Promotion of Improved Cookstove in Rural Bangladesh

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190

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191

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Abstract

This study aimed to explore the factors affecting the promotion of improved cookstove (ICS) to replace traditional stove and hence to combat indoor air pollution (IAP). The study was conducted in 58 randomly selected villages of Jamalpur *sadar* and Hatia *upazilas* (29 villages in each) in 2008. Both qualitative and quantitative methods were used. Focus group discussions were performed in each village to divide the villages in three equal clusters as well as *Paras* and listed the opinion leader of the villages. Fifty randomly selected households and nine households of the opinion leaders were surveyed in each village. Thus, a total of 3,080 households were selected for quantitative survey with pre-designed questionnaire. These households were also offered two types of ICSs – portable and with-chimney under different experimental conditions. Among those who adopted ICS as was offered usually chose portable ICS since they believed this would reduce fuel consumption while they chose ICS with chimney to reduce pollution. We found that households were usually aware of IAP but not so much so of the existence of ICS. But once they came to know about it through this survey, they would expect ICS to be better than traditional stoves in producing better tasting food, less smoke emissions, less cooking and fuel collection time, etc. When compared with those who did not know about ICS before, prior knowledge on ICS was found to be associated with greater share of people thinking ICS was better than traditional in terms of taste of food and smoke emission. In most cases financial constraints was stated as a reason for not to adopt an ICS. The adoption decision was also found to be highly responsive to price. On the other hand, opinion leaders appeared to have a stronger impact on households' decisions when the leaders decided against ICS as opposed to when they decided in its favour. Although this is a very product specific study the results can provide a guideline to understand similar constraints for many other improved technologies that exist but are not generally adopted.

Introduction

The leading killer of children worldwide is acute respiratory infections (ARI) – accounting for 22% of all communicable child deaths in 2004 (WHO 2005). Strikingly, this exceeds the combined toll of diarrhoeal diseases, tuberculosis, and malaria. Epidemiological studies identify indoor air pollution (IAP) as a principal culprit, reporting powerful associations between IAP exposure and ARI symptoms (Smith *et al.* 2000, Ezzati and Kammen 2001, Ezzati *et al.* 2004, Pokhrel *et al.* 2005). Biomass combustion within the household is thought to be the main contributor to IAP (Ezzati *et al.* 2004), so women who cook and the infants and children they care for are particularly affected. World Health Report identifies IAP as the single largest environmental risk factor for female mortality, attributing 5% of all female deaths in the developing world to indoor smoke (WHO 2002).

Despite these large health hazards, half of the world's population and over 75% of South Asians continue to rely on dung, brush, and wood as their primary source of energy for cooking and heating (WHO 2002, Ezzati *et al.* 2004, Pokhrel *et al.* 2005). Biomass combustion with traditional cookstoves is an important contributor to climate change as well. Other than carbon dioxide, the leading contributor to rising global temperatures is black carbon ('soot'), accounting for 18% of the increase (with CO accounting for 40%). In Asia and Africa, traditional household cookstoves that burn solid biomass fuels produce the majority of black carbon; household energy use in Africa alone will produce 6.7 billion tons of carbon by 2050 (Levine and Beltramo 2009). Climate change activities targeting black carbon emissions can have a much more rapid impact that those focusing on CO–CO remains in the atmosphere for years, while black carbon lingers for only a few weeks.

Traditional stoves generally have an unnecessarily large distance between the pot and the fuel bed which leads to heat loss, very low heat transfer to the cooking pot and inefficiency. The fuel gas exits between the cooking pot and the stove are also very large in size, which allows some fuel-gas to escape without coming into contact with the cooking pot, further lowering conventional heat transfer. Apart from this low efficiency, traditional stoves emit smoke high in pollution content, which affects users' health. The smoke exposure is particularly harmful for cooks closest to the fire, and others such as children who spend time in the kitchen. Stove-use also dirties the kitchen and soot blackens kitchen walls (Dasgupta *et al.* 2005). Due to incomplete combustion of biomass fuels in traditional cookstoves, appreciable quantities of irritants, toxins and carcinogens are released into the kitchen environment and these pose a major threat to the respiratory system of the users (Sarkar *et al.* 2006). In general, the combustion products of wood are carbon dioxide, water vapour and carbon monoxide, particulate and polycyclic organic matters, the last three of which are known to be pollutants hazardous to human health (Sarkar *et al.* 2006).

Improved cookstoves or ICS, instead of traditional biomass cookstoves can ensure efficiency in the use of traditional fuels (World Energy Council 2005). Moreover, improved stove reduces smoke emission and health hazards especially to the cook. In the case of chimney stove, fuel gases are also taken out of the kitchen so that the kitchen becomes cleaner for the cook. Other benefits of improved stove include reduced cooking time, less smoke, less blackening of the utensils, saving fuel, portability for portable stoves especially during rainy season, etc. Institute of Fuel Research and Development (IFRD) in Bangladesh developed a number of models of improved stoves. Besides, some of the non-governmental organizations (NGOs) in Bangladesh are actively involved in disseminating ICS technology among the community members especially in the rural areas. A variety of ICS have been designed and developed which include fixed and portable type, metal and clay, single and multiple pot, with chimney and without chimney, with grate and without grate, etc. At present, more than 100 NGOs in Bangladesh are working locally with different models of ICS (Sarkar *et al.* 2006). This study also found different models of ICS which were popular in different areas of the country. For instance, grate-less portable single stove was popular in Jessore, grate-less fixed double stove with chimney in Jhinaidah, portable single stove with filter plate in Bogra and Dinajpur, and fixed single stove with filter plate in Gaibandah and Rangpur. Grate-less single stove was popular in many areas due to its flexibility in using different types of fuel (such as wood, agricultural residues, and dung). On the other hand, double stove with chimney was popular as it reduced smoke emission especially in the kitchen. Portable cookstove was preferred during rainy season. Besides, fixed single stove without filter plate and fixed or portable double stove without chimney were also found in different places in the country.

Strikingly, simple technologies to reduce IAP and black carbon emissions exist, but efforts to promote the adoption of these ICS have often proven ineffective. Given their important intra-household health externalities and the public goods nature of their environmental benefits, there are likely strong rationales for subsidizing the use of improved cookstoves, but financial barriers are not likely to be the only barriers to adoption. An important but under-studied implication of assuming individuals to be the best decision-makers for themselves is that failure to adopt a seemingly worthwhile technology maybe based on other considerations not well understood by outsiders (Hayek 1945). By extension, low adoption rates of improved cookstoves – even free ones – suggest a potentially important role for 'nontraditional' factors in adoption decisions. By non-traditional, we mean factors other than those motivating the design of a new technology (i.e., not necessarily related to its effectiveness in reducing emissions or burning fuel more efficiently). This category of explanations may hold power for a broader set of low technology adoption 'puzzles' observed with point-of-use drinking water disinfectants and insecticide-treated bed nets, for example.

Background and existing practices

Quick survey to assess current practices

In order to better design the main study, a quick survey was conducted in 2006 among 2,400 households to understand the cooking practices across the country. The whole country was divided into four regions based on agro-ecological characteristics. From each of these four regions, 30 *upazilas* and then 30 unions and finally 30 villages (one from each preceding administrative unit) were randomly selected. Eventually, 20 randomly selected households were surveyed from each village (4 regions X 30 villages per region X 20 households per village = 2,400 households). This survey was nationally representative but excluded the major urban centers.

In urban areas of Bangladesh where gas connections are available, people cook three times a day – once for each of the main meals (morning, noon and night). Our qualitative research and exploration before launching the quantitative component of the study suggest that people spend 4 to 5 hours a day in cooking. In rural areas, amount of time spent for cooking varies by season. Women in Bangladesh are primarily the cooks, and they spend up to 6-8 hours of their time in the kitchen to complete a variety of food-related tasks, such as preparing for cooking, gathering utensils, cleaning, washing, gathering fuels, and cooking.

Cooking practices

Women are primarily (and almost exclusively) the cooks in both urban and rural areas of Bangladesh. The most commonly cooked items are the mainstays of the Bangladeshi diet, such as *roti* (bread), rice, lentils, vegetable, fish, meat, snacks, tea, sweets, cakes and puffed rice. The stove is also used to boil water. Our qualitative and quantitative data gathered initially indicate that meat is not cooked very often in most of rural Bangladesh. Lentils, fish and vegetable are the much more common sources of protein. The longest cooking episode is typically for lunch which takes about 3-5 hours. In rural areas cooking times vary seasonally. During winter season (typically dry), people usually cook three times a day but in rainy seasons people cook mostly twice a day (morning and noon). They cook their dinner along with their lunch during rainy seasons. An alternative practice is to cook both their breakfast and lunch in the morning, and dinner in the afternoon/evening. Although common patterns exist, these practices depend on individual culture and choice of cooking along with the seasonal variation and availability of the fuel.

