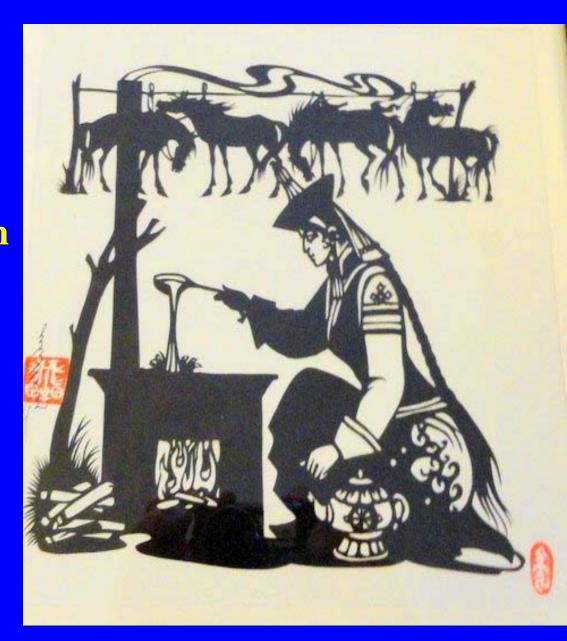
Smoke, health, and climate: the unfinished global agenda of incomplete combustion

Kirk R. Smith Professor of Global Environmental Health University of California, Berkeley

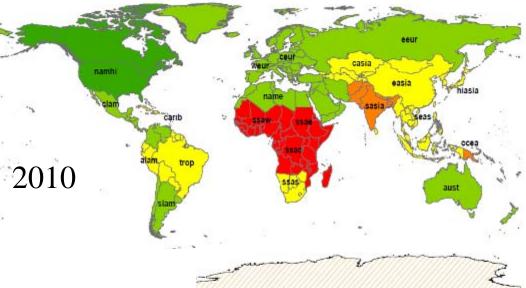
Global Health Sciences UCSF, Oct 13, 2011

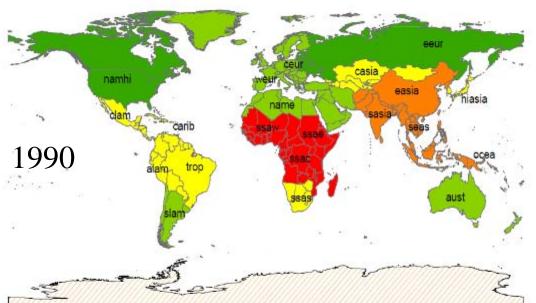


300-400 thousand years ago, hearths became a regular feature in human habitation

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

Households using biomass or coal to cook



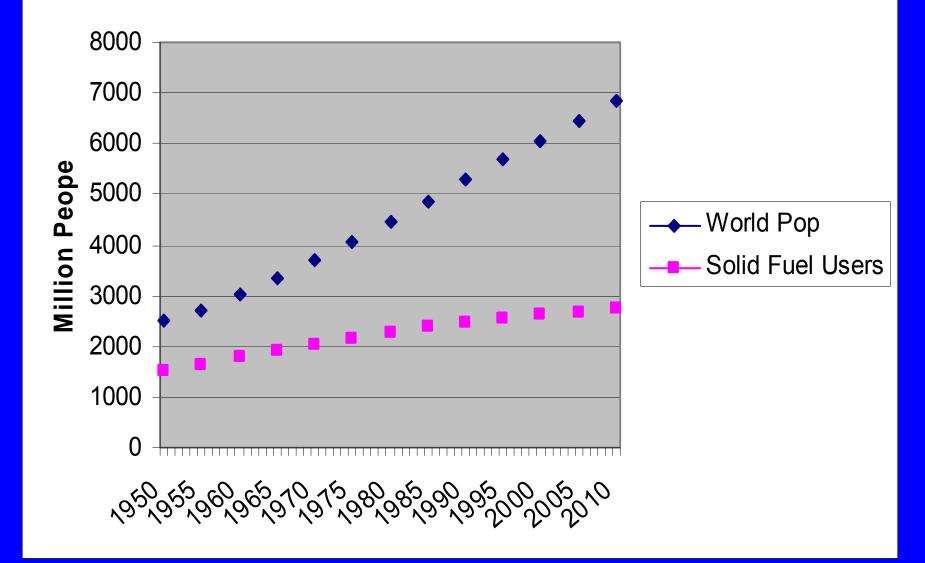


% of HH Exposed to HAP



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

World Population Using Solid Fuels



Biomass Cooking in History

- Today, ~43% use solid fuels, about 3 billion people
- Although the percentage is dropping, the absolute number is still rising.
- Perhaps 20 million people a year are added to the total each year.
- Indeed, there are more people using solid fuels today for cooking than the total world population in 1950
- Or any year previously

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)?

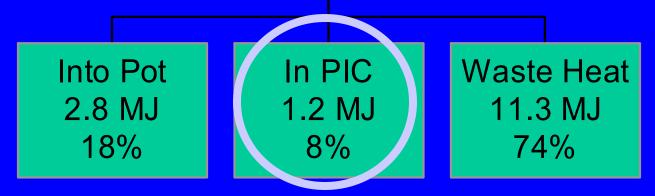


Reason: the combustion efficiency is far less than 100%

Energy flows in a well-operating traditional wood-fired Indian cooking stove

A Toxic Waste Factory!!

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

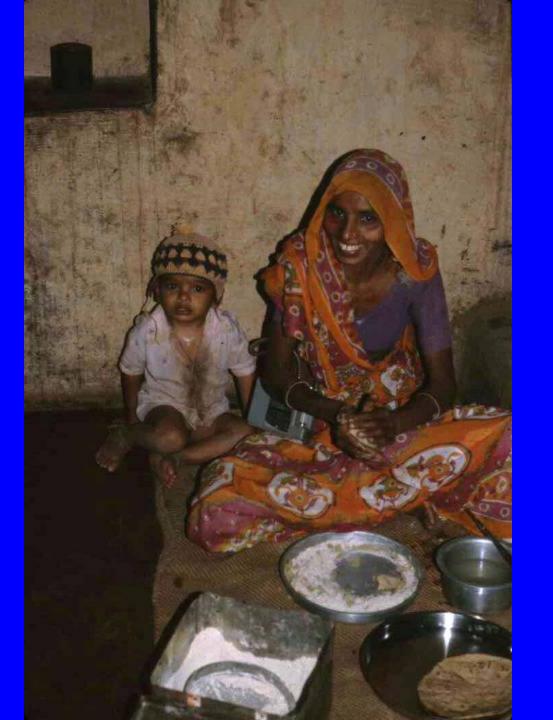


PIC = products of incomplete combustion = CO, HC, C, etc.

Source: Smith, et al., 2000

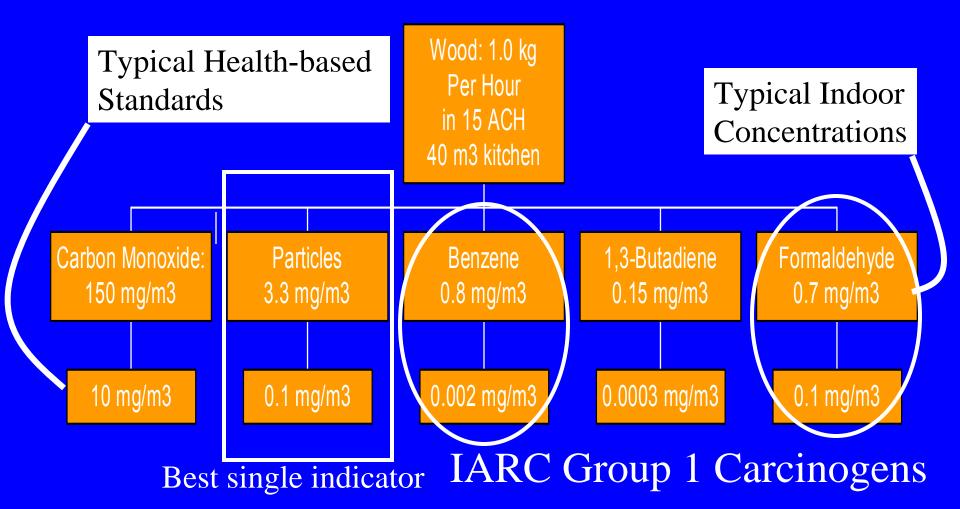
Toxic Pollutants in Biomass Fuel Smoke from Simple (poor) Combustion

- Small particles, CO, NO₂
- 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 $benzo(\alpha)pyrene$
- 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
- Source: Naeher et al, *J Inhal Tox*, 2007
- Chlorinated organics such as *methylene chloride* and *dioxin*



How much Ill-health?

