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Information and Fuel Choices in Unequal Rural Households

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1. Introduction

Indoor air pollution caused by burning solid fuels is one of the major sources of morbidity and mortality in rural households. These fuels include firewood, coal, charcoal, animal dung cakes, agricultural residue, dry twigs and leaves. The latest Census report states that more than 85 percent of rural Indian households still depend on these polluting fuels and appliances for their daily cooking, heating and lighting requirements (Census of India, 2011). Combustion of these fuels release pollutants which have deleterious effects on human health and the environment. The pollutants emitted include suspended and respirable particulate matter (PM), carbon monoxide, sulfur and nitrogen oxides, arsenic, fluorine, benzene, polycyclic aromatic hydrocarbons (PAH) and other organic compounds (The World Energy Assessment, 2000). Some of these emissions are carcinogenic and genotoxic in nature. Inadequate ventilation combined with incomplete combustion of these inferior fuels may lead to high levels of indoor air pollution that may exceed standard air quality guidelines by several hundred times (Ezzati and Kammen, 2001). Prolonged exposure to such high levels of indoor air pollution increases both morbidity and mortality risks (Smith-Sivertsen, 2009; Smith, 2000; Bruce et al., 1998).

Women and children who spend time near the domestic hearth are more likely to suffer from the ill-effects of indoor air pollution (The World Development Report, 1997; Bruce et al., 1998; Pitt, Rosenzweig and Hassan, 2005). According to the World Health Report (2002), indoor air pollution is responsible for 36% of all lower respiratory infections and 22% of chronic obstructive pulmonary disease and 1.5% of trachea, bronchitis and lung cancer. It is also associated with heart disease, adverse pregnancy outcomes such as low birth weight and still births, tuberculosis, cataract, blindness and asthma (World Health Report, 2002; Smith, 2000; Smith-Sivertsen, 2009, Bruce et al., 1998). Poor health outcomes due to indoor air pollution can lead to a fall in labour productivity which may in turn result in deterioration of the household's economic status (Duflo, Greenstone and Hanna, 2008).

The project studies the factors that affect household's choice of fuels and associated devices. It attempts to determine how these choices are made when additional information about the costs and benefits associated with fuel used is provided, in particular, when there is unequal bargaining power among the members of the household. This would be accomplished through field experiments that will study the following.

1. The type of information that results in higher uptakes of cleaner fuel related alternatives.
2. In households where male and female members have unequal bargaining power, who should be the recipient of information so that uptakes are higher?
3. Assuming variation in bargaining power of female members, how are uptake levels affected with the variation in the recipient of information?

2. State Policies

There have been several State initiatives that have attempted to mitigate the harmful effects of solid fuel usage. These include subsidies for clean fuel alternatives such as LPG, kerosene and biogas plants. The effectiveness of these clean fuel options has been limited as these alternatives are largely unavailable in most rural regions. Households in these regions are compelled to use solid fuels due to income and supply constraints (The Hindu, 17 April 2012). Most policy interventions are therefore designed to promote devices that help in reducing indoor air pollution in households that continue using solid fuels. The National programme on Improved Chulha started by the State in 1986-89 was one such intervention. Subsidies were given to households that purchased improved stoves under this initiative. Other interventions such as Rajiv Gandhi LPG Vitaran Yojana and provision of subsidy for setting up biogas plants in Kerala in 2011-12, aim at reducing the supply bottlenecks for clean fuels.

In addition to these State policies, there are other 'improved stove programmes' implemented by NGOs. For instance, in 2011, an NGO called Wildlife Trust of India promoted and helped households in rural Bihar switch to improved stoves. Nevertheless, literature indicates that improved stoves that use biomass are not as effective as a switch to clean fuels in ridding indoor air pollution (Ezzati and Kammen, 2001).

However, uptake of these cleaner alternatives, especially in the case of smokeless chulhas, is still far from what is optimal. Some of the reasons for the low uptake as cited in the literature are inappropriate design, short shelf life and insufficient of maintenance support[1]. In an attempt to overcome these deficiencies, the Ministry of New and Renewable Energy launched the National Biomass Cookstove Initiative in December 2009. This initiative is aimed at developing strategies for provisioning of better designs of improved stoves at subsidised prices in future. Lack of information regarding the benefits of switching to less polluting fuels and appliances was also seen as a reason for this inertia of sticking to traditional fuel related practices.

