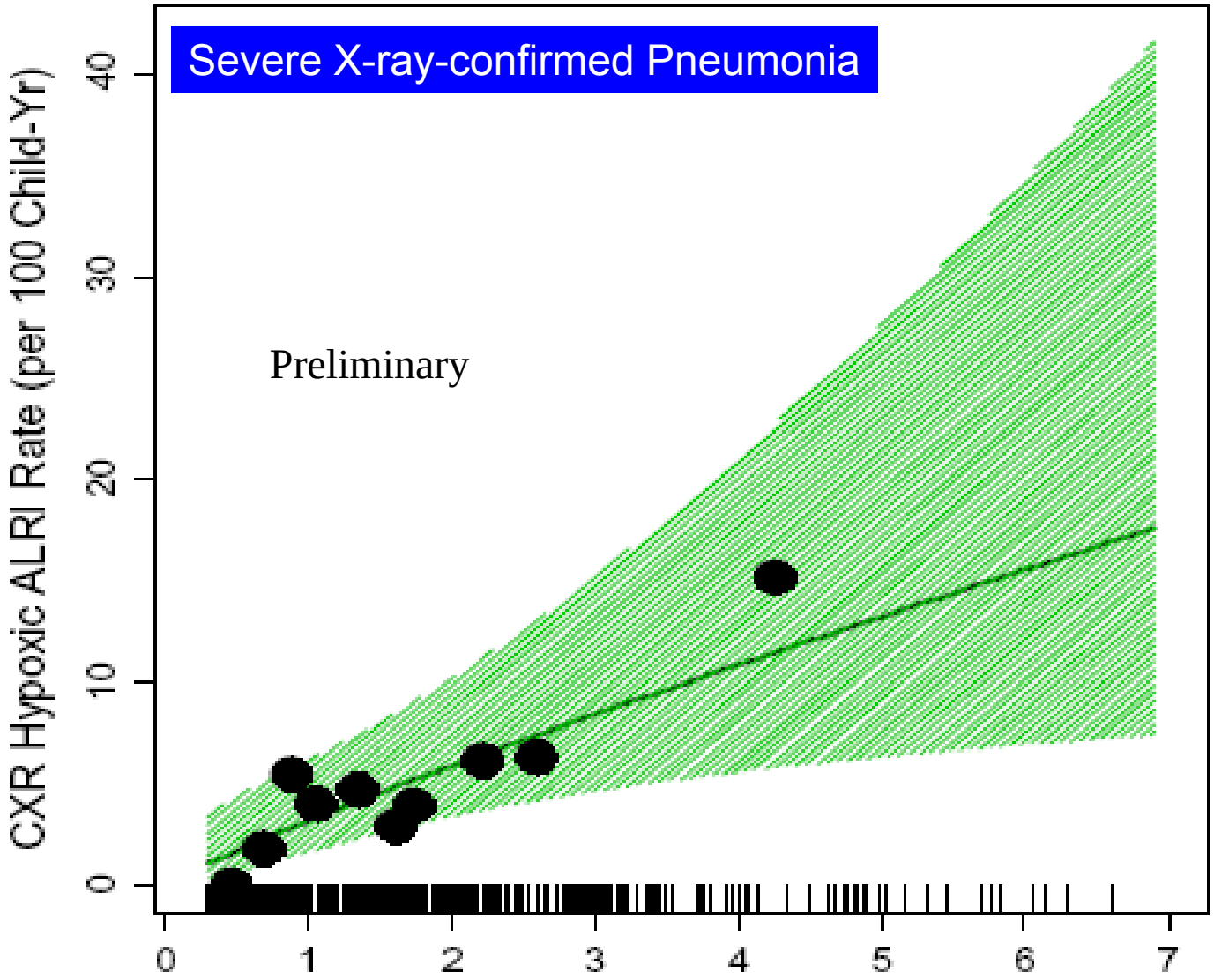


Approximate Mean PM2.5 exposure in 100s of ug/m3


MD-diagnosed Severe Pneumonia
Hypoxic ALRI Rate (per 100 Child-Yr)
10
20
30
40
50
60
0
1
2
3
4
5
6
7
Preliminary
Approximate Mean PM2.5 exposure in 100s of µg/m3