Health-Damaging Air Pollutants From Typical Woodfired Cookstove in India.



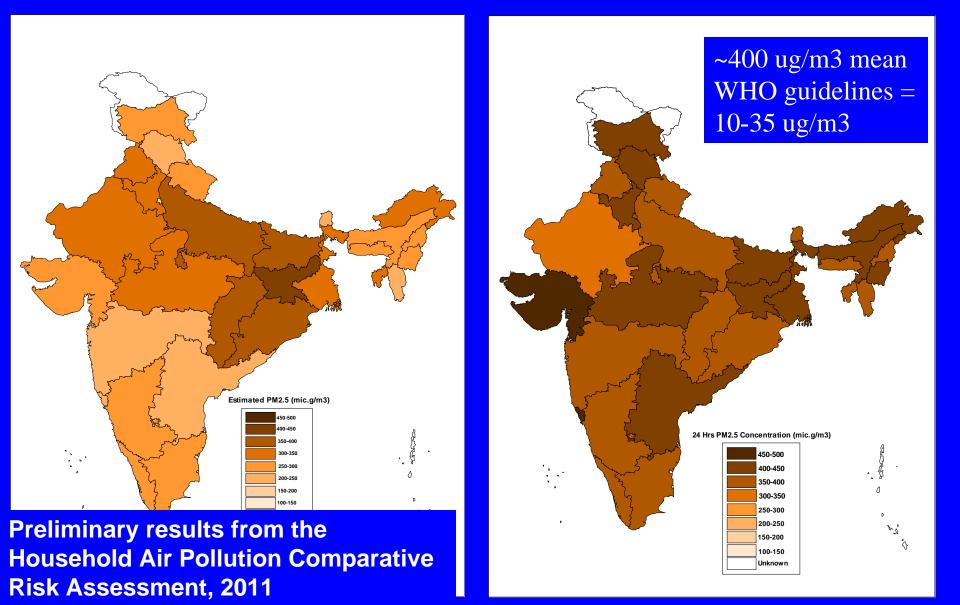
First person in human history to have her exposure measured doing the oldest task in human history

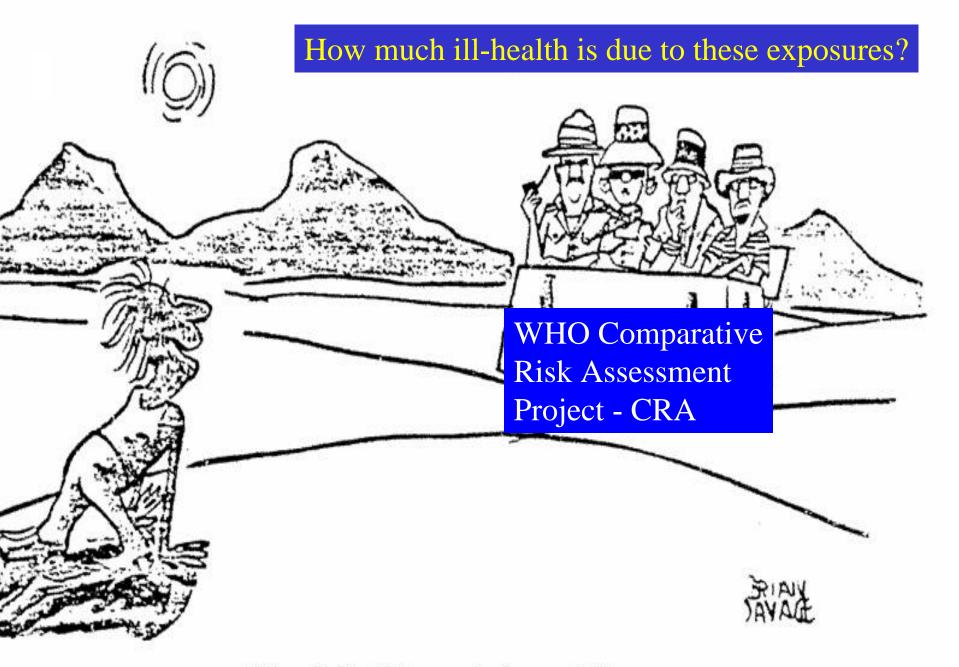
Emissions, yes, but what about exposures?

> Kheda District, Gujarat, 1981

Estimated PM2.5 indoors for <u>all</u> households

Estimated PM2.5 for <u>only</u> solid-fuel-using households





"Thank God! A panel of experts!"

Courtesy of Ross Anderson

ALRI/ Pneumonia

Diseases for which we have epidemiological studies

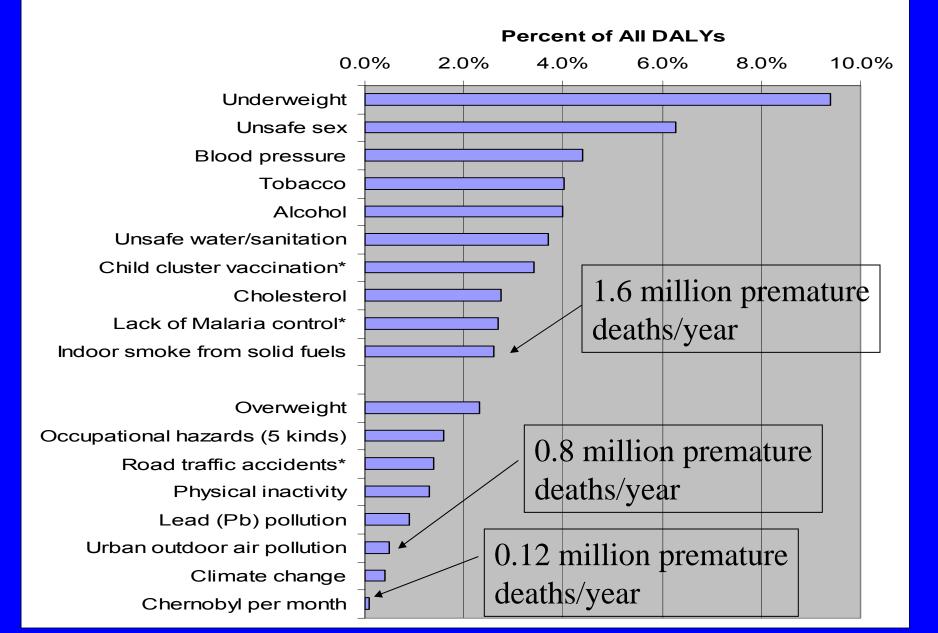
COPD Lung cancer (coal)



