Health and Household Solid Fuel Use (HHSFU): Recent Developments

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Disease for which there are multiple epidemiological studies in households using solid fuels for cooking

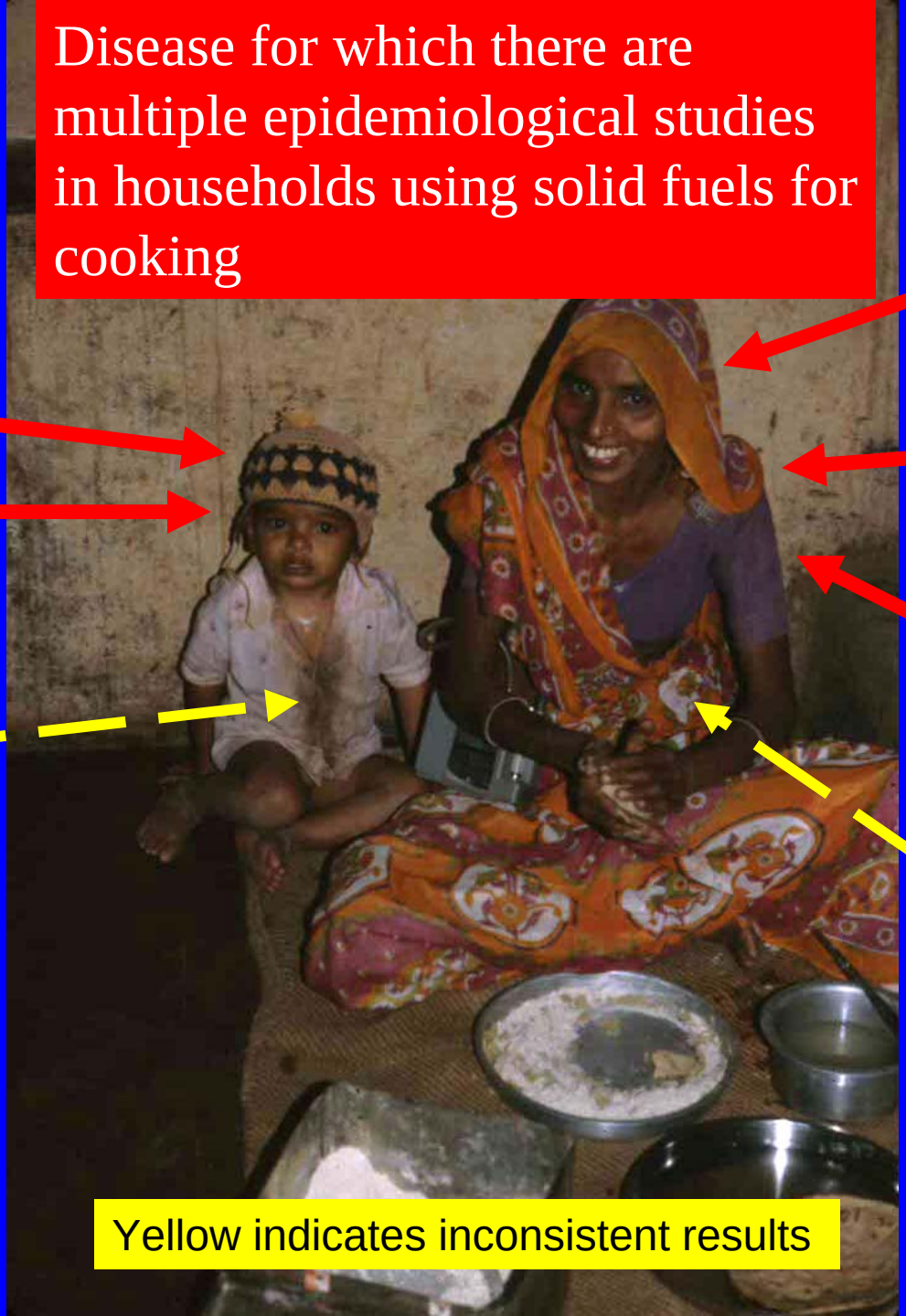
ALRI/ Pneumonia (meningitis)

Low birth weight

Asthma

Cognitive Impairment?

Birth Defects?



Chronic obstructive lung disease

Cancer (lung, NP, cervical, aero-digestive)

Blindness (cataracts, trachoma)

Tuberculosis

Heart disease?