Fuel use

While 37.9% of urban and 1% of rural households use gas, 43.5% urban and 41.5% rural households use wood, and 12.1% urban and 51.4% rural households use straw/leaves/cow-dung as fuels in their households (BBS 2008). With around 75% of the country's population living in rural areas, consumption of biomass fuels is therefore significant (BBS 2008). Biomass fuels include dry leaves, wood branches, smashed wood, bamboo, straw, wood dust, husk, dried cow-dung, jute stick, etc. Another fuel used is charcoal made of husk or wood dust and coal, mixed in a machine to produce a long cylindrical shape with hollow inside. Non-biomass fuels used in households for cooking include kerosene oil, electricity, paper, plastic, tire, etc. but their use is relatively rare. Use of fuel also varies across seasons. Normally during the winter or dry season people use agricultural residue for their cooking (especially in the rural areas of Bangladesh) which includes, straw, jute stick, dry leaves, husk, etc. However, during rainy season they use their stored biomass (e.g. wood, wood brunches, bamboo pieces, dried cow-dung, charcoal, etc.)

From the quick survey we found that during the dry season, respondents were using leaves as a primary fuel source. The use of *toosh* (crop residues in dust form) was the second most common type of fuel used in the dry season. *Khorkuta* (hay) and tree branches were the most important tertiary fuels in the dry season. Cow-dung is not a preferred fuel in the dry season as very few respondents were using it either as a primary, secondary, or tertiary fuel. In the rainy season, respondents were usiing leaves, *toosh*, *khorkuta*, and tree branches as a primary fuel. No single biomass-based fuel type dominated over other biomass-based fuel types. It was noticed that more respondents were usiing wood branches for cooking in the rainy season compared to the dry season. Furthermore, cow-dung was more commonly used in the rainy season than during the dry season.

Cost of fuel

Our nationally representative quick survey for rural households found that 68% respondents paid for biomass-based fuels in the dry season compared to 63% in the rainy season. The average money paid by the respondents for sourcing biomass-based fuels in the dry and rainy season was Tk. 76.3 (standard deviation Tk. 189.2) and Tk. 98.6 (standard deviation Tk. 212.4), respectively.

Stove type

The type of stove a household can use depends on the types of fuels that are available and preferred. It is most common to use biomass fuels in traditional cookstoves. Consistent with the popularity of biomass fuels noted above, the most common cookstoves are the traditional ones. A traditional cookstove typically consists of a mud-built cylinder, built under or over ground, with three raised points on which cooking utensils rests, resulting in three spaces in between these raised points, one of which is used as fuel feed and the other two for fuel-gas exits. Traditional stoves vary in size, design and other characteristics such as number of burners, whether it is fixed to the ground (as opposed to a portable variety), whether it is placed indoors or outdoors, etc. Traditional stoves used for preparing molasses (*gur*) or boiling paddy/rice are larger in size than regular stoves.

Our quick survey found that all over rural Bangladesh, traditional stoves are used in 99% of all households. The majority of households (67%) use multiple stoves, but in almost all cases, both (or all) stoves are of the traditional variety. The use of multiple stoves is more common during the dry season when people can cook both indoors and outdoors. Use of multiple stove drops to 61% during the rainy season.

The single most important finding from the quick survey that is relevant to the ultimate design of this project is that the penetration of ICS varieties is abysmally low in rural Bangladesh. Less than 1% of rural households use any form of ICS. In fact ICS had been available for at least 15-20 years before the launch of our study. This issue, therefore, requires further exploration, and our randomized interventions were conceived to uncover demand-side reasons for this lack of penetration. Deficiencies in supply may also be important factors that explain this low take-up, but our experiments concentrate on demand-side issues.

Table 1 and Table 2 show some statistics, obtained from the survey, on the types of primary cookstoves used in dry season and rainy season respectively. The survey found that less than 1% of the households in the country use any form of ICS in either of the two seasons; the majority use traditional stoves. In fact, even among these small number of ICS users, around half used a traditional stove in addition to the ICS. High comfort level due to prolonged practice with traditional stoves and easy availability of fuel for it were among the reasons for use of a traditional stove even if they had an ICS.

Table 1. Distribution of primary cooking stoves in dry season: findings from quick survey

	Frequency	Percent	Cumulative percent
Improved	18	.8	.8
Traditional	2369	98.7	99.5
Kerosene	2	.1	99.5
Bio gas	1	.0	99.6
Chimney stove	10	.4	100.0
Total	2400	100.0	

Table 2. Distribution of primary cooking stoves in rainy season

	Frequency	Percent	Valid percent	Cumulative percent
Improved	12	.5	.5	.5
Traditional	2375	99.0	99.0	99.5
Kerosene	2	.1	.1	99.5
Bio gas	1	.0	.0	99.6
Chimney stove	10	.4	.4	100.0
Total	2400	100.0	100.0	

Table 3 to 6 show the use of different types of primary and secondary fuels in both dry season and rainy season. In dry season, leaves appear to be the most popular primary fuel source while husk of grains are the most popular as a secondary source. Straws and twigs and tree-branches are also used as fuels in dry season but the other types of fuel are very little used.

In the rainy season, leaves are not used as much as are used in the dry season, perhaps because dry leaves are not easily available in the rainy season. Yet, leaves, husks of grains and, straws and twigs in that order are the more popular primary fuel sources in rainy seasons. Tree branches are also popular as a secondary fuel source.

Table 3. Primary fuel sources in the dry season

	Frequency	Percent	Cumulative percent
Leaves	1659	69.1	69.1
Toosh (Husk of grains)	334	13.9	83.0
Khorkuta (Straws and twigs)	243	10.1	93.2
Tree-branches	75	3.1	96.3
Dung	8	.3	96.6
Others	55	2.3	98.9
Wood grains	9	.4	99.3
Kerosene	2	.1	99.4
Jute stalk	4	.2	99.5
Bamboo	8	.3	99.9
Water hyacinth	1	.0	99.9
Gas	1	.0	100.0
Wheat/mustard flakes/grains	1	.0	100.0
Total	2400	100.0	

Table 4. Secondary fuel sources in the dry season

	Frequency	Percent	Valid percent	Cumulative percent
Leaves	51	2.1	2.2	2.2
Toosh (Husk of grains)	1298	54.1	56.0	58.2
Khorkuta (Straws and twigs)	351	14.6	15.1	73.4
Tree-branches	428	17.8	18.5	91.8
Dung	28	1.2	1.2	93.1
Wood	1	.0	.0	93.1
Others	108	4.5	4.7	97.8
Wood grains	7	.3	.3	98.1
Jute stalk	30	1.3	1.3	99.4
Bamboo	12	.5	.5	99.9
Water hyacinth	1	.0	.0	99.9
Wheat/mustard flakes/grains	2	.1	.1	100.0
Total	2317	96.5	100.0	

Table 5. Primary fuel sources in the rainy season

	Frequency	Percent	Valid percent	Cumulative percent
Leaves	771	32.1	32.1	32.1
Toosh (Husk of grains)	674	28.1	28.1	60.2
Khorkuta (Straws and twigs)	570	23.8	23.8	84.0
Tree-branches	260	10.8	10.8	94.8
Dung	22	.9	.9	95.7
Wood	1	.0	.0	95.8
Others	72	3.0	3.0	98.8
Wood grains	11	.5	.5	99.2
Kerosene	2	.1	.1	99.3
Jute stalk	8	.3	.3	99.6
Bamboo	8	.3	.3	100.0
Gas	1	.0	.0	100.0
Total	2400	100.0	100.0	

Table 6. Secondary fuel sources in the rainy season

	Frequency	Percent	Valid percent	Cumulative percent
Leaves	15	.6	.7	.7
Toosh (Husk of grains)	575	24.0	25.8	26.5
Khorkuta (Straws and twigs)	489	20.4	21.9	48.4
Tree-branches	757	31.5	33.9	82.3
Dung	111	4.6	5.0	87.3
Wood	3	.1	.1	87.4
Others	203	8.5	9.1	96.5
Wood grains	7	.3	.3	96.9
Kerosene	1	.0	.0	96.9
Jute stalk	41	1.7	1.8	98.7
Bamboo	23	1.0	1.0	99.8
Sugarcane fiber	1	.0	.0	99.8
Water hyacinth	1	.0	.0	99.9
Beter-nut fiber	1	.0	.0	99.9
Wheat/mustard flakes/grains	2	.1	.1	100.0
Total	2230	92.9	100.0	

So, around 80% of the households, on average, used agricultural residues as fuel and the number was higher in flat in-land areas. Use of fuel wood, on the other hand, was relatively higher in hilly, forest, coastal and mangrove areas. There was no particular way of acquiring fuel; little less than 90% of the households collected fuel free of cost, two-fifth of all the households prepared fuels themselves while only one-third would buy it from local market. As far as kitchens were concerned, 45% of the households cooked in closed kitchen, 35% in semi closed, and 20% in open kitchens.

