Household Solid Fuel Pollution: Recent Health Effects Results from Guatemala

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Workshop on Emissions of Toxic Air Contaminants from Biomass Burning for Cooking and Brick Production

CIEco-UNAM, Morelia, Michoacan
September 30, 2008
Household Solid Fuel Burning

• Why solid fuel use might be a hazard
• Summary of current risk estimates for child pneumonia
• Recent results from the first randomized trial – RESPIRE in the Guatemalan Highlands
  – Pneumonia in children <18 mo
  – Blood pressure in women
  – Low birth weight
World Energy – 2001

Population: 6.102 billion
Total energy use: 10.2 Gtoe
Per capita energy consumption: 1.67 toe

World Energy Assessment, 2004
Usarios leña por localidad

- 100 - 1,500
- 1,501 - 2,500
- 2,501 - 50,111

Usuarios de leña por localidad, áreas prioritarias - 2000
Determinación de 18 áreas prioritarias de acuerdo al Índice de Prioridad por uso de Leña (IPL).

Fuente: Censo de población y Vivienda 2000.
Creado en ArcGIS 9.2 utilizando ArcMap.

Albers Equal Area Conic Projection
North American Datum 1927
Ver detalles en el Anexo II
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$_2$O 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

Into Pot 2.8 MJ 18%
In PIC 1.2 MJ 8%
Waste Heat 11.3 MJ 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
- 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

In US regulatory terminology, there are significant emissions of 3 Criteria Air Pollutants and at least 28 Hazardous Air Pollutants (HAPs).

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

Typical Health-based Standards

- **Carbon Monoxide**:
  - Typical: 150 mg/m³
  - Indoor: 10 mg/m³

- **Particles**:
  - Typical: 3.3 mg/m³
  - Indoor: 0.1 mg/m³

- **Benzene**:
  - Typical: 0.8 mg/m³
  - Indoor: 0.002 mg/m³

- **1,3-Butadiene**:
  - Typical: 0.15 mg/m³
  - Indoor: 0.0003 mg/m³

- **Formaldehyde**:
  - Typical: 0.7 mg/m³
  - Indoor: 0.1 mg/m³

IARC Group 1 Carcinogens

- Best single indicator

Typical Indoor Concentrations

- Wood: 1.0 kg per hour in 15 ACH 40 m³ kitchen
First person in human history to have her exposure measured doing one of the oldest tasks in human history

Exposures seem to be high in a large vulnerable population. But what are the health effects?

Kheda District, Gujarat, India
1981
How Much Global Ill-Health can be Attributed to Household Indoor Air Pollution?

• What do we mean by “ill-health?”

• What do we mean by “attributed?”

• What do we mean by “indoor air pollution”
What do we mean by ill-health?

- Lost life-years, which accounts for age of premature death and duration of illness
- DALYs = Disability adjusted life years lost
What do we mean by “indoor air pollution”

- Too few measurements worldwide to determine exposures by measurements
- Can use solid fuel use as a proxy as widespread surveys available
- Makes physical sense because of larger pollutant emissions
- There is a growing epidemiologic literature showing health effects
# The Energy Ladder: Relative Pollutant Emissions Per Meal

<table>
<thead>
<tr>
<th></th>
<th>Biogas</th>
<th>LPG</th>
<th>Kerosene</th>
<th>Wood</th>
<th>Roots</th>
<th>Crop Residues</th>
<th>Dung</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO</strong></td>
<td>0.1</td>
<td>1.0</td>
<td>3</td>
<td>19</td>
<td>22</td>
<td>60</td>
<td>64</td>
</tr>
<tr>
<td><strong>Hydrocarbons</strong></td>
<td>0.3</td>
<td>1.0</td>
<td>4.2</td>
<td>17</td>
<td>18</td>
<td>32</td>
<td>115</td>
</tr>
<tr>
<td><strong>PM</strong></td>
<td>2.5</td>
<td>1.0</td>
<td>1.3</td>
<td>26</td>
<td>30</td>
<td>124</td>
<td>63</td>
</tr>
</tbody>
</table>

Smith, et al., 2005
Attributable Risk?