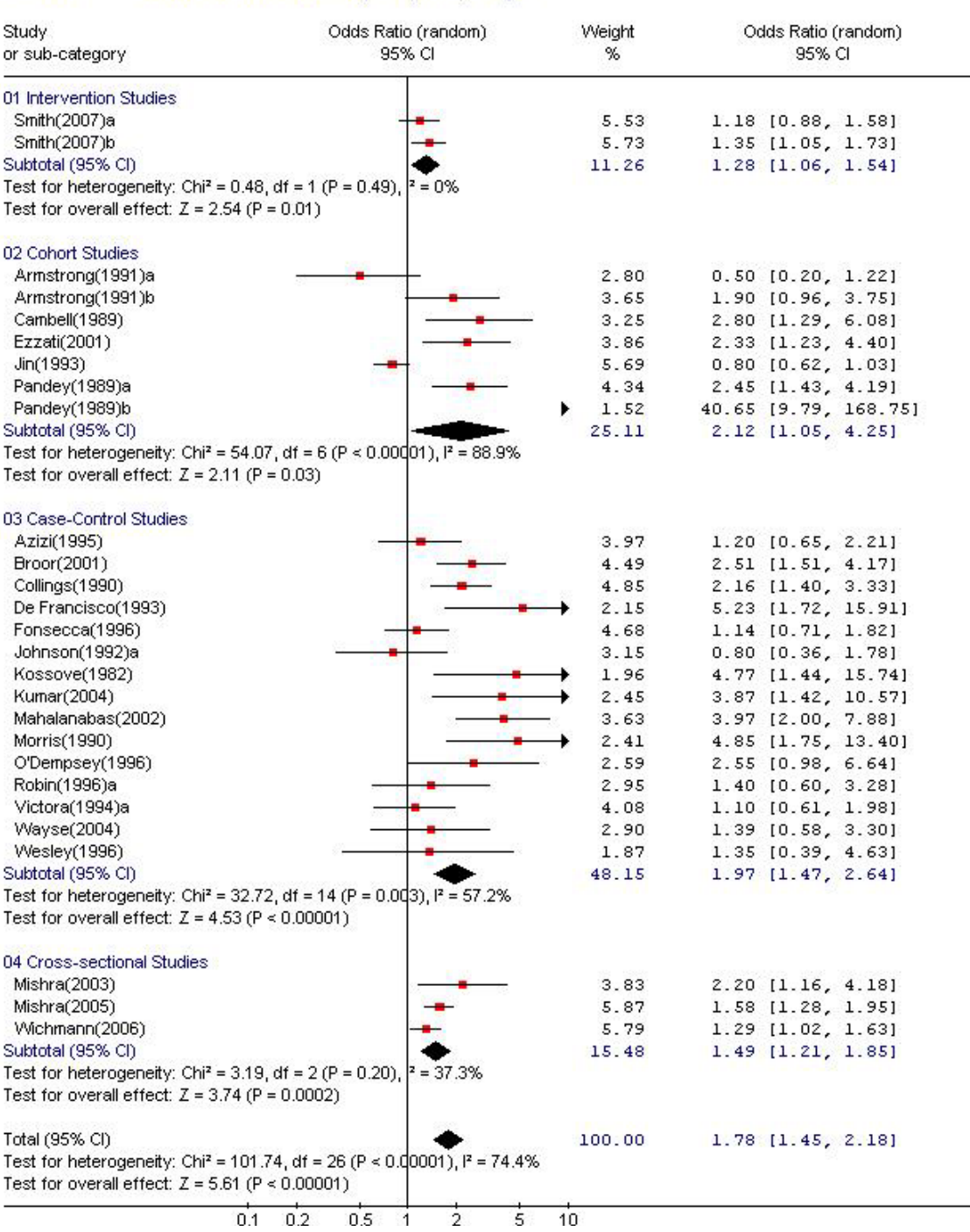
Yellow indicates inconsistent results

Evidence for health effects is strengthening for established diseases – ALRI, COPD, cataracts

- All these diseases are multi-causal – smoking for example is a major cause of COPD, UV exposure for cataracts, and malnutrition for ALRI
- Thus, sophisticated epidemiological studies are needed to pick out separate effect of HHSFU
- New systematic reviews and meta-analyses for the dozens of published studies now available confirm with less uncertainty the earlier reviews that HHSFU is a significant independent risk factor for all three, but with somewhat smaller risks than found before.
- First exposure-response results now available for largest single effect – acute lower respiratory infections (ALRI) in children - pneumonia

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	1.97	1.47, 2.64
Cross-sectional	3	1.49	1.21, 1.85
All	26	1.78	1.45, 2.18

Dherani et al., 2008
Bull WHO



There is growing evidence for inclusion of additional diseases

- Adverse pregnancy outcomes – low birth weight and/or prematurity (APO leads to a range of childhood and adult diseases and increased mortality)
- Lung and perhaps other cancers
- ALRI in adults
- Heart disease – here, however, evidence is indirect, i.e., based on studies of other combustion smoke mixtures.

Still insufficient and/or inconsistent evidence

- Tuberculosis
- Asthma

Evidence from Animal Studies – CO effects

- Birth defects – cleft palette (lip)
- Cognitive impacts – lower learning ability (IQ) in animals exposed through their mothers during pregnancy
- Can also expect effects on IQ if exposure occurs during brain development, i.e. in early childhood

Exposure Lessons, based on good data, but to date limited in geography

- Even well-operating chimney stoves without significant changes in combustion efficiency seem not to reduce average exposures by more than a factor of 2-3.
- Even if kitchen levels go down by a factor of 10.
- Pollution is just moved, not eliminated
- Most chimneys in the field do not operate at optimal levels – thus real reductions over time are less

Exposure, cont.

- Field conditions, particularly the significant natural variations in operator behavior and fuel used (type/size/moisture) lead to substantially lower performance than might be predicted from lab tests even when the stove is used.
- Also, some aspects of normal usage are difficult to mimic in the lab, for example long-term smoldering between regular meals

Adoption is important

- We define adoption as the total meals for which the stove is used divided by the total meals actually cooked and thus it includes full, partial, and no use by different households over time.
- Adoption rates are not ever 100% even when stoves are bought.
- There is growing recognition that even 70% over a long period may be pretty good
- From a policy standpoint, this kind of “intention to treat” approach makes most sense for planning. It is termed “effectiveness” in the health field
- For promotion, of course, one would probably emphasize the impact of full use as intended, which is called “efficacy” in the health field.

Lab performance of current generation of advanced combustion stoves

- Substantial reduction of particles, volatile organics, and other non-CO components of incomplete combustion – factors of 20-30 in some studies depending on the metric used.
- Not such good reductions in CO, however, perhaps factors less than 5.
- Still few field measurements

