Monitoring & Evaluation of Improved Cookstove Programs using Standard Protocols for Indoor Air Quality

Experiences from the Pilot Phase of the Shell Foundation's Household Energy & Health Project

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Rationale for IAQ M&E

- Evaluation of improved stove programs is needed so that programs & stoves can be better designed & programs better targeted.
- Unlike stove performance, M&E methods, suitable for NGOs, for establishing changes in IAQ have not been developed previously for improved cookstove programs.
- We developed a training program & inexpensive PM & CO monitors that stove disseminators can use to evaluate their stove programs.

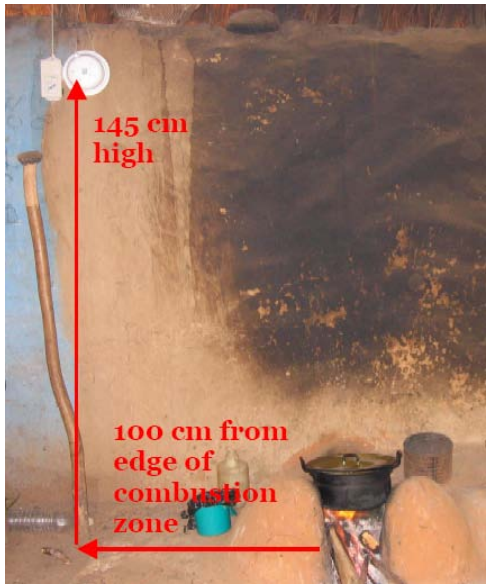
Objectives

- Methods
- Results
- Recommendations

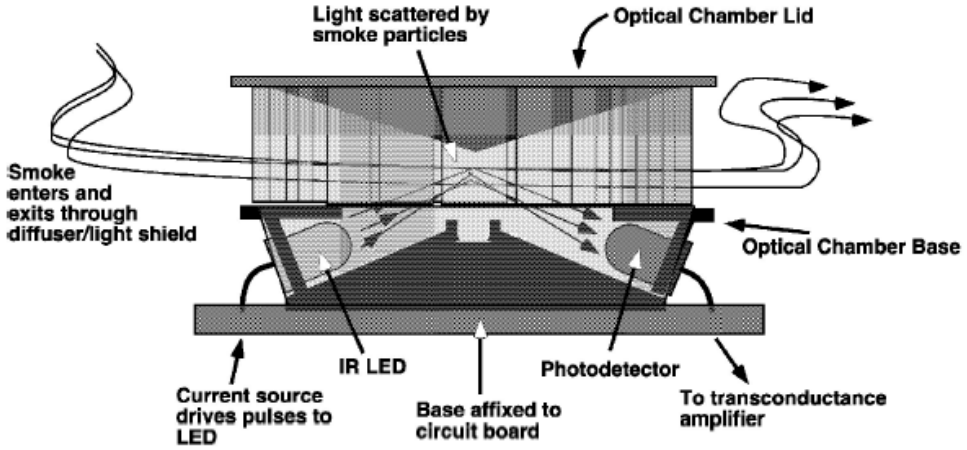
IAP Training & Monitoring Package

- Reference Materials
  - Survey Design & Sample Size Calculation
  - Methods for Reducing Variability
  - QA/QC
- Equipment
  - UCB Particle Monitor
  - UCB Software & Computer Cables
  - HOBO CO Monitor
  - HOBO Software
  - IAP Monitoring Data Sheets
  - Sampling Questionnaires
  - Stove Performance Test Protocols & Equipment (Rob Bailis)
  - Field Supplies (batteries, voltmeter, hammer, flashlight, nails, tape, etc)
- Internet Site
  - http://ceihd.berkeley.edu/heh.mande.htm

Fine PM monitoring:
UCB Particle Monitor



Photoelectric Chamber



- Manufactured by UCB
- Light scattering instrument
- Continuous sample
- Passive
- Area Sample

CO Monitoring:
HOBO Monitor

- Commercially available ~$220
- Electrochemical Sensor
- Continuous Sample
- Passive
- Area Sampler

Our 4 NGO Partners

Two in India

One in Mexico

One in Guatemala

NGO 1 (India):
Appropriate Rural Technology Institute (ARTI)

- Study Design: Paired, before & after, no control
  - M&E 6 and 12 months after installation of Laxmi
- Improved stove – Laxmi stove (& Bhangyalaxmi)
  - 2 pot stove
  - Has chimney

NGO 1:
ARTI Indoor Air Pollution Results

		Before			After				
	N	Mean	SD	Max	Mean	SD	Max	Wilcoxon SRT (p-value)	Mean % Change
PM: (mg/m^3)	87	1.25	1.61	11.08	0.94	1.05	5.19	<0.007	24%
CO: (ppm)	98	10.82	8.71	40.8	6.65	7.10	47.3	<0.001	39%

All Laxmi (vented) stoves compared to traditional stoves.
All communities (n=8) pooled together.