To address this lack of awareness, information campaigns are being increasingly used to aid and supplement the implementation of these policy initiatives. A large scale awareness programme: 'Energy Clinic for Housewives', regarding energy conservation initiated by Energy Management Centre, Kerala in 1996, is an example of such a campaign. Efficacy of information campaigns on household's cooking fuel and related choices has not been sufficiently explored in literature. Most of the earlier work on the effect of information and 'feedback on households' fuel choices' was focused on energy conservation. Majority of this research was undertaken in the context of developed countries (Steg and Vlek, 2009; Lutzenhiser et. al., 2010).

Nevertheless in certain cases, providing information or spreading awareness may not be sufficient to make households switch to better fuel related options. A reason for this can be the asymmetric benefits and costs accruing to different individuals within the household. These differential gains may be attributed to the time spent by individual in the vicinity of the domestic hearth. As individuals gaining

[1] Kishore and Ramana, 2002, Energy, p.57; Dankelman and Davidson, 2004, p.75

the most from the fuel switch may not be the same as the ones with the highest say in the household, the decision to switch may not remain a monotonic function of the benefits (or costs).

3. Conceptual Framework

3.1. Intra-household bargaining and decision making

Household members may value the costs and benefits of using clean fuel related alternatives differently. This variation usually stems from the differences in the amount of smoke individuals are exposed to. The heterogeneity in the valuation can be further heightened due to variation in prior perceptions about the costs and benefits of alternatives. This may then result in differential levels of transmission and absorption of `additional information' on fuel related alternatives among household members. Conventional wisdom suggests that female members are likely to be more receptive to information, but may have little decision making power. Household decisions are often made by the male household members. In such situations, giving information to the male members may seem to ensure households becoming more likely to switch to cleaner fuel related alternatives. Nevertheless, their valuation of benefits may be lower by the virtue of time they spend near the hearth, leading to lower actual uptake of the cleaner alternatives.

Existing literature on information transmission suggests that information can be conveyed to the decision makers by non-decision makers if individuals have similar preferences. In case of asymmetric preferences, it is better to give information to the decision maker as non-decision makers may not be able to convince the former (Crawford and Sobel, 1982; Banerjee and Somanathan, 2001; Dessein, 2002). As a result, fuel based decisions can be expressed as a function of preferences, decision making power, income, information and the availability of preferred choices.

In the following section, the paper attempts to model the household's fuel related choices in a two member household setting with asymmetric distribution of decision making power.

3.2. Theoretical model

Consider a representative household comprising of one male and one female member. In each period, the household is endowed with a total income, y. The preference of each member can be expressed using the utility function, U. This utility is assumed to depend on a composite consumption good which is used as the numeraire, and the type of fuel used. Each individual cares only about his or her own consumption. Here, these utilities are denoted using individual concave and twice differentiable utility functions.

$$U_i = u(y - Cp) + \rho_i \theta C \qquad \dots (1)$$

where U_i is a utility function that states the utility derived by an individual $i = \{m, f\}$ using a particular type of fuel related alternative: dirty or clean. $C = \{0, 1\}$ is the share of clean alternative in the total fuel related alternatives used, where if $C=1$ then only clean alternative is used. We assume that dirty alternatives are freely available and that *p* is the monetary price of the cleaner ones. This is a reasonable assumption as in case of most Indian rural households, the dirtier fuel options such as firewood, cow dung cakes and agricultural residue are often gathered and not bought.

u is the consumption utility function such that $u'_y > 0$ and $u''_y < 0$. The perceived value of high health benefits from using clean fuel alternative (or serious health implications from dirty alternative usage) to member i is $\rho_i\theta$, where ρ_i is the valuation of θ, benefits (costs) of using a fuel. Furthermore, it is assumed that θ follows a distribution *F(θ)* such that $\sum_\theta f(\theta) = 1$ and that $\underline{\theta}$ and $\overline{\theta}$ are the lowest and highest possible values of θ, respectively, $\theta \in [\underline{\theta}, \overline{\theta}]$.

