Clean Cooking in Central America: Why do we Care?

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“CHALLENGES AND OPPORTUNITIES TO UNIVERSAL ACCESS TO CLEAN BIOMASS COOKSTOVES IN CENTRAL AMERICA”
Regional Workshop Organized by SICA’s General Secretariat and the World Bank in Coordination with the Ministry of Energy and Mines of Nicaragua and the Secretariat of Natural Resources and Environment of Honduras.

May 24, 2013
The Environmental Health Pathway
The three major solid fuels
World Population Using Solid Fuels

~40% of the world
~2.8 billion people
More than any time in human history
<table>
<thead>
<tr>
<th>Country</th>
<th>Biomass Use 2010</th>
<th>2010 Biomass Use for Cooking in Latin America</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>0 (0, 12)</td>
<td></td>
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<tr>
<td>Belize</td>
<td>12 (0, 25)</td>
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<tr>
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<td>6 (0, 19)</td>
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<td>Mexico</td>
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</tr>
<tr>
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<td>Domin Repub</td>
<td>7 (0, 20)</td>
<td>Peru</td>
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<tr>
<td>Ecuador</td>
<td>2 (0, 15)</td>
<td>St Vinc/Grenad</td>
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<td>El Salvador</td>
<td>22 (9, 35)</td>
<td>Suriname</td>
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<tr>
<td>Grenada</td>
<td>0 (0, 0)</td>
<td>Uruguay</td>
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<tr>
<td>Guatemala</td>
<td>57 (44, 70)</td>
<td>Venezuela</td>
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2010 Biomass Use for Cooking in Latin America

Argentina 0 (0, 12)
Belize 12 (0, 25)
Bolivia 29 (32, 58)
Brazil 6 (0, 19)
Chile 6 (0, 19)
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Dominica 1 (0, 14)
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Ecuador 2 (0, 15)
El Salvador 22 (9, 35)
Grenada 0 (0, 0)
Guatemala 57 (44, 70)
Guyana 7 (0, 20)
Haiti 91 (78, 100)
Honduras 51 (38, 64)
Jamaica 11 (0, 24)
Mexico 14 (1, 27)
Nicaragua 54 (41, 67)
Panama 18 (5, 31)
Paraguay 49 (36, 62)
Peru 36 (24, 50)
St Vinc/Grenad 3 (0, 16)
Suriname 12 (0, 25)
Uruguay 0 (0, 13)
Venezuela 0 (0, 8)
The Environmental Health Pathway

SOURCE ➔ EMISSIONS ➔ CONCENTRATION ➔ EXPOSURE ➔ DOSE ➔ HEALTH EFFECTS
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%
Toxic Pollutants in Wood 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*(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

The Environmental Health Pathway

SOURCE → EMISSIONS → CONCENTRATION → EXPOSURE → DOSE → HEALTH EFFECTS
Health-Damaging Air Pollutants From Typical Wood-fired Cookstove.

Typical Health-based Standards

Carbon Monoxide: 150 mg/m³
10 mg/m³

Particles: 3.3 mg/m³
0.1 mg/m³

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

Wood: 1.0 kg Per Hour in 15 ACH 40 m³ kitchen

Typical Indoor Concentrations

Best single indicator
The Environmental Health Pathway

SOURCE ➔ EMISSIONS ➔ CONCENTRATION ➔ EXPOSURE ➔ DOSE ➔ HEALTH EFFECTS
First person in human history to have her exposure measured doing the oldest task in human history.

~5000 ug/m³ during cooking
>500 ug/m³ 24-hour
-typical in Central America

Emissions and concentrations, yes, but what about exposures?

India, 1981
The Environmental Health Pathway

SOURCE ➔ EMISSIONS ➔ CONCENTRATION ➔ EXPOSURE ➔ DOSE ➔ HEALTH EFFECTS

R.I.P.
How much PM$_{2.5}$ is unhealthy?

- WHO Air Quality Guidelines
  - 10 ug/m$^3$ annual average
  - No public microenvironment, indoor or outdoor, should be more than 35 ug/m$^3$

- USEPA
  - Was 15 ug/m$^3$ until 2012: annual outdoors
  - Now 12 ug/m$^3$
  - Same as California since ~2000


CRA published on Dec 14, 2012 in The Lancet
Metrics

• Mortality – important, but can be misleading as it does not take age into account or years of illness/injury
  – Death at 88 years counts same as at 18, which is not appropriate

• Disability-adjusted Life Years (DALYs) lost do account for age and illness.