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



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A B	ICDE F	G	Н	l I	J	K	L	M	N	0	P G	F S	T	U	V	W	Х	
1 Population (6224384.81	317077.27	622741.70	817442.87	66.3968.38	42707129	166160.20	30443.11	28143.24	3131052.05	301091.79	589229.34	782702621	646519.90	427846.34	181906.42	110
2 GBD 200	D2: DALYs by age, sex and cause	se for the y	year 2002	2														
3 WORLD														-				
4					-		Male	200.000		1000						Female		
5 Code	Cause	Total	0-4	5-14	15-29	30-44	45-59	60-69	70-79	80+	Totai	0-4	5-14	15-29	30-44	45-59	60-69	
6 U000	All Causes	1490125643	222552079	56142418	141637847	130501742	115374678	60641455	36229210	9832834	772912264	211279454	54559890	141633214	108257333	90621463	53460940	40'
U001 I.		610319230		20979812	29721889	36148775	16651072	5676094	2915759	849889	******		23248712	59740290	35979204	114.99502	4476964	25
7	and nutritional conditions																	
8 U002 9 U003	A. Infectious and parasitic diseases 1. Tuberculosis	350332571 34735908	87977510 839261	12810197 782431	25516201 5497848	33372707 7335503	14085712 4868489	3710016 1832663	1519252 658401	315539 90612	179307135 21905208	89749119 738745	13534884 821735	31549467 4163278	23070592 3822011	8616676 2041939	2658113 833205	14
10 U004	2. STDs excluding HIV	11347067	1521528	26245	1080828	660600	423721	1032003	31641	7415		1726606	97221	4158088	1147558	260537	71612	
11 U005	a. Syphilis	4200039	1039452	2292	151945	285546	354596	99162	30394	6987	1970375	1265722	3432	521758		107605	42492	
12 U006	b. Chlamydia	3571404	1199	7209	241593	50929	1169	136	0	0	302234	1152	69338	2635460	439449	109658	14084	
13 U007 14 U008	c. Gonorrhoea d. Other STDs	2265159	462045	16668	CONCA	201215	CCC4	710	Q1	2	14 70160	447700	04000	000000	422675 22947	6262 37012	1616 13420	
15 U009	3. HIV/AIDS		Clak		Durc	lon	of F	liec			atab	200			13746555	2624463	230670	
16 U010	4. Diarrhoeal diseases	· · · · · ·	GIUL	Jali	Juic			JISE	a30		alab	ase			545936	373258	201900	1
17 U011	5. Childhood-cluster dise					4									53966	19174	4837	
18 U012 19 U013	a. Pertussis		and	Co	mna	arat	ive_	RIS	κA	sse	ssm	ent_			0	13	0	
20 U014	b. Poliomyelitis c. Diphtheria											ont			16931 386	3822 572	615 29	
21 U015	d. Measles				orld		lth-	Ore		Zot	ion-				29	30	23	
22 U016	e. Tetanus				Ла	Пee			all	Zal	ION				36620	14737	4192	
23 U017	6. Meningitis*							C							167759	110215	48775	
24 U018	7. Hepatitis B														115391	110437	36630	
25 U019 26 U020	Hepatitis C 8. Malaria														53705	61307 280704	30322	
27 U021	9. Tropical-cluster disea				•			1 - 1-							453207 593336	496341	99111 75537	
28 U022	a. Trypanosomiasis			Ве	ing	con	nble	ten	/ UD	nai	led				79329	46509	3694	
29 U023	b. Chagas disease														51644	48058	15987	
30 U024	c. Schistosomiasis					or O	011	rol	000						128589	58850	17056	
31 U025 32 U026	d. Leishmaniasis					ע וכ		IEI	eas	e					67203	30097	11647	
33 U026	e. lymphatic filariasis f. Onchocerciasis														206680 59892	266630 46198	15772 11380	
34 U028	10. Leprosy														15828	9135	4389	
35 U029	11. Dengue														10408	6396	2644	
36 U030	12. Japanese encephalitis				ha					11 4					26926	7282	2513	
37 U031	13. Trachoma			FOI	hoi	usei		l all	$\mathcal{D}\mathcal{O}$	ΠUL	ION.				517423	559520	344796	1
38 U032 39 U033	14. Intestinal nematode in a. Ascariasis														5192 161	5921 21	3469 111	
40 U034	b. Trichuriasis			ΔΥΙ	nnei	Iro ·	200	200	ma	nt r	node	aling			388	433	238	
41 U035	c. Hookworm disease				1030		233	-33			noue	Jing			4212	4859	2723	
42 U036	Other intestinal infection		. 1		1						1				432	607	397	
43 U037	Other infectious disease	W OL	JICO	me	esti	mai	es l	oas	ea	on	meia	a-an	aivs	ses	1795391	1650048	667703	
44 U038 45 U039	B. Respiratory infections 1. Lower respiratory infect														1481589 1434738	1357246 1329549	1460806 1425397	13
46 U040	2. Upper respiratory infec			Λ	RI, (חכ		na C	20	cor				1434738 45228	26339	1425397 34405	
47 U041	3. Otitis media			AL	$\overline{\mathbf{N}}, \underline{\mathbf{V}}$		$-\mathcal{D},$	LUI	<u>I</u> <u>y</u> <u></u>	Jan					1622	1358	1004	
48 U042	C. Maternal conditions														9947305	403615	19	
49 U043	1. Maternal haemorrhage		7 bir	th w	<u>/eia</u>	ht c	cata	rac	ts (car	diova	ASCL	Ilar_		1944088	133887	0	
50 U044 51 U045	2. Matemal sepsis					, (rao							1625431	72999	0	
51 0045 52 U046	3. Hypertensive disorders 4. Obstructed labour	3048291	ů O	n	0	n	n	n	n	ñ	0	0	0.0	2241561	722909 794568	40216 12162	U	
53 U047	5. Abortion	4652171	0		0	0	0	0	0	0	0	0		3721304	705860	1596	0 0	
54 U048	Other maternal conditions	12427759	0	0	0	0	0	0	0	0	0	0		8128555		142755	19	
55 U049	D. Perinatal conditions*	٥	53209265	1343	1031	347	89	12	9	0		44121066	1195	498	158	34	29	
56 U050	1. Low birth weight	46334234	25061999	52	13	20	0	9	0	0	25062092	21272111		0	0	0	0	
57 U051 58 U052	 Birth asphyxia and birth trauma Other perinatal conditions 	34445758	19353003 9794262	790 502	302 716	73 253	33 56	3 0	0	0	19354204 8795799	15090851		107 392		15 19	0 29	
58 0052 59 U053	E Nutritional deficiencies	16555094 34416632	8794262 10258276	502 1921013	1793247	203 1025783	56 698252	230984	9 132831	39983		7758104 10385030		392 2149411		19 1121930	29 357998	
60 U054	1. Protein-energy malnutrition	16910328	7556012	560106	156056	69278	103279	71114	45451	18671	8579966	7350453		66437		81418	70683	
61 U055	2. Iodine deficiency	3519322	1283895	471857	528	748	1215	641	236	50		1305105		1681		1287	439	
62 U056	3. Vitamin A deficiency	792562	257306	84825	3330	6358	7864	3519	983	100	364284	320394	84034	10506	3807	6687	ull Scree	• x
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ALRI/ Pneumonia

Low birth weight

Diseases for which we have epidemiological studies - 2011 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

Stillbirth

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

Tuberculosis
ALRI

Other cancers (cervical, NP, upper airway)

Asthma?