In addition, it may be the case that the valuation of benefits obtained by the female household members is greater or at least as much as that of the male members. This may be true because in most cases, it is the female member, who spends more time around the domestic hearth. As a result, at any given level of information, as compared to the male member, she may be more willing to switch to a cleaner alternative. Thus WLOG,

$$\rho_f \geq \rho_m \qquad \text{... (2)}$$

Individuals prefer using clean fuel related alternative to its dirty counterpart if and only if

$$U_i(C = 1) \geq U_i(C = 0)$$

$$\Rightarrow u(y - p) + \rho_i\theta \geq u(y)$$

Solving for θ for a given ρ_i at the margin, gives the following.

$$\theta = \frac{u(y) - u(y - p)}{\rho_i} \equiv \theta_i \qquad \text{... (3)}$$

Where θ_i is the threshold value of θ for an individual i, therefore for $\theta \geq \theta_i$, i prefers clean fuel alternatives.

Therefore, using (2) and (3), the following is obtained

$$\theta_m \geq \theta_f$$

When additional information, θ is given, individual's utility *U* changes conditional on the value of ρ.

In a household with male decision makers, if information is provided to the male decision makers, then the utility function changes as discussed above. In such a case, the expected utility obtained by the female household members can be expressed in the following form.

$$V_f = \int_{\underline{\theta}}^{\theta_m} u(y)f(\theta)d\theta + \int_{\theta_m}^{\overline{\theta}} \big(u(y - p) + \rho_f\theta\big)f(\theta)d\theta \qquad \text{... (4)}$$

For simplicity, it is further assumed that θ follows a uniform distribution, $\theta \sim U[\underline{\theta}, \overline{\theta}]$. Solving (4),

$$\Rightarrow \;\; V_f = \frac{\theta_m - \underline{\theta}}{\overline{\theta} - \underline{\theta}} u(y) + \frac{\overline{\theta} - \theta_m}{\overline{\theta} - \underline{\theta}} (u(y-p) + \rho_f \frac{\overline{\theta} + \theta_m}{2})$$

Now, if information is provided to the female member, then she can convey this additional information using a binary message m, such that m=*{dirty, clean}*.

For an informative equilibrium in this situation, information conveyed by the female household member must result in higher expected utility for the male household member when he listens to her as compared to situations where he doesn't, when $m = clean$. This can be stated as the following.

$$u(y) \leq V_m \, (\theta \geq \theta_f)$$

Where V_m is the expected utility of the male members when the following holds true.

$$u(y) \leq u(y-p) + \rho_m \frac{\overline{\theta} + \theta_f}{2}$$

Solving the above expression, the following is obtained.

$$\Rightarrow \frac{u(y) - u(y-p)}{\rho_m} \leq \frac{\overline{\theta} + \theta_f}{2}$$

Using (3),

$$\theta_m \leq \frac{\overline{\theta} + \theta_f}{2} \qquad \ldots (5)$$

Likewise if

$$\theta_m > \frac{\overline{\theta} + \theta_f}{2}$$

then the female member is never able to successfully convey this additional information.

Within this case, two sub-cases can arise.

Case I: If

$$\theta_m > \frac{\overline{\theta} + \underline{\theta}}{2}$$

Then in the absence of additional information being directly provided to him, the decision maker prefers to use dirtier alternatives. Therefore, the utility obtained by the female member is *u(y),* regardless of the type of message she transmits. In such situations, information given to the female member yield higher utility to her if

$$u(y) \geq \int_{\underline{\theta}}^{\theta_m} u(y)f(\theta)d\theta \ + \ \int_{\theta_m}^{\overline{\theta}} \big(u(y-p) + \ \rho_f\theta\big)f(\theta)d\theta$$

Solving this,

$$\Rightarrow u(y) \geq u(y-p) + \ \rho_f \frac{\overline{\theta} + \ \theta_m}{2}$$

$$\Rightarrow \ \frac{u(y) - \ u(y-p)}{\rho_f} \geq \frac{\overline{\theta} + \ \theta_m}{2}$$

$$\Rightarrow \ \ \theta_f \geq \frac{\overline{\theta} + \ \theta_m}{2}$$

which is a contradiction. Therefore, additional information can induce switching behavior only when it is provided to the decision making household members.

Case II: If

$$\theta_m \leq \frac{\overline{\theta} + \ \underline{\theta}}{2}$$

Then this implies that the male decision maker prefers to use clean fuel in absence of additional information. However, this situation will never arise as

$$\theta_m > \frac{\overline{\theta} + \ \theta_f}{2}$$

Therefore, if preferences of household members are close enough then giving information to the female household member may result in higher likelihood of switching to cleaner alternatives. In case of identical preferences, giving information to either member results in same outcome. However, if preferences are very different, information must be given to the decision maker.

3.3 Empirical validation

Often more than one individual may have bargaining power in household's fuel related decisions. In such situations, the choice of recipients of 'additional information' may not be unambiguous.