24% reduction in kitchen area [PM] **1 year** after installation of Laxmi.
39% reduction in kitchen area [CO] **1 year** after installation of Laxmi.

NGO 1:
ARTI Project Challenges

- #1: Motivate HH members to purchase the Laxmi stove.
- #2: Ensure that HH made the transition to using the Laxmi as their primary stove.
- #3: Monotonous nature of field work resulted in inaccuracy and a tendency by some field workers to complete questionnaires without consulting the HH members.

NGO 2 (India):
Development Alternatives (DA)

- Study Design: Paired, before & after, no control
  - M&E 1, 6 and 12 months after installation of Sukhad
- Improved stove – Sukhad Stove
  - 2 pot mud stove
  - Has chimney

NGO 2:
DA Indoor Air Pollution Results

All Sukhad stoves compared to traditional stoves; all communities (n=13) pooled together.

Monsoon Season		Before			After				
	N	Mean	SD	Max	Mean	SD	Max	Wilcoxon SRT	Mean % Change
PM: (mg/m^3)	30	0.52	0.75	4.14	0.33	0.39	2.09	<0.02	36%
CO: (ppm)	37	7.88	6.73	29.9	5.38	3.89	18.9	<0.01	32%

36% reduction in kitchen area [PM] **1-2 months** after installation of Sukhad (vented).
32% reduction in kitchen area [CO] **1-2 months** after installation of Sukhad (vented).

Summer Season		Before			After				
	N	Mean	SD	Max	Mean	SD	Max	Wilcoxon SRT	Mean % Change
PM: (mg/m^3)	15	0.65	1.01	4.14	0.36	0.47	1.93	<0.01	44%
CO: (ppm)	15	8.67	7.8	29.9	2.68	2.8	8.4	<0.001	69%

44% reduction in kitchen area [PM] **1 year** after installation of Sukhad (vented).
69% reduction in kitchen area [CO] **1 year** after installation of Sukhad (vented).

NGO 2:
DA Project Challenges

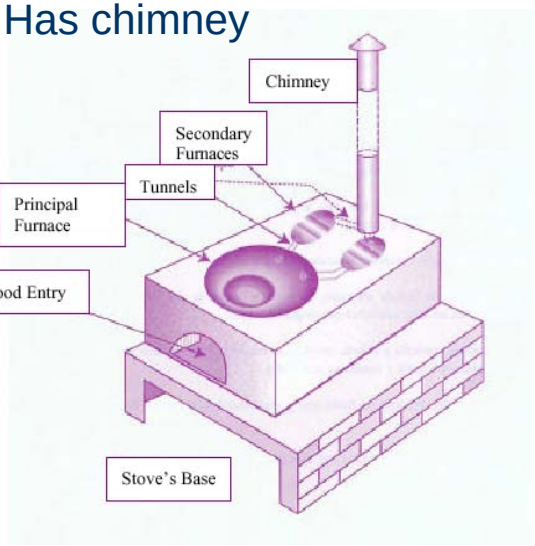
- #1: HH drop out
  - No longer wanted to participate in study.
  - No longer regular users of Sukhad stove.

