THE MILLENNIUM VILLAGES PROJECT

The Earth Institute
AT COLUMBIA UNIVERSITY

Energy and Transport Program
Director : Prof. Vijay Modi

Indoor Air Pollution & Cooking Technologies Interventions

In many developing countries solid fuels account for up to 95% of the population's energy needs. Burning solid fuels inside the home for cooking and heating purposes is commonplace in these areas. These biomass-burning systems produce many pollutants, such as particulate matter (PM) and carbon monoxide (CO). The result is indoor PM concentrations hundreds of times the levels deemed acceptable by international standards.

Epidemiological studies define two distinct yet strong connections between indoor air pollution (IAP) and health. These are acute respiratory illnesses (ARI) in children—of which the most serious are acute lower respiratory illnesses (ALRI)—and chronic obstructive pulmonary disease (COPD) in adults. Both of these conditions are among the leading causes of death in developing countries. Without any intervention, mortalities caused by the use of biomass are projected to greatly increase. Thus, the development of inexpensive and effective measures is imperative. Currently, a large focus of international attention is on the treatment of disease, as opposed to prevention. The cost of this approach would, by current estimates, exceed $1 trillion. Treatment of disease is almost certainly less cost-effective than implementing the presently available interventions and any future developments. It is the goal of the Millennium Villages Project (MVP) to examine preventative interventions that will also relieve the suffering of those who are already afflicted.

The best results will likely be seen by instituting a fuel switch away from biomass. Charcoal, one possibility, would greatly reduce PM emission but would not decrease CO emissions. Use of charcoal will also amplify the burden on natural resources. Switching to a liquefied petroleum gas (LPG) is the most effective intervention being considered. Such fuels and the devices required by them produce significantly less pollution than the combustion of biomass. Though it is extremely effective in reducing both CO and PM, LPG is very expensive relative to other interventions, in both initial and recurring costs. A reliable infrastructure to transport fuel is also required. Due to the high costs of a fuel switch, the MVP is researching various mechanical interventions. Cost analyses will ultimately determine whether a fuel switch is the best solution.

The MVP is currently researching three intervention options: improved stove design, chimney stoves and smoke hoods. Chimney stoves and smoke hoods, when operating effectively, remove smoke from the home. The goal for improved cooks stoves is to eliminate the smoke produced by traditional stoves, without sacrificing fuel efficiency.

Chimneys and smoke hoods utilize a draft induced by the heat from the stove to drive smoke from the home. A chimney stove is a well-enclosed structure that has either a cooking surface or a hole that is covered by a pot. This option would require either an alteration to the stove currently being used or a complete replacement of the cooking instrument. Smoke hoods, however, are placed over the current traditional or improved stove, and look similar to home fireplaces. The opening must be large enough to enable those doing the cooking to work comfortably, but small enough to prevent pollutants from entering the room. An ideal smoke hood would be placed relatively high above the cooking surface, so as to not bother the person operating the stove. Effective similar technologies being used in developed countries require a fan, which is another consideration.

An important issue being studied by MVP engineers in relation to these interventions is the draft through the buildings. Drafts are caused by wind, ambient temperatures and by the characteristics of the stoves themselves. Other contributing factors include the location of open doors and windows, the orientation of the home, and the placement and operation of the cooking mechanism. The effects of a draft are quite varied. Depending on the factors mentioned above, it is possible that a draft could either help or hinder smoke extraction, as well as either improve or decrease efficiency. A proper understanding of these issues is vital to determining an appropriate intervention design.

It is necessary to perform an extensive and proper analysis of the effectiveness of each design being considered. MVP engineers are developing analytical models of the systems to gain an understanding of how each intervention would function and to determine its effectiveness. It is necessary to determine the processes by which the biomass combusts and heat is transferred to the pot or cooking surface. Computer modeling of design selections is also being employed in this process. By performing thermodynamic and thermal analyses, a full understanding of cooking mechanisms can be developed.

Currently, MVP energy group engineers are developing new designs, while compiling a database of available improved cookstoves and developing an understanding of the operation of and engineering principles behind the stoves. It is imperative that all interventions be tested in a controlled environment for their PM and CO emissions, functionality and efficiency. Initial experiments will be performed in closed laboratories, with subsequent testing being conducted in the villages involved in the project and using local food and cooking methods. The results of extensive testing will determine whether there is a proven effective existing product or if new designs are needed.

