The Ecostove – getting rid of nearly 90% of kitchen wood smoke

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Introduction

In the developing world, exposure to Indoor Air Pollution (IAP) is the second most dangerous environmental health risk after dirty water and is estimated to kill 1.6 million people each year, most of them children under five. Increasingly, international donors want to know that the technologies they support are combating this deadly 'kitchen killer'.

During the 1990s, Rogerio de Miranda, as the director of the NGO PROLEÑA, had witnessed the stifling conditions within households cooking on traditional wood fires (Figure 1). PROLEÑA personnnel were convinced that the Ecostove (see *Boiling Point* 47 – page 3) made families healthier; their homes looked, smelled, and felt cleaner. PROLEÑA had been manufacturing, distributing, and selling the energy-efficient Ecostove (an offspring of Aprovecho's Rocket Stove with a chimney), in Nicaragua and Honduras for several years. PROLEÑA needed proof to show policymakers and funders in order to secure the grants and loans needed to expand its woodstove enterprise.

Evaluating the Ecostove

In January 2002, John McCracken, a technical advisor from the Center for Entrepreneurship in International Health and Development (CEIHD), arrived in Nicaragua with an oversized suitcase full of sampling equipment to help find this proof. Initially PROLEÑA envisaged having a medical team visit homes with and without Ecostoves to collect health information and symptoms like coughing and wheezing and children's health data, but making the links between health benefits and installing a specific stove requires hundreds of families and many weeks worth of data and is hugely expensive.

Figure 1 Typical house without vented woodstove in Nicaragua (photo: Rogerio de Miranda)

Linking reductions in IAP with health impacts

Instead, the team chose to assess the health benefits by measuring exposures to IAP in households with and without Ecostoves and assessing how the reduction in IAP would affect their health . (The combined results of several studies support the use of IAP exposure as an indicator of health risk.) The PROLEÑA study could link reduced exposure to smoke with reductions in illnesses affecting both children and adults. However, since the relationship between the amount of wood smoke and the levels of ill-health is not well documented, the study would not be able to calculate how much of each disease had been avoided.

Design methodology

CEIHD designed a study that compared the performance of two different Ecostove designs – 'closed' (Figure 2) and 'semi-open' (Figure 3) – in reducing indoor concentrations and personal exposures to IAP. PROLEÑA believed that the 'semi-open' model would increase energy efficiency and affordability, but might increase IAP. The 'closed' model has a completely sealed steel griddle, while the slightly less expensive 'semi-open' model, offered a smaller griddle and one open pothole providing direct contact between the fire and the pots. Both stoves had metal tube chimneys open above the roof. The team decided to measure very small particles ($PM_{2.5}$) in the wood smoke, as these have most consistently been associated with negative health effects involving the lungs and heart.

Figure 2 Ecostove with completely enclosed cooking surface (photo: Rogerio de Miranda)

Figure 3 Ecostove with partially open cooking surface – pothole under pot (photo: Rogerio de Miranda)

Implementation

This project had a very limited budget – around USD $12,000 – so sampling equipment was borrowed from the University of California, Berkeley, laboratory analysis facilities were donated by Harvard University, while CEIHD and PROLEÑA provided a lot of staff time at no cost. The study was funded by the Energy Sector Management Assistance Program of the World Bank.

The stove comparison study took place in a village of 1000 homes approximately 15 Km from Managua. The residents relied exclusively on wood burned in open fires for cooking. We were fortunate to recruit a Nicaraguan environmental scientist with a masters degree and a Guatemalan fieldwork supervisor with IAP-monitoring experience to conduct the monitoring with assistance from two residents of the study village. The study team recruited families whose kitchens had walls on all four sides so they would be able to detect the influence of stove type where emissions would be more concentrated and where the houses were all of similar design.

Thirty pairs of houses were 'matched' according to street block and kitchen type. In each home, the cooks were asked to wear particle monitors for 24 hours of monitoring (Figure 4). The same devices were hung on kitchen walls at a height of 1.5 meters and 1 meter from the stove to obtain 24-hour average particulate concentrations.

After the first round of measurements, in each pair of households, PROLEÑA staff installed the closed stove in one household, while the other received the semi-open model. In addition, each family received a set of three new pots, since the Ecostove for optimum performance requires flat bottom pots. The cooks participated in PROLEÑA's standard training session on recommended ways for using and maintaining the stoves. The study team did not require the families to use only the improved stove, as they wanted to imitate real-life conditions and determine how many people would use the Ecostoves in reality.

Figure 4 Personal exposure monitoring setup with filter unit in breathing zone and monitor pump inside backpack

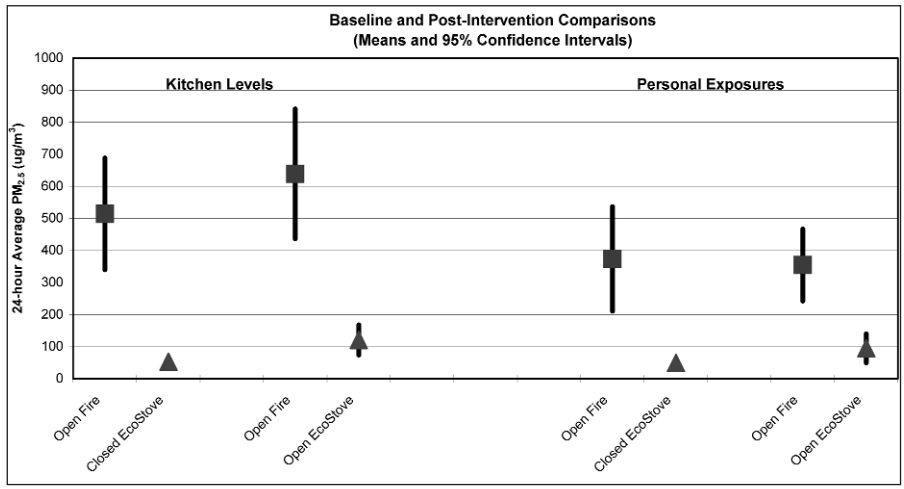

Figure 5 Reductions in indoor air pollution and exposure

One month after installation, the study team repeated the same air pollution measurements. Data collection included observations and questions on time / activity patterns and housing characteristics. This helped control any effect these variables had on IAP exposures, so that any reduction in pollution level could be attributed to each stove type.

Analysis and results

Results showed that the two groups were very similar for the household variables and time-activity data collected. Differences between them once the stoves were installed were unlikely to have been caused by differences in kitchen volume, duration of stove use, or other sources of smoke (such as cigarettes).

The study showed that both Ecostove models achieved large reductions in indoor air pollution and exposure among the cooks in the study (Figure 5 & Table 1). The closed Ecostove model reduced kitchen $PM_{2.5}$ levels significantly more than the semi-open model (p-value = 0.028), though there was not a significant difference in personal exposures. The data showed that very little time was spent at the fire after the stove was received. Given the magnitude of the exposure reductions, CEIHD concluded that both Ecostove models would offer strong health benefits to Nicaraguan families.

The study proved to be a success, and PROLEÑA has since used the results to promote the Ecostove to policymakers and funding agencies across Latin America. It is hoped that further studies will determine whether these improvements continue after the stove has been installed for a longer period of time.

Table 1 Per cent reductions in personal exposures and kitchen levels of $PM_{2.5}$

Model	Mean %reductions (95% CI)	
	Personal exposure	Kitchen levels
Closed	**87** (76, 90)	**94** (83, 97)
Semi-open	**82** (66, 90)	**87** (67, 94)

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