Approximate Mean PM2.5 exposure in 100s of ug/m3



Approximate Mean PM2.5 exposure in 100s of ug/m3

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)

Other studies at San Lorenzo Household Air Pollution Research Site

- First: Blood pressure, *Environmental Health Perspectives*, 2007
- First: ST-segment, *Environmental Health Perspectives*, in press
- Low birth weight, *Environmental Health Perspectives,* 2011 (first with exposure measures)
- First: measurements of dioxin levels in village kitchens using biomass – in review
- First: cognitive function in children related to prenatal exposures of mothers – in review
- CRECER – chronic respiratory outcomes

New exposure methods

- Inexpensive datalogging particle monitor based on smoke alarm technology
- Inexpensive time-activity monitor based on ultrasound technology
- Inexpensive stove-use monitor based on temperature dataloggers
- Application of industrial hygiene monitors to determine long-term exposure of infants
- Urinary biomarkers of woodsmoke exposure

SMALL, SMART, FAST, & CHEAP

monitoring devices for household energy & health

Ajay Pillarisetti, Ilse Ruiz-Mercado, and Nick Lam on behalf of Prof. Kirk R. Smith's Research Group at University of California, Berkeley
Visit ehs.sph.berkeley.edu/krsmith for more information

STOVE USE MONITORS
UTILIZATION

Time-of-use measuring devices allow more accurate estimations and objective definitions of usage patterns including cooking periods, meal times, and technology adoption rates.

Stove Use Monitors (SUMS) quantify utilization of cookstoves to improve estimates of personal exposure and enviromental benefits related to household energy use. SUMS are based on commercially available, low-cost, small temperature loggers.

The stainless steel temperature sensors are the size of a coin and can record time, date, and temperature. Programming and downloading data can be easily performed in the field. They are easy to use, unobtrusive, waterproof and tamper-resistant. They come with algorithms and software to systematically assess stove use patterns.

Measurements of stove surface temperature can be used to test the effectiveness of behavioral interventions on stove use. Because they give precise, unbiased measures of a simple physical parameter, statistically reliable information is provided using smaller sample sizes than required for a household survey.

PARTICLE AND TEMP SENSOR
CONCENTRATION

The ability to measure concentrations of small airborne particles is vital in understanding adverse health effects from combustion-derived air pollution. Available instrumentation to conduct such measurements is complex and expensive. Such devices are appropriate for developed countries and ambient air monitoring stations. However, their routine use in real-world household environments is expensive & cumbersome. Monitoring locations may also be remote, where security is questionable and electrical power not available, limiting the applicability of conventional instruments. In an effort to fulfill the needs for small, smart, fast, and cheap particle monitors that could be deployed easily in remote settings, a commercial smoke detector that uses optical scattering was identified and modified so that real-time signals could be logged continuously. This modified particle and temperature sensor is dubbed the UCB-PATS. Customized software handles data importing, graphing, and manipulation.

TIME-ACTIVITY MONITORING
LOCATION

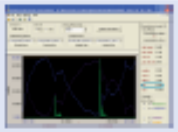
Measurement of exposure to pollutants is vital to the field of environmental health. The significance of a hazard depends on the amount of time a person is in contact with it. For instance, high indoor air pollution levels have been found in many homes globally. The risk of respiratory disease depends on the amount of time people spend in the presence of this pollution.

Time-Activity Monitoring System (TAMS) detects the presence or absence of individuals in an enclosed space. The system consists of one to five small ultrasound emitting devices worn on an individual's clothing. Each produces a distinct pattern that is emitted every few seconds. An ultrasound receiver is mounted on the wall of a room and detects the unique pattern from the device worn by an individual.

If the identifying signal pattern emitted from a particular locator is received a certain number of times during a minute, that locator, and presumably the person wearing it, is recorded as being present in the room. Field trials show good results, with a 93% accuracy rate as measured against direct observation.