These and other findings from these surveys were later used to address the most relevant aspects, ask better questions, and draw a representative sample for the main study. Despite the valiant efforts of NGOs and government agencies in both stove development and dissemination, our 'quick survey' reveals that 1.3% of rural Bangladeshi households use any form of ICS. Given the importance of ARI as a risk factor for child and female mortality and morbidity, and given traditional stoves' links to climate change, the lack of penetration of ICS requires deeper exploration.

Objective

This study aimed to explore the factors affecting the promotion of ICS to replace traditional stoves, and hence to combat IAP.

Methods and materials

Study area for the randomized intervention study

The areas for the intervention study were chosen after analyzing data from the quick survey on the major cooking fuels used by households in different parts of Bangladesh. The quick survey reveals that mainly two types of fuel were used for cooking at household level in Bangladesh viz. fire wood (sliced trees, tree branches, etc.) and agri-residues (straw, husk, dry leaves, etc.). A list of potential study areas (*upzailas*) was then compiled such that more than 85% of the households in each of them used one of the two most common fuels, firewood or agri-residues. In Jamalpur Sadar *upazila* about 94% of the households were using agri-residue as fuel for cooking. So, it was selected to represent areas using this particular fuel type. In Rangamati Sadar and Fenchuganj *upazilas* more than 90% of the households were found to use firewood as fuel, but none of these areas could be selected for physiographic, communication and language constraints. Hatia *upazila*, next to these two areas where about 88% of the households were using firewood as fuel, was selected to represent areas where firewood is the most common fuel. Jamalpur Sadar *upazila* of Jamalpur district and Hatia *upazila* of Noakhali district were chosen to represent two distinct geographic regions that maximized the variation in environmental conditions under which this study examines cookstove adoption decisions.

Description and comparison of the study areas

Jamalpur Sadar *upazila* with an area of 489.56 sq km, is located in the northern part of the country. In terms of administrative units, the *upazila* consists of one municipality, 12 wards, 15 unions, 300 mouzas and 353 villages. According to the population census of 2001, the *upazila* has 132,265 households with a population of 568,726. The literacy rate is 39.7% (BBS 2001). Main occupations of the people include agriculture (42.06%), fishing (1.29%), agricultural labour (21.5%), wage labour (3.35%), commerce (11.42%), construction (1.28%), service (6.24%), transport (3.07%) and others (9.79%) (Banglapedia 2006).

Hatia *upazila* is located in southern part of Bangladesh with an area of 1508.23 sq km and bounded by Bay of Bengal on the south and the east. This *upazila* consists of many big and small offshore islands. The *upazila* consists of 10 unions, 52 mouzas, and 62 villages. A total of 66,728 households in the *upazila* have a population of 341,176. The literacy rate is 38% (BBS 2001). The area represents an extensive flat, coastal and deltaic land, located on the tidal floodplain of the Meghna river delta, characterized by flat land and low relief. Main occupations include agriculture (38.65%), agricultural labour (24.23%), wage labour (3.77%), commerce (8.69%), service (3.58%), fishing (5.37%) and others (15.71%) (Banglapedia 2006).

Jamalpur Sadar *upzaila* is located near Madhupur *Shal* forest of Bangladesh. It is under the Modhupur tract and physiographically it is mainly a plain land. Most of the land of this region is occupied for agricultural use. For fuels, people of Jamalpur mainly depend on their agricultural residue which they also store for use in rainy season. On the other hand, Hatia *upazila* is an island of Bay of Bengal located in the Noakhali district. This is mainly a larger *char* land where the soil has high pH and salt content. Clay soil is not available in all areas which are required for preparing any type of mud stoves. People of the area mainly depend on biomass collected from the forest and also on the agricultural residue, especially during winter when residues are plentiful. The two study areas are, therefore, quite different from each other in terms of their physiographic formation and fuel-use. Also there are some cultural differences between the areas. During the reconnaissance survey, people of Hatia were found to be more religious and conservative than Jamalpur Sadar. The Muslim women of Hatia area are more likely to use veils, which made it more challenging for enumerators to collect data.

Sample size and sampling

The survey was conducted in 2008 in 58 villages of Jamalpur Sadar and Hatia *upazilas*, 29 villages in each selected randomly using BRAC's complete national sampling universe of villages. Both qualitative and quantitative methods were followed. Before quantitative part with pre-designed questionnaires, focus group discussions (FGD) were held. It was the "village level module" where the answers were filled from FGDs. The idea was to divide the village in three equal clusters as well as *Paras* (neighbourhood) and list the opinion leaders of the village. One FGD was performed in each village and eight to ten persons were present in each FGD. Through random selection, 50 households were to be surveyed per village and in the villages selected for interviewing opinion leaders (explained below), and additional 9 households of the opinion leaders were to be surveyed. All the Paras were named and numbered. From Para 1, 17 households were selected for interview while the number was 16 for Para 2 and 17 for Para 3. Therefore, the sample size was 2,900 for households for general household survey plus 180 for opinion leader's household survey, thus totaling 3,080.

At this stage it is worth mentioning a little on the concept, rationale, and role of opinion leaders in this study. Social networks have long been through to play an important role in the diffusion of new behaviours (including the adoption of technologies) (Rogers 1962). Among the social sciences, the study of social networks has been most prominent in sociology. Sociologists have proposed two distinct mechanisms of diffusion through social networks- contagion by cohesion and contagion by equivalence (Merton 1968, Burt 1999). Contagion by equivalence refers to transmission within groups among similar types of people. This type of network effect has been studied relatively more by economists – the current work aims at studying it in the second round. Contagion by cohesion, on the other hand, refers to the transference of information by brokers across social boundaries between dissimilar groups. These between-group brokers in this study are referred to as opinion leaders who channel information between outsiders (such as development organizations or even our own research team) and villagers in Bangladesh.

To study the importance of opinion leaders in the adoption of ICS, we first identified three leaders in each *para* through village-level FGDs. Through a participatory process, we asked the villagers to nominate a leader in each of the three dimensions of socio-cultural space that are considered most important in rural Bangladeshi society: economics, politics; and education/literacy. The FGD first identified 3 neighborhoods within each village, and then identified three types of leaders representing each of the *paras*. For economic leadership, we asked villagers to nominate a person who owns the largest amount of land, which is the most important durable asset people own in rural agrarian regions such as Jamalpur and Hatia. For political leadership, we first asked whether any elected politician lives in that neighbourhood, but most commonly the leaders we identified did not hold any formal political office. Instead, it is more useful to think about the political leaders as the 'village elder' types who the villagers might approach to mediate or resolve disputes. Finally, we asked villagers to nominate the most educated person from the neighbourhood (not already chosen as an economic or political leader) as the third leader. The median individual in rural Bangladesh remains illiterate, and the relative dearth of the skill makes the social and economic returns to achieve any level of formal education quite high.

Lab tests and selection of ICS

To understand the underlying determinants of cookstove choices we decided to work with multiple types of ICS with different benefits. At a broad level, two types of ICS were considered for intervention: chimney-based ICS and portable ICS. But before the final selection of particular stoves, two rounds of stove tests were done in the field, but in controlled kitchen environments.