• The amount of ill-health that would not exist today if the exposure to the risk factor had not occurred in the past.
• Assumes all other risk factors remain constant
• Need to compare to some feasible alternative such as clean fuels (no cooking is not feasible)
• Calculated as if all other risk factors remain the same and thus addition of attributable risks must be done with care
2-3 million ALRI Deaths in Children Under 5

- Poor Housing? 40%?
- Underweight 40%
- Lack of breastfeeding 10%
- Diarrhea 20%
- Measles 10%
- Zn Deficiency 15%
- No vaccines 25-50%
- Genetic Susceptibility?
- Household solid-fuel burning?
- Outdoor pollution?
- Poor case-management 50%?

Attributable Fractions do not add to 100%

Rough estimates only
Comparative Quantification of Health Risks
Global and Regional Burden of Disease Attributable to Selected Major Risk Factors
Volume 1

Edited by
Majid Ezzati, Alan D. Lopez, Anthony Rodgers and Christopher J.L. Murray

World Health Organization
Geneva

Published in late 2004, 2 vols, ~2500 pp

Available on World Health Organization website

http://www.who.int/publications/cra/en/
Comparative Risk Assessment Method

Exposure Levels: Past actual and past counterfactual

Exposure-response Relationships (risk)

Disease Burden by age, sex, and region

Attributable Burden by age, sex, and region
Diseases for which we have epidemiological studies linking indoor air pollution to disease

ALRI/Pneumonia (meningitis)

Chronic obstructive lung disease

Only two qualified with sufficient evidence to be included in the WHO CRA
Acute lower respiratory infections (ALRI)

Chief cause of death among the world’s children (>2 million per year). Thus, it is the chief global cause of lost healthy life years.

Child mortality occurs almost entirely in developing countries, and as pneumonia.

Well-accepted risk factors (malnutrition, micro-nutrient deficiencies, other diseases, crowding, chilling) do not account for its scale.
Not so long ago, pneumonia was the chief cause of death in developed countries.

ALRI associated with use of solid fuels: analysis of ~10 observational studies

<table>
<thead>
<tr>
<th>Subgroup analyses</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All studies</td>
<td>2.3 (1.9-2.7)</td>
</tr>
<tr>
<td>Use of solid fuel</td>
<td>2.0 (1.4-2.8)</td>
</tr>
<tr>
<td>Duration of time child spent near the cooking fire</td>
<td>2.3 (1.8-2.9)</td>
</tr>
<tr>
<td>Studies adjusting for nutritional status</td>
<td>3.1 (1.8-5.3)</td>
</tr>
<tr>
<td>Studies not adjusting for nutritional status</td>
<td>2.2 (2.0-3.0)</td>
</tr>
<tr>
<td>Children aged &lt;2 years old</td>
<td>2.5 (2.0-3.0)</td>
</tr>
<tr>
<td>Children aged &lt;5 years old</td>
<td>1.8 (1.3-2.5)</td>
</tr>
</tbody>
</table>

Smith et al in WHO, Comparative quantification of health risks, 2004
Consistent with

- Controlled animal and human exposures showing effects on respiratory immune system
- Dozens of studies of the effect of environmental tobacco smoke exposures in children
- A few studies of outdoor air pollution
Other Environmental Risk Factors

Global Burden of Disease from Top 10 Risk Factors
plus selected other risk factors

- Underweight
- Unsafe sex
- Blood pressure
- Tobacco
- Alcohol
-Unsafe water/sanitation
- Child cluster vaccination
- Road traffic accidents
- Cholesterol
- Indoor smoke
- Overweight
- Low fruit and veg
- Occupational (5 kinds)
- Lead (Pb)
- Urban outdoor air
- Climate change

Percent of All DALYs in 2000

1.6 million premature deaths/y (~1 million in children under 5 y)