Cognitive

Impairment

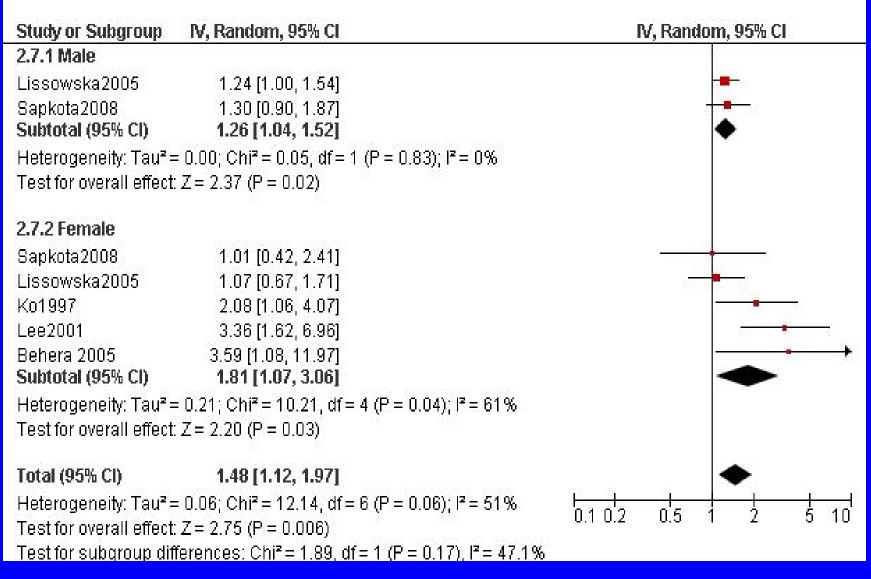
Birth defects

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) Subtotal (I-squared	1996-1998 118 d = .%, p = .)	235	0.74 (0.17, 3.14) 0.74 (0.17, 3.14)
Europe Lissowska(2005) Subtotal (I-square	1998-2001 2861 d = .%, p = .)	3118	1.13 (0.93, 1.38) 1.13 (0.93, 1.38)
North America Wu(1985) Subtotal (I-squared	1981-1982 220 d = .%, p = .)	220	2.30 (0.96, 5.50) 2.30 (0.96, 5.50)
India Gupta(2001) Sapkota(2008) Subtotal (I-square	1995-1997 265 2001-2004 793 d = 4.4%, p = 0.307)	525 718	1.52 (0.33, 6.98) 3.76 (1.64, 8.63) 3.02 (1.42, 6.46)
Mainland China an Wu-Williams(1990) Sun(1991) Chengyu(1992) Ger(1993) Li(1993) Lin(1996) Dai(1996) Luo(1996) Ko(1997) Hao(1998) Huang(1999) Wu(1999) Lan(2000) Lee(2001) Kleinerman(2002) Sun(2002) Lu(2003) Liang(2004) Galeone(2008) Lan(2008)		959 398 135 524 161 122 120 306 117 440 244 258 122 805 1724 618 445 152 436 498	1.30 $(0.99, 1.70)$ 2.26 $(1.53, 3.33)$ 1.59 $(1.22, 2.07)$ 1.44 $(0.44, 4.69)$ 2.08 $(0.85, 5.08)$ 3.24 $(1.05, 9.94)$ 4.70 $(1.29, 17.18)$ 6.00 $(5.07, 7.10)$ 1.30 $(0.29, 5.80)$ 1.99 $(1.16, 3.43)$ 1.92 $(1.40, 2.62)$ 1.58 $(0.89, 2.80)$ 2.40 $(1.31, 4.40)$ 2.10 $(1.19, 3.70)$ 1.29 $(1.03, 1.61)$ 2.20 $(1.25, 3.86)$ 3.44 $(1.38, 8.57)$ 2.02 $(1.20, 3.39)$ 2.19 $(1.08, 4.46)$ 7.40 $(4.18, 13.10)$
-	a = 90.3%, p = 0.000) = 90.4%, p = 0.000)		2.28 (1.66, 3.13) 2.16 (1.62, 2.90)
		.8 1 1.5 2 2.53 5 10	

Odds ratio

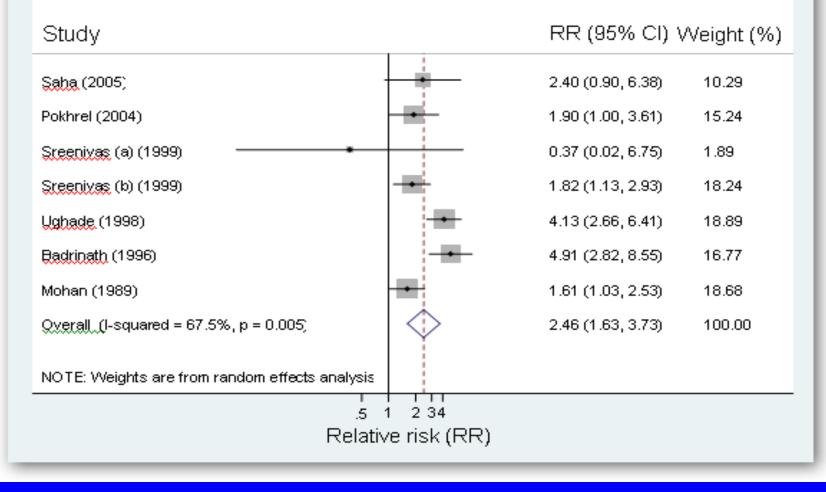
Lung Cancer: Biomass vs. clean fuel



CRA, Imran et al. preliminary

Cataracts and Biomass Cooking Smoke*

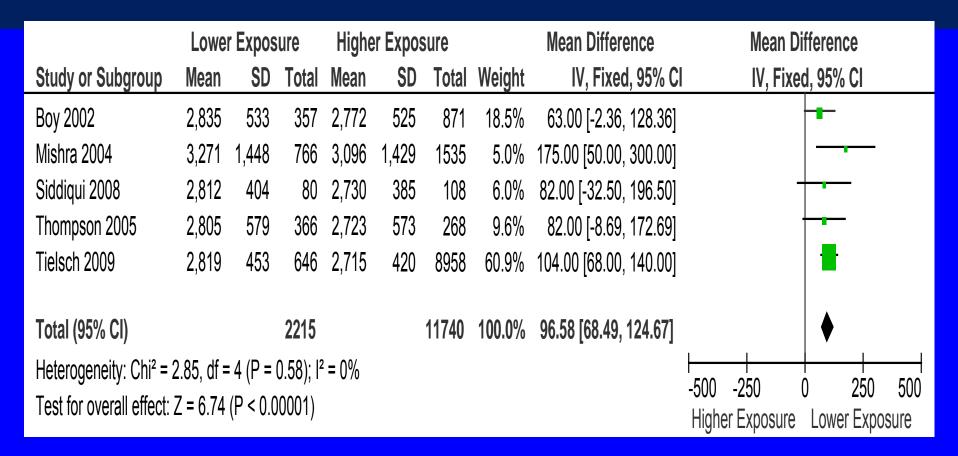
Active Smoking Adjusted- Random Effects Model



CRA Preliminary, Adair et al.

* Adjusted for UV

Pooled birth weight difference (low minus high exposure): Adjusted estimates (Boy and Tielsch have GA)



All estimates: +96.6g (68.5, 124.7) Excluding self-reports +93.1g (64.6, 121.6)

CRA: Pope et al., 2010

				Study Odds Ratio (randor		Odds Ratio (random)
Study design	N*	OR	95% CI	or sub-category 95% Cl	%	95% CI
ciady accigin				01 Intervention Studies		
Intervention	2	1 00	1 06 1 54	Smith(2007)a	5.53	1.18 [0.88, 1.58] 1.35 [1.05, 1.73]
Intervention	2	1.28	1.06, 1.54	Subtotal (95% Cl)	5.73 11.26	1.28 [1.06, 1.54]
				Test for heterogeneity: Chi ² = 0.48, df = 1 (P = 0.49), ² = 0%	11.26	1.28 [1.06, 1.84]
				Test for overall effect: $Z = 2.54$ (P = 0.01)		
Cohort	7	2.12	1.06, 4.25	02 Cohort Studies		
Conort	· '	2.12	1.00, 1.20	Armstrong(1991)a	2.80	0.50 [0.20, 1.22]
				Armstrong(1991)b		1.90 [0.96, 3.75]
				Cambell(1989)	3.25	2.80 [1.29, 6.08]
				Ezzati(2001)	3.86	2.33 [1.23, 4.40]
				Jin(1993)	5.69	0.80 [0.62, 1.03]
				Pandey(1989)a	4.34	2.45 [1.43, 4.19]
				Pandey(1989)b	▶ 1.52	40.65 [9.79, 168.75]
				Subtotel (95% CI)	25.11	2.12 [1.05, 4.25]
		П	٠		00.3%	
Coop control	45	Pne	eumonia –	- the biggest single		
Case-control	15				3.97	1.20 [0.65, 2.21]
		Car	ise of chil	d death in the world	4.49	2.51 [1.51, 4.17]
		Cut			4.85	2.16 [1.40, 3.33]
				De Francisco(1993)	2.15	5.23 [1.72, 15.91]
				Fonsecca(1996)	4.68	1.14 [0.71, 1.82]
				Johnson(1992)a	3.15	0.80 [0.36, 1.78]
				Kossove(1982)	→ 1.96	4.77 [1.44, 15.74]
				Kumar(2004)	2.45	3.87 [1.42, 10.57]
				Mahalanabas(2002) -	3.63	3.97 [2.00, 7.88]
				Morris(1990)	2.41	4.85 [1.75, 13.40]
				O'Dempsey(1996) Robin(1996)a	2.59 2.95	2.55 [0.98, 6.64] 1.40 [0.60, 3.28]
				Victora(1994)a	4.08	1.10 [0.61, 1.98]
				Wayse(2004)	- 2.90	1.39 [0.58, 3.30]
				Wesley(1996)	1.87	1.35 [0.39, 4.63]
				Subtotal (95% CI)	48.15	1.97 [1.47, 2.64]
				Test for heterogeneity: Chi ² = 32.72, df = 14 (P = 0.003), I ² = 5	57.2%	
				Test for overall effect: Z = 4.53 (P < 0.00001)		
Cross-	3	1.49	1.21, 1.85	04 Cross-sectional Studies		
a settem al				Mishra(2003)	3.83	2.20 [1.16, 4.18]
sectional				Mishra(2005)	5.87	1.58 [1.28, 1.95]
				Wichmann(2006)	5.79	1.29 [1.02, 1.63]
				Subtotal (95% CI)	15.48	1.49 [1.21, 1.85]
				Test for heterogeneity: Chi ² = 3.19, df = 2 (P = 0.20), ² = 37.3		
				Test for overall effect: Z = 3.74 (P = 0.0002)		
All	26	1.78	1.45, 2.18			
	20	1.70	1.40, 2.10	Total (95% CI) Test for heterogeneity: Chi ² = 101.74, df = 26 (P < 0.00001), P	100.00	1.78 [1.45, 2.18]
				Test for overall effect: Z = 5.61 (P < 0.00001)	- / 4,470	
Dherani et a	Ru		(2008)			
Diferant et a	Bui			0.1 0.2 0.5 1 2	5 10	
				Increased risk Decrea	ased risk	