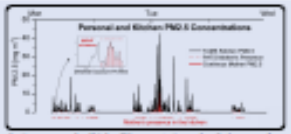
Device Software & Sample Output

Each device is controlled by software allowing equipment launch, data download and manipulation, and exporting of data files for further analysis. Devices connect with the software over a serial port or via an USB to Serial connector.



Viewing and processing downloaded data in the UCB-PATS Data Browser

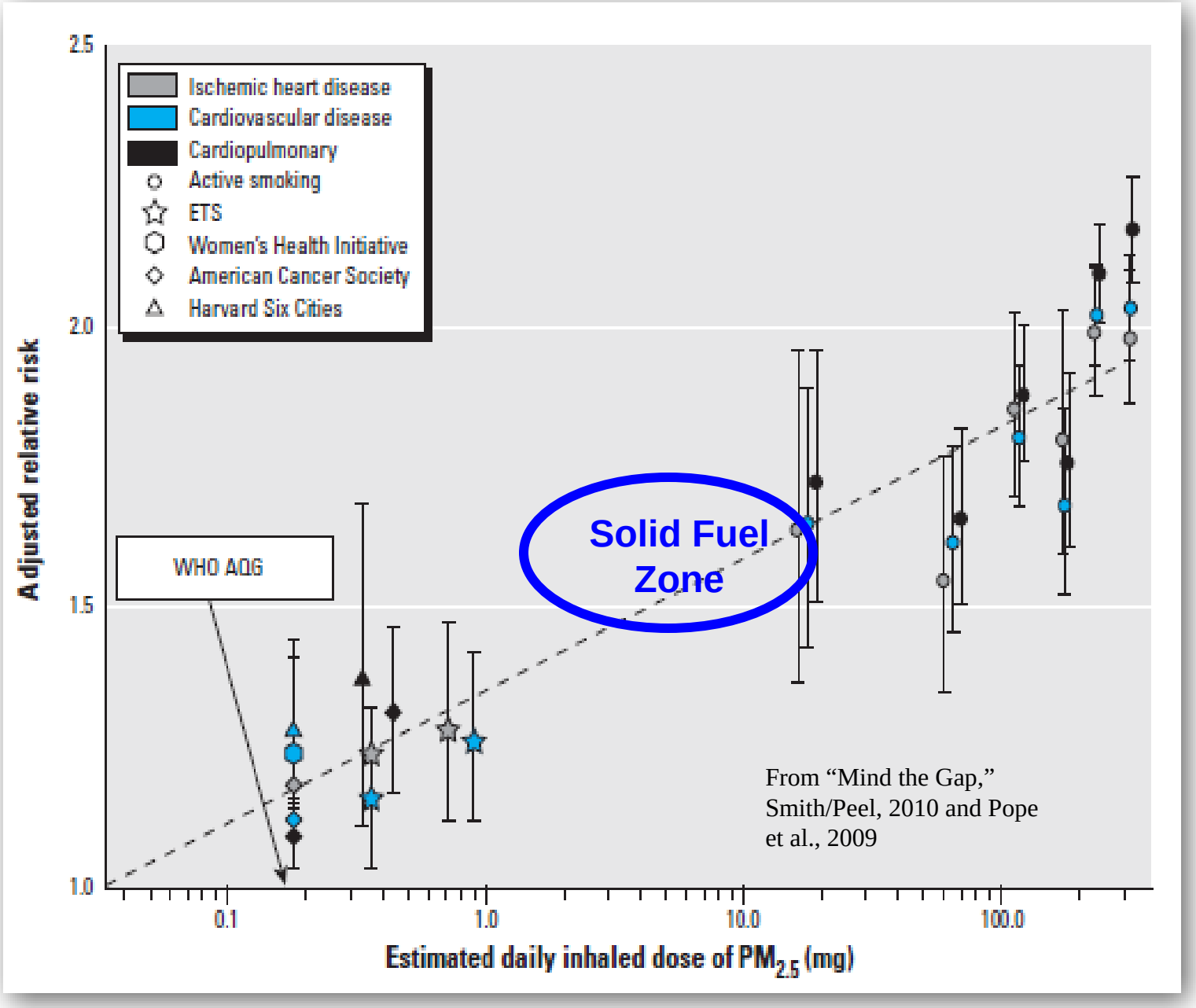
Graphical view of reading on three channels – Stages, traditional wood and improved wood in one household from UCBAS Software.



