The Surprisingly Large Health Benefits of Clean Household Fuels

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“Cooking for Life Initiative”

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Cooking with solid fuels

- Wood
- Straw
- Coal
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
First person in human history to have her exposure measured doing one of the oldest tasks in human history

Kheda District, Gujarat, India
1981
Health-Damaging Air Pollutants From Typical Woodfired Cookstove in India.

Typical Health-based Standards

- Carbon Monoxide: 150 mg/m³
  - 10 mg/m³
- Particles: 3.3 mg/m³
  - 0.1 mg/m³

Typical Indoor Concentrations

- Wood: 1.0 kg Per Hour in 15 ACH 40 m³ kitchen
- Benzene: 0.8 mg/m³
  - 0.002 mg/m³
- 1,3-Butadiene: 0.15 mg/m³
  - 0.0003 mg/m³
- Formaldehyde: 0.7 mg/m³
  - 0.1 mg/m³

Best single indicator: IARC Group 1 Carcinogens
Diseases for which we have many epidemiological studies

ALRI/Pneumonia

Chronic Lung Disease

These diseases are included in the 2010 Comparative Risk Assessment
Being released in Fall 2012 as part of the Global Burden of Disease Project
Diseases for which we have epidemiological studies - 2011

Cognitive Impairment
Asthma
Tuberculosis
Birth defects
Other cancers (cervical, NP, upper airway)
Pneumonia
Low birth weight
Stillbirth
Cognitive Impairment
Birth defects
Asthma?

There is some evidence for these other diseases, but considered insufficient to include in the 2010 Comparative Risk Assessment

Burns and the health/safety impacts of fuel gathering
How to compare across diseases, risk factors, and age groups?

• International health metric – the DALY
• Disability-Adjusted Life Years
• Basically, the number of healthy life years lost to a disease or risk
• Includes allowance for lost of life expectancy and the severity of the disease
• Global Burden of Disease – 2010
• Being published this fall, 2012
Slides removed

- From the Global Burden of Disease 2010, now under peer review
- Please watch my website or the journal Lancet for the papers, which should be published by December 2012
- http://ehs.sph.berkeley.edu/krsmith/
Actually even worse

• Because household solid fuels add significantly to outdoor air pollution as well
• As well as emit climate-altering pollutants such as black carbon
Sectoral contributions to total PM2.5 (population-weighted), 2010

- **India**
  - Household Cooking: 5
  - Household (other): 5
  - Non-household: 25

- **China**
  - Household Cooking: 10
  - Household (other): 10
  - Non-household: 30

- **United States**
  - Household Cooking: 15
  - Household (other): 15
  - Non-household: 7

- **Indonesia**
  - Household Cooking: 20
  - Household (other): 20
  - Non-household: 7

- **Brazil**
  - Household Cooking: 10
  - Household (other): 10
  - Non-household: 2

- **Pakistan**
  - Household Cooking: 10
  - Household (other): 10
  - Non-household: 2

- **Bangladesh**
  - Household Cooking: 10
  - Household (other): 10
  - Non-household: 4

- **Nigeria**
  - Household Cooking: 4
  - Household (other): 4
  - Non-household: 2

Chafe et al., CRA-2010
How Clean Does It Have to be?
Integrated Exposure-Response: Outdoor Air, SHS, and Smoking

Heart Disease risks from Combustion Particles
Annual average PM2.5 in ug/m3

- Smokers
- Solid Fuel Zone
- Secondhand Tobacco Smoke
- Outdoor Air Pollution

GBD-2010
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>
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<tr>
<td>CO</td>
<td>0.1</td>
<td>1.0</td>
<td>3</td>
<td>19</td>
<td>22</td>
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<tr>
<td>Hydrocarbons</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>
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<tr>
<td>PM</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>

Legend:
- **CO**
- **Hydrocarbons**
- **PM**
Exposure-response relationship

Child pneumonia

Risk
3
2
1

WHO air quality annual guideline:
IT1 : 35 µg/m³

PM2.5 Exposure
25
Fan
Chimney/Rocket
‘Simple’ improved
O/Fire
2
1

LPG

Exposure

PM2.5 Exposure

25
125
200
300 µg/m³
Is LPG Cookstove Technology Perfect?

• No, old and out of date: does not use modern technology
• Now that the lack of gas cookfuel is understood to be such a major risk
• The LPG industry needs to respond with a new range of products oriented toward the needs of the poor.
Uganda: August 2012

Note: Both stoves are in good visual condition.

Blue Flame
Nominal Combustion Efficiency:
> 99%

Yellow Flame
Nominal Combustion Efficiency:
96-97%

Courtesy M. Johnson, BAMG
Better Heat Transfer

For example, the Turbo Pot™
Use the Waste Heat

For example, the BioLite™

Thermal Electric Generation (TEG)
BioLite Home™ Stove
Being test-marketed in India

USB Port to charge Cellphones, Lanterns, etc.
Is Kerosene a Clean Alternative?
In India, kerosene cooking associated with
  - 108 gram reduction in birthweight (secondhand tobacco smoke - ~35 g)
  - And probably a doubling of early infant deaths

In Nepal,
  - 70% increase in child pneumonia
  - 3 times the risk of tuberculosis
Indonesia Cooking Fuel Situation 2007-2010

- LPG users rapidly increase after 2007, in replacement of the kerosene users
  - 10.6% to 45.6% (5.6 million to 27.6 million)
- Kerosene users decrease significantly, accounting for only 11.7% of all households in 2010.
  - 36.6% to 11.7% (19.5 to 7.1 million)

Number of wood users remains large and not much affected by the LPG program

Why not eliminate kerosene subsidies everywhere?

• It is used for lighting in those many areas where there is no electricity or it is very unreliable, i.e., South Asia
• New LPG technology thus needed to respond to lighting as well as cooking needs
The Problem

• 41% of the human race still relies on solid fuels (biomass and coal) for household cooking fuel

• Such fuels produce large amounts of health-damaging pollution in households exposing women and children in particular

• The resulting human exposure is a major cause of ill-health in the world.

• It is not going away by itself.
World Population Using Solid Fuels

~40% of the world
~2.8 billion people
More than any time in human history
The Role of Liquefied Petroleum Gas in Reducing Energy Poverty

Masami Kojima
World Bank
Distribution of Household Cooking Fuel by Income in India

- 160 million households

Income Quintal:
- Lowest
- 2
- 3
- 4
- Highest

Fuel Types:
- Solid Fuel
- LPG + Kero

NFHS, 2006
Figure 3.1 LPG and Biomass as the Primary Cooking Fuel

Source: Kojima, Bacon, and Zhou 2011.
What needs to be done.

- 3 billion people need clean cooking fuel
- All poor, but some more than others
- The poorest one billion probably have to have significant public assistance to obtain better biomass stoves
- The middle one billion might be able to adopt clean advanced biomass stoves and fuels such as biogas and ethanol on a semi-commercial basis
- With better technology and better reliability LPG could extend its market to serve the top billion of the current population using biomass
- Millions of premature deaths of women and children could be averted
- This should be the target of the Cooking for Life Program of the WLPGA
Thank you

Publications and presentations at my website

Just Google “Kirk R. Smith”