The performance of a design, while vital, is not the only consideration in selecting which interventions to implement. Geographic, cultural and behavioral factors are also an integral part of any design. Certain geographical aspects might provide for design considerations that are not necessary in most areas. In some regions, cooking methods are more conducive to chimney stoves than smoke hoods, while the opposite is true in other areas.

Some cultures may prefer one design to another, regardless of whether or not one is slightly better than another. The aesthetics of a design also cannot be ignored.

In conjunction with the intervention in place, there are necessary behavioral adjustments. These include considering the location of the cooking area and keeping children away from that area. Also, when biomass is being used for cooking, it should be allowed to dry first, as this would reduce the emission of unhealthy air contaminants. It is also important to note and consider that while a certain intervention may be effective in reducing the concentration of pollutants in the room, it may not decrease the risk to the person doing the cooking. The final design must consider the well-being of the entire household, including the operator.

After evaluating the acceptability, health benefit, cost and effectiveness of a design, it will be installed in households affected by the issues described above. With successful operation of the interventions in the pilot households, necessary steps will be taken to make the interventions available to those in need of proper cooking and ventilation technologies. It is the goal of the Millennium Villages Project to prevent the health problems caused by solid fuel use in the villages involved, and to determine cost-effective ways to improve the health of all those living in developing countries.

For further information contact Michael Waite at mbw2113@columbia.edu or Vijay Modi at modi@columbia.edu.

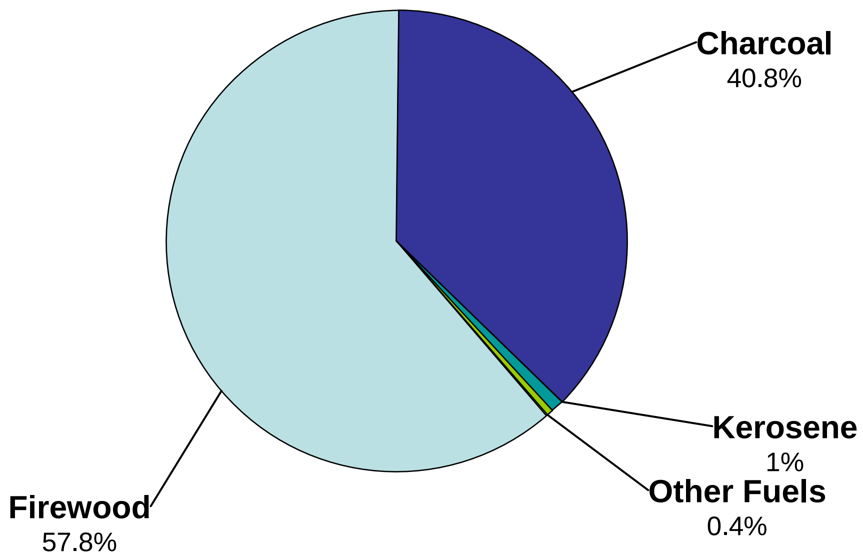
Indoor Air Pollution (IAP) and Public Health

- >80% of villagers use solid fuels for cooking
- Leads to high levels of airborne pollutants:
  - particulate matter (PM), carbon monoxide (CO)
- Evidence: Smoke & PM from biomass burning:
  - Acute Respiratory Infections (ARI / ALRI)
  - Chronic Obstructive Pulmonary Disease (COPD)
- Conservative estimates (2000)
  - 1.6 million deaths annually
  - 3-4% of total worldwide mortality

Current Household Energy Consumption in MV

Annual Fuel Costs

Fuel	**Expenditure per Year**	**Primary Usage**
Firewood	3000 Ksh ($US 37.50)	Cooking
Charcoal	3900 Ksh ($US 48.75)	Cooking
Kerosene	3000 Ksh ($US 37.50)	Lighting
Disposable Batteries	2000 Ksh ($US 25.00)	Lighting /Radio
Other	~500 Ksh ($US 6.25)	Varied



Quantity of Fuel Used for Cooking

(in kg firewood equivalent)

All data acquired from Millennium Village's Energy Survey preliminary testing results of 33 households in Bar Sauri, Kenya