In order to explore the factors determining household choice and effect of additional information, fuel related choices made by households in rural regions of Uttar Pradesh and Kerala were studied over a period of three months. A sample of households belonging to villages in Bijnor district in Uttar Pradesh and Thiruvananthapuram district in Kerala were interviewed in a baseline and a follow-up survey. Households in these regions depended on solid fuels and kerosene for their day to day cooking and lighting fuel requirements. According to the Annual Health Survey 2010-11 Fact Sheet for Uttar Pradesh, 86.2 percent of rural households in Bijnor used firewood, crop residue or cow dung cake as their main source of cooking fuel and 62.2 percent used kerosene as their main fuel used for lighting.

Among these, a sub-sample received additional information regarding costs and benefits of various fuel related alternatives. Mode of information dissemination may also affect household's receptiveness to the supplied information. Earlier studies based on energy conservation suggest that different ways of information dissemination affect household behaviour differently (Hyes and Cone, 1977, Journal of Applied Behavior Analysis; Van Houwelingen and Van Raaij, 1989, Journal of Consumer Research). Therefore, the information provided in these villages was further varied by the recipient and mode of information dissemination to help capturing the difference in choice outcomes due to both the mode of spreading information as well as the gender of the household member.

4. Research Questions and Methodology

4.1. Questions

(i) If households that receive information will switch to cleaner fuel related alternatives as compared to those who do not receive any information.

(ii) Among households who receive information, whether adoption of cleaner alternatives in households given more intensive form of information will be higher.

Our theoretical model predicts that when preferences are very similar, giving information to the female member would result in higher uptakes. It is assumed that the male member is the sole decision maker however this may not be always true. Also, we do not know if preferences of the non-decision making members are similar to that of the decision makers.

(iii) Whether provisioning information to female members will result in higher uptake levels of cleaner alternatives relative to uptake levels when the same information is given to male members.

(iv) If levels of bargaining power of female members affects uptake levels of cleaner alternatives in households in which female members receive information

(v) Household members with greater say may also have greater access to the household's financial resources. Therefore, whether informing female members will result in higher adoption levels of expensive alternatives such as LPG connections, solar lanterns etc. vis-à-vis informing male members.

4.2. Methodology

These hypotheses will be tested using data collected during the field experiments. In particular, information regarding the fuels and related alternatives used by the households, amount of time that households spend using various types of fuels and appliances, stated reasons for the usage, frequency of usage will be used to determine the fuel/ alternative usage pattern. Other variables that describe the availability and price of the alternatives, demographic characteristics, individual's intra-household bargaining power and preferences/ perceptions will be used to explain the ex-ante variation in the usage.

Intra-household bargaining power of members will be measured using indices constructed using data collected on household decision making, perceptions on domestic violence, education levels, work status, ownership of assets and mobility constraints. An index of decision making will be constructed based on who takes household decisions. Higher scores will be assigned when respondent is a part of the decision making process. In particular, in cases where the respondent is the sole decision maker, 1 points will be assigned; in case of joint decisions including the respondent, 0.5 point will be assigned and 0 point will be given in cases where the respondent is excluded from the decision making process. Scores for household decisions on various aspects will then be aggregated to construct an index for decision making. Similar indices on mobility and perceptions on domestic violence will also be constructed depending on how often the female respondents are able to go out of the dwelling to perform various tasks and respondents opinions on domestic violence respectively. Ownership of assets, education and work status can be further used as proxies for bargaining power.

Impact of the information on the fuel related practices will be measured using regression analysis such as difference-in-differences. As previously mentioned, the dependent variable will be the pattern of usage of fuel related alternatives. Furthermore, these will be of two types, namely discrete and continuous. Uptake of new alternatives will be captured using the discrete choice models whereas changes in existing pattern of usage will be accounted for using fraction of time spent on different alternatives as the dependent variable. Apart from the treatment variable, variables used for explaining the variations in the pattern of fuel associated practices will be used as explanatory variables.

There will also be an attempt to link the observed lung-power to the fuel practices of the household using correlations and regression analysis.