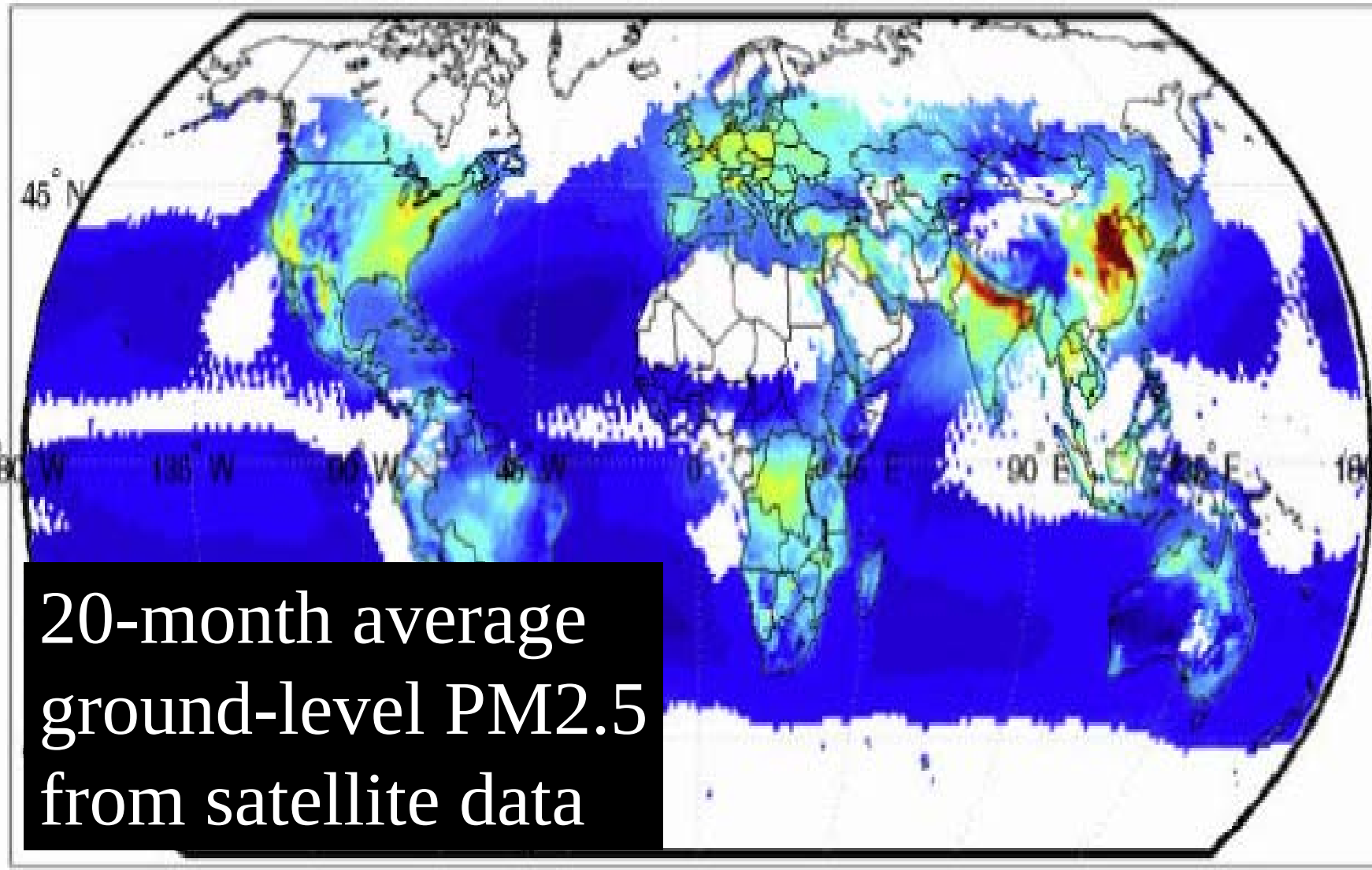
Problems of differential reduction of CO and non-CO PICS

- CO becomes the important limit to health acceptability if no venting
- Lower non-CO/CO ratio also means that even lower CO emissions become more dangerous for short-term acute poisoning risk – the ‘natural’ warning is stripped out.
- Proposed new WHO Air Quality Guidelines for CO (approved by expert committee this month, but not yet official) will retain previous short-term limits (e.g., 100 mg/m3 -86 PPM- for 15 minutes), but add a 24-h limit of 7 mg/m3 ~6 PPM.
- This is because of growing evidence of long-term chronic health effects of CO that do not operate through changes in blood hemoglobin, e.g., on immune system
- Expect, however, that the short-term rather than 24-h limits will be the most important constraints on stoves in most settings.

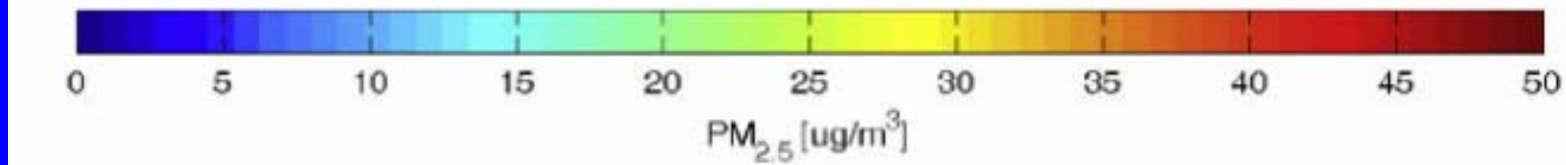
Other current issues

- Black carbon particles, which are powerful global warming pollutants, seem as toxic as the other particles in biomass smoke, but the first study of long-term health effects of BC being published next week does not provide convincing evidence that they are more so.
- This recent evidence, however, does strongly support that ozone and sulfates, which are produced downwind from precursors emitted by households and other sources, are major independent risks for health.
- About one-sixth of human-generated ozone precursors in the world come from household combustion
- Thus, outdoor air pollution health effects from household combustion are now understood to be significant, particularly in large river basins with dense rural populations, such as the Yangtze and Ganges.

MODIS



20-month average ground-level PM2.5 from satellite data



Although we have focused on fine PM mass, remember

- PM should be considered mainly as an indicator of the non-CO PIC mixture, something well established in other settings – outdoors, occupational, tobacco smoke, etc. Pure inert PM has much lower impacts – it is the stuff it is mixed with as much as the PM itself.
- In the case of simple stoves, the PIC mixture contains a wide range of other Non-PM noxious materials – indeed in mass nearly 20 times greater than the PM (5-10 times more not including CO)