4.9 million premature deaths/y
<table>
<thead>
<tr>
<th>Study design</th>
<th>N</th>
<th>OR</th>
<th>95% CI</th>
<th>Odds Ratio (random) 95% CI</th>
<th>Weight %</th>
<th>Odds Ratio (random) 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td>2</td>
<td>1.28</td>
<td>1.06, 1.54</td>
<td></td>
<td>11.26</td>
<td></td>
</tr>
<tr>
<td>Cohort</td>
<td>7</td>
<td>2.12</td>
<td>1.06, 4.25</td>
<td></td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>Case-control</td>
<td>15</td>
<td>1.97</td>
<td>1.47, 2.64</td>
<td></td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>Cross-sectional</td>
<td>3</td>
<td>1.49</td>
<td>1.21, 1.85</td>
<td></td>
<td>2.12</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>26</td>
<td>1.78</td>
<td>1.45, 2.18</td>
<td></td>
<td>4.25</td>
<td></td>
</tr>
</tbody>
</table>

New ALRI-IAP Systematic Review and Meta-Analysis

Dherani et al.

Bull WHO, 2008
Problems with all Previous ALRI and IAP Studies

• Studies were all observational and there may have been residual confounding, i.e., the effect may be due to poverty-related issues not air pollution itself.
• Little or no exposure assessment.
• Given distribution of upper and lower respiratory infections, disease measures used were sensitive (not too many false negatives) but not specific enough, i.e., there were too many false positives.
## Acute Respiratory Infections in the World – 2002
### In Children 0-5 years

**Acute Lower Respiratory Infections (ALRI) + Acute Upper Respiratory Infections (AURI)**

<table>
<thead>
<tr>
<th>Incidence/100,000</th>
<th>ALRI</th>
<th>AURI</th>
<th>ALRI/AURI</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>41,000</td>
<td>536,000</td>
<td>0.08</td>
</tr>
<tr>
<td>OECD</td>
<td>3,000</td>
<td>450,000</td>
<td>0.01</td>
</tr>
<tr>
<td>India</td>
<td>45,000</td>
<td>700,000</td>
<td>0.06</td>
</tr>
<tr>
<td>Ratio Poor/Rich</td>
<td>15</td>
<td>1.6</td>
<td></td>
</tr>
</tbody>
</table>

In India, if an ALRI assessment method is 82% sensitive and 88% specific,* then only 31% of the ALRI found by the method is actually ALRI. The rest is probably AURI or nothing!

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*WHO, Global Burden of Disease Database

*Average of three best studies
History of a RCT

• ~1980: Early studies of health effects in Nepal and elsewhere
• 1981: First measurements of pollution levels in India
• 1984: International meeting to decide on needed research
  – Chose randomized control 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
• 1996-1999: Unfunded proposals
• 2001: NIEHS funding secured
• 2002-2005: Fieldwork completed
• 2007: First results published
• 23+ years from deciding to conduct RCT to results!
First Randomized Trial in Air Pollution History*

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

* In normal populations
Setting

- Rural highlands of San Marcos, western Guatemala
- Population nearly all indigenous Mayan Indians
- Nearly all depend on wood for cooking and heating
- Traditional stove is the 3-stone fire – no venting to outside
- Very poor, high IMR, pneumonia, diarrhea and stunting common
- Poor health service uptake - culture, language, transport, time
- Intervention is a stove with chimney that is well-accepted by community
RESPIRE: (Randomized Exposure Study of Pollution Indoors and Respiratory Effects)

Highland Guatemala

Traditional 3-stone open fire

Plancha chimney wood stove
RESPIRE Teams

• 25-35 fulltime field staff
  – 17-25 locally hired bilingual (Mam-Spanish) fieldworkers
  – Field manager
  – 2 field supervisors
  – Data manager
  – 2-3 physicians
  – Environment engineer for air pollution monitoring
  – 4-6 office/data entry staff
  – All Guatemalan

• Investigators and students in Berkeley, Guatemala, Liverpool, Boston, Geneva, and Bergen