5. Field experiments

5.1. Sampling design

In order to test these hypotheses, households in rural regions of Uttar Pradesh and Kerala were surveyed. In each of these states, one district was first chosen based on logistical considerations such as cost of the survey and availability of enumerators. Bijnor and Thiruvananthapuram were the chosen districts in Uttar Pradesh and Kerala respectively. Two to four blocks were further selected within each of these districts based on the population size of these blocks so that the sample of districts was comparable across the two states. Grampanchayats were then selected from these blocks in each state using weighted random sampling, where weights were the population of each of these Grampanchayats[2]. Roughly 40 households were randomly sampled from each of the selected Grampanchayats in Uttar Pradesh. Only in one of the Grampanchayats, Tisotra, we could survey 20

[2] Number of households or population in each village in Bijnor could not be found therefore weighted random sampling could not be done at village level.

households because of weather and time limitations. Due to issues such as spatial distance between houses, size of the village, geographical limitations, we surveyed roughly 30 households in the Grampanchayats selected in Kerala. Households selected in each of these Grampanchayats usually belonged to a single village randomly picked from these Grampanchayats. In case when a village contained less than 40 households and was a part of a cluster of two villages in the same Grampanchayat with common amenities, equal numbers of households were selected in each village so that the sum was 40.

A sample of 723 households was surveyed. Out of these, 423 households belonged to Kiratpur and Najibabad blocks in Bijnor district. The rest of the households were from Nemom, Perumkadavila, Vellanad and Chiranyinkeezhu blocks in Thiruvanathapuram district[3].

In Bijnor, the list of blocks, Grampanchayats, and villages and their population were obtained from the District Magistrates office, Vikas Bhawan and Block Development office. The District Panchayat office and local self-governance website (http://lsg.kerala.gov.in/) provided us with the same lists in Thiruvananthapuram.

5.2. Survey Instruments

Each of the selected household was administered two questionnaires: 'woman's questionnaire' and 'man's questionnaire'. The former was used to interview the woman in the household who spent most time in cooking related chores. The latter was administered to the husband of the interviewed woman or the male household head in case the husband was unavailable for the survey.

The questionnaires were prepared after a round of pre-pilot and a pilot survey. The woman's questionnaire comprised of questions about the household's fuel related history, perceptions and preference over different fuel and fuel related alternatives, autonomy, health profile of the woman and the household, queries regarding child schooling and child health. The man's questionnaire consisted of questions regarding the household demographic characteristics, household assets and consumption expenditure, apart from questions about household decision making, his perception and preference for various fuel related alternatives.

A village questionnaire was also administered to the Gram Pradhans, school teachers or any other educated individuals in the villages. These questionnaires recorded the village characteristics and amenities available in the village. It also included a section on map, where a map of the village with major landmarks and indicators of social composition of the residing population was drawn. This helped in the randomized selection of the households.

Apart from these questionnaires, anthropometric measures such as height, weight and lung power of the interviewed woman was also recorded. The height was measured using a stadiometer, the weight was measured using a standard Salter scale and the lung pressure was measured using a peak flow meter. One reading each was recorded for the height and weight measures. Respondents were asked to

[3] Detailed list of sampled villages is provided in the Appendix.

blow thrice into the peak flow meter and all three readings were recorded. The maximum of these three readings were to be used for further analysis.

5.3. Baseline survey findings

The baseline survey was conducted in November-December 2012 in Bijnor and Thiruvananthapuram districts in Uttar Pradesh and Kerala respectively. As mentioned before, a male and a female member were surveyed in each of the sampled households. The baseline survey gathered information regarding household's fuel related history, perceptions and preference over different fuel and fuel related alternatives, autonomy of respondents, health profile of the woman and the household, child schooling and child health, demographic characteristics, household assets and consumption expenditure. In addition, anthropometric measures such as height, weight and lung power of the interviewed woman were also recorded. Information about village characteristics and amenities were collected using a village level questionnaire.

We find that most households in our sample used solid fuels for cooking in both Uttar Pradesh and Kerala. Usage of kerosene for lighting purposes was also fairly common in these regions. However, intensity and reasons for these fuel usages differed across the two states.

5.4. Fuel usage

(i) Cooking fuel

Cooking fuels used by the sample households included firewood, cow dung cakes, crop residue, dry leaves and twigs, LPG, biogas, kerosene and electricity for cooking needs. Households in both Bijnor and Thiruvananthapuram used multiple fuels for cooking and lighting requirements.

Firewood and LPG were two main cooking fuel sources reported by households in Thiruvananthapuram. Out of a sample of 300 households, 289 and 218 households used firewood and LPG respectively. Households used firewood to prepare food that took greater duration to cook such as rice, meat and boiling water. Other fuels used by households in Thiruvananthapuram included biogas, kerosene, electricity and dry palm leaves and twigs. 28 households used kerosene to cook food. This was mainly to initiate the combustion of other solid fuels.