• GBD 2010 compares deaths against best life expectancy in world – 86 years
Diseases for which we have many epidemiological studies

- ALRI/Pneumonia
- COPD
- Lung cancer
- Blindness (cataracts, opacity)
- Heart disease
  - Blood pressure
  - ST-segment

These diseases are included in the 2010 Comparative Risk Assessment (released in 2012)
Global DALYs 2010: Top 20 Risk Factors

**Premature Deaths**
- HBP - 9.3 million
- Alcohol – 7.7
- Tobacco – 5.7
- SHS-T – 0.6
- House AP – 3.5
- SHS-C – 0.5
- High BMI – 3.4
- Phys Inactive – 3.2
- Outdoor AP – 3.3
- High Sodium – 3.1
Guatemala
57%*

* % using biomass cookfuel
Nicaragua
54%
Honduras 51%
Mexico 14%
Costa Rica
6%
Not in the top 15 risks
Central America

- 37,000 premature deaths annually from household air pollution from biomass cookfires
- About 10% in children
The framing

- Household air pollution from use of solid fuels for cooking
- Not called “indoor” because stove smoke enters atmosphere to become part of general outdoor air pollution (OAP)
- HAP contributes about 16% to OAP globally, but much more in some countries
- Thus, part of the burden of disease due to OAP is attributable to cooking fuels in households \( \sim 500,000 \) premature deaths.
Framing, cont.

- Much effort made to make estimates consistent across the four combustion particle groups in the new GBD/CRA
- Active tobacco smoking, household air pollution, secondhand tobacco smoking, and outdoor air pollution
- HAP and OAP use the same counterfactual level for nearly all diseases: ~7 ug/m^3 annual mean PM2.5 concentration
- Roughly equivalent to cooking with a vented gas stove or electricity
Integrated Exposure-Response: Outdoor Air, SHS, and Smoking and Heart Disease

CRA, 2012
Summary of CRA

• One of the top risk factors in the world for ill-health.
• Most important environmental risk factor among all examined
• Biggest impact in adults --3 million premature deaths (two-thirds the DALYs)
• Still important for children ~500,000 deaths (one-third the DALYs)
• Important source of outdoor air pollution
• Impact going down slowly because background health conditions improving
• Actual number of people affected is not going down
Not all diseases included

• Many with evidence not included yet
  – Low birth weight
  – TB
  – Other cancers – cervical, upper respiratory, etc
  – Cognitive effects
  – Pneumonia in adults

• Can expect that HAP effects, over time, will be found for nearly all the many dozen diseases found for smoking.

• But at lower risk levels
Much evidence from Central America

• Oldest and most productive HAP research site in the world – highland Guatemala
  – Pneumonia in children
  – Low birth weight
  – Impaired cognitive ability
  – Chronic lung disease in women

• Several studies of cervical cancer in Honduras
Three papers; two done in Honduras with four groups, one in Columbia
RESPIRE
Impact on pneumonia up to 18 months of age

Traditional open 3-stone fire:

Chimney woodstove, locally made and popular with households
The Plancha
Pneumonia from combustion particles
Annual average PM2.5 in ug/m³
Stove reduced kitchen pollution by 10x, but children exposure by only 2x-

- The kids do not spend their entire day in the kitchen
- A chimney does not reduce smoke, but just shifts it outside into the household environment,
- No significant difference in bedrooms or patios

To reduce exposures more requires reducing smoke as well as moving it.
Important!

- Implied health benefit from HAP reduction only potentially achieved by shifting to clean cooking – gas & electricity
- Not achievable with a chimney alone
- Must be very clean combustion
- Can we do this with biomass fuels?
- The big question!
What is to be done?

A fresh look
World cooking in Pictograms –

One billion people each

With apologies to Hans Rosling at Gapminder*
*”Magic Washing Machine”

And thanks to Ajay Pillarisetti
What do the richest one billion people cook with?

Gas or electric stoves

Plus
~4 billion worldwide cook with liquified petroleum gas, natural gas, and electricity
What about the other 3 billion?
Around half have some access to electricity

**UNPURCHASED**
- Wood
- Dung
- Crop Residues

**PURCHASED**
- Coal
- Kerosene
- Charcoal
- Wood
- Electricity

**Not willing or able to join market**

**Willing & able to join market**

**Consumer & Market Participant**
SMOKING

- UNPURCHASED
  - NO MARKET ACCESS
- UNPURCHASED BUT WILLING TO USE THE MARKET
- PURCHASED
  - MARKET USER

NON-SMOKING
Utilize the health care system through primary health and antenatal care.

