Indoor Air Pollution from Biomass Cooking in Developing Countries

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The Issue

• Nearly 3 billion people in the developing world cook food and heat their homes with traditional cook-stoves or open fires
  – Wood, animal dung, crop waste, coal, charcoal
• 4 million premature deaths occur every year due to smoke exposure from these methods
• Women and children are the most affected
• Nearly 50% of pneumonia deaths among children under five are due to particulate matter inhaled from indoor air pollution
• More than 1 million people a year die from chronic obstructive respiratory disease (COPD) that develop due to exposure to such indoor air pollution
  – Both women and men exposed to heavy indoor smoke are 2-3 times more likely to develop COPD
Health Effects from Exposure to Indoor Biomass Smoke

- Acute Respiratory Infections in Children < 5 years
- Chronic Obstructive Pulmonary Disease in Women ≥ 30 years
- Lung Cancer (coal smoke)
- Low Birth weight
- Asthma
- Tuberculosis
- Interstitial Lung Disease
- Cataracts
- Cardiovascular Disease
- Others…
Biomass Fuel Combustion

• Complex gas mixtures depending on type of biomass fuel and combustion process:
  – Carbon monoxide
  – Carbon dioxide
  – Nitrogen oxides
  – Volatile organic compounds

• Particles:
  – Carbon, hydrocarbons
Global Use of Biomass as cooking fuel

WHO report 2009
Global Burden of Disease Study 2010 (Lancet 2012; 380: 2197–223)

Figure 5: Global disability-adjusted life year ranks with 95% UI for the top 25 causes in 1990 and 2010, and the percentage change with 95% Uls between 1990 and 2010.

UI=uncertainty interval. COPD=chronic obstructive pulmonary disease. *Includes birth asphyxia/trauma. An interactive version of this figure is available online at http://healthmetricsandevaluation.org/gbd/visualizations/regional.
Global Burden of Disease Study 2010 (Lancet 2012; 380: 2224–60)

### Figure 3: Global risk factor ranks with 95% UI for all ages and sexes combined in 1990, and 2010, and percentage change

PM=particulate matter. UI=uncertainty interval. SHS=second-hand smoke. An interactive version of this figure is available online at http://healthmetricsandevaluation.org/gbdt/visualizations/regional.
Orientation
Particulate Matter Concentration

90 ug/m³

12 ug/m³

Indoor air in Peru
10,000 – 15,000 ug/m³

London smog 1952
1,000 – 2,000 ug/m³
Peru Study - Puno
Peru Study
Optical Methods for Particle Detection

- DataRAM
Peru Study – Indoor Particulate Matter

Mean traditional stoves – 3.4 mg/m³
Mean “improved stove” – 1.1 mg/m³
Evening Cook Time PM Levels (mg/m³) in Rural Homes (Passive MIE)
Peru Study – Locally Designed Chimney
Peru Study – Chimney Impact
Dominican Republic
Charcoal Smoke Study

• Investigated the effect of charcoal smoke exposure on risks of acute upper and lower respiratory infection (AURI and ALRI) among children under age 18 months in Santo Domingo, Dominican Republic (1991–1992)

Santo Domingo
Santo Domingo
Charcoal Cooking
Dominican Republic Study of Charcoal Cooking
Study Design

• Participants
  – Children living in households using charcoal for cooking (exposed, n = 4201)
  – Age-matched to children living in households using propane gas (nonexposed, n = 214)
• Followed for 1 year or until 2 years of age
• Fuel use and new episodes of AURI and ALRI were ascertained biweekly through interviews and medical examinations
• Household indoor-air concentration of respirable particulate matter (RPM) was measured in a sample of follow-up visits
## Acute Lower Respiratory Infection Risk

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Number of Episodes</th>
<th>Adjusted* OR (CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propane</td>
<td>174</td>
<td>1.00</td>
</tr>
<tr>
<td>Charcoal/propane</td>
<td>76</td>
<td>1.16 (0.85-1.58)</td>
</tr>
<tr>
<td>Charcoal</td>
<td>117</td>
<td>1.38 (1.06-1.81)</td>
</tr>
<tr>
<td>Particulate matter (10 µg/m³ increase)</td>
<td>346</td>
<td>1.17 (1.02-1.34)</td>
</tr>
</tbody>
</table>

*Age, nutritional status, crowding
Respirable PM Concentrations

• 968 24-hr RPM samples were collected in 186 charcoal using houses
  – GM: 27.9 ug/m³
  – GSD: 3.3

• 1,087 24-hr RPM samples were collected in 203 propane using houses e collected
  – GM: 16.1 ug/m³
  – GSD: 3.0
Conclusions

• Modifying indoor exposures can reduce risk
  – Intervention trials

• Charcoal has been proposed as a less-dirty fuel
  – Still has significant risks
  – Larger environmental footprint
    • Traditional production techniques convert just 20%–25% of wood to char
Nepal Cook-stove Intervention Trial
Where in the world is...
Nepal Cook-stove Study

- Cluster-randomized, community-based trial of cook-stove replacement in a rural population of southern Nepal
  - Replacement of cook stoves in 3600 homes
  - Surveillance continue for an additional 6 - 18 months
  - Enrollment and follow-up of is being completed
  - Measure indoor PM and CO
    - Seeing about a 50% reduction in PM
  - Funding NIEHS
Follow-up Studies

• Global Alliance for Clean Cookstoves
  – Extension to the current trial by appending a comparison of Envirofit stove to a LPG stove on ALRI incidence
  – 1600 of the households in the current trial will be enrolled
Cook-stoves Black Carbon and Climate Change

• What is Black Carbon?
  – Emitted from incomplete combustion of biomass fuels used for cooking
    • Other sources: fossil fuels, industrial sources, open biomass burning
  – Believed to cause warming by absorbing radiation in the atmosphere and reducing snow/ice albedo
  – In South Asia, BC emission from residential biofuel cooking is largest source of BC atmospheric concentrations

• Climate implications
  • Weakens hydrological cycle and increases drought potential
  • Accelerating glacial melt via change in surface albedo
Early morning haze from biomass burning – village in northern India

Conclusions

• Exploding awareness of the problem
  – US State Department
    • Global Alliance for Clean Cookstoves
      – Supported by the UN Foundation
      – The United States Government has committed more than $50 million to the Alliance
      – Goal - 100 million homes to adopt clean and efficient stoves and fuels by 2020.
    • NIH/DOE/EPA/USAID/NSF research priority
Improved Cook-stoves
Questions ?