Firewood and cow dung cakes were the most frequently used fuels in Bijnor. Only 2 households households sampled in this region used electricity for cooking. One reason may be low access and availability of this source of energy. This is discussed in greater details in the `Access and availability' section. These fuels were often used in combination as firewood gave a good flame and cow dung cakes provided a burnt steady. Wheat chapattis are a part of the staple diet in the region and households preferred cooking these directly on the chulha flame from firewood and/or cow dung. The reasons reported by households for this was taste and texture that this cooking method and fuel imparted. Households substituted firewood with cow dung cakes and crop residue in monsoon and winter respectively. Most households that used LPG reported to use it only as an `emergency' fuel for preparing tea. Very few households used kerosene for cooking. As in the case of households in

Thiruvananthapuram, kerosene was sparingly used in order to initiate the combustion. The cooking fuel usage is summarized in Table 1.

Table 1: Cooking fuel usage

Fuel	Percentage of households using fuel		Percentage of households using as main fuel		Percentage of households using single fuel	
	Kerala	U.P.	Kerala	U.P.	Kerala	U.P.
Firewood	96.33	95.51	81.78	67.14	18.54	5.20
Cow dung cakes	0	86.05	0	30.73	0	0.47
Crop residue	0	1.89	0	0	0	0
Dry leaves/ Palm leaves/ Twigs	6.29	4.73	0	0.47	0	0
Kerosene	9.33	1.65	0	0	0	0
LPG	72.67	36.64	23.84	13.95	1.99	4.49
Biogas	0.99	0.47	0.66	0	0	0
Electricity	14.24	0.47	1.98	0	0	0

(ii) Lighting Fuel

In Thiruvananthapuram, 292 households out of 300 households had access to electricity, whereas, in Uttar Pradesh, only 251 households out of a sample of 423 households had electricity access. This included both legal and illegal power connections households had obtained. Use of kerosene lamps were reported in both UP and Kerala. Duration of use of these fuels, however, differed greatly across these states. Households using kerosene for lighting usually used lamps called *`mitti ki dibiya'*. These were bottles containing kerosene with a wick put through a hole pierced on the lid of the bottle. These lamps emitted smoke and households complained of blackening of dwelling interiors.

In addition to electricity and kerosene, households also reported the use candles and battery charged lamps. Table 2 provides further details regarding lighting fuel usage.

Table 2: Lighting fuel usage

Fuel	Percentage of households using fuel		Percentage of households using as main fuel		Percentage of households using single fuel	
	Kerala	U.P.	Kerala	U.P.	Kerala	U.P.
Kerosene	71.85	79.00	2.32	66.43	2.32	40.66
Electricity	97.33	59.33	93.37	27.42	26.49	0

(iii) Heating Fuel

Fuels used for space heating were recorded only for Bijnor as they were not used in Thiruvananthapuram. Majority of households in Bijnor who used space heating used dry twigs, leaves etc. for the purpose. Other fuels like coal, charcoal, wood, cow dung cakes and crop residue were also used by some households.

5.5. Access and availability

The location of the survey in Thiruvananthapuram had several rubber plantations. Therefore, wood from these trees was the major source of firewood, followed by those from coconut and mango trees. Firewood was both collected as well as purchased. Among 289 firewood using households, 204 households bought this fuel. About 239 households collected firewood and only 6 households both purchased and collected it. On an average, households gathered 50 kg of firewood in a month. The average amount purchased was 48 kg per month. Among households that gathered wood, most owned either homestead or cultivable land. In Bijnor, 404 households depended on firewood for cooking fuel and as many as 163 of these households purchased it. Most frequently used wood in this region included branches of Eucalyptus, Indian rosewood 'Sheesham', mango trees, Populus and Dencha.. The price of wood escalated during monsoons and winters by Rs 100 to 150. Households reported to use a quintal of wood in almost 2 months.

Sampled households in Thiruvananthapuram burnt firewood along with dry coconut palm leaves. These leaves were available abundantly free of cost. A small share of the sampled households in this state reported that they used agricultural residue for cooking. On the contrary, usage of crop residue as cooking fuel was a fairly common practice in Bijnor. Since this district specialized in sugarcane cultivation, agricultural residue such as dried sugarcane leaves was used as fuel during harvesting in winters. Mustard crop residue was also frequently used.