The first round aimed at comparing fuel efficiency, cooking time and smoke emission among different variations of the ICS and traditional stoves. In particular, the following types of stoves were tested:

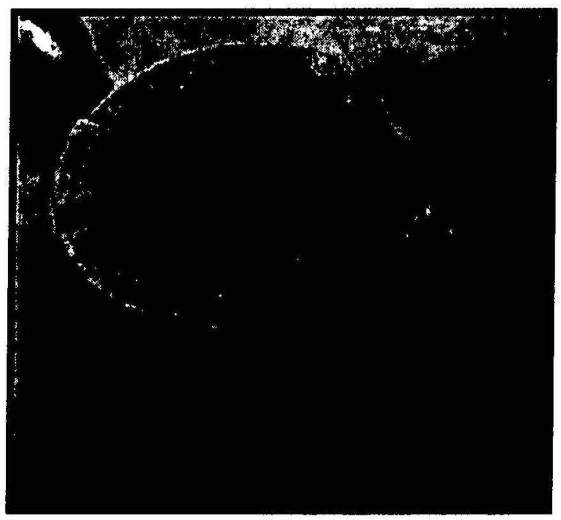
a) Traditional single pot portable stove
b) Portable single pot improved stove with grate
c) Portable improved stove single pot without grate
d) Improved stove double pot with grate and with chimney
e) Improved stove double pot without grate and with chimney

The tests were carried out with a machine called Side Pack PM 2.5µ. The results showed that, compared with traditional stoves the chimney stoves reduced pollution but not fuel use or time. On the other hand, the portable stoves reduced fuel use but did not reduce pollution per unit of time. Use of grate did not reduce smoke emissions significantly but did reduce the cooking time with portable stoves by about 20% and hence on average, fuel use per cooking period and exposure of the cook to pollution was also reduced. With such supportive test results we moved on to more particular corresponding designs. As a chimney-based ICS, a design by German

Technical Cooperation (GTZ), (GTZ is now GIZ) was selected while for portable ICS, a design of Practical Action Bangladesh was used. Brief descriptions of the two stoves are provided below.

In a second round of pollution monitoring, conducted after the interventions were launched, similar stove tests were carried out with a bigger sample using only these two ICS types and traditional stoves. Smoke emissions were recorded using similar machines as before at three different points: cook's body, a close-to-stove point and a point at some distance from the stove. This additional round of test allows us to look at the actual performance of the stoves in the field, in kitchen environment where regular users were using the stoves for their everyday cooking.

Portable ICS with grate



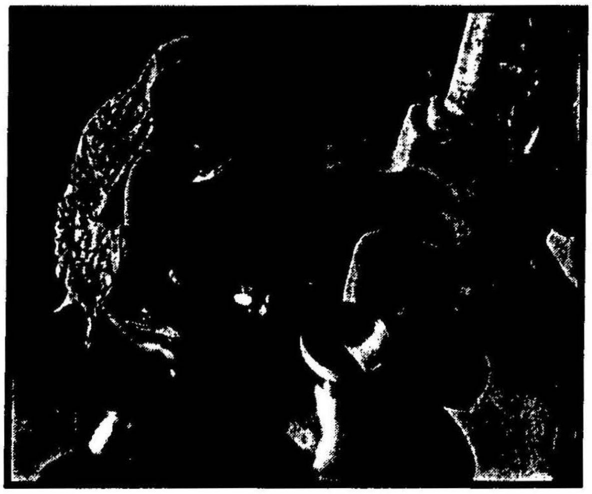
The selected portable ICS with grate is made of mud like the traditional one but there are some specific measurements of fuel chamber, grate, air flow chamber, stove top diameter, ash collection chamber, height, weight, etc. to be followed during preparing such stoves. All the traditional biomass fuels cannot be used in this type of stove. Specifically, husk, dry leaves, straw, etc. are not convenient to use as fuel as porous cast iron grate is used here. Only fire woods like tree branches, bamboo, charcoal, cow-dung, etc. can be used. The main difference of this stove with the traditional stove is that it burns the firewood more effectively which reduces the quantity of firewood required for cooking. Time for cooking can be same or less than the traditional and produces same amount of smoke like the traditional stove. It can be moved easily from one place to another for which it can be used during rainy season inside the house. Price of such stove in the market varies from Tk. 800 to Tk. 1000.

Chimney-based ICS with grate

The selected chimney-based ICS with grate, fixed with the ground/earth is made of mud like the traditional one. But there are some specific measurements of fuel chamber, grate, air flow chamber, stove top diameter, ash collection chamber, height, weight, etc. which to be followed while preparing such stoves. In terms of shapes, this can take the form of I or L, and consist of single or double burner. Beside porous cast iron grates, six inches dia concrete chimney, air pipe, smoke cap, etc. are used. These stoves can be set up 50% under the ground (in terms of height) or 100% above the ground. In most of the cases, mostly clay materials are

205

used inside the stove to channel smoke to the roof top smoke cap through chimney. Not all of the traditional biomass fuels can be used in this stove. Specifically, husk,



dry leaves, straw, etc. are not convenient to use as fuel in this stove as porous cast iron grate is used here. Only firewoods like tree branches, bamboo, charcoal, cow-dung, etc. can be used as fuel in this stove. The main difference of this stove with the traditional stove is that it burns the firewood more effectively thus reducing the quantity of firewood required for cooking. Time for cooking can be same or less than the traditional stove. It produces less amount of smoke compared to the traditional stove. Price of such stove in the market varies from Tk. 1,500 to Tk. 2,500 depending on the availability of the clay soil and use of brick or cement coat.

Pollution tests

We also assessed the impact of cookstove choice on human exposure to IAP, accounting for differences in cooking behaviour with each type of stove. To do so, 216 emission tests were conducted using randomly selected adopters of each type of stove who cook in one of the three types of kitchen environments characterized by ventilation attributes (closed, semi-closed and open kitchens). For each test, primary household cooks were asked to prepare 1kg of rice (a standard staple meal in all parts of Bangladesh), and three PM2.5 monitors were used to collect continuous real-time pollution data in each cooking episode.

Firstly, a monitor was run for 5 minutes in the kitchen before cooking to have a baseline level of particulate matter in the air. During each cooking episode, three monitors were positioned. The first monitor was placed immediately next to the combustion chamber to measure emissions at the point of cooking. A second monitor was then placed in the corner of the kitchen furthest from the stove to assess how diffusion of pollution emissions throughout the room (depending on air flow, for example we also collected data on kitchen characteristics, including number of position of windows and doors, ventilation spaces between walls and ceilings, etc.) Finally, a third monitor was affixed to the body of the person (commonly on a sash) with an air intake tube positioned near the cook's neck. This monitor is especially useful in distinguishing changes in human exposure due to emissions from the stove vs. changes in exposure due to changes in cooking behaviour. For example, an ICS that reduces emissions at the point of cooking but requires more attention from the cook may not produce meaningful reductions in exposure because the benefits of lower emissions are offset by requiring cooks to spend more time next to the stove.

Intervention

All the villages and households were randomly assigned to the eight incentive conditions (Table 7).

Table 7. Experimental conditions and distribution of villages and households

Intervention condition	Area: Jamalpur	Area: Hatia
A: Control: Information plus stove offered at full price	Village: 1-6 Household: 300 50 households/village 16-17 households/cluster	Village: 1-6 Household: 300 50 households/village 16-17 households/cluster
B: Subsidy: Information plus stove offered at half price	Village: 7-11 Household: 250 50 households/village 16-17 households/cluster	Village: 7-11 Household: 250 50 households/village 16-17 households/cluster
C: Information plus stove offered at full price and households told whether opinion leaders accepted offer of that stove at full price	Village: 12-16 Household: 250 68 households/village 22-23 households/cluster	Village: 12-16 Household: 250 68 households/village 22-23 households/cluster
D: Information plus stove offered at half price and households told whether opinion leaders accepted offer of that stove at half price	Village: 17-21 Household: 250 68 households/village 22-23 households/cluster	Village: 17-21 Household: 250 68 households/village 22-23 households/cluster
E: Men (husband) given the choice of either a portable stove or a chimney stove at free of cost	Village: 22-23 Household: 100 50 households/village 16-17 households/cluster	Village: 22-23 Household: 100 50 households/village 16-17 households/cluster
F: Women (wife) given the choice of either a portable stove or a chimney stove at free of cost	Village: 24-25 Household: 100 50 households/village 16-17 households/cluster	Village: 24-25 Household: 100 50 households/village 16-17 households/cluster
G: Men (husband) given the choice of either a portable stove or a chimney stove at subsidized price	Village: 26-27 Household: 100 50 households/village 16-17 households/cluster	Village: 26-27 Household: 100 50 households/village 16-17 households/cluster
H: Women (wife) given the choice of either a portable stove or a chimney stove at subsidized price	Village: 28-29 Household: 100 50 households/village 16-17 households/cluster	Village: 28-29 Household: 100 50 households/village 16-17 households/cluster

Thus, 42 out of the 58 project villages were allocated to incentive conditions A-D (randomizing price and opinion leader information – for one randomly assigned type of ICS or the other), while the other 16 villages were allocated to conditions E-H (randomizing sex of the household member making the cookstove choice as well as cookstove price in the context of a choice of either type of stove). Half of the 42 A-D villages (i.e., 21 villages) were randomly selected for the full price condition, implying that these villages would either be in group A or group C. The other 21 villages were assigned to 50% subsidy conditions (groups B or D). This village-level assignment to price conditions A-D was done because locally the same stove could not be offered at different prices to households living in the same village.