Market-ready advanced stoves + fuels
Heavily utilized but only moderately more clean
heart of the hearth

LONG-LASTING
LOW EMISSIONS
COMBUSTION UNIT
Corazón de la casa (hogar)

Multi-million Dollar Global Innovation Prize for a Truly Clean Biomass Combustion “Engine” for Household Stoves

Newborn Stove (NBS) Project

SOMAARTH Surveillance Site – Haryana ~200,000 people

Berkeley, Columbia INCLEN, SRU
NBS Project
Introducing advanced combustion stoves to pregnant women through the official ante-natal care system in India

Monitoring air pollution, usage, birth outcomes, and infant pneumonia
These graphs show the number of stove uses and the duration of Philips use over time. The top graph represents the number of stove uses, while the bottom graph shows the duration of Philips use. Both graphs are plotted against the week since intervention, with two lines: one for traditional stoves and one for Philips stoves.
Temperature dataloggers as stove use monitors (SUMs): Field methods and signal analysis

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\textsuperscript{c} Centro de Estudios en Salud, Universidad del Valle, Guatemala City, Guatemala
Lesson

You don’t get what you expect, but what you inspect

(No lográs lo que esperás, sino lo que inspeccionás)
Bottom Lines

- HAP a major health problem in poor populations
- Interventions must be very clean to make a difference
  - Exposure-response evidence – non-linear
  - Field performance does not come up to lab
  - Usage less than 100%
  - Traditional devices not given up 100%
- A very difficult problem – not amendable to simple technologies or dissemination schemes
Just because we know it’s a risk, does not mean we know how to fix it

- **~1900**: Mosquito-born disease cause established, but still 1.4 million die of malaria today
- **~1890**: causation of health risk from human waste in drinking water firmly established: still today one-third of world population without adequate sanitation/water
Why is it so hard?

• What we know works, but gas and electricity (piped water/flush toilets), not “affordable” by the poor.
• Other technologies difficult and less effective and insufficient profits for private sector to enter
• Particularly difficult because of the high component of behavioral change required
• Easy unhealthy alternatives available – gathered biomass (and open defecation)
• Yet, the fact that 60% of the world is now protected, gives us reason to think we can protect the other 40%
What to do

2. Develop really clean biomass stoves– close to gas performance in the lab needed
3. Deploy with chimneys where at all possible
4. Upgrade kitchens – lift cooking off the floor – change social expectations of the kitchen
5. Treat seriously – big problems require big solutions – need best combustion, materials, manufacturing, marketing, financing solutions the world can find
Problem

• Word “improved” is highly misleading.
• Should be avoided as it is relative to something usually undefined.
• Absolute terms are needed
  – High efficiency
  – Clean or low emissions
• And, very unfortunately, the two often do not go together
International Standards Process

• International Standards Organization (ISO)
  – Preliminary standards now available for emissions, efficiency, etc. (IWA)
• World Health Organization (WHO)
  – Indoor air quality guidelines
  – Total and indoor emissions limits to be published late this year
• Final ISO standards to incorporate WHO AQGs
Pollutant Emissions and Energy Efficiency under Controlled Conditions for Household Biomass Cookstoves and Implications for Metrics Useful in Setting International Test Standards

James Jetter, Yongxin Zhao, Kirk R. Smith, Bernine Khan, Tiffany Yelverton, Peter DeCarlo, and Michael D. Hays

EPA Testing Lab, North Carolina
Only Independent Stove Lab in the World at Present
Using Modern Methods
EPA Testing Lab Results 2012
Total Emissions: Woodstoves

<table>
<thead>
<tr>
<th>Cookstove</th>
<th>Tier</th>
<th>CO (g/MJ&lt;sub&gt;delivered&lt;/sub&gt;)</th>
<th>Sub-Tier</th>
<th>CO (g/min/L)</th>
<th>Sub-Tier</th>
<th>PM2.5 (g/MJ&lt;sub&gt;delivered&lt;/sub&gt;)</th>
<th>Sub-Tier</th>
<th>PM2.5 (mg/min/L)</th>
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Jetter et al., 2012
Many thanks to

Guatemala Ministry of Health, NIEHS, WHO,
Griffin Trust,
Daniele Agostino
Derossi Foundation

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