RAPIDC
Regional Air Pollution In Developing Countries

SEI STOCKHOLM ENVIRONMENT INSTITUTE

Indoor air pollution

Presentation
by
Dieter Schwela
Stockholm Environment Institute, University of York

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Learning objectives

To introduce indoor air pollution due to biomass combustion with a focus on Asia.

To highlight the epidemiological evidence of the association between indoor air pollution and child ARI.

To discuss current knowledge of interventions.

Introduction

- **50% of the global population (3 billion) are reliant on biomass fuels such as wood, cow dung and crop residues.**

- **The incomplete combustion of biomass fuels releases high concentrations of pollutants such as carbon monoxide, particulate matter, sulphur dioxide, nitrogen dioxide and organic compounds such as benzo[a]pyrene into indoor spaces.**

- **Concentrations 10-100 times higher than international guideline valuess.**

National Household Solid Fuel Use, 2000

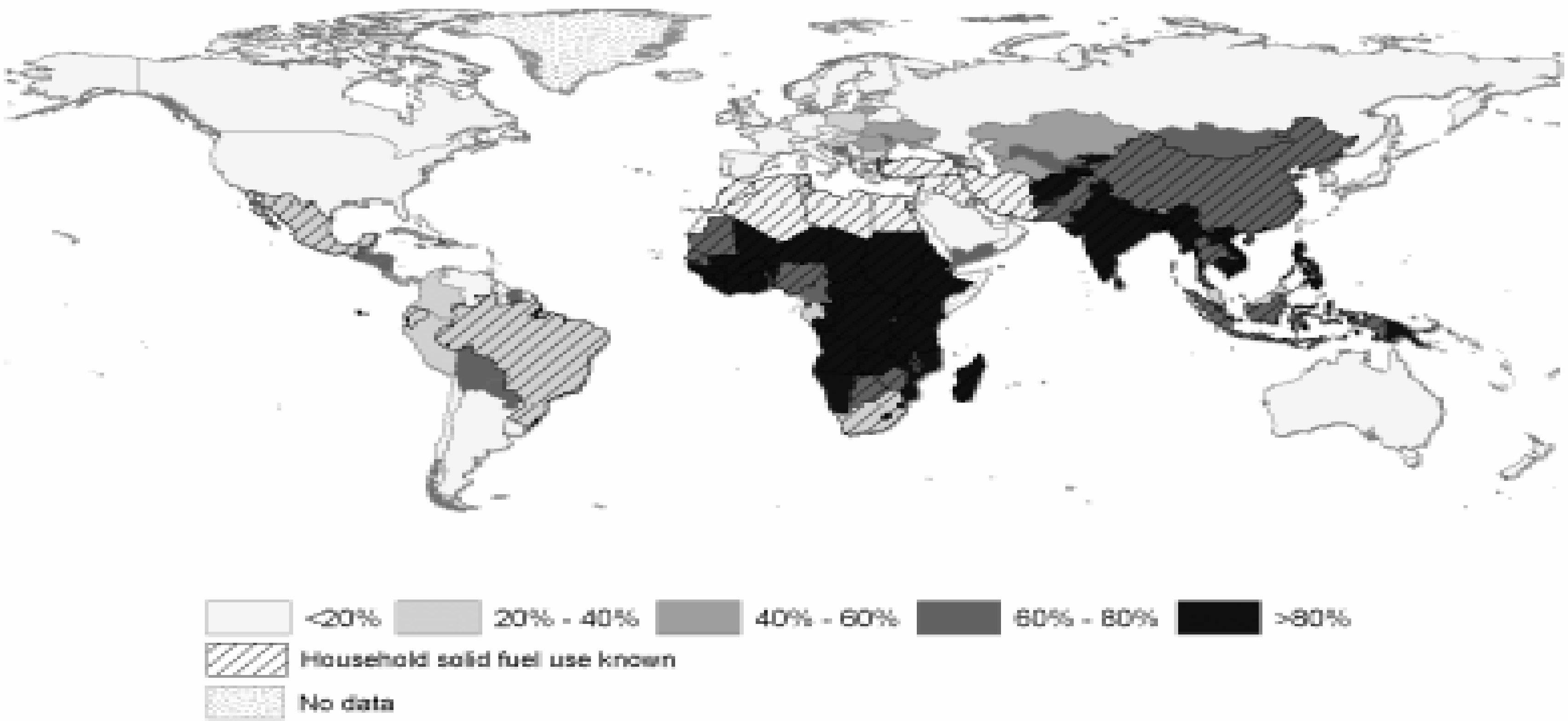
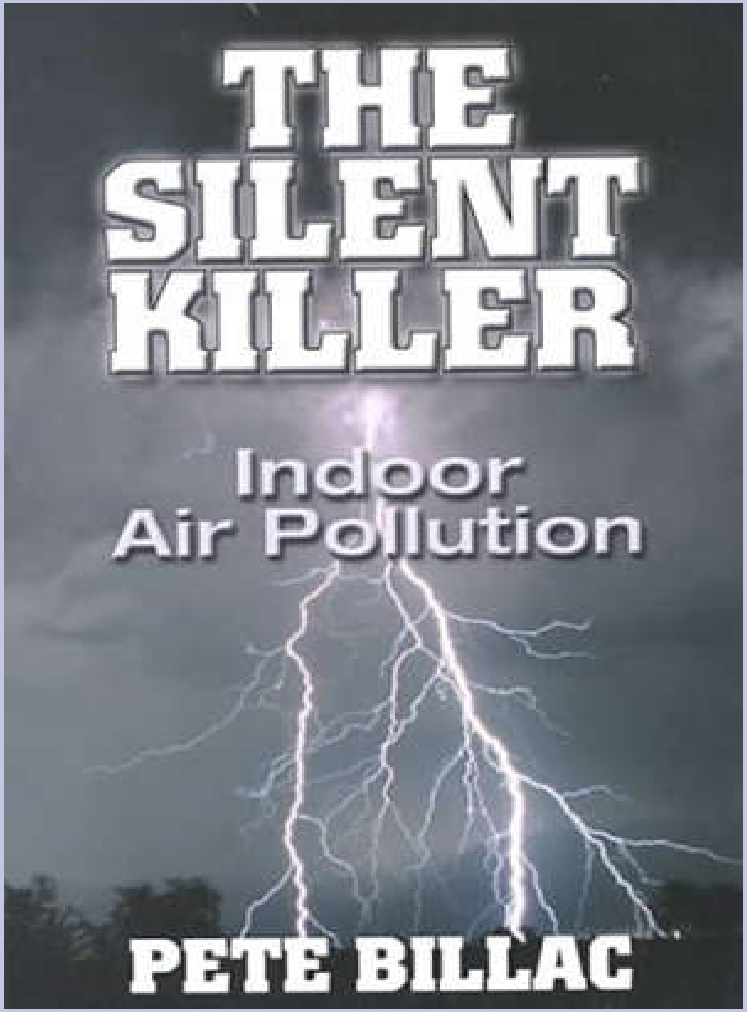


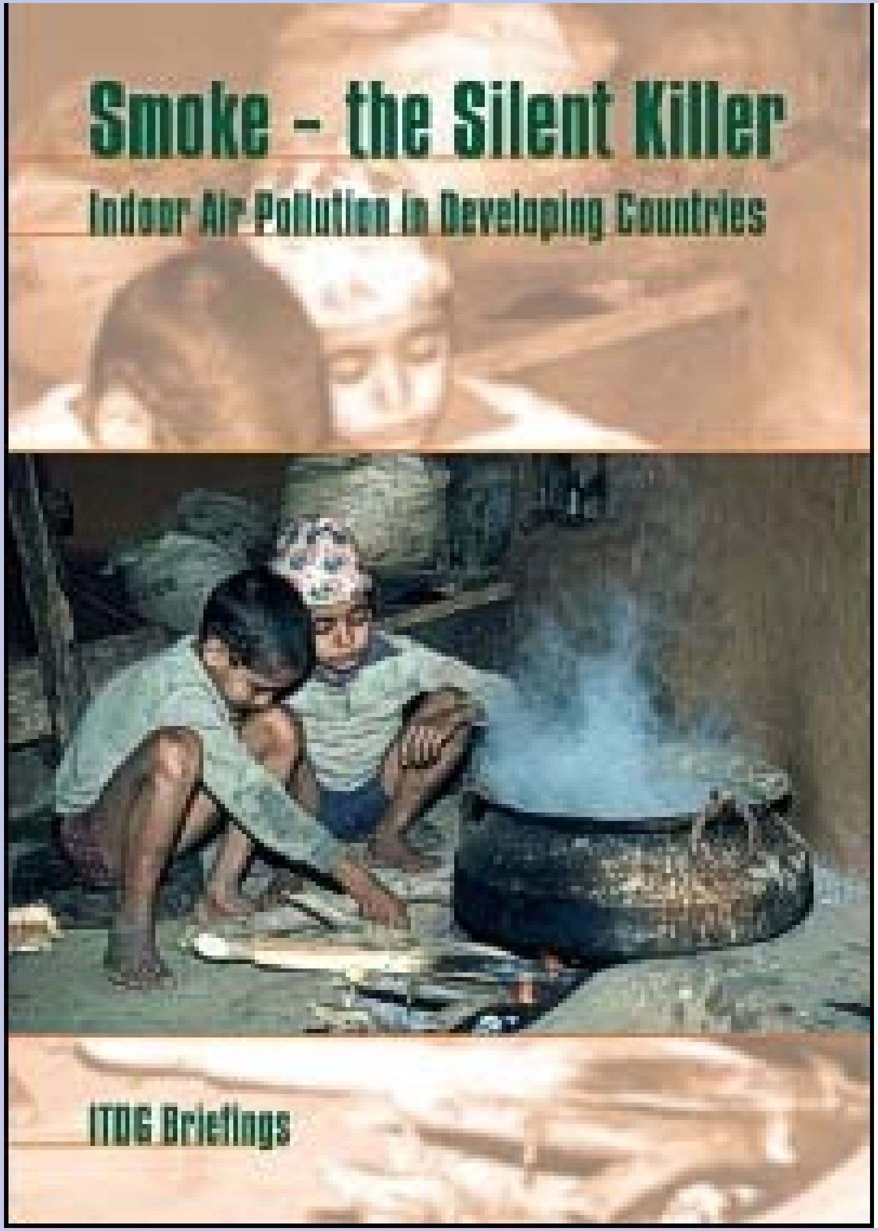
Figure 1 : Household fuel use across world regions

RUBES By Leigh Rubin

It wasn't long after fire that primitive man discovered the hazards of secondhand smoke.

The kitchen kills more than the sword
Latin proverb

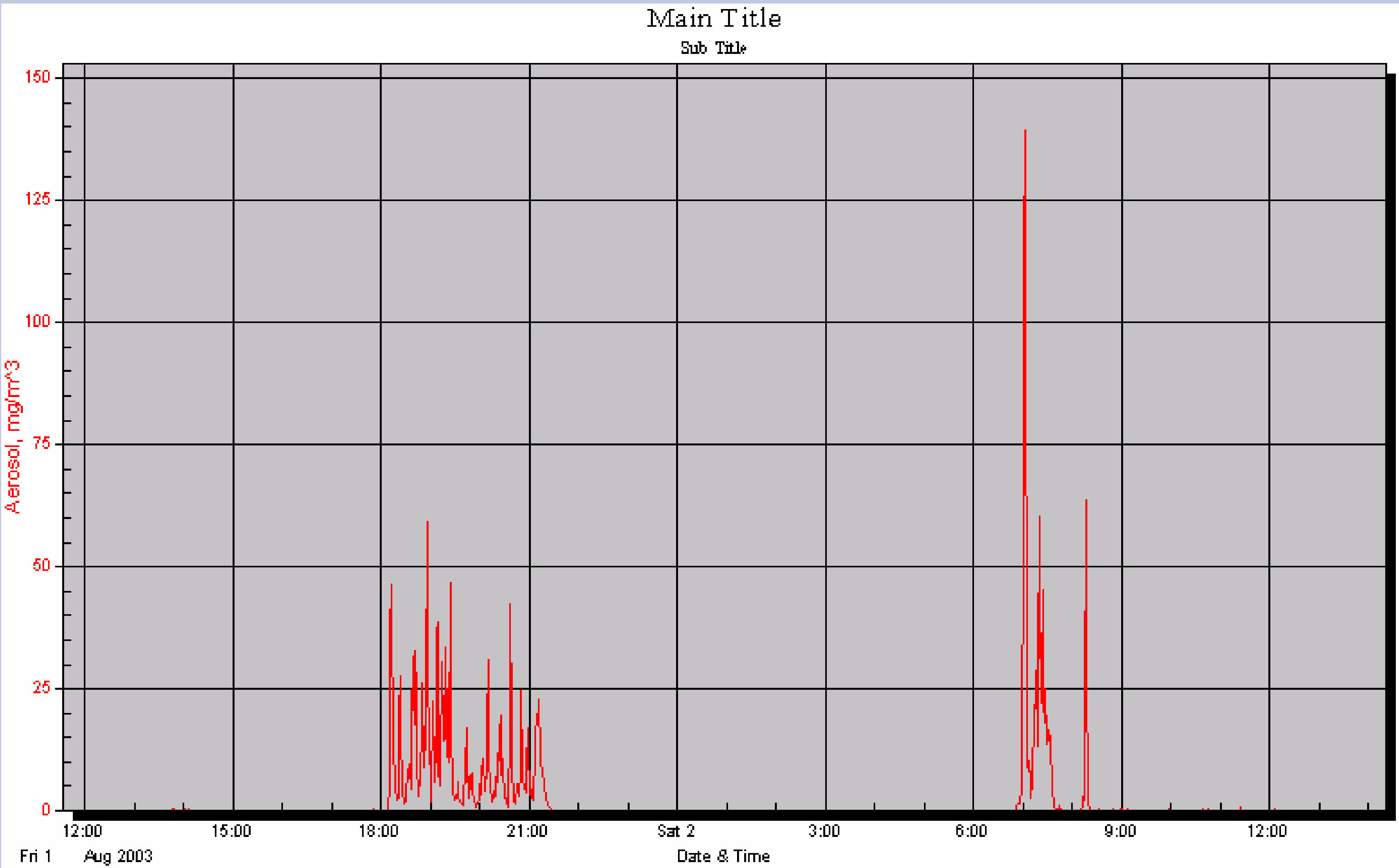




- **Major indoor air pollutants:**

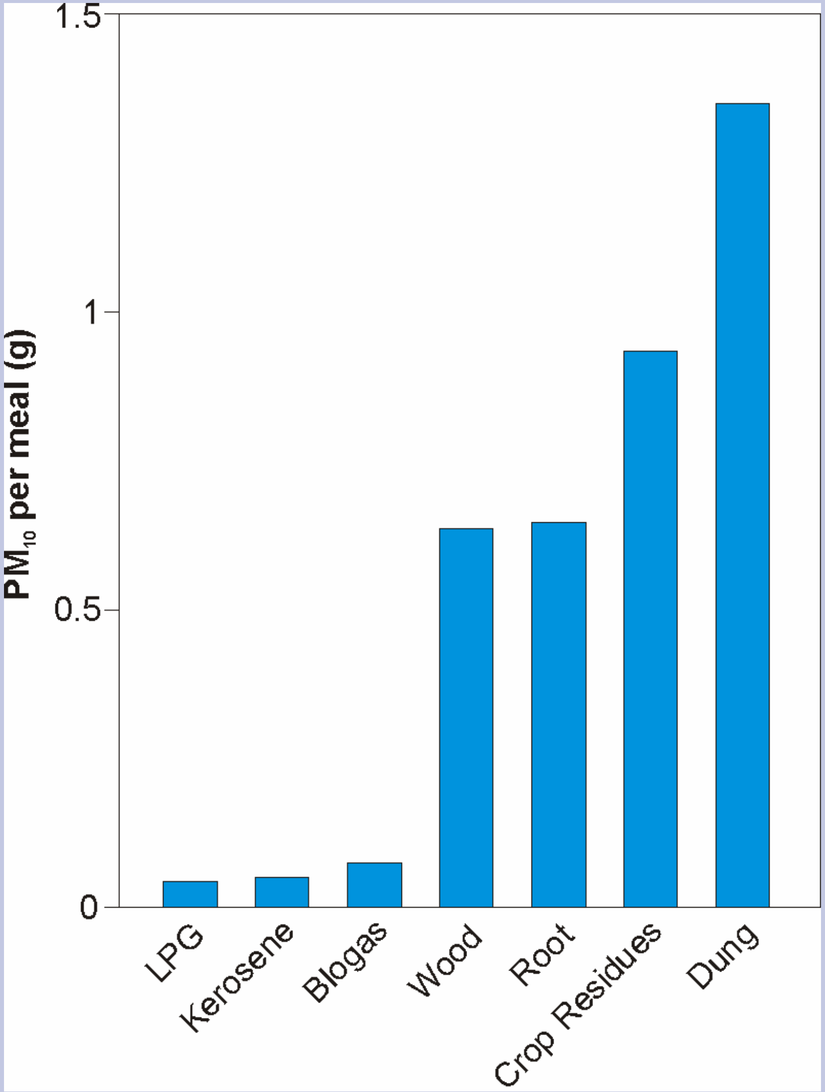
  *** Inhalable particles (PM_{10}), nitrogen oxides, sulfur dioxide, carbon monoxide, volatile organic compounds (PAH, formaldehyde, benzo[a]pyrene), radon, asbestos, tobacco smoke, and fluoride & arsenic compounds (from coal)**

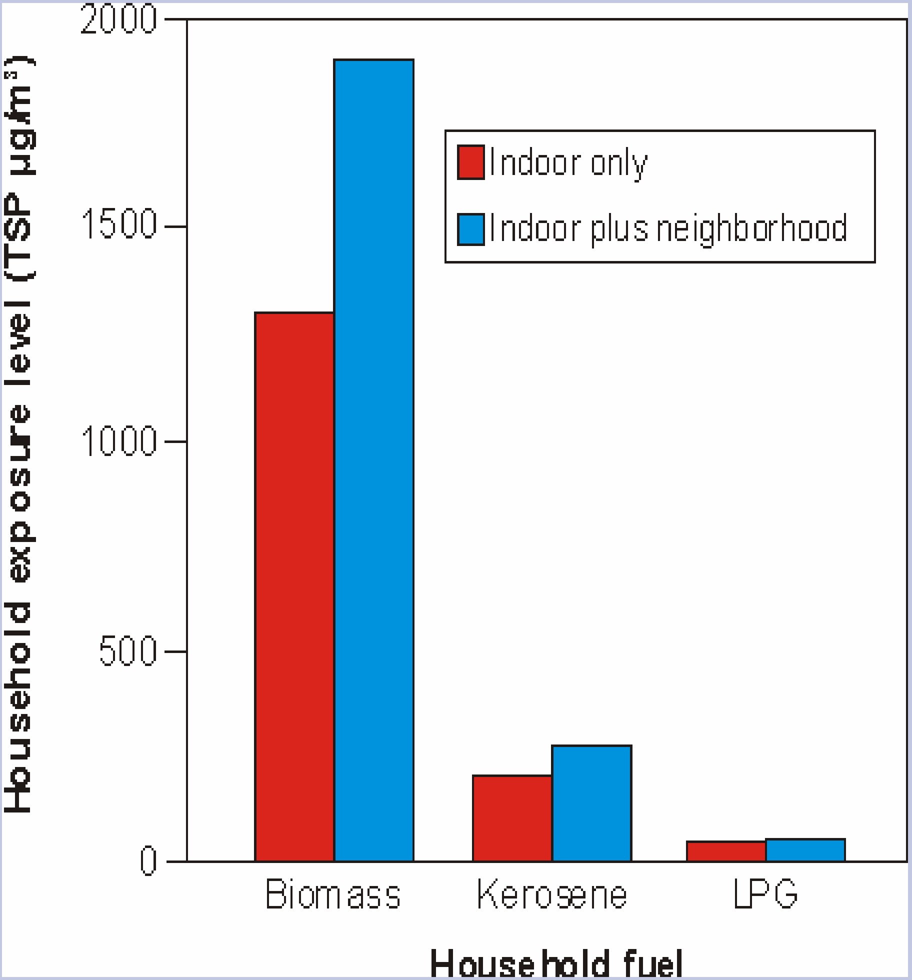
  *** most PM in biomass fuel smoke less than 3µm in diameter**



Main Title
Sub Title
Aerosol, mg/m^3
150
125
100
75
50
25
0
12:00
15:00
18:00
21:00
Sat 2
3:00
6:00
9:00
12:00
Fri 1
Aug 2003
Date & Time

Indoor PM concentrations



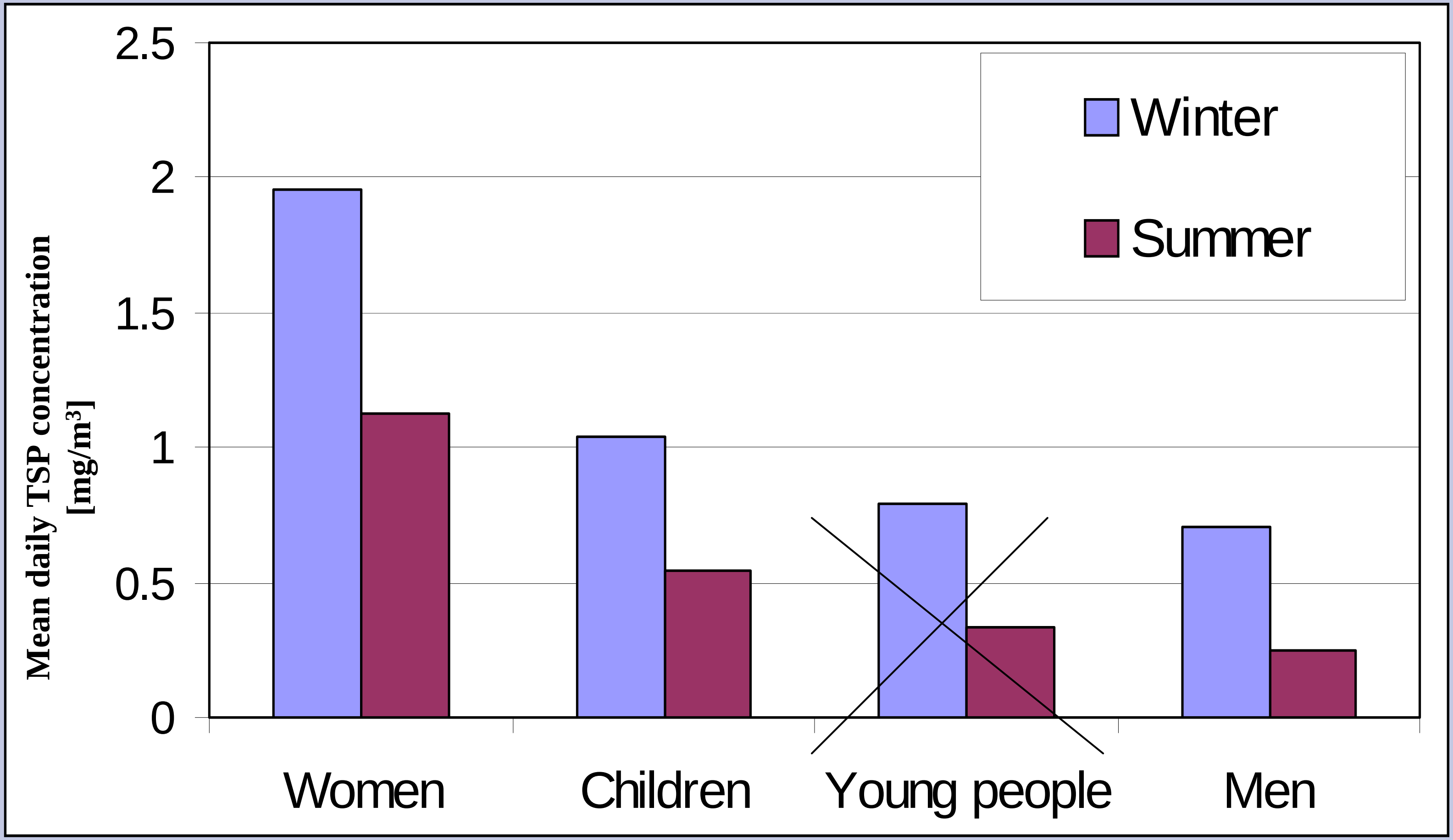


PAH concentrations [µg/m³] in houses in Chinese rural areas using different fuels

Polycyclic aromatic hydrocarbons	Low grade bituminous coal	Firewood	Anthracite	Unit risk estimate (• 10-²)
Benzo(a)anthracene	12	0.2	0.4	0.1
Benzo(k)fluoranthene	13	0.6	#	0.9
Benzo(a)pyrene	5	3	0.2	9
Chrysene	17	0.9	0.4	0.9
Fluoranthene	19	*	0.1	0.09
Indeno(123-cd)pyrene	16	*	*	2

** --- in trace amount;* *# --- below detection limit* *(Cao, 1986)* WHO, 2000)

Exposure to indoor air in rural areas of India



Health impacts associated with IAP

Health impact	Odds ratio
Acute lower respiratory infections	2-5
Chronic bronchitis or COPD	1.8-9.7
Upper respiratory infection/ear	1.5
Pulmonary tuberculosis	2.6
Perinatal mortality	1.5
Infant respiratory mortality	1.4
Sudden infant death syndrome	1.3

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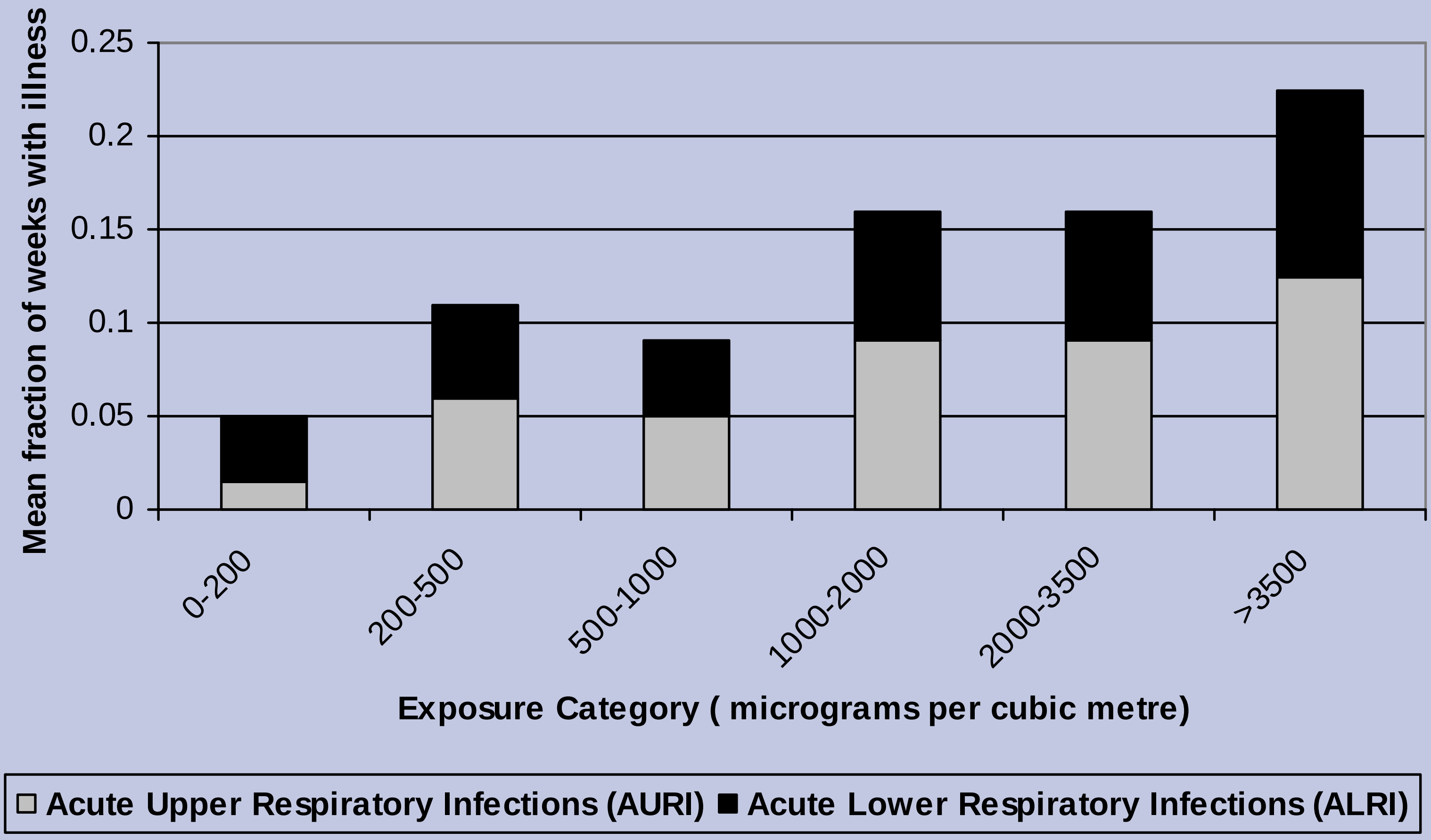
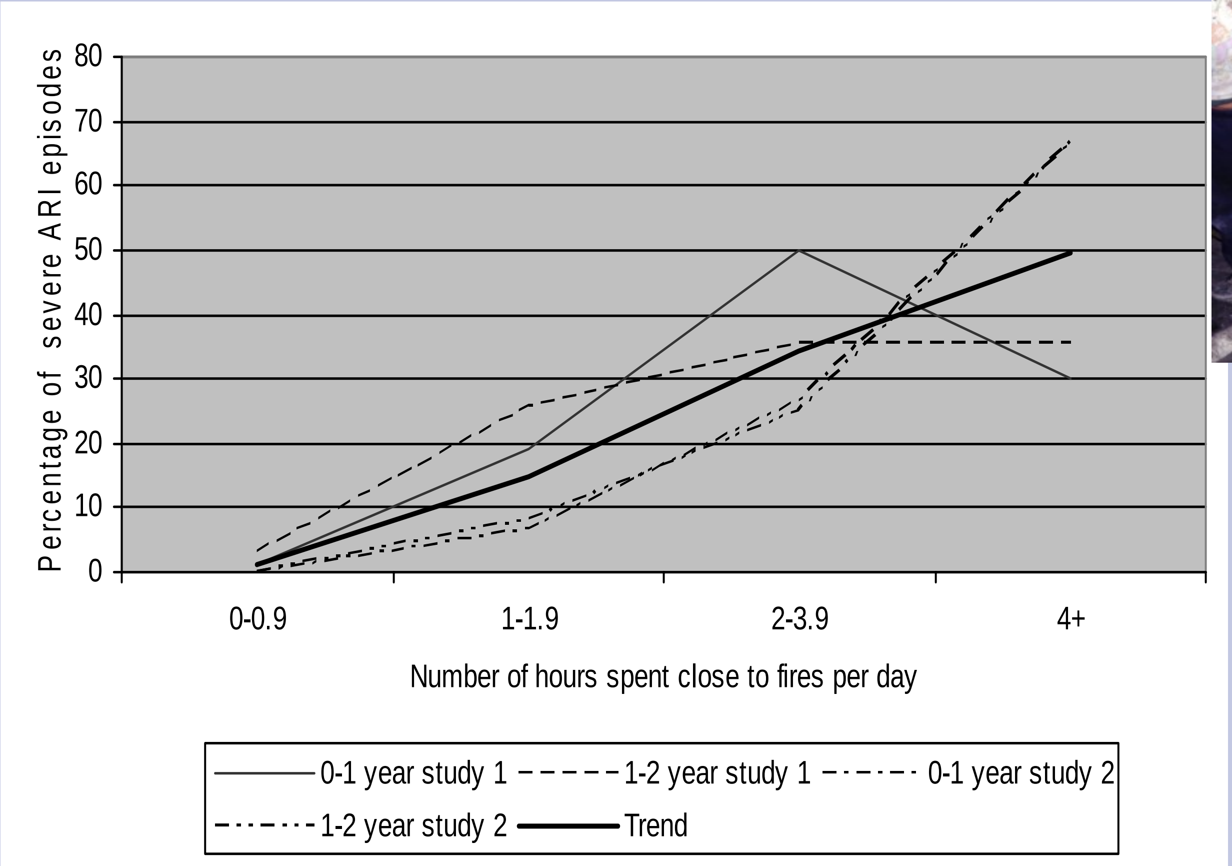
Indoor air pollution and child ARI



Indoor exposure and child ARI

- **Time activity patterns**
- **For how long? When? Where?**



Confounding: child susceptibility

- Low socio-economic status.
- Nutrition (Vitamin A, breastfeeding, wasting, stunting).
- Reproductive (low birth weight).
- History of infection.
- Environment (crowding, ETS, dust, damp).

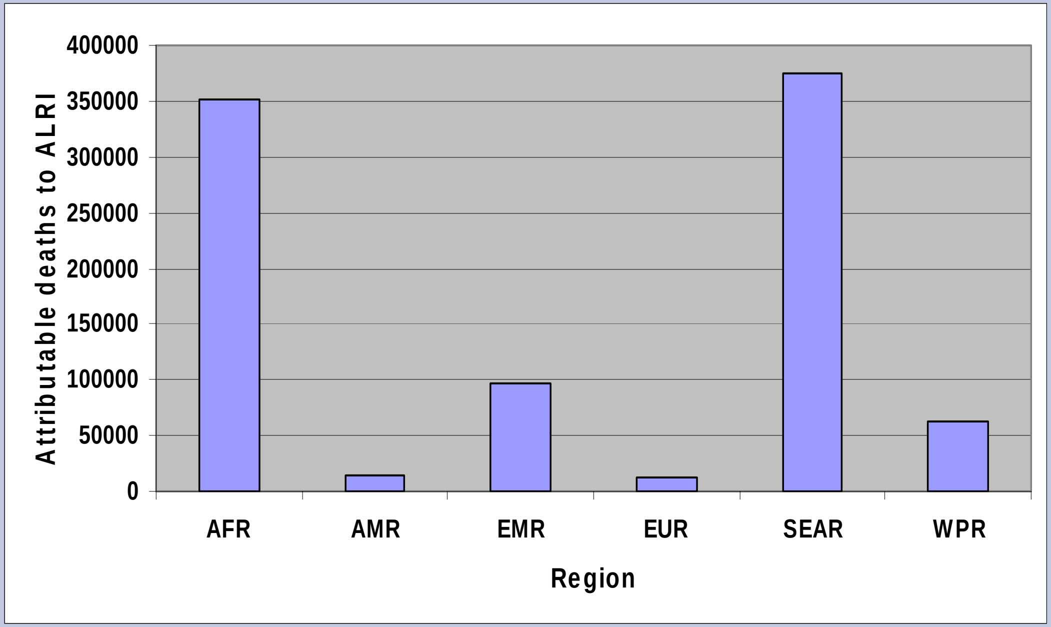
Indoor air pollution and child ARI

Despite weaknesses of the epidemiological evidence, concern is galvanized by:

- **The high burden of child ARI in developing countries (particularly in SE Asia and Africa).**
- **The high domestic reliance on biomass fuels.**

Attributable deaths (AD) and disability-adjusted life years (DALYs) for ARI in children aged 0-4 years (due to indoor air pollution – solid fuel use)

Region	AD	DALYs (000)
AFR	351 000	11 967
AMR	15 000	606
EMR	96 000	3 365
EUR	13 000	439
SEAR	374 000	13 267
WPR	62 000	2 275
World	911 000	31 919



Attributable mortality and disability adjusted life years (DALYs) from indoor air pollution (solid fuel use), for children by age group and gender

	Age group [years]		Gender	
	0-4	5-14	Male	Female
Distribution of attributable deaths [%]	56	0	41	59
Distribution of attributable DALYs [%]	83	0	49	51