Next, 42 villages were divided into *paras* (with approximately 3 *paras* per village), yielding 126 *para* clusters. Each *para* in the full price villages (A-C block) was randomly assigned to receive information about the decisions opinion leaders made (group C) or not (group A). All households living in the same neighbourhood (*para*) within the village were placed in the same group. Similarly, each *para* in the 50% subsidy villages (B-D block) were randomly assigned to receive information about the decisions opinion leaders made (group D) or not (group B). In total, we sampled and marketed stoves to 50 households per village, yielding 2,100 sampled households in the 42 A-D villages. All assignment was split into equal portable and chimney stove groups at the village level as well (for logistical reasons).

The 16 villages randomly assigned to conditions E-H were given a different choice – a choice of either type of cookstove under their respective incentive conditions. Eight were randomly assigned to the 'free stove' condition (groups E and F) while the other eight received more highly subsidized stoves (groups G and H). Within the E-F block villages, the 400 sampled households were then randomly assigned to male (group E) or female (group F) groups (denoting the sex of the household member selected to make the cookstove choice) at the individual level. Similarly, 400 sampled households in the G-H block villages were randomly assigned to either group G or group H at the individual level. To summarize, while price in these 16 villages were randomly assigned at village level, the sex condition – as to whether the male household head or the wife/primary cook made the stove choice – was randomized at individual level. Individual, rather than *para* or village level randomization, of course provides greater statistical power, but it was also necessary to be mindful of the practical constraint of not being able to market the same stove at two different prices in the same village.

Four price levels for each type of ICS were considered. These were as follows:

Table 8. Price offers to different intervention groups

Price level	Conditions	Chimney-based ICS (Tk.)	Portable ICS (Tk.)
Full price	A, C	750	500
Half price	B, D	375	250
Free	E, F	-	-
Subsidized price	G, H	200	50

Finally, after assigning the experimental conditions, the first-round survey and marketing visits to all 2,900 project households were carried out during July–September 2008. At the time of the survey, participants were also offered a cookstove (or their choice of cookstove) according to the experimental arm to which they were assigned. Cookstove orders were then given to participating NGO manufacturers, and the cookstoves were delivered during November 2008 – February 2009.

Field enumerators, training and data collection

Seventy-one field enumerators were recruited and trained in two phases. At the first phase all of them received five days intensive technical training on ICS construction by Germen Technical Corporation (GTZ), (GTZ is now GIZ). Later, the same team received another five days training on data collection and survey technique by the core research team. In each of the areas (Jamalpur sadar and Hatia) a team of 30 field enumerators was deployed. These 60 enumerators (30 X 2) were divided into 30 teams; 15 teams for Hatia and another 15 teams for Jamalpur sadar *upazila*. To monitor the quality of work, 5 field enumerators (3 for Hatia and 2 for Jamalpur) were deployed while the rest 6 (3 for Hatia and 3 for Jamalpur) were given the task of supervision. For qualitative part, 15 teams were responsible to conduct 29 FGDs in 29 villages in each region in 6 days while for quantitative part 15 teams were responsible to interview 1,540 households in 35 days (minimum 4 questionnaires/ team/day). There were two parts of each quantitative questionnaire, viz. male and female and a team of two field enumerators was responsible to interview them separately.

209

Results and discussion

Table 9 briefly summarizes the profile of the survey respondents. Most of the participants were 20–59 years old, almost all were married and about half of them were literate. The main occupation among males was agriculture followed by business but the females invariably reported household work as their profession.

Table 9. Demographic profile of respondents

Indicators	Jamalpur		Hatia	
	Male (%)	Female (%)	Male (%)	Female (%)
Age group				
Adolescent (10 – 19 years)	-	2.9	-	2.1
Adults (20 – 59 years)	83.4	92.7	81.2	93.9
Older (60+)	16.6	4.4	18.8	4.0
Married	99.5	99.5	99.9	99.6
Literate	45.5	48.1	59.5	54.1
Occupation				
Agriculture	44.4		41.0	
Business	21.2	0.3	23.1	0.1
Day labour	19.1	0.1	18.4	0.3
Household work		98.4		97.5
Others	15.3	1.5	17.5	2.1
Earning member	98.2	28.0	97.6	9.2
Average Family size	5.76 (±2.196)		7.34 (±2.928)	
N	1539	1539	1540	1539

Kitchen and stoves

To get an idea about the stoves and kitchens that are currently used in the survey areas, a few questions tried to address the issues like what stoves were in use, the costs of obtaining such stoves, the status of the kitchens and ventilation, etc.

Among a total of 3,079 households surveyed all had one stove in their households, except for one. Most of the stoves were placed inside an enclosed space near the main building (57.53%) or at some distance from the main building (34.81%). Very few were placed inside the main building (3.73%) or completely in open space (3.93%). The location of the stoves give us an idea about how much the pollution from the stoves affect other living areas and thus the exposure of family members other than the cook herself/himself. As it appears from these statistics, most of the stoves were placed at least at some distance from the main living area and hence other members of the family would not be exposed to the smoke as much as they would have been if the stoves were inside the main building. The exposure of the cook herself/himself to the smoke from the stoves partially depends on the status of ventilation in the kitchens. As per an on-spot assessment by the field enumerators, 28.87% of the stoves were placed in well ventilated spaces while 41.79% were averagely ventilated. Our main concern should be the around 29.35% households where the stoves were located in ill ventilated spaces, almost 4.64% of them being in very bad conditions.

Over 98% of the stoves were traditional and the remaining were some form of ICS. Around 1% of these traditional stoves had chimneys but still could not pass as ICS. Almost all of these traditional stoves (98.7%) in the study area were made by the participant households themselves and were not purchased. Table 10 shows the cost of making such stoves in terms of both money and time spent to make them. The direct monetary cost of materials required to make the stoves was almost zero, implying they were collected rather than purchased. While the total time spent to make a stove is around 2.5 hours in Jamalpur, it is much higher in Hatia - almost four hours or more (depending on installation of a chimney).

Table 10. Cost of making traditional stoves

With/without chimney	District	HH making and possessing traditional stoves on their own (%)	Cost of materials (Tk.)	Time spent (mins)
Without chimney	Jamalpur	98.12	0.1	147.06
	Hatia	97.34	0.95	227.01
	Total	97.73	0.53	186.9
With chimney	Jamalpur	1.10	1.76	153.53
	Hatia	0.84	530.77	352.31
	Total	0.97	231	239.67

**Sample:- Households - Jamalpur:1539; Hatia:1540. Stoves - Jamalpur:1539; Hatia:1541.*

Knowledge on indoor air pollution

Demand for ICS cannot probably be properly understood unless we understand how well the participants understand IAP and its consequences. Table 11 shows a few statistics on people's perceptions on IAP. While less than 5% thought that there was no IAP inside their house, 27.67% thought there were significant amount of IAP taking place. About 67% thought that there were little to moderate amount of IAP taking place. Table 11 also shows the shares of these households who thought cooking was indeed a source of pollution. One-fifth of the respondents who thought no IAP occurs inside their houses thought of cooking as a source of pollution (which could perhaps explain why they thought no pollution occurs in their houses in the first place). Most of the other respondents recognized cooking as a source of IAP. Of the latter group, 89.42% attributed this pollution to fuel, while 20.23% attributed this pollution to stove. Regardless of everything else, 87.3% of all the respondents realized that pollution was harmful to health.

Table 12 shows who the respondents thought were more likely to suffer from particular diseases due to IAP. Most of the respondents identified wives of the households to suffer from the listed diseases, followed by husbands and children. This is perhaps because the wives (and females in general) usually do the cooking and hence are more exposed to IAP. Eye problem, breathing problem and dry cough were the more popularly perceived diseases caused by IAP.