No household in the sample from Thiruvananthapuram used cow dung as fuel whereas a large share of households in Bijnor used it for their daily cooking needs. Of the364 households using cow dung for cooking purposes, 141 purchased it. Households usually used 6 to 10 cow dung cakes a day. The ones that did not purchase but used these dung cakes often owned cattle and prepared these during the winter months. These cakes would then be stored in a dry place either to be used during the year or to be sold in the village.

As mentioned previously, in Thiruvananthapuram, most households in our sample had access to electricity. The official load shedding consisted of 1 hour of power cut per day: half an hour during the day and half an hour during the night. Almost half of these households, however, experienced an additional unscheduled power cut of 2-3 hours each day. Very few households reported power cuts for longer duration. Almost two-thirds of the sample used kerosene lamps as a subsidiary lighting fuel. In Bijnor, the situation looked much grimmer. Although majority of the households had access to electricity, the availability was still low due to long durations of power cut. During winters, households reported 16 to 20 hours of daily power cut, whereas during summers these may increase to 22 hours of power cut a day. Furthermore, the power cut schedule was such that only on alternate weeks, households had access to electricity after dark. In other words, every alternate week, households had to rely on sources other than electricity for their lighting needs. These long durational power cuts are also a reason for households not opting for electricity as a cooking fuel. Due to this low availability, almost all households used kerosene for lighting purposes.

Kerosene was seldom available at stores other than the fair price shops. In rare cases of households purchasing kerosene from these other shops, the per-unit was much higher. The price of kerosene in such cases varied between Rs 40 and 51 in Bijnor, whereas in Thiruvanathapuram, it ranged between Rs 60 and Rs 70. Households preferred to use their limited stock of kerosene for lighting purposes instead of for cooking requirements. This was particularly true for Bijnor as the region suffered from long durations of power cut.

Households in Bijnor that used LPG had to incur an extra cost for transporting the cylinder from the gas agency to their dwelling. Unlike in Thiruvananthapuram, the LPG cylinders were not delivered to the dwellings. Households spent long hours standing in queues at these gas agencies to receive the refills. Table 3 presents detailed information on access and availability of various fuel sources.

Table 3: Access and availability

Fuel used	Per unit price (Rs/ unit)		Availability/ ceiling on quantity		Additional costs incurred	
	Kerala	U.P.	Kerala	U.P.	Kerala	U.P.
Firewood	10-25/kg	4.50/ Kg	None	None	None	None
Cow dung cakes	NA	1-2 /cake	NA	None	NA	None
Crop residue	None	None	None	None	None	None
Dry leaves/ Palm leaves/ Twigs	None	None	None	None	None	None
Kerosene	14/L	16/L	0.5 L	3 L	None	None
LPG	417	480	6 cylinders	6 cylinders	None	Rs 20-60 (transport)
Electricity	Block pricing	230	None	None	None	None

* All numbers are based the reported figures by households

5.6. Fuel related appliances

(i) Cooking appliances

In the sample from Thiruvananthapuram, 64 and 162 households used brick chulhas and mud chulhas respectively. Almost two thirds of these households used such stoves inside their dwellings. 81 households used chimneys in kitchen for ventilation. Almost a third of the households that reported possession of pressure cookers also used them, although frequency of usage varied across households.

In Bijnor, 24 households used brick chulhas. 392 households in the sample used mud chulhas without chimneys and a majority of these used these stoves inside their dwellings. In most cases, these were ill-ventilated spaces. The rest of the mud chulha users used them in open courtyards; however during monsoons and peak winters, they used them indoors. Only seventeen households in the sample used chimneys. 388 households possessed pressure cookers but almost 43 percent reported low usage.

(ii) Lighting appliances

All households in Thiruvananthapuram that had access to electricity used bulbs, tube lights and compact florescent lights (CFL) for lighting needs. Other sources like kerosene lamps were used only during the short duration of power cuts. This trend was reversed in case of the sample from Uttar Pradesh. The most commonly used appliances for lighting were kerosene lamps. 358 household depended on these lamps as their main source of lighting appliance.

Table 4: Fuel related appliances

Appliances used	Percentage of households possessing appliances	
	Kerala	U.P.
Brick Chulha	21.33	5.67
Mud/ Non- brick chulha	54.00	92.67
Mud chulha with chimney	27.00	4.25