Outcome – 1a Binary exposures	Sex and Age	Estimates from SR/MAs	Estimates from 2004 CRA
ALRI*	M/F under 5 y	1.78 (1.45-2.18)	2.3 (1.9-2.7)
COPD	F >15 y	2.70 (1.95-3.75)	3.2 (2.3-4.8)
COPD	M >15	1.90 (1.15-3.13)	1.8 (1.0-3.2)
Lung Cancer-coal	F >15 y	1.98 (1.16, 3.36)	1.94 (1.09-3.47)
Lung Cancer -coal	M >15 y	1.31 (1.05, 1.76)	[1.51 (0.97-2.46)]
Lung Cancer -	F >15 y	1.81 (1.07-3.06)	
biomass			
Lung Cancer -	M >15y	1.26 (1.04-1.52)	
biomass			
Cataracts	F >15 y**	2.47 (2.04-3.15)	
Low Birth Weight***	M/F	1.52 (1.28, 1.80)	
Deficit Birth	M/F	93.1g (64.6, 121.6)	
Weight			

Risk Estimates for New CRA: Household Air Pollution



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

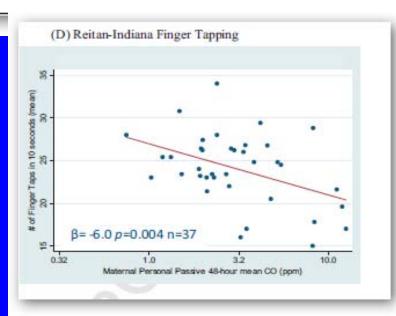
u Linda Dix-Cooper^a, Brenda Eskenazi^b, Carolina Romero^c, John Balmes^{a,d}, Kirk R. Smith^{a,*}

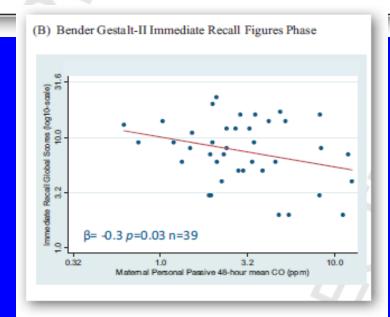
* Division of Environmental Health Sciences, School of Public Health, University of California, Berkeley, CA 94720-7360, USA

^b Center for Environmental Research and Children's Health (CERCH), School of Public Health, University of California, Berkeley, CA, USA

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





Story of Two Conferences

- Air pollution conference

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

History of an RCT

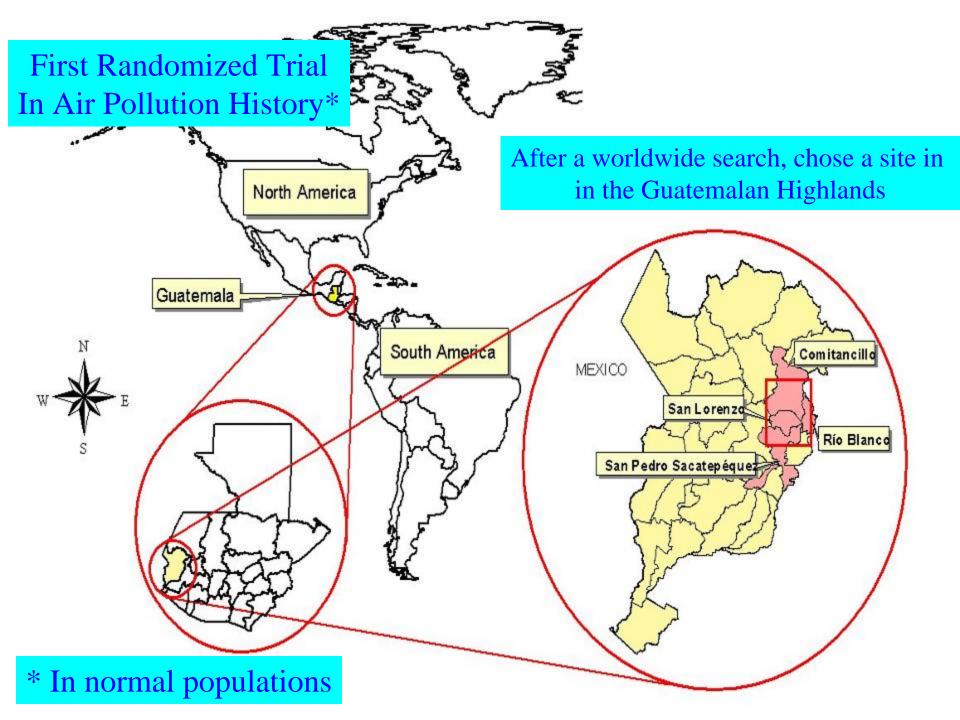
- ~1980: Case reports of health effects in South Asia
- 1981: First measurements of pollution levels in India
- 1984: International meeting to decide on needed research
 - Chose randomized controlled trial (RCT) of ALRI
- 1986-89: Unfunded proposals to do RCT in Nepal
- 1990: WHO establishes committee 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!

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

In press, Oct 2011



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/m³

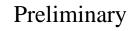


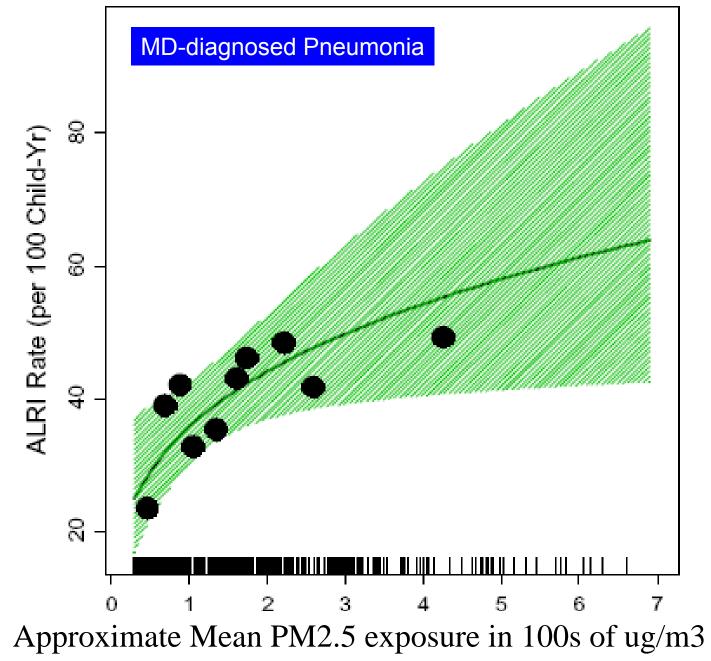
Chimney wood stove, locally made and popular with households