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

Known toxins or carcinogen in italics

- 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*

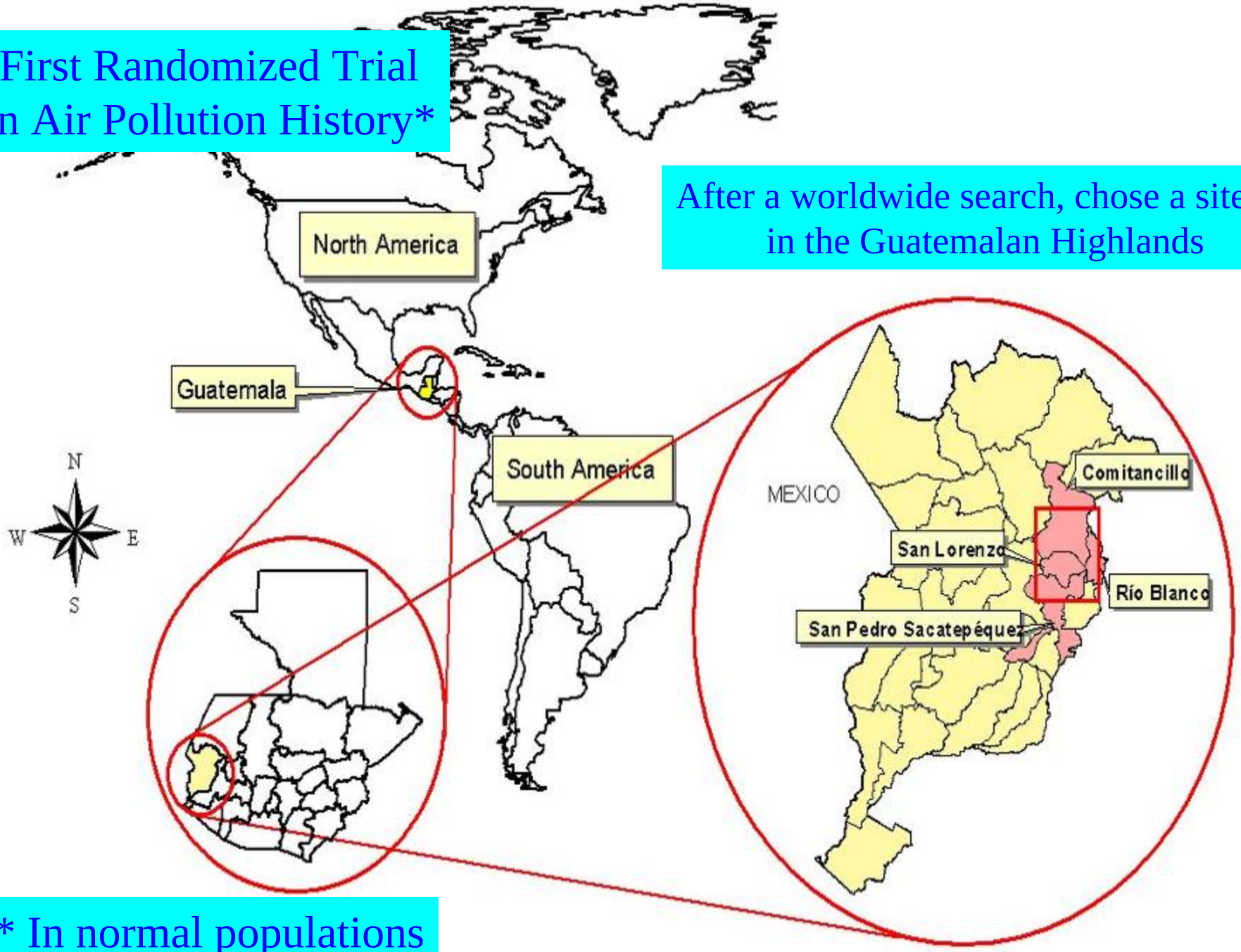
Source: Naeher et al, *J Inhal Tox*, 2007

Thus, it is probably true to say that

- Not only is the highest total public PM exposure in world found in village households, but also those for
- Formaldehyde
- Benzene
- PAH (both particulate and vapor)
- Ultrafine particles
- Dioxin
- And many others
- Probably not for CO, however, because in spite of high peaks, mean levels are not high compared to other public settings.

First Randomized Trial In Air Pollution History*

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



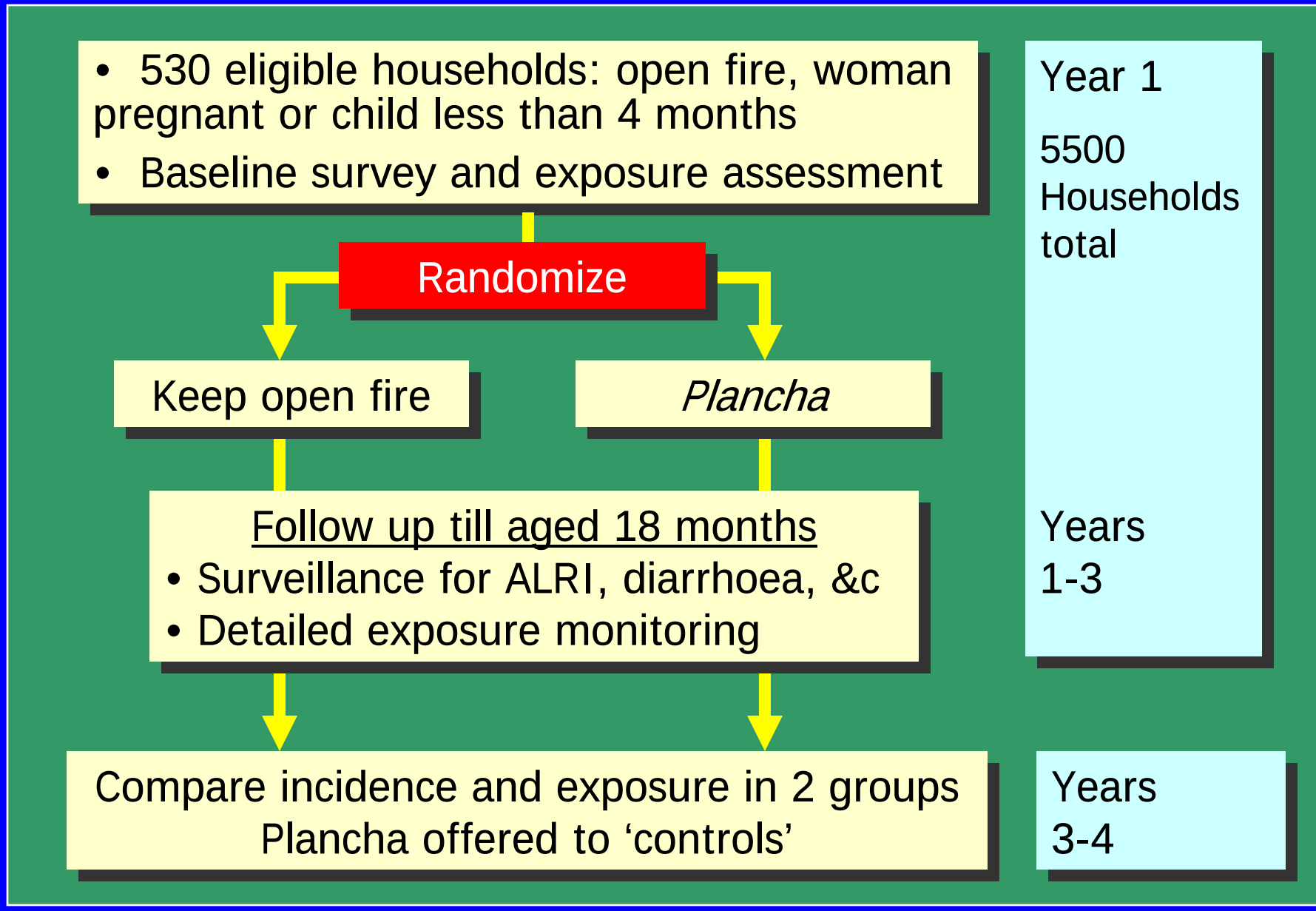
* In normal populations

RESPIRE: (Randomized Exposure Study of Pollution Indoors and Respiratory Effects)