Table 11. Perception of respondents about indoor air pollution that happens inside their households (Female respondents only)

	Perception on magnitude of pollution[1]	Share of HH who thought cooking was a source of IAP
Magnitude	% HH	% HH
Not at all	4.42	21.32
A little bit	46.96	83.68
A moderate amount	20.23	85.23
Lots	17.21	87.17
A huge amount	10.46	75.47
N	3079	
Source of IAP through cooking[2]		% HH
Stove		20.23
Fuel		89.42
N		2477
Does pollution harm people?		% HH
Yes		87.30
No		9.65
N		3079

[1]Perception of the households on the magnitude of IAP that happens inside their households
[2]as perceived by households who thought cooking pollutes

Table 12. Perception on 'Who' would suffer from particular diseases caused by IAP (Female respondents only)

Disease name	Household member likely to suffer from a disease (as perceived by respondent)			
	Wife (% HH)	Husband (% HH)	Children (% HH)	Someone in general (% HH)
Eye problem	89.51	48.21	41.63	90.10
Breathing problem	77.49	49.11	36.94	79.13
Dry cough	71.28	46.24	34.56	72.58
Diarrhoea	39.66	33.41	21.73	40.22
Sweating at night	34.90	23.10	15.89	35.86
Cough with phlegm	32.22	24.03	15.89	33.11
Fever	31.18	24.85	16.41	31.88
Blood in sputum	18.42	13.76	8.93	19.46

*expressed as a percentage of people who thought air pollution harms health
**n = 2688

As to the question what measures they could take to prevent IAP, a variety of responses came up (Table 13). Most popular response related to cooking was to change fuel type. However, the number of households sharing such views differed considerably across the two study areas (85% households in Jamalpur and 28% households in Hatia). Cooking outside and ensuring proper ventilation were among the next widely responded measures. Interestingly, using ICS was a solution to only about one-tenth of the respondents.

In a nutshell, the respondents were generally well aware of IAP and its harmful effects but attributed this pollution more to fuel than to stove. Similarly, changing fuel was their solution to prevent IAP not changing stove.

Table 13. Measures respondents thought they could take to prevent IAP (Female respondents only)

Details	% HH		
	Jamalpur	Hatia	Total
Change fuel type	84.99	27.99	56.48
Cook outside	19.82	14.87	17.34
Add ventilation	11.24	17.01	14.13
Use ICS with chimney	5.72	12.21	8.96
Use ICS without a chimney	5.20	1.75	3.48
Other kitchen related measures	5.00	5.00	5.00
Other measures	14.29	49.68	31.99

*Sample:- Households - Jamalpur:1539; Hatia:1540 Stoves - Jamalpur:1539; Hatia:1541

Fuel-use and collection

Table 14 shows the fuels used by the households, and their average share in the total volume of fuels across all the households in the study areas. The fuel-use varies across the study areas and also seasons.

Table 14. Fuels used by households

Fuel Type	District	Rainy season		Dry season	
		%HH using the fuel	Weighted share of fuel in total volume (%)	%HH using the fuel	Weighted share of fuel in total volume (%)
Firewood	Jamalpur	51.1	36.2	30.4	16.0
Agri-residues	Jamalpur	87.0	49.2	96.8	79.5
Cow dung	Jamalpur	7.5	3.4	4.4	1.6
Bamboo	Jamalpur	23.7	11.1	7.2	2.9
Kerosene	Jamalpur	0.1	0.1		
Firewood	Hatia	78.9	52.9	42.5	17.9
Agri-residues	Hatia	92.8	33.1	98.9	78.2
Cow dung	Hatia	30.0	13.9	10.5	3.7
Kerosene	Hatia	0.7	0.1	0.3	0.1
Paper	Hatia	0.1	0.0	0.1	0.1
Bamboo	Hatia			0.1	0.0

*Sample:- Households - Jamalpur:1539; Hatia:1540 Stoves - Jamalpur:1539; Hatia:1541

In terms of weighted share of the use of fuel [(share of fuel in total volume of fuel)*(percentage of households who reported the use of the fuel)] during rainy season, firewood was most widely used in Hatia (a share of 52.94%), whereas agricultural residues (leaves, husk of grains, straws, bushes and stalks and crop plants) were the most popular in Jamalpur (a share of 49.22%). However, in dry season, both these regions switched to agricultural residues as fuel, which then constituted the biggest share in their fuel basket (78.24% in Hatia and 79.49% in Jamalpur). Agricultural residues were likely to be more easily available and usable in dry seasons and not so much so in the rainy season. While more people could switch to firewood in rainy season in Hatia, an increase of 36.36% households, use of firewood as fuel was perhaps constrained by its availability in Jamalpur (compared to dry seasons, only 20.73% more households reported its use).

Tables 15 and 16 show that most of the fuels were collected free of cost in both the regions and seasons, and the females of the households were responsible to do it.

Table 15. Fuel collection method

Sources	Jamalpur		Hatia	
	Rainy season (%)	Dry season (%)	Rainy season (%)	Dry season (%)
Collect free of cost	83.5	90.5	86.6	92.1
Buy from local market	16.0	9.1	11.5	7.1
Collect and buy	0.4	0.3	1.9	0.8

Table 16. Responsible for fuel collection

Household member	Jamalpur		Hatia	
	Rainy season (%)	Dry season (%)	Rainy season (%)	Dry season (%)
Female	73.7	81.1	60.7	61.6
Male	26.3	18.7	33.7	30.4
Children <18 years	0.4	0.5	4.0	6.8
Servant			2.6	2.7

Experience with and perception on ICS

To take a quick look at the exposure of the respondents to ICS, Table 17 summarizes some statistics of experience/association of the respondents with ICS. In general, households in Jamalpur were unaware of the existence of ICS while more than 50% of the households in Hatia knew about it. Almost one-third of households in Hatia knew at least one people who were using ICS at the time of the survey. Almost 18% of the female respondents in Hatia had tasted food cooked in ICS and around 62.68% of them thought the food tasted better than cooked in a traditional stove. More males found food cooked in ICS tastier than that cooked in traditional stoves. On the other hand, less than 7% of the female respondents in Hatia had firsthand experience of cooking in ICS, and around a quarter of them thought it was tougher than the traditional stove.

Table 17. Previous experience with ICS

Description	Jamalpur (%)		Hatia (%)		Total (%)	
	Female	Male	Female	Male	Female	Male
Already knew about ICS*	7.28	-	51.56	-	29.43	-
Knew people who uses ICS*	3.31	2.99	34.87	32.79	19.10	17.90
Knew people who stopped using ICS*	1.69	1.49	3.51	1.56	2.60	1.53
Tasted food cooked with ICS*	2.08	1.36	17.92	12.66	10.00	7.02
Cooked food with ICS*	0.91	-	6.82	-	3.86	-
Thinks ICS is tougher than traditional (of those who cooked food with ICS)**	14.29	-	25.71	-	24.37	-

Description		Female respondents			Male respondents		
		Worse	Same	Better	Worse	Same	Better
Taste of food to those who tasted food cooked with ICS***	Jamalpur	0.00	59.38	31.25	0.00	33.33	66.67
	Hatia	2.90	34.06	62.68	1.54	26.67	71.79
	Total	2.60	36.69	59.42	1.39	27.31	71.30

*Jamalpur n=1539; Hatia: n=1540 **Jamalpur n=14; Hatia: n=105
***Females: Jamalpur n=32; Hatia: n=276; Males: Jamalpur n=21; Hatia: n=195

To understand the demand for ICS, it is important to understand the perception of users about ICS. Tables 18a to 18d show that what the respondents thought about the various aspects of ICS. Although the direct user of the stoves would be the females in the households, the decision to purchase the stoves would very likely depend on the males. So, the same questions on such aspects were asked to both the female and male respondents from each household.

In Table 18a we look into what the respondents thought about any change in taste of food that might occur if it was cooked in an ICS instead of a traditional stove. Apart from the question as to what the taste of food would be like to the respondent herself/himself, we also asked how the spouse of the respondent would like its taste. The latter question is particularly important in case of the female respondents since, everything else remaining same, a wife (who is also the cook) is unlikely to decide to switch from traditional stove to ICS if her husband does not like the taste of food cooked in it. The responses are also grouped into two: uninformed group of respondents who had never tasted food cooked in ICS, and informed group comprising of those who had tasted such food. Although this will not establish causality by any means, it will give us a glimpse of any difference in perception between these two groups.