Continuous personal and kitchen $PM_{2.5}$ concentrations and mother's presence for a few children on open fire stove.

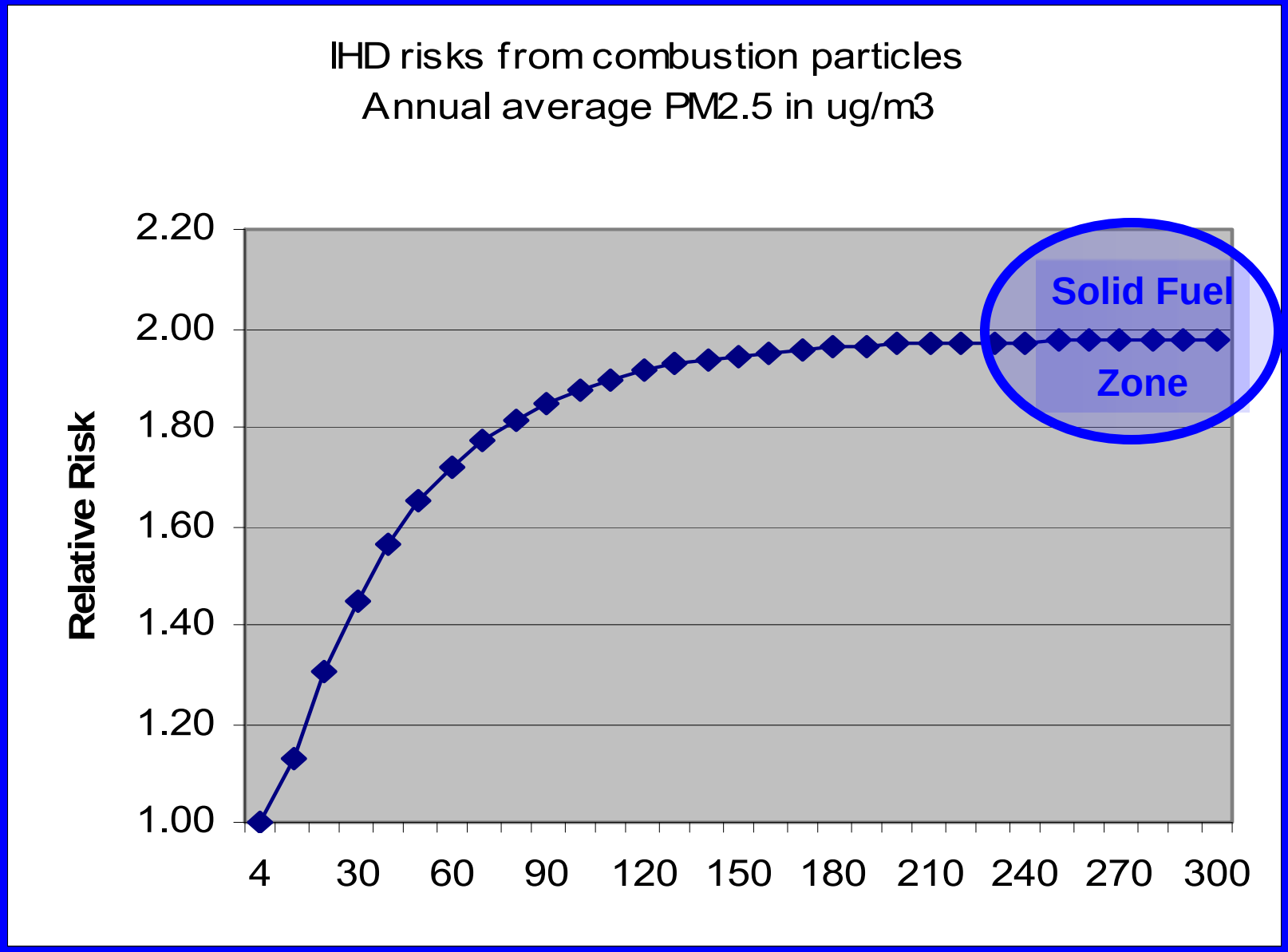
For more information, google "Kirk R Smith" • To acquire devices, visit berkeleyair.com