• International **Data Safety Management Board** for ongoing protection of human subjects

• NIH and several other funders
Overview of RESPIRE study design

- 530 eligible households: open fire, woman pregnant or child less than 4 months
- Baseline survey and exposure assessment

Randomize

Keep open fire

Plancha

Follow up till aged 18 months
- Surveillance for ALRI, diarrhoea, &c
- Detailed exposure monitoring

Compare incidence and exposure in 2 groups
Plancha offered to ‘controls’

Year 1
5500 Households total

Years
1-3

Years
3-4
## Randomisation: balance of groups at baseline

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

Follow-up at weekly visit

Home

Weekly visit
• Well
• Mild illness
• Referral to study doctor

Child dies

Verbal autopsy

Community centre

Study doctor examines
• Pulse oximetry
• If pneumonia, RSV* test and refer for CXR
• Refer if very ill

Health outcome definitions

Hospital

Assessed by duty doctor
Study team obtain CXR and inpatient data and diagnosis

Child dies

Verbal autopsy

* Respiratory syncitial virus
## Overview of weekly visits

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

* * P < 0.001
Clinical assessment is the key outcome

Needed to standardise

Six employed (four assessed 96.4% referrals)

Use of agreed terms and signs

Initial ‘calibration’ and ongoing (± monthly) clinical sessions
PULSE OXIMETRY

- Non-invasive and well-accepted (99%)
- Measure of severity (of respiratory illness):
  - mortality up to x5 in hypoxaemic
- Well children (n=55)
  - Mean (SD) 93.2% (3.0)
  - Hypoxaemic defined as mean – 2SD = 87%
- Bogota (5d – 24mo) altitude 2640m, mean (SD) 93.3% (2.1)
Chest X-rays

- Eligible: all pneumonia cases
- 207 (79 %) of cases attended for CXR
  - Plancha: 82.3%
  - Control: 76.3%
- Reading - WHO protocol*
  - Training
  - Test films: 75% agreement
  - Study films read independently, & blind
  - Agreement assessed
  - WHO readers (TC, HO) assisted re disagreements

*Standardised method for pneumonia interpretation
Pneumonia by month and RSV status
Exposure-response relationship
(Preliminary Results from Guatemala RCT)

Reference point (RR=1) is mean CO in controls

Reduction of 2x exposure ~30% drop in serious pneumonia

Log linear function provided the best fit
Studies underway in our group on several other diseases

ALRI/Pneumonia (meningitis)
Low birth weight
Asthma
Early infant death
Cognitive Impairment?

Chronic obstructive lung disease
Interstitial lung disease
Cancer (lung, NP, cervical, aero-digestive)
Blindness (cataracts, trachoma)
Tuberculosis
Heart disease
Chimney Stove Intervention to Reduce Long-term Woodsmoke Exposure Lowers Blood Pressure among Guatemalan Women

John P. McCracken,
Kirk R. Smith, Murray A. Mittleman, Anaité Díaz, Joel Schwartz

(Published in Environmental Health Perspectives, July 2007)
Objectives

**Goal**: To evaluate the effect of long-term reductions in woodsmoke exposure on systolic (SBP) and diastolic blood pressure (DBP).

**Specific hypotheses**:
1. Personal fine particle (PM$_{2.5}$) exposures will be lower among women using chimney stoves to cook.
2. Chimney stove intervention will be associated with lower SBP and DBP.
Study Design

• Study population
  – Eligible: Women ≥ 38 years, cooking daily
  – Excluded: pregnant, breastfeeding

• Two follow-up periods
  – Trial period (7/03-12/04)
  – Echo-intervention period (3/04-3/05)

Personal PM$_{2.5}$  SBP and DBP
### Measures by Group and Period

#### Subjects (Measures)

<table>
<thead>
<tr>
<th></th>
<th>Trial Period</th>
<th>Echo-Intervention Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention Group</td>
<td>49 (115)</td>
<td></td>
</tr>
<tr>
<td>Control Group</td>
<td>71 (111)</td>
<td>55 (65)</td>
</tr>
</tbody>
</table>
## Between-Groups Results