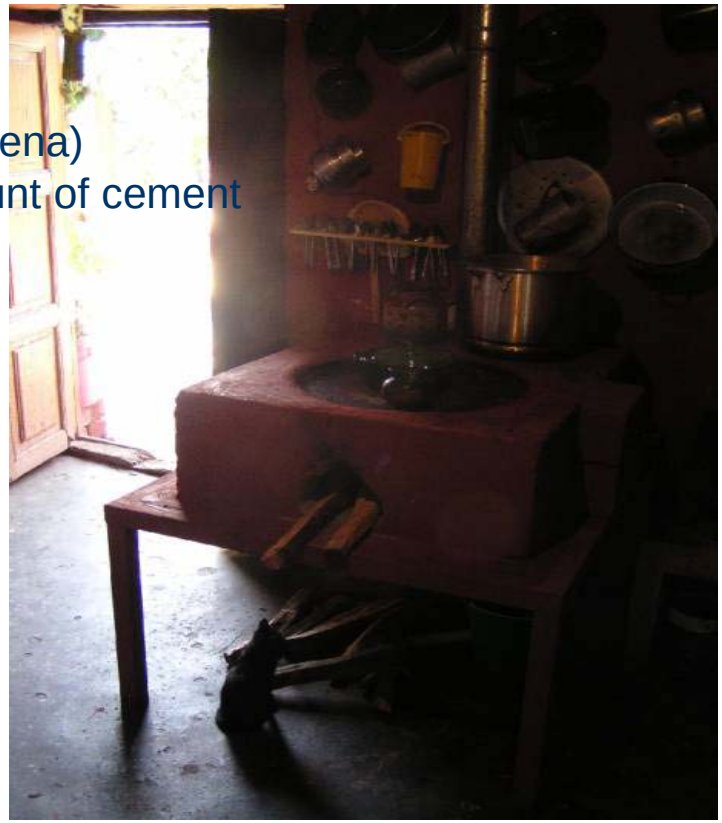
- #2: Use & maintenance of UCB Particle Monitor

“When conduct our next improved stove monitoring and evaluation project, we plan to hire local project consultants to do our statistical analysis (comparison of means tests) and to aid in the interpretation of the IAP data.” - DA

NGO 3 (Mexico):
Grupo Interdisciplinario de Technologia Rural Apropiada (GIRA)

- Study Design: Paired, before & after, no control
- Improved stove
  - Patsari improved stove (modified Lorena)
  - Made of sand,mud and a small amount of cement
  - 1 or 2 combustion chambers
  - Has chimney





NGO 3:
GIRA Indoor Air Pollution Results

		Before			After				
	N	Mean	SD	Max	Mean	SD	Max	Wilcoxon SRT (p-value)	Mean % Change
PM: (mg/m^3)	33	1.02	0.79	4.23	0.34	0.27	1.16	<0.001	67%
CO: (ppm)	32	8.88	4.44	22.61	3.02	2.66	12.1	<0.001	66%

All Patsari (vented) stoves compared to traditional stoves.

~70% reduction in kitchen area [PM] & [CO] 1 year after installation of Patsari.

All NGOs:
Comparison to WHO Guidelines

	Before [traditional stove] 48-hr mean	After [improved stove] 48-hr mean	WHO interim target-1 0.075 mg/m^3) (24-hr mean)	WHO Air Quality Guideline (24-hr mean)
$PM_{2.5}$ (ARTI)	1.25 mg/m^3	0.94 mg/m^3	~12 times higher	0.025 mg/m^3 (24-hr mean)
CO (ARTI)	12.4 mg/m^3	7.6 mg/m^3	NA	10 mg/m^3 (8-hr mean)
$PM_{2.5}$ (DA - Mon)	0.52 mg/m^3	0.33 mg/m^3	~4.5 times higher	
CO (DA - Mon)	9.02 mg/m^3	6.17 mg/m^3	NA	
$PM_{2.5}$ (GIRA)	1.02 mg/m^3	0.34 mg/m^3	~4.5 times higher	
CO (GIRA)	10.2 mg/m^3	3.4 mg/m^3	NA	

Key Lessons Learned during the HEH Projects

- Project achieved its main objective in providing an estimate of the IAQ changes due to the ICSs for the 3 programs.
- Decision to train NGO staff in simplified statistical theory & analysis methods may have been too ambitious.
- Drop out of HH between sampling rounds plagued all the groups requiring care in choosing sample sizes with sufficient margins of safety and extra effort in motivating participation.
- Multiple fuel and stove use in some areas complicated the collection and interpretation of changes in fuel use and air pollution.
- The UCB monitor underwent significant development throughout the projects. Thus, our direct participation was required in additional checking of data files, analysis, data processing, and data cleaning.

Key Recommendation for Future Standard IAP Monitoring Protocols

- “Effectiveness” field-based measures deployed in the HEH project may not be suitable for many NGOs in the future due to challenges discussed.
- Using lab tests for IAQ assessments has not been validated and would seem to suffer from all those drawbacks related to SPTs.
- An intermediate “efficacy” test – or test house approach - might be an appropriate alternative in many circumstances.

- The full evaluation report can be downloaded from: http://ehs.sph.berkeley.edu/krsmith/page.asp?id=1

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