Heart Disease and Combustion Particle Doses



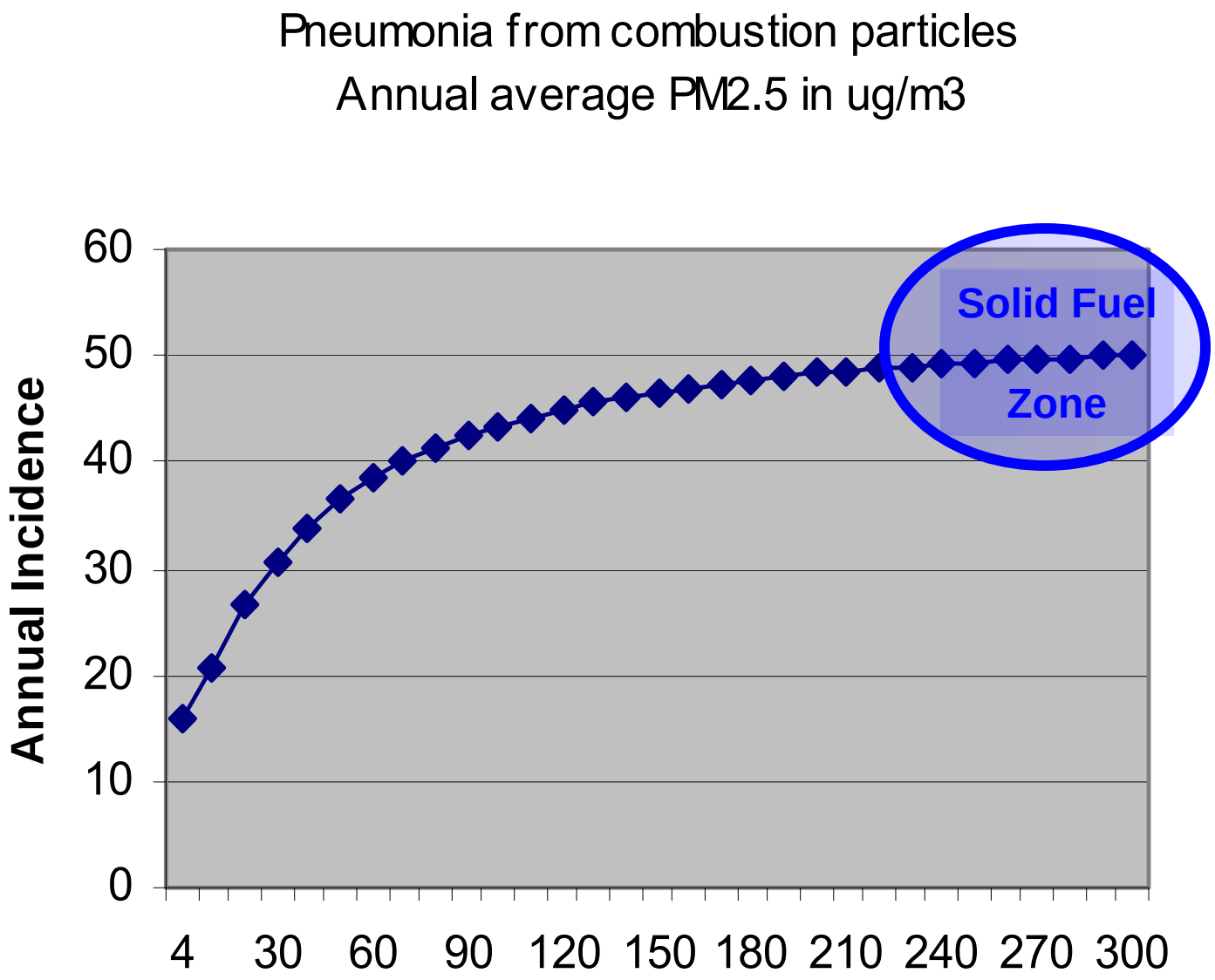
From "Mind the Gap," Smith/Peel, 2010 and Pope et al., 2009