<table>
<thead>
<tr>
<th>Number of subjects (measures)</th>
<th>Adjusted mean difference*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control group</td>
</tr>
<tr>
<td>SBP 71 (111)</td>
<td>49 (115)</td>
</tr>
<tr>
<td>DBP 71 (111)</td>
<td>49 (115)</td>
</tr>
</tbody>
</table>

* Adjusted for age, body mass index, daily temperature, season, day of the week, time of day, use of wood-fired sauna, household electricity, an asset index, ever smoking, and secondhand tobacco smoke exposure
### Before-and-After Results

<table>
<thead>
<tr>
<th>Number of subjects (measures)</th>
<th>Adjusted mean difference*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial period</td>
<td>Echo-intervention</td>
</tr>
<tr>
<td>SBP</td>
<td>55 (88)</td>
</tr>
<tr>
<td>DBP</td>
<td>55 (88)</td>
</tr>
</tbody>
</table>

* Adjusted for age, body mass index, daily temperature, season, day of the week, time of day, use of wood-fired sauna, household electricity, an asset index, ever smoking, and secondhand tobacco smoke exposure.
Low birth weight
(associated with IAP)

- Large direct impact on child mortality
- Of which perhaps 25% is ALRI
- LBW now linked to chronic disease over lifetime
Low Birth Weight

- Small number of studies conducted appearing to show results for IAP consistent with evidence from ETS and ambient air pollution.
- Pregnant women in countries with high rates of (a) solid fuel use, and (b) adverse pregnancy outcomes rarely able to avoid activities that expose them and their unborn children to IAP.
- Hence, even modest increase in risk for these conditions can be expected to translate into a substantial population attributable risk.
- Systematic review carried out in order to:
  - summarise the extent and quality of the evidence for the relationship between IAP from solid fuel use and adverse pregnancy outcomes
  - quantify these associations by meta-analysis.
Results: IAP and LBW (<2500gms)

Heterogeneity - ($I^2 = 0\%$; $\chi^2 (df=5) = 4.89, p=0.43$)

Funnel plot asymmetry - Begg’s test ($p = 0.566$) Egger’s test ($p=0.989$)
Results: IAP and birth weight

Heterogeneity - ($I^2 = 0\%$; Chi$^2$ (df=3) = 2.79, p=0.43)

Funnel plot asymmetry - Begg’s test (p = 0.308) Egger’s test (p=0.479)
Results: IAP and still birth

<table>
<thead>
<tr>
<th>Study</th>
<th>Odds Ratio (fixed)</th>
<th>Weight</th>
<th>Odds Ratio (fixed)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>95% CI</td>
<td>%</td>
<td>95% CI</td>
<td></td>
</tr>
<tr>
<td>Siddiqui 2005</td>
<td></td>
<td>17.29</td>
<td>1.90</td>
<td>[1.12, 3.23]</td>
</tr>
<tr>
<td>Mavalankar 1991</td>
<td></td>
<td>35.28</td>
<td>1.50</td>
<td>[1.04, 2.17]</td>
</tr>
<tr>
<td>Mishra 2005</td>
<td></td>
<td>47.43</td>
<td>1.44</td>
<td>[1.05, 1.98]</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td></td>
<td>100.00</td>
<td>1.53</td>
<td>[1.23, 1.91]</td>
</tr>
</tbody>
</table>

Test for heterogeneity: Chi² = 0.79, df = 2 (P = 0.67), I² = 0%
Test for overall effect: Z = 3.80 (P = 0.0001)

Heterogeneity - (I² = 0%; Chi² (df=2) = 0.79, p=0.67)

Funnel plot asymmetry - Begg’s test (p = 0.296) Egger’s test (p=0.083)
In the updated Comparative Risk Assessment being conducted now, depending on the exposure modeling, the estimate will probably be around 750k child ALRI deaths due to household solid fuel smoke globally, but LBW will add others.
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