For those who had never tasted food cooked in ICS before, the share of respondents who believed that they would find the taste of food cooked in ICS better than that cooked in traditional stoves hovered around mid 70% in the two areas combined. The same is true when it comes to how they thought their spouse would find its taste. Very negligible portion of the respondents thought that ICS-cooked food would taste worse. However, for the informed group, the share of people who believed that

ICS-cooked food would taste better goes up by 7.04 and 7.77 percentage points for female and male respondents respectively, in the two regions combined. When it comes to taste likely to be found better by their spouses, the proportion of people believing this goes up by even more, 8.63 and 13.04 percentage points for females and males respectively, in the two regions combined. This is, in fact, in line with statistics in Table 17 where we find a good share of people liking the food cooked in ICS that they tasted. At disaggregate level, the females in Jamalpur do not seem to be very optimistic about ICS but this could also be because of deducing the statistics from small size of informed group in Jamalpur.

Table 18a. Expected/perceived performance of ICS as compared to traditional stoves

Basis of comparison	District	Expected performance of ICS compared to traditional stoves							
		Worse (%)		Could be worse or better (%)		Better (%)		*n*	
		Females	Males	Females	Males	Females	Males	Females	Males
Among those who never tasted food cooked with ICS before:									
Taste of food	Jamalpur	2.32	1.54	20.04	21.54	76.91	76.19	1507	1495
	Hatia	3.16	0.83	21.04	26.28	75.79	72.90	1264	1332
	Total	2.71	1.20	20.50	23.77	76.40	74.64	2771	2827
Taste of food to husband/ wife	Jamalpur	2.32	1.20	21.77	23.61	75.05	74.38	1507	1495
	Hatia	2.85	1.28	27.61	23.20	69.54	75.53	1264	1332
	Total	2.56	1.24	24.43	23.42	72.54	74.92	2771	2827
Among those who tasted food cooked with ICS before:									
Taste of food	Jamalpur	3.13	0.00	28.13	9.52	68.75	90.48	32	21
	Hatia	2.90	1.54	11.96	16.92	85.14	81.54	276	195
	Total	2.92	1.39	13.64	16.20	83.44	82.41	308	216
Taste of food to husband/ wife	Jamalpur	3.13	0.00	37.50	9.52	59.38	90.48	32	21
	Hatia	1.81	1.54	14.49	10.77	83.70	87.69	276	195
	Total	1.95	1.39	16.88	10.65	81.17	87.96	308	216

Table 18b shows the respondents' perceptions about ICS performance on three other dimensions: smoke emission, time required for fuel collection and chance of food getting burnt. In this table, we group the female respondents into two again: households who had never heard of ICS before (uninformed) and households who had heard of ICS before (informed). This might help us see some differences among these two groups because of possible prior information that the informed group might possess. However, such differences could not be drawn for males. Here again, shares of people believing ICS would perform better than traditional stove are high in all the three dimensions. But it is interesting to see that the share of people in favour of ICS is the highest when it comes to the issue of reduced smoke emission, but falls a bit regarding time required for fuel collection and falls further regarding chance of food getting burnt. But these drops are absorbed in the groups of those who were not too sure of which of the stoves would actually be better. People against ICS are still negligible in proportion.

Table 18b. Expected/perceived performance of ICS as compared to traditional stoves

Basis of comparison	District	Expected performance of ICS compared to traditional stoves			
		Worse (%)	Could be worse or better (%)	Better (%)	n
Among those who did not know about ICS from before:					
Smoke emission	Jamalpur	2.31	11.63	85.35	1427
	Hatia	3.49	18.23	78.28	746
	Total	2.72	13.90	82.93	2173
Time required for fuel collection	Jamalpur	1.68	15.98	81.50	1427
	Hatia	5.23	28.15	66.49	746
	Total	2.90	20.16	76.35	2173
Chance of food getting burnt	Jamalpur	3.71	30.83	64.75	1427
	Hatia	6.84	55.63	37.53	746
	Total	4.79	39.35	55.41	2173
Among those who knew about ICS from before:					
Smoke emission	Jamalpur	3.57	9.82	86.61	112
	Hatia	1.76	4.79	93.32	794
	Total	1.99	5.41	92.49	906
Time required for fuel collection	Jamalpur	0.89	21.43	77.68	112
	Hatia	10.20	25.19	64.61	794
	Total	9.05	24.72	66.23	906
Chance of food getting burnt	Jamalpur	3.57	27.68	68.75	112
	Hatia	5.29	42.82	51.76	794
	Total	5.08	40.95	53.86	906

Comparing uniformed vs. informed groups, we see an interesting pattern too. For females in the informed group, as compared to uninformed group, the share of respondents who believed ICS would lead to reduced smoke emission, increase by 10 percentage points. But when it comes to time required for fuel collection, the informed group has 10% less respondents who believed ICS could lead to reduction in fuel collection time, than the uninformed group. On the contrary, the share of respondents who thought ICS would lead to an *increase* in time required for fuel collection, has gone up by 6 percentage points. Regarding chance of food getting burnt, the two groups do not differ much.

Table 18c shows the respondents' perception on fuel expenditure changes. Once again, more respondents (female) thought ICS would lead to reduced fuel expenditure than otherwise. Such proportions are 82.9% in uninformed group and 73.7% in informed group. Compared to uninformed group, share of females who believed the expenditures would not change go up by about 8 percentage points, and share of those who thought the expenditure would actually increase, go up by 4 percentage points.

Table 18c. Expected/perceived performance of ICS as compared to traditional stoves (Females)

Basis of comparison	District	Expected performance of ICS compared to traditional stoves					n
		Will increase (% HH)	Amount of increase (Tk.)	Will decrease (% HH)	Amount of decrease (Tk.)	Will remain same (% HH)	
Among those who did not know about ICS from before:							
Fuel expenditure	Jamalpur	1.26	221.11	89.00	117.75	2.80	1427
	Hatia	5.76	188.14	71.18	115.38	9.38	746
	Total	2.81	197.87	82.88	117.05	5.06	2173
Among those who knew about ICS from before:							
Fuel expenditure	Jamalpur	2.68	316.67	79.46	145.84	10.71	112
	Hatia	7.43	114.75	72.92	125.22	13.35	794
	Total	6.84	124.51	73.73	127.96	13.02	906

Most of the females thought that ICS would lead to reduced cooking time (for rice) in both rainy and dry seasons (Table 18d). Comparing across uninformed vs. informed groups, however, we find a drop in such shares for the informed group, and increase in shares for those who thought the time would increase or remain same.

In summary, most of the respondents had expectations of better performance by ICS in all the factors viz. taste of food, smoke emission, time required for fuel collection, chance of food getting burnt, fuel expenditure change and time required to cook rice. Comparing across informed and uninformed groups, prior information seems to be associated with more people thinking of ICS as better than traditional stoves in terms of taste of food and smoke emission. However, such information is associated with a fall in share of people who thought ICS could perform better in terms of time required to collect fuel, fuel expenditure and cooking time, and slight increase in the proportion of people who thought the other way.

Stated reasons for acceptance and refusal of improved cookstoves

Overall, the most common reason given for choosing a portable cookstove is that they reduce the fuel required for cooking, while the most common reason given for adopting a chimney stove is that they reduce pollution emissions. For refusal of either type of improved stove, the most common reason given is financial expense (the only other notable one is preserving tradition, consistent with our focus on 'non-traditional' as well as financial considerations) (Tables 19a and 19b).