Traditional 3-stone open fire

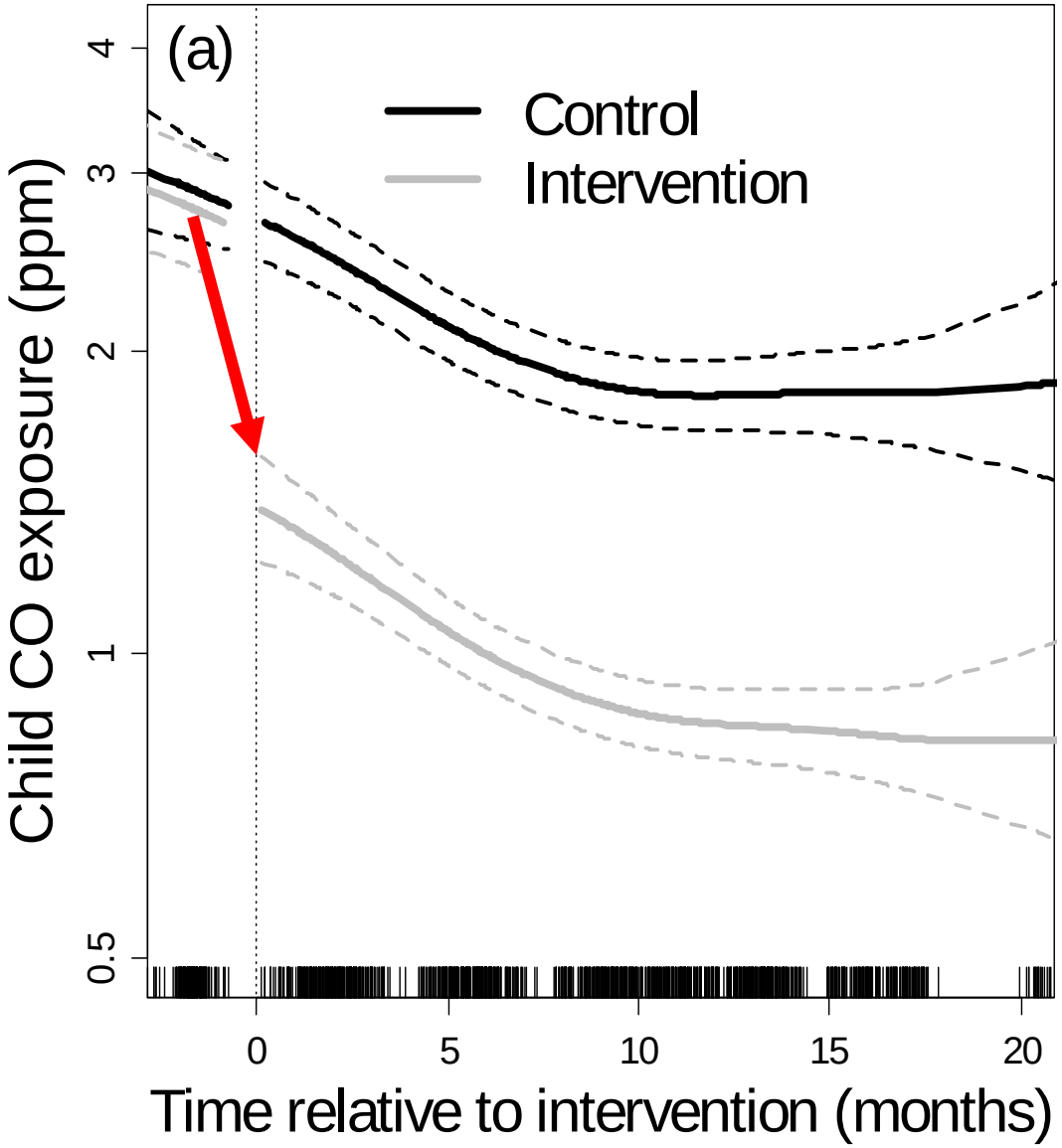
Plancha chimney wood stove

Overview of RESPIRE study design




Tubito
Tubito

Effect of the Chimney Stove on Infant Exposures in RESPIRE



1888 48-h measurements