Avenues for IAP Intervention

INTERVENTION

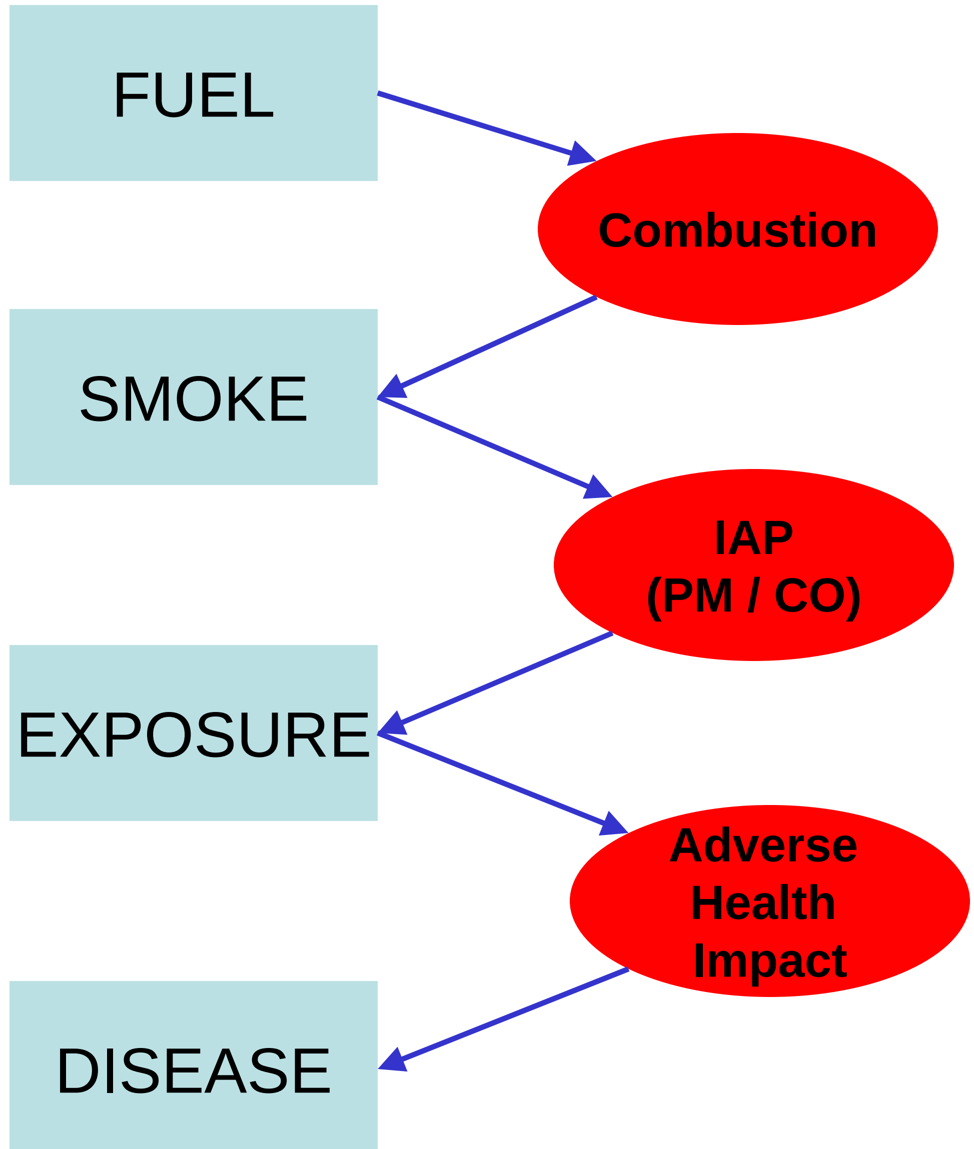
ACTIVITIES AND CONSEQUENCES

Cleaner energy source

Smoke Alleviation / Ventilation

Behavioral Intervention:
Removal of children from cooking area, cooking outdoors, limit smoldering time, etc.)

Treatment:
Antibiotics, Clinics, etc



Possible Interventions

Intervention	Initial Cost	Annual Cost	CO Emission Reduction	PM Emission Reduction
Improved Cook stoves -Upesi, Kuni Mbili	$6	N/A	~40-43%	~48%
Charcoal (Fuel Switch)	$1.50-6.00	$15/capita	None or Increase	90%
LPG (Fuel Switch)	$50	$42/capita	~99%	100%
Eave Space	~$10	N/A	~34%	~63%
Smoke hood	$10-60	N/A	74-78%	70-76
Chimney stove	$10-150	N/A	Up to 80%	Up to 80%