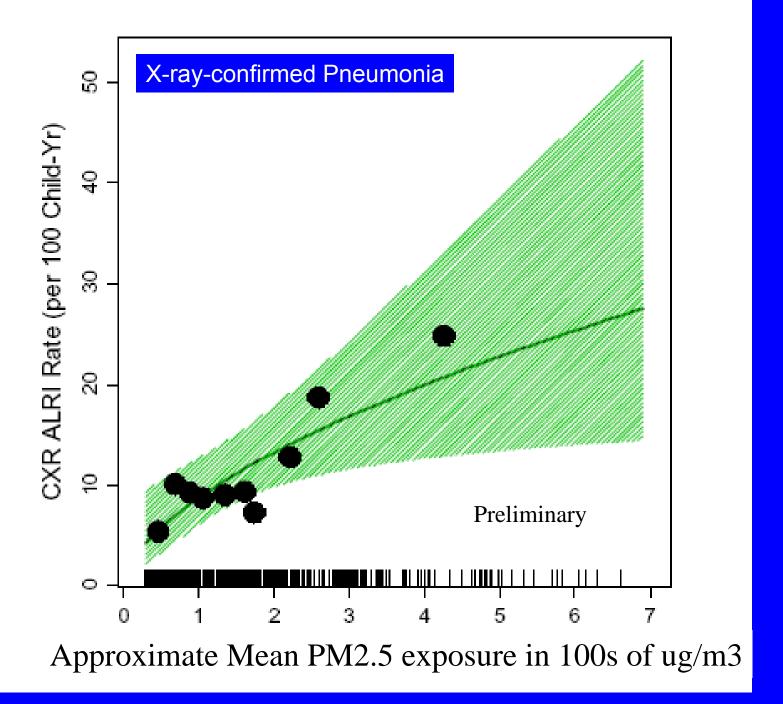
CO monitor

CO monitor

Im





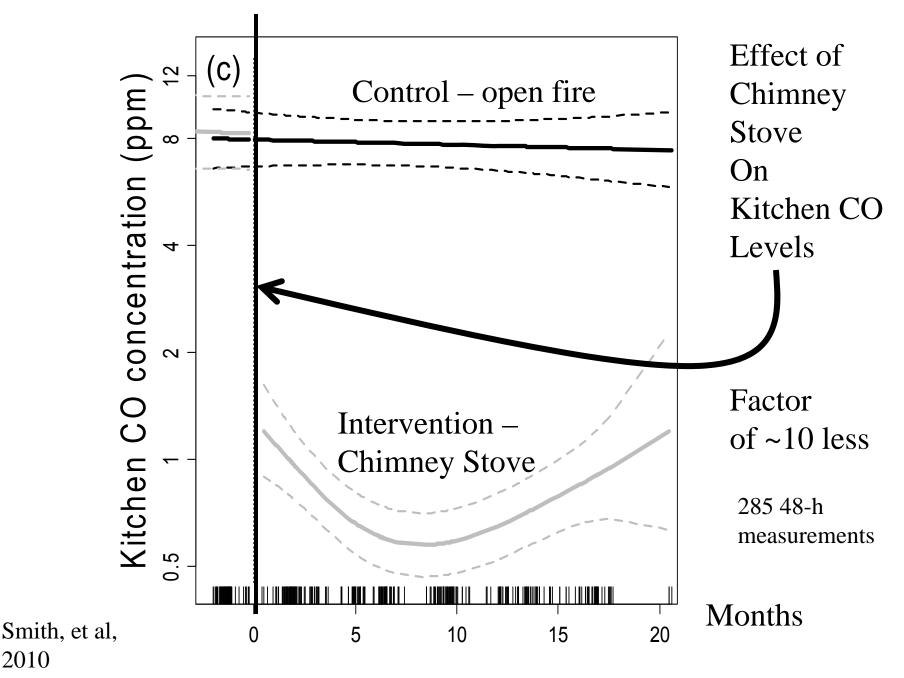


RESPIRE: Pneumonia Reductions with Exposure Reduction **Preliminary Results**

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)