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



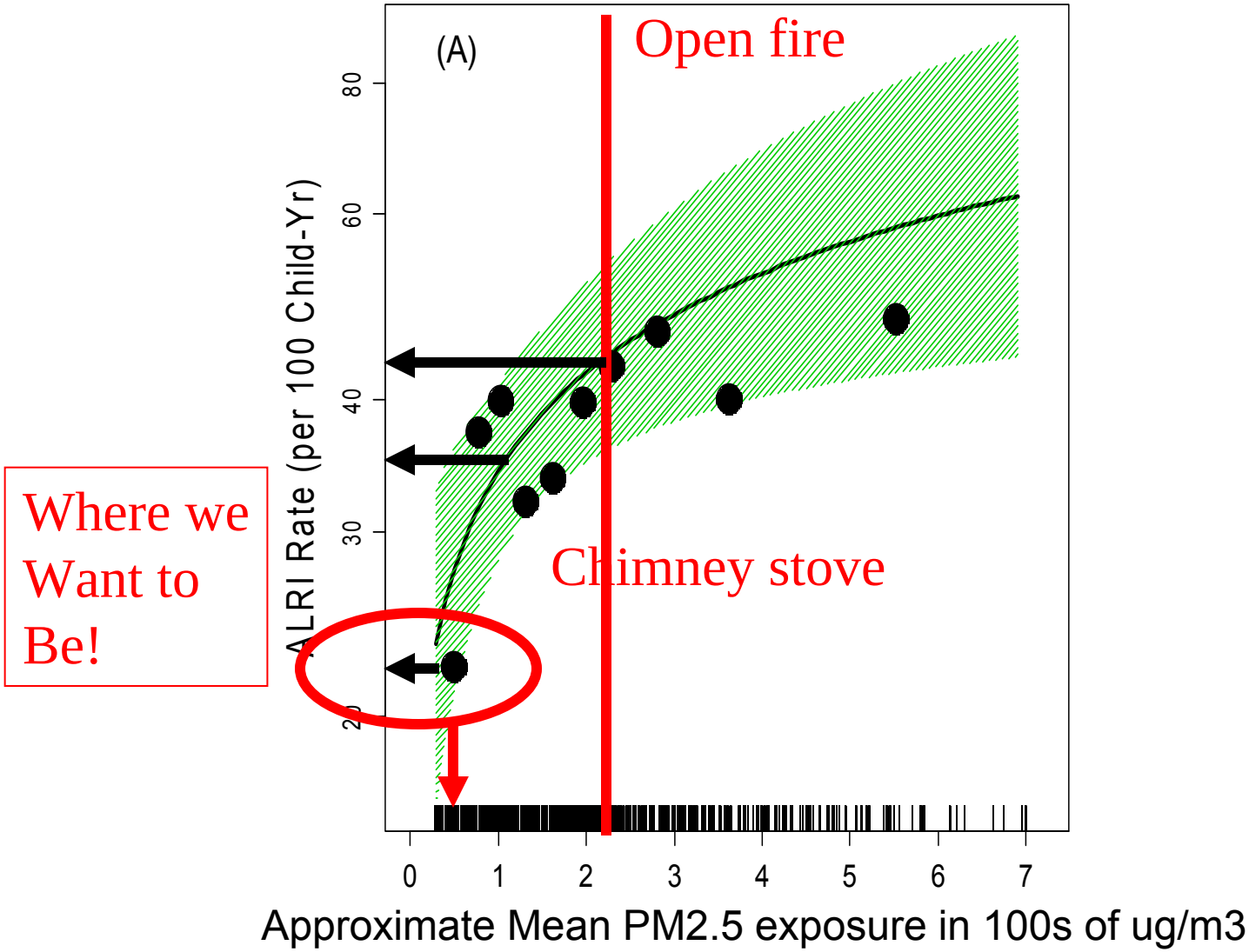
CRA, 2011

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



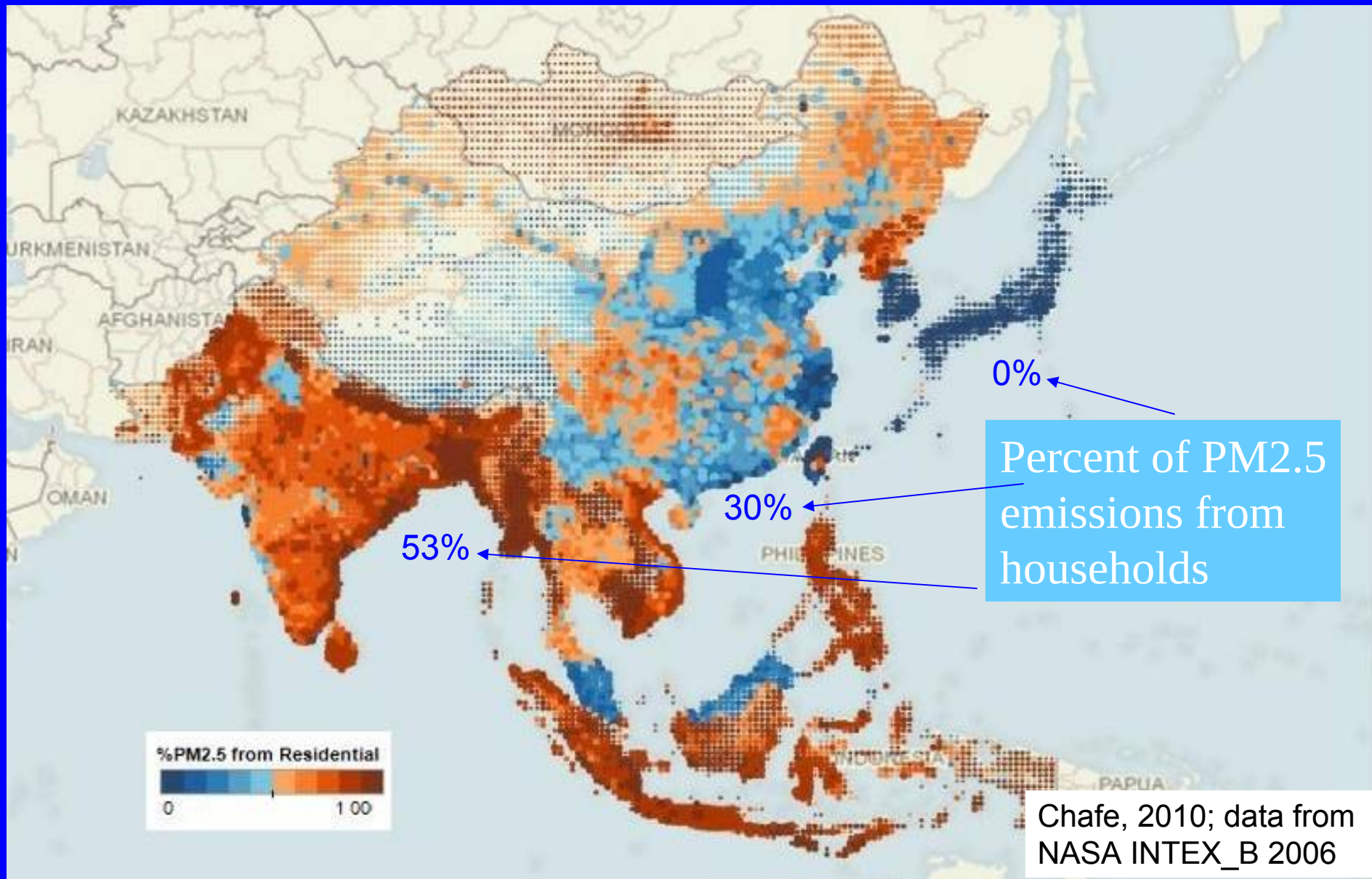
CRA, 2011

MD-diagnosed Acute Lower Respiratory Infection



RESPIRE-Guatemala

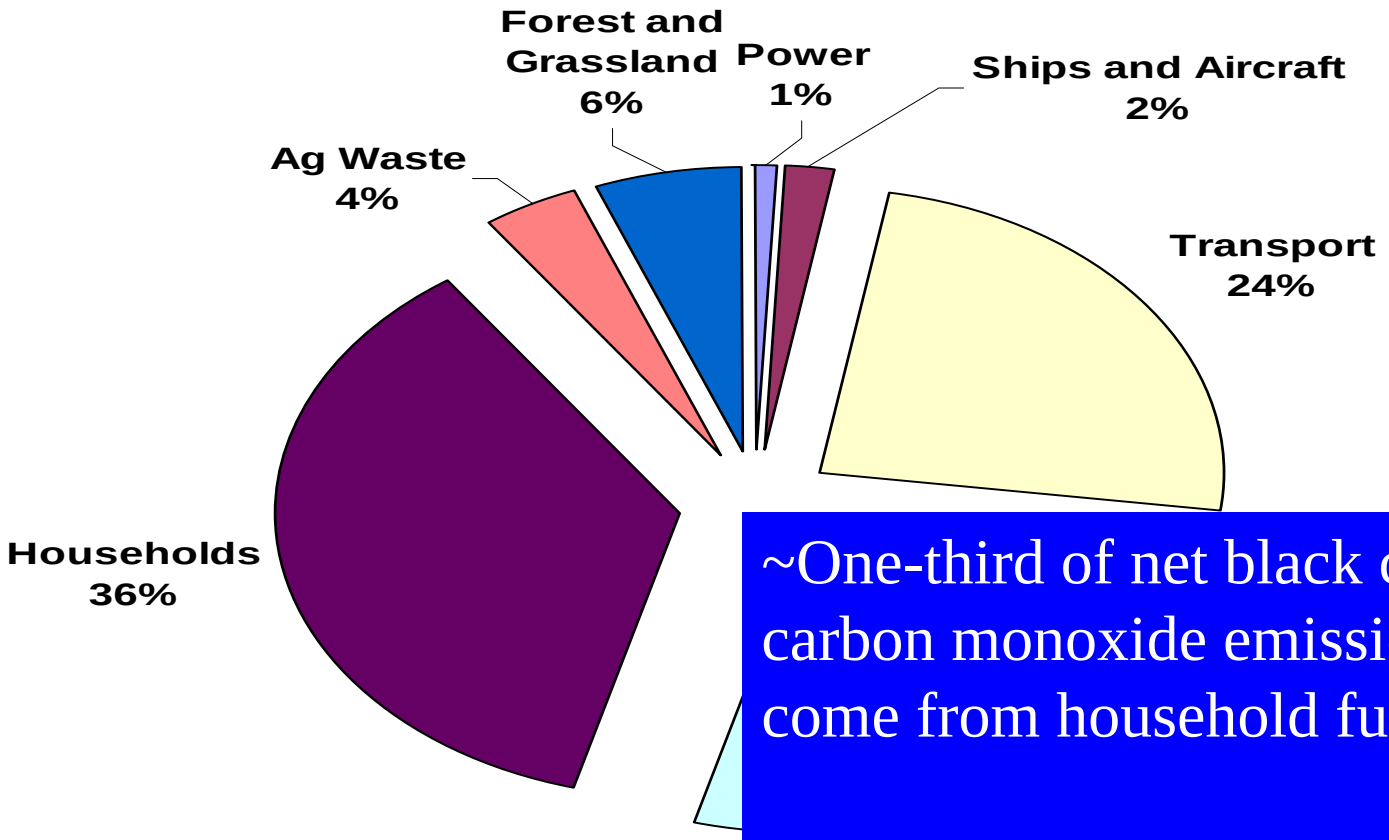
NASA INTEX_B Database
Percent $PM_{2.5}$ emissions from households



Chafe, 2010; data from NASA INTEX_B 2006

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 pollutan

~One-twentieth of methane

Many thanks to collaborators and funders

- Ministry of Health, Centro de Estudios en Salud, Universidad del Valle, and others
- National Institute of Environmental Health Sciences, Centers for Disease Control, World Health Organization, and others
- Our highly skilled field staff and fieldworkers
- And the participating women and children of San Lorenzo and Comitancillo

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

Muchas Gracias