About 50% less exposure over the entire period

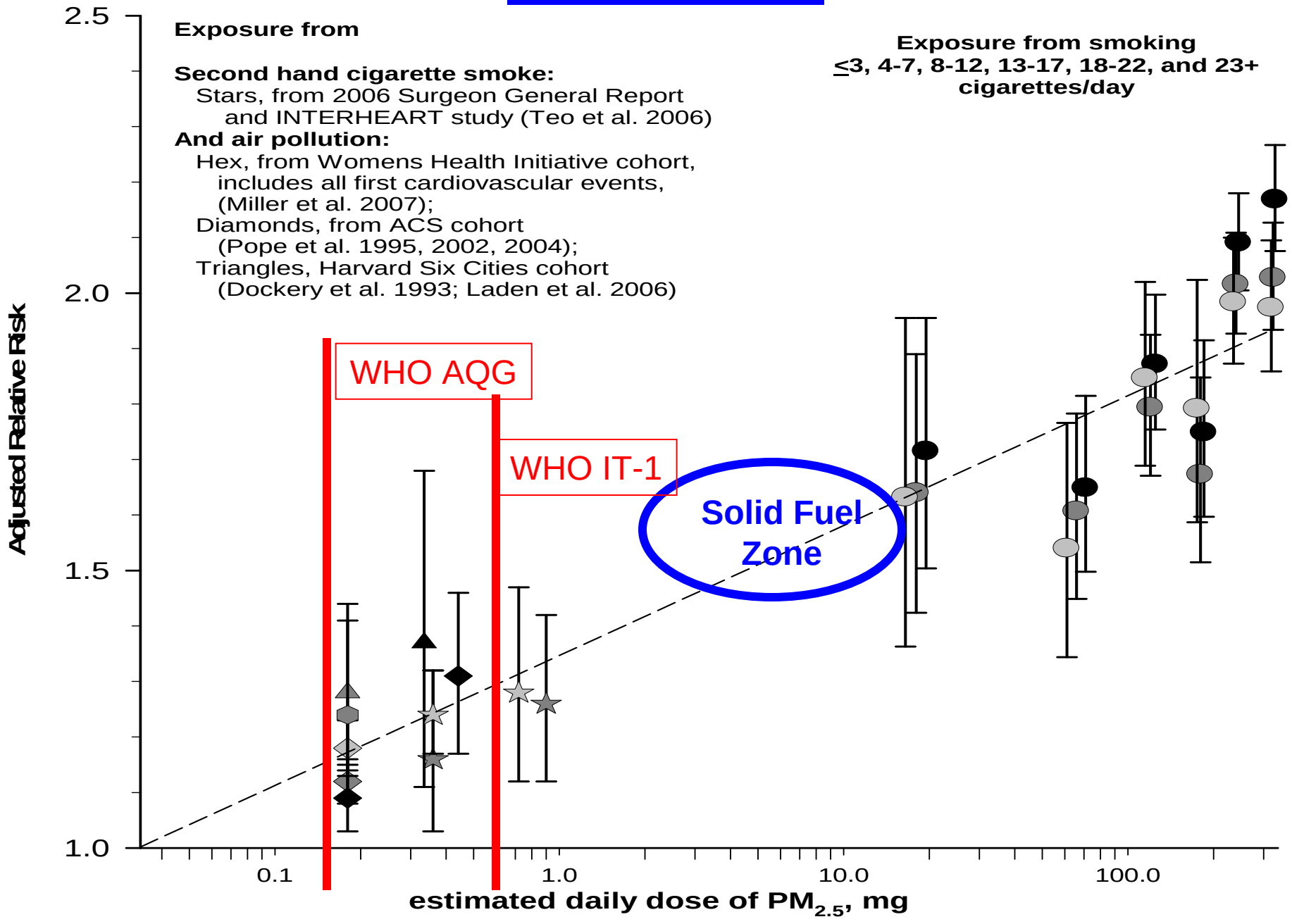
Smith, et al, 2009

Unpublished results from RESPIRE have been removed

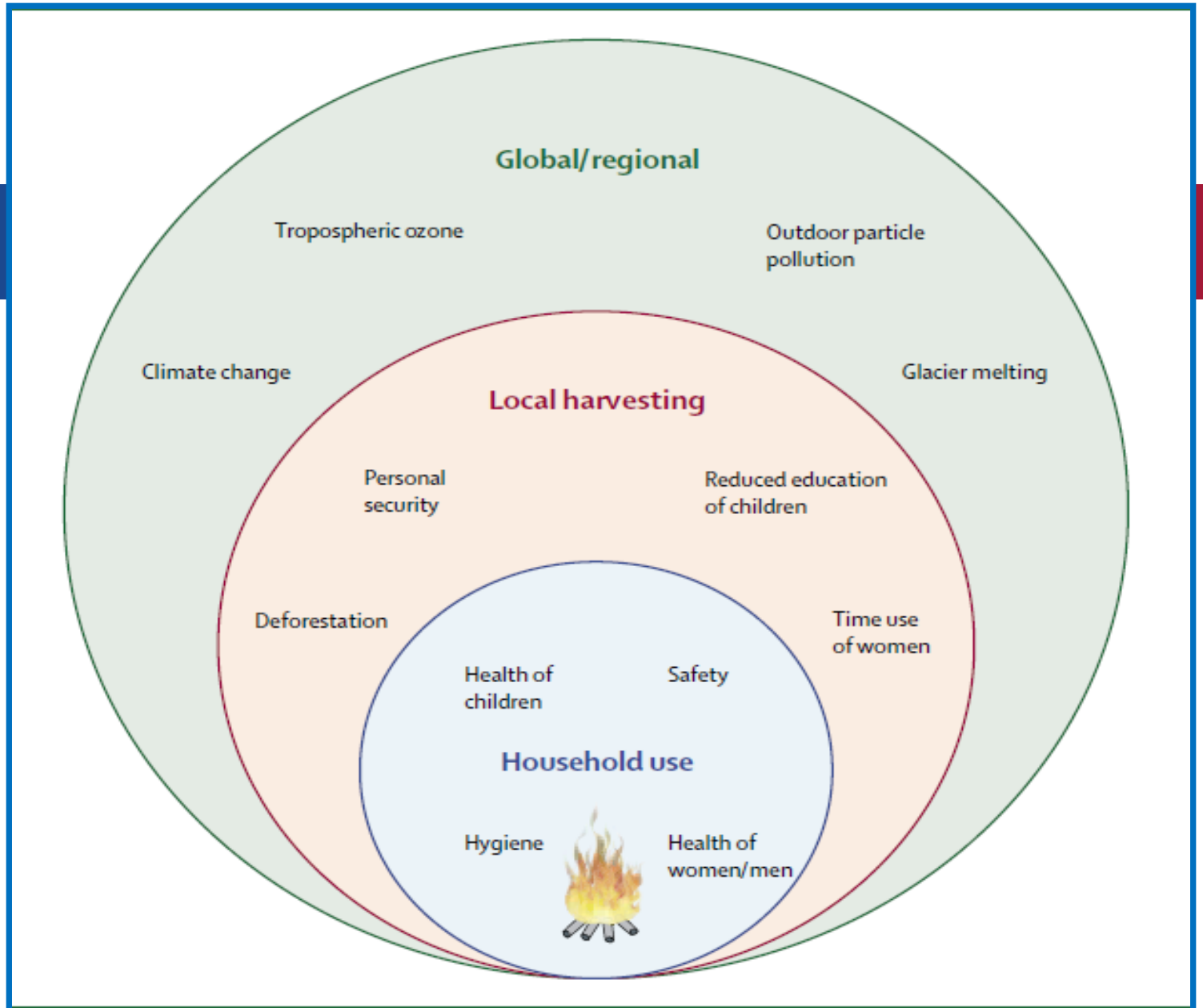
Watch the website below where they will be posted as soon as they are published.