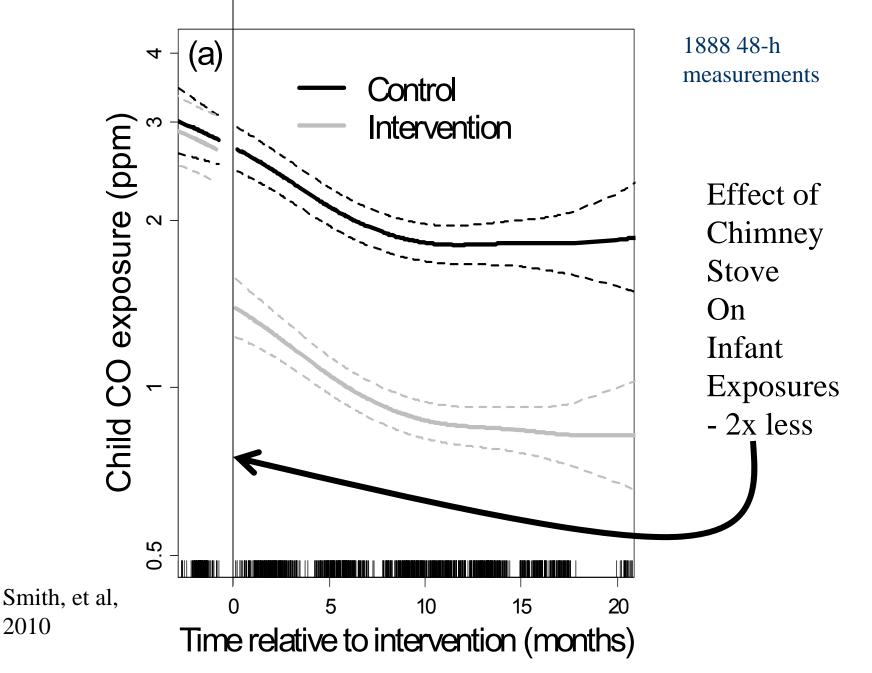
RESPIRE - Guatemala

Guatemala RCT: Kitchen Concentrations



2010

Infant Exposures



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

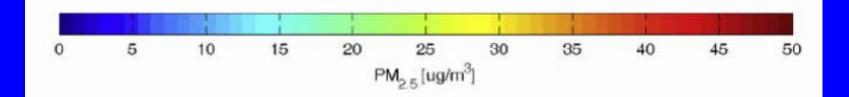




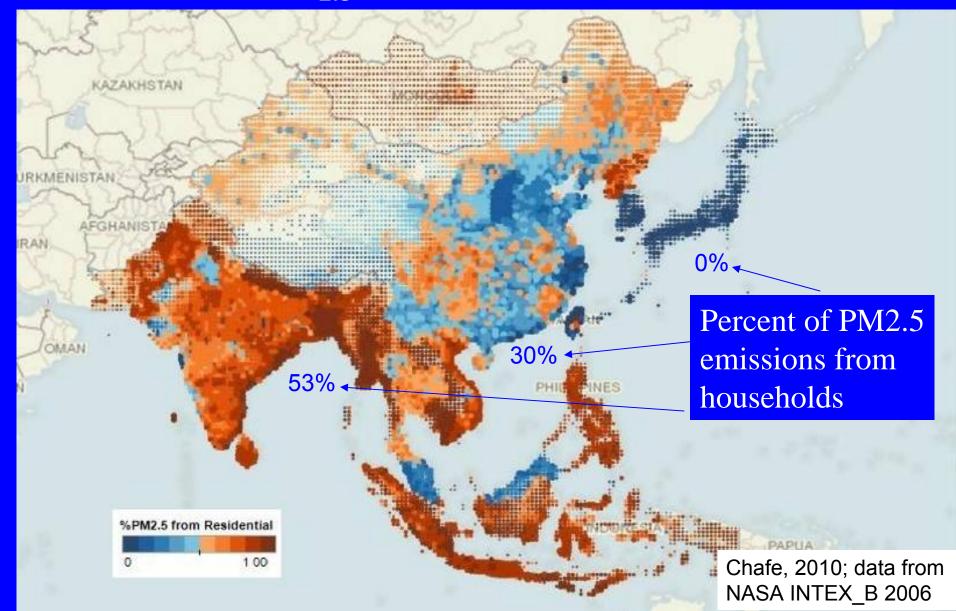
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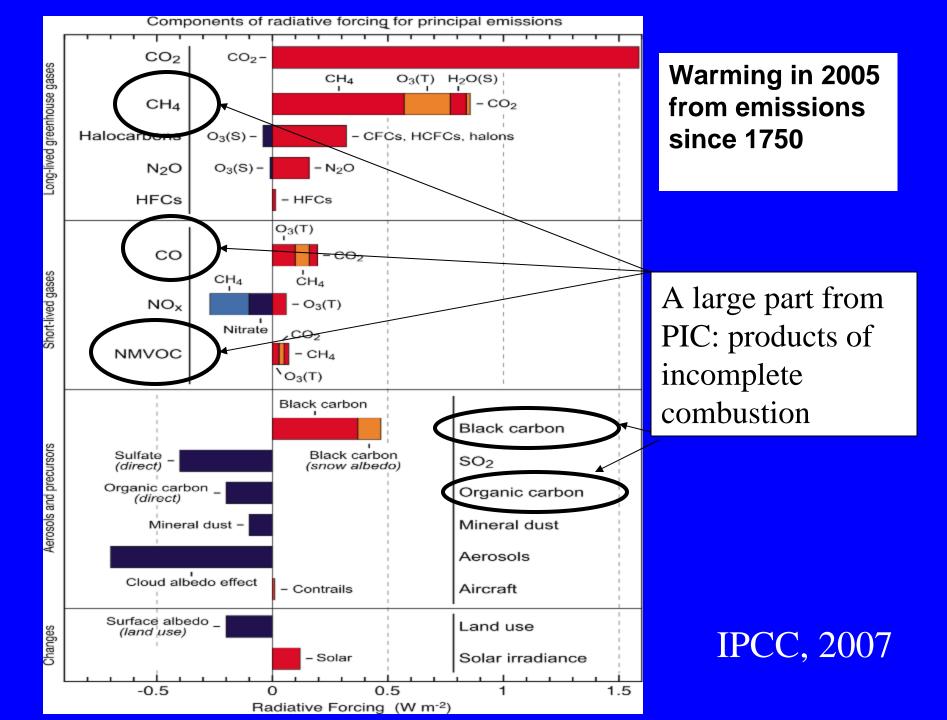
MODIS

Large areas of rural India and China have high ambient air pollution – much from household fuel

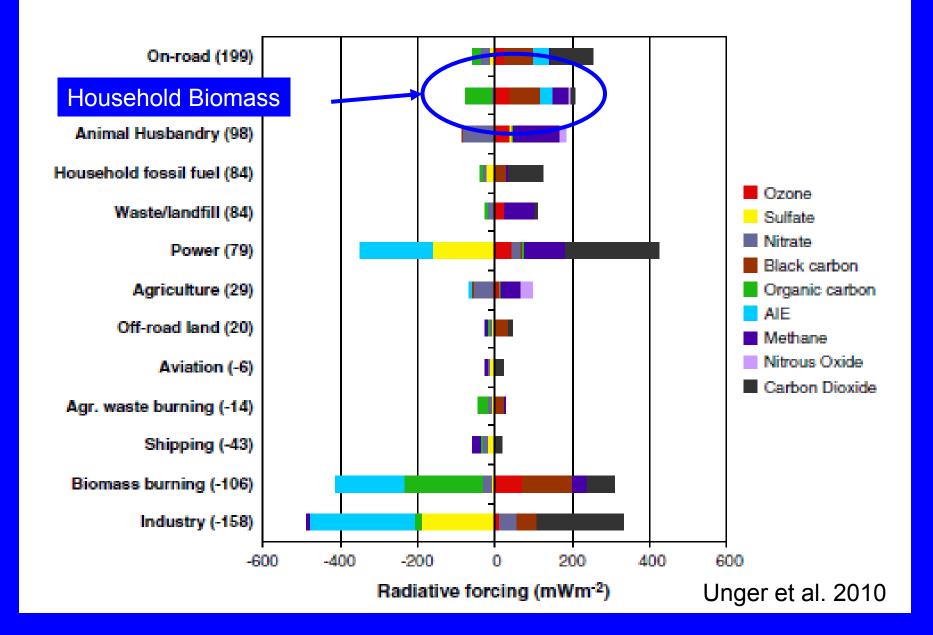


NASA INTEX_B Database Percent PM_{2.5} emissions from households





Climate Warming in 2020 Under Present Trends



Combustion Particles

The Generalized Exposure Response (GER)

Heart Disease and Combustion Particle Doses

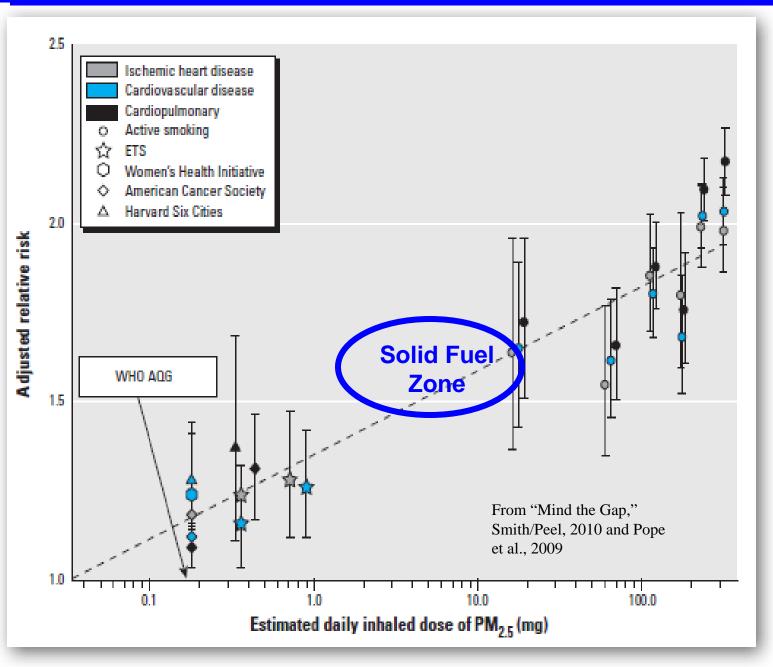
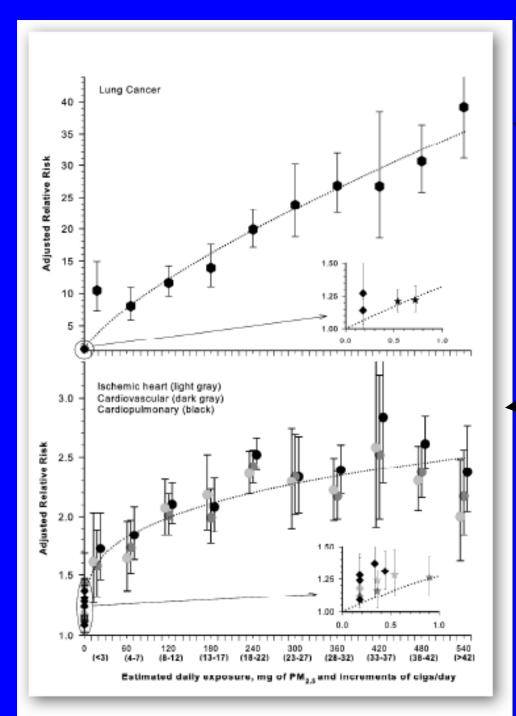


Table 2. Adjusted relative risk estimates^a for various increments of exposure from cigarette smoking (versus never smokers), second hand cigarette smoke, and ambient air pollution from the present analysis and selected comparison studies.

	Increments of	Adjusted RR (95% CI)				Estimated Daily
Source of risk estimate	Exposure	Lung Cancer	IHD	CVD	CPD	Dose PM2.5 (mg)b
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/m ³ ambient PM2.5			-tota	1.31(1.17-1.46)	0.44
ACS-air pol. extend.	10 µg/m ³ ambient PM2.1	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 PM25		and an an an and a start of the		1.37(1.11-1.68)	0.33
HSC-air pol. extend.	10 µg/m ³ ambient PM _{2.5}	1.21(0.92-1.69)		1.28(1.13-1.44)		0.18
WHI-air pol.	10 µg/m ³ ambient PM _{2.5}		12000	1.24(1.09-1.41) ^c	0.000	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



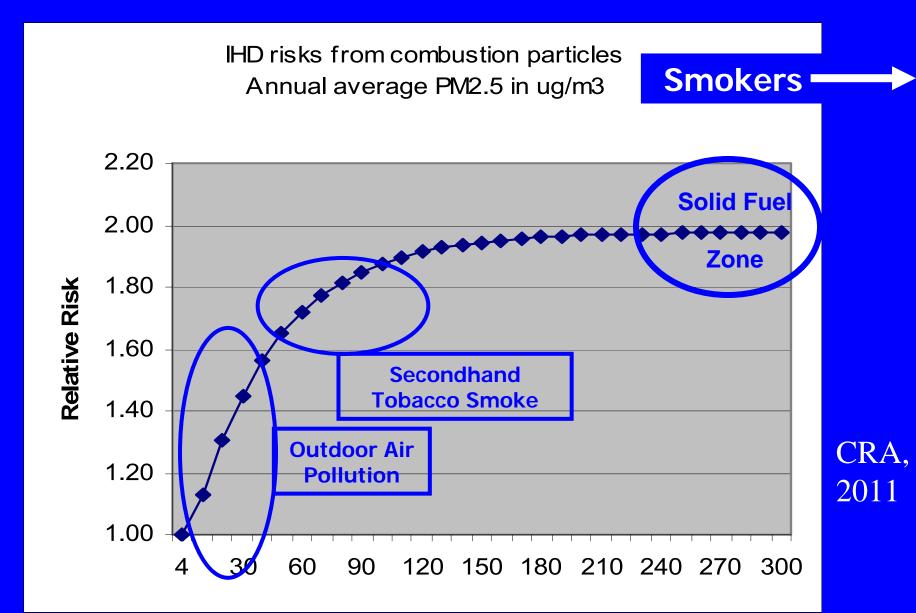
Heart Disease

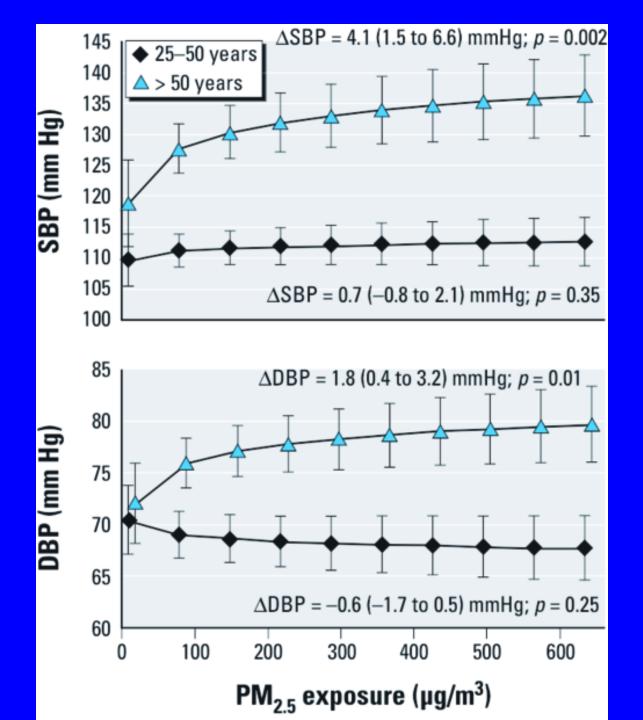
Lung

Cancer

Pope et al. Environmental Health Perspectives 2011, in press

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



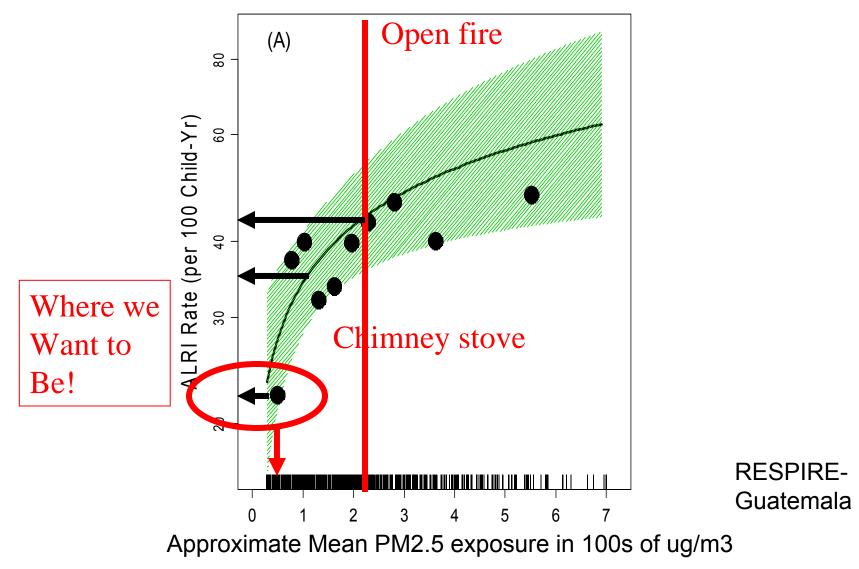


Household Air Pollution and Blood Pressure

In Yunnan

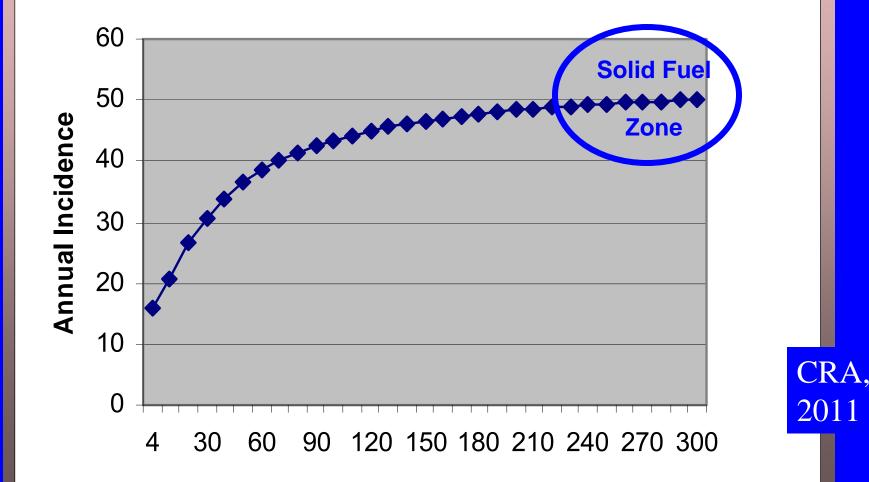
Baumgartner et al. Environmental Health Perspectives 2011, Oct

MD-diagnosed Acute Lower Respiratory Infection



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

Pneumonia from combustion particles Annual average PM2.5 in ug/m3



Outcome - 1b Generalized Exposure-Response (GER)	Sex and Age	Exposure ug/m3 PM2.5, annual average* (China)	Estimates from GER**
GER from OAP, SHS & HAP ALRI Interpolate GER from OAP, SHS, & ATS	M/F under 5 y	286 (143)	3.10 (2.54)
IHD IHD	F >15 y M >15	335 (167) 205 (102)	1.98 (1.96) 1.97 (1.88)

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
- Chimneys do not help need to stop producing the pollution at all.

Many thanks

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