Table 18d. Expected/perceived performance of ICS as compared to traditional stoves (Females)

Basis of comparison	District	Expected performance of ICS compared to traditional Stoves: Will increase (% HH)	Amount of increase (Min.)	Will decrease (% HH)	Amount of decrease (Min.)	Will remain same (% HH)	n
Among those who did not know about ICS from before:							
Time needed to cook rice in rainy season	Jamalpur	0.84	21.67	88.51	17.05	4.20	1427
	Hatia	6.30	34.47	70.38	33.16	9.12	746
	Total	2.72	31.86	82.28	21.78	5.89	2173
Time needed to cook rice in dry season	Jamalpur	0.63	21.67	89.28	17.58	3.43	1427
	Hatia	5.36	34.00	70.78	32.88	9.25	746
	Total	2.25	31.73	82.93	22.06	5.43	2173
Among those who knew about ICS from before:							
Time needed to cook rice in rainy season	Jamalpur	2.68	20.00	74.11	17.01	11.61	112
	Hatia	10.08	32.64	70.78	33.95	12.85	794
	Total	9.16	32.18	71.19	31.77	12.69	906
Time needed to cook rice in dry season	Jamalpur	1.79	22.50	75.89	18.73	10.71	112
	Hatia	8.82	29.57	72.17	37.38	12.34	794
	Total	7.95	29.38	72.63	34.97	12.14	906

Table 19a. Primary reasons underlying adoption decisions, by stove type for conditions A-D (Ranking on a scale of 1-5)

Adoption	Reasons	Portable N	Portable Ranking score Mean	Portable Ranking score SD	Chimney N	Chimney Ranking score Mean	Chimney Ranking score SD	Total N	Total Ranking score Mean	Total Ranking score SD
Yes	Reduce smoke emissions	210	4.14	1.09	337	4.57	0.76	547	4.41	0.93
	Reduce time required to cook	223	3.99	0.87	168	3.47	0.8	391	3.76	0.88
	Reduce fuel required to cook	295	4.2	0.79	190	3.53	0.97	485	3.94	0.92
	Reduce attention required to cook	22	3.73	0.88	10	3.5	1.18	32	3.66	0.97
	Portability	160	3.64	1.03	3	4.33	0.58	163	3.65	1.03
	Good for cook's health	112	4.16	1.16	201	3.85	1.01	313	3.96	1.07
	Good for children health	22	3.86	0.89	46	3.22	1.07	68	3.43	1.06
No	Too expensive	554	4.8	0.66	557	4.86	0.62	1,111	4.83	0.64
	Increase time to cook	18	4.56	0.62	23	4.65	0.49	41	4.61	0.54
	Increase fuel required to cook	11	4	0.89	8	4.13	0.99	19	4.05	0.91
	Increase attention required to cook	3	3.67	0.58	10	4.1	0.32	13	4	0.41
	Afraid to burning food	0			4	3.75	0.5	4	3.75	0.5
	Change the taste of food	0			1	5		1	5	
	Preserve Tradition	270	4.42	0.56	154	4.49	0.59	424	4.45	0.57

Findings from randomized treatments

Assigning households to control groups and treatment groups allows us to get unbiased estimates of various demand side factors and impacts. As mentioned earlier, we randomly offered each type of stove – one or the other, not both – at full price (in arms A and C) or at 50% subsidy (in arms B and D). We sold portable stoves at either Tk. 400 (US $5.81) or Tk. 200 ($2.91) and chimney stoves at either Tk. 750 ($10.90) or Tk. 375 ($5.45). We also offered larger subsidies for ICS purchases – but in the context of a different choice. In arms E-H, we randomly offered some participants a choice of either type of stove for free and other participants a choice of either type of stove at heavily subsidized prices (Tk. 50 for the portable stove and Tk. 250 for the chimney stove).

Our results from arms A-D suggest that decisions to adopt ICS are extremely responsive to price. For portable stoves, the subsidy increased actual adoption by 12 percentage points, and it also increased purchases of chimney stoves by 5 percentage points. In arms E-H, moving from the free condition to the heavily subsidized one acceptance of both types of stoves falls meaningfully, although the reduction is larger for chimney stoves. Adoption of portable stoves declines by 7 percentage points, while adoption of chimney stoves falls by 34 percentage points. Since the chimney stoves are relatively more expensive than portable stoves in subsidized arms, as compared to free-offer arms where they are equally priced (free), one would indeed expect such greater reductions in adoption of chimney stoves than for portable stoves.

As for the impact of opinion leaders' decisions on villagers' decisions, we find that simply knowing what opinion leaders chose to do (regardless of what choice opinion leaders made) had no effect on adoption choices for either type of improved stove. However, opinion leaders' choices are related to adoption decisions depending on the specific pattern of choices opinion leaders made. If all three opinion leaders chose to adopt either a portable or a chimney stove, this was ultimately unrelated to actual villager adoption decisions. On the other hand, unanimous refusal of portable and chimney stoves by opinion leaders led to absolutely no adoption of either portable or chimney stoves. Thus, a leader accepting a stove does not necessarily imply that the technology is an appropriate expense to bear for the average villager, whereas leaders rejecting the stove certainly signals that a poorer villager ought to reject as well.

To investigate sex differences in choices about ICS, we randomly chose male or females from different households (male household heads or females with primary responsibility for cooking – typically spouses of male household heads) and offered them their choice of either a portable or chimney stove (arms E/G and F/H). Additionally, we also randomized cookstove prices across men and women: the stoves were either available for free (in arms E and F) or at a heavily subsidized price (Tk. 50 for the portable stove and Tk. 250 for the chimney stove, or about US $0.73 and $3.63, respectively, in arms G and H). The crossing of randomized cookstove offers by sex and by price allows us to learn both about systematic differences by sex as well as how men and women might respond differently to cookstove price.

For actual adoption of either type of ICS (portable or chimney), we surprisingly find no statistically significant mean differences in choices made by men and women (the effect is an almost identical 36 percentage increase in actual adoption among both males and females). This absence of average sex differences applies both to extrinsic and intrinsic margins (i.e., whether or not to adopt stove and which stove to adopt conditional on accepting one).

Table 19b. Primary reasons underlying adoption decisions, by stove type for conditions E-H (Ranking on a scale of 1-5)

Adoption	Reasons	Portable			Chimney			Total		
		N	Ranking score		N	Ranking score		N	Ranking score	
			Mean	SD		Mean	SD		Mean	SD
Yes	Reduce smoke emissions	34	4.09	0.97	527	4.63	0.66	564	4.6	0.69
	Reduce time required to cook	65	3.45	0.66	291	3.66	0.78	356	3.62	0.76
	Reduce fuel required to cook	81	3.96	0.73	325	3.81	0.87	406	3.84	0.85
	Reduce attention required to cook	6	4.33	0.82	15	3.13	1.06	21	3.48	1.12
	Portability	84	4.68	0.78	8	3.5	1.31	92	4.58	0.89
	Good for cook's health	29	3.34	1.23	271	3.58	0.89	303	3.56	0.93
	Good for children health	8	1.63	0.92	54	2.41	1.37	62	2.31	1.34
No	Too expensive							58	4.72	0.59
	Increase time to cook							3	4.33	1.15
	Increase fuel required to cook							7	4.14	0.38
	Increase attention required to cook	Not applicable			Not applicable			2	3.5	0.71
	Afraid to burning food							1	5	
	Change the taste of food							0		
	Preserve tradition							52	4.69	0.7

Concluding remarks

Realizing the adverse environmental and health impacts of traditional cookstoves so widely used in rural Bangladesh, this study aims to understand the constraints underlying the demand and promotion of ICS. Besides, we also investigated the ways of replacing traditional stoves and hence to combat indoor air pollution.

This report outlined some preliminary findings from a first round survey conducted on 2,900 households in 60 villages of two rural districts of Bangladesh. Findings suggest that households were usually aware of IAP but not so much so of the existence of ICS. But once they came to know about it through this survey, they would expect ICS to be better than traditional stoves in producing better tasting food, less smoke emissions, less cooking time, less fuel collection time, etc. When compared with those who did not know about ICS before, prior knowledge on ICS was found to be associated with greater share of people thinking ICS was better than traditional stove in terms of taste of food and smoke emission.

Among those who adopted ICS as was offered through different interventions, people usually chose portable ICS since they believed this would reduce fuel consumption while they chose ICS with chimney to reduce pollution. In most cases financial constraints was stated as a reason for choosing not to adopt an ICS. The adoption decision was also found to be highly responsive to price. On the other hand, opinion leaders appeared to have a stronger impact on households' decisions when the leaders decided against ICS as opposed to when they decided in its favour. Although this is a product specific study the results can provide a guideline to understand similar constraints for many other improved technologies that exist but are not generally adopted.

The findings of this study are only basic and primary and more comprehensive analysis can be conducted only after the second round data, follow-up and social network data to be specific, are considered as well. Such analysis and findings will be available in the final report of this study.

Next steps

The next step to this first round intervention was a follow-up survey conducted about a year after the first round survey. The follow-up survey was intended to capture the experiences of ICS adopters vs. non-adopters among almost half the households covered in the first round. Further, to understand the effect of adoption/non-adoption decision of households on other households in their social network another survey called 'Social Network Survey' was also designed and conducted at the same time of the follow-up survey. Similar interventions as in the first round were made to these new social network households, their adoption/non-adoption decisions were recorded and the same types of stoves were delivered to households deciding to use ICS. Detailed discussions on these two surveys are to follow in the next report.

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