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

Heart Disease Risk
Pope et al, 2009

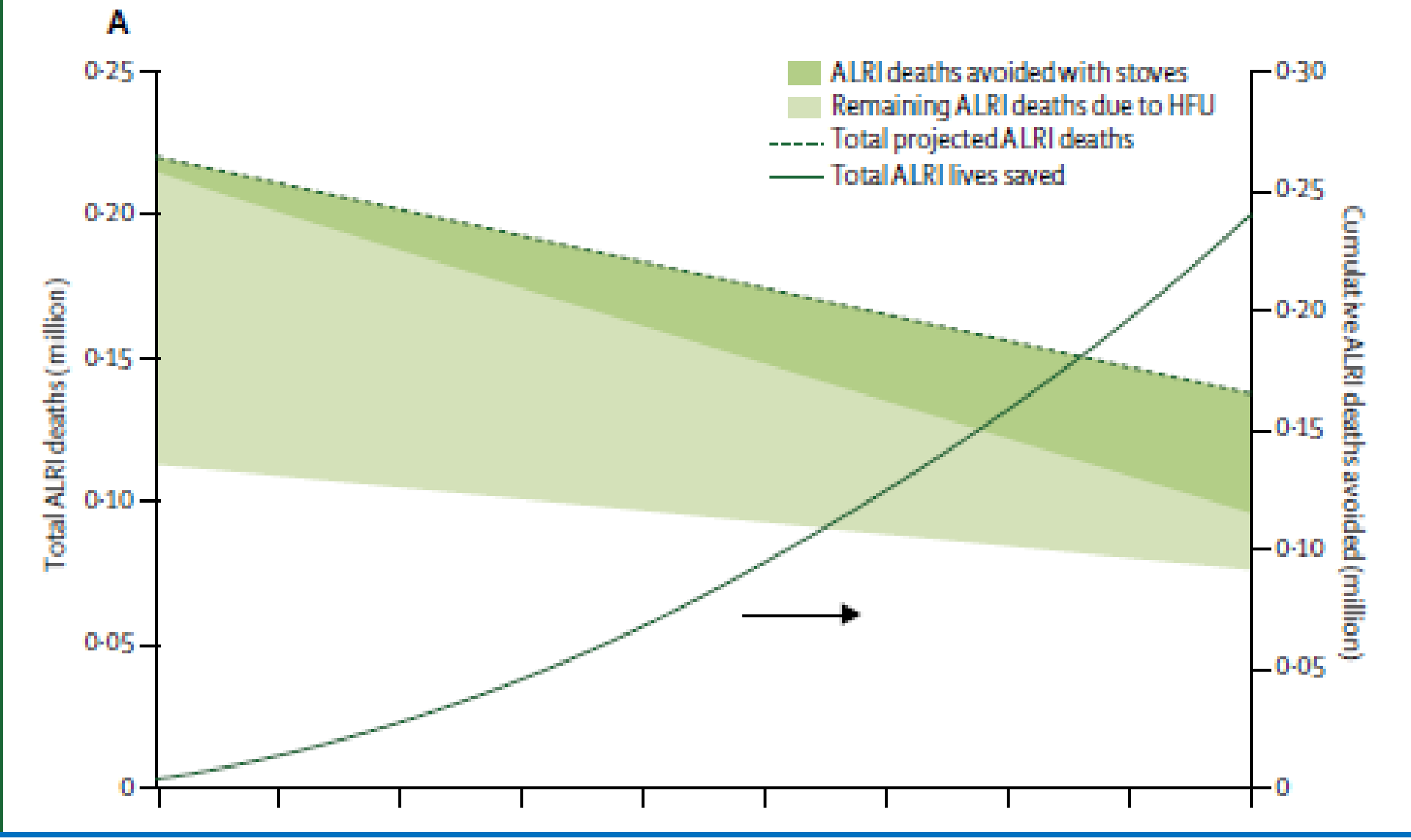


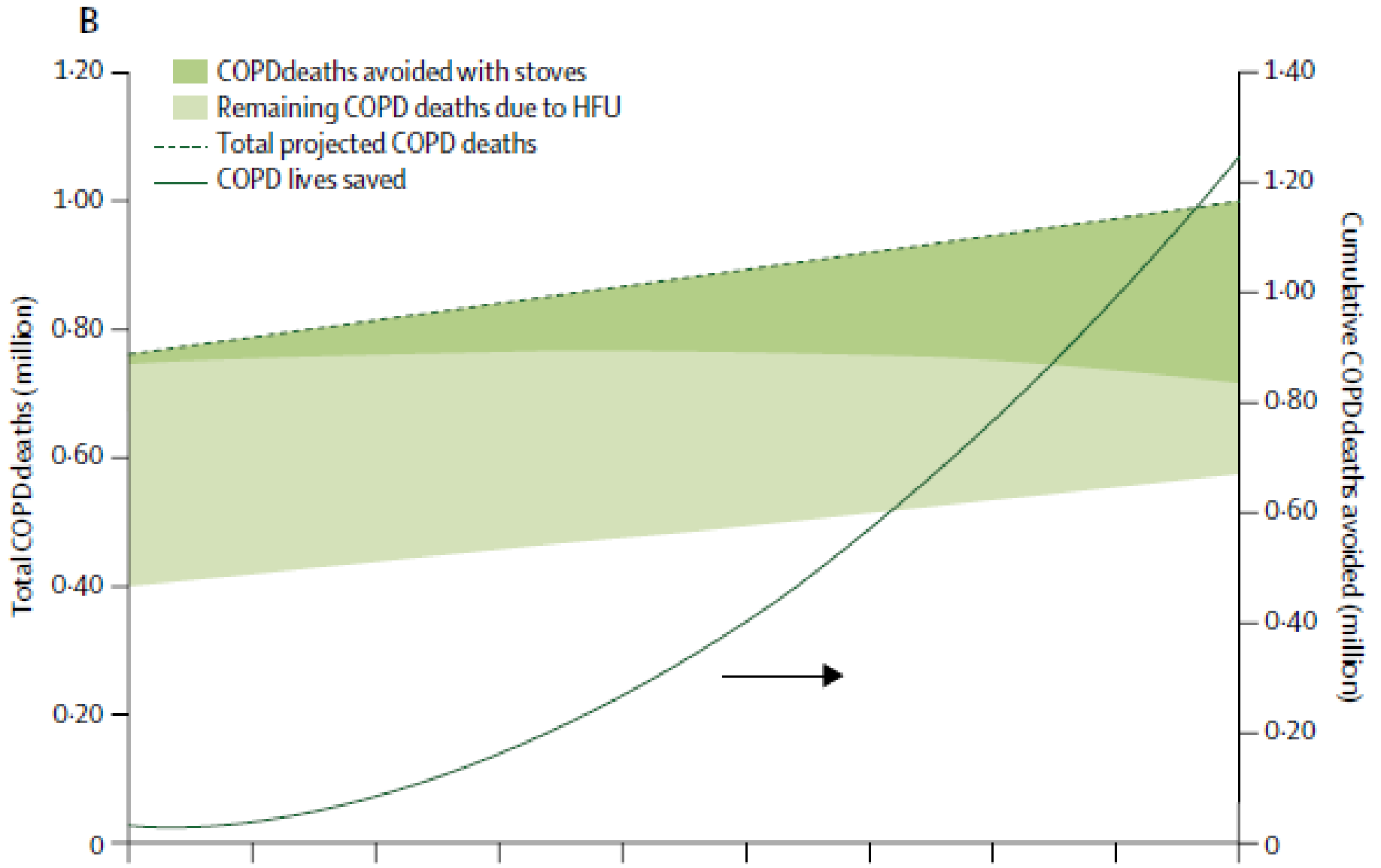
Health effects of Traditional Household Fuel Use