Attributable mortality, DALYs, YLLs for air pollution

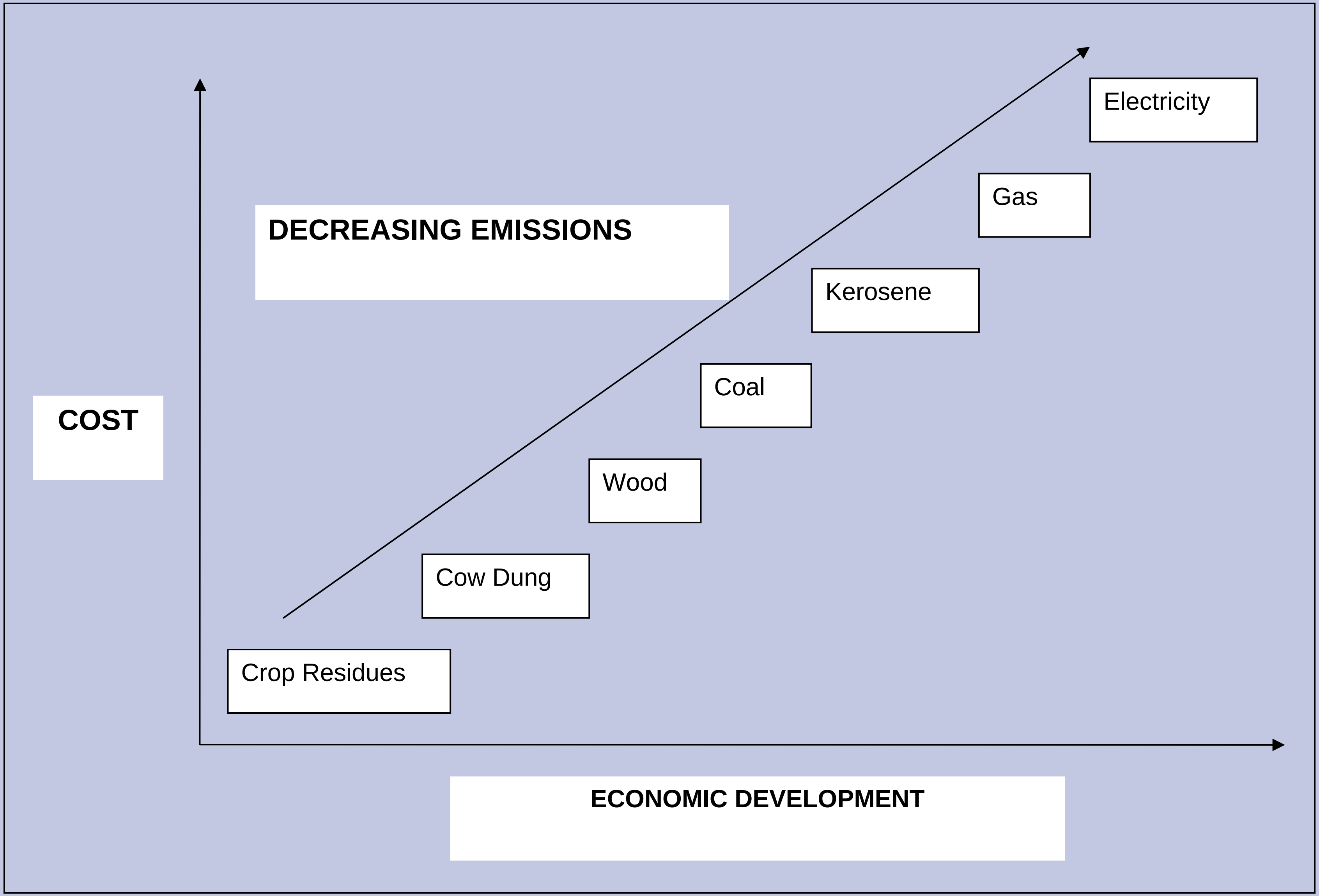
S-E-Asia	Urban air pollution	Indoor air pollution (fuel use)	Lead	Smoking
Attributable mortality	164,000	559,000	66,000	1,110,000
Percentage	20.5	34.5	28.2	22.6
DALYs	1,852,000	15,227,000	3,403,000	14,987,000
Percentage	23.5	39.5	26.3	25.4
YLL	1,594,000	14,240,000	784,000	12,264,000
Percentage	24.9	40.5	28.0	26.9

DALY = Disability adjusted life years   YLL = Years of life lost   WHO (2002)

The epidemiological evidence is far from adequate!

Interventions

- Technology and policy
- Improved cook stoves (ICS), stove maintenance
- Affordability, sustainability of ICS
- Cleaner fuels, fuel efficiency
- Ventilation
- Dwelling modification
- Awareness raising, behavioural changes, training


DECREASING EMISSIONS
COST
Electricity
Gas
Kerosene
Coal
Wood
Cow Dung
Crop Residues
ECONOMIC DEVELOPMENT

Fuels and improved cook stoves

Study	Study Type	Objective	Indoor air pollution/exposure
Raiyani et al. India	Matched field experiment	Compared pollutants across households using five different fuel types: cattle dung, wood, coal, kerosene and LPG over cooking times (2-4 hours).	TSP: Cattle dung = 3 470 μg/m³ Wood = 2 630 μg/m³ Coal = 1 190 μg/m³ Kerosene = 520 μg/m³ LPG = 500 μg/m³ CO: Cattle dung = 174 mg/m³ Wood = 189 mg/m³ Coal = 110 mg/m³ Kerosene = 137 mg/m³ LPG = 24 mg/m³
Reid et al. Nepal	Cross-sectional	Compared improved 'Chulo' vs traditional stoves	PM_{10} during cooking: Improved = 1 130 μg/m³ Traditional = 3 140 μg/m³ CO during cooking: Improved = 67 ppm Traditional = 300 ppm
Pandey et al. Nepal	Longitudinal before-after	Compared improved 'Tamang' vs traditional stoves	RSP during cooking (1 hr): Tamang = 3000 μg/m³ Traditional = 8200 μg/m³ CO during cooking (1hr): Tamang = 11.6 ppm Traditional = 82.5 ppm
Ramakrishna et al India	Cross sectional	Compared CO and TSP in homes using improved versus traditional fires	CO significantly reduced in homes using improved stoves compared to traditional fires. TSP varied greatly and non conclusions could be drawn.

Behaviour

Study	Study type	Objective	Indoor air quality/exposure
Reid et al. 1986	Field experiment	Impact of stove maintenance on indoor air quality	PM reduced from 4900 to 1100 μg/m^3 and CO from 500 to 31 parts per million (ppm) when correct fitting pots were used. The study found that cleaning stove flues (by removing 1.5 liters of soot) reduced CO from 500 to 56 ppm.
Albalak et al. 1999	Cross sectional	How burning location (indoors versus outdoors) affects indoor air quality.	Significant reductions in PM in households burning outdoors

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Conclusion

- IAP is a major public health hazard, especially in developing countries.
- IAP is different in developing & developed countries, also country specific.
- ARI, COPD: most important health impacts
- Interventions needed