ALRI < 5 years

THE LANCET




B
COPDdeaths avoided with stoves
Remaining COPD deaths due to HFU
Total projected COPD deaths
COPD lives saved
1·20
1·00
0·80
0·60
0·40
0·20
0
Total COPDdeaths (million)
1·40
1·20
1·00
0·80
0·60
0·40
0·20
0
Cumulative COPDdeaths avoided (million)

Ischaemic Heart Disease

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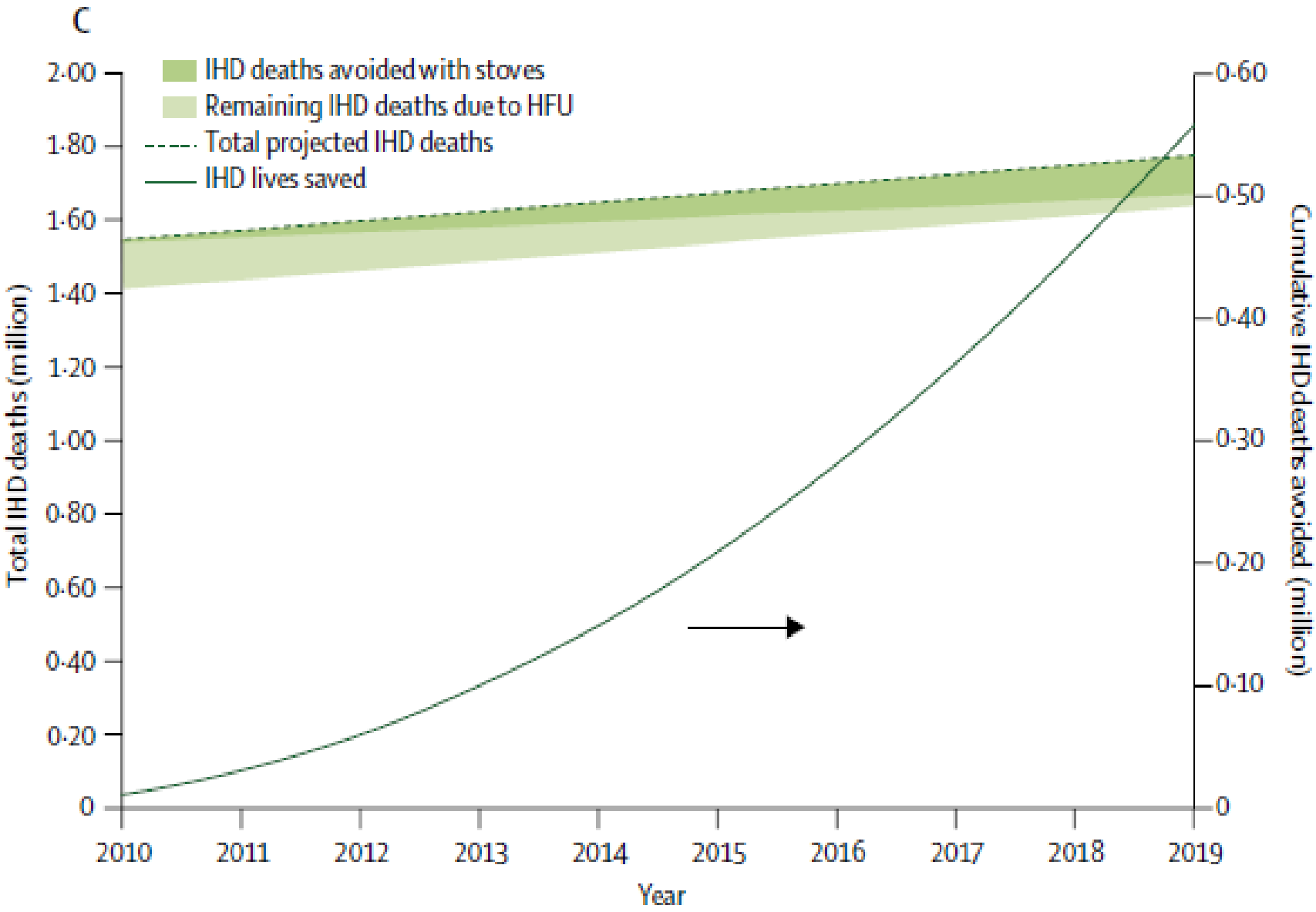

Summary of Disease Burden Avoided

THE LANCET

	Deaths from ALRI	Deaths from COPD	Deaths from IHD	Total DALYs for these diseases
Avoided in 2020 (%)	30·2%	28·2%	5·8%	17·4%
Annual number in 2020 without stoves (×10⁶)	0·14	1·00	1·77	63·0
Total avoided 2010–20 (×10⁶)	0·24	1·27	0·56	55·5

ALRI=acute lower respiratory infections. COPD=chronic obstructive pulmonary disease. IHD=ischaemic heart disease. DALY=disability-adjusted life-year.

Table 6: Health benefits of the Indian stove programme

What's coming

- If the RESPIRE results are accepted for publication in near their submitted form, HH SFU will be on the international health map much more than ever before.
- RESPIRE shows a potential benefit for the most important cause of child mortality in the world equal to or greater than vaccines or nutrition programs – the other two major types of intervention available.
- Even so, it will be up to us to show that major reductions in exposure can be reliably achieved at large scale as there is much cynicism on this point.

Bottom Line for Stoves

- The biggest single question still remains
- “Is it possible to promote a stove without a chimney for health?”
- Not only a question of lab and field performance of the advanced combustion devices, but also
- Can CO emissions be brought under WHO short-term AQGs in a reliable manner

Best is both

- Low emissions and high tolerance for fuel and operator variability
- And a chimney
- This is the approach taken in China
- Remember, lower emissions means that the chimney as well as the people and the outside environment is protected
- Thus greatly reducing at least one problem with chimneys – poor lifetime and need for cleaning

Thank you

Papers being published next week in *the Lancet* series on *Health Benefits of Strategies to Reduce Greenhouse Gases* *will be available on my website shortly after. These include the new data on black carbon health effects and the health benefits of the 150-million stove program in India;*

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

Watch the website also for the Guatemala pnemonia studies and the new WHO Air Quality Guidelines, which both should be ready in the first few months of 2010.

The new Comparative Risk Assessment should be out in mid-2010 and will also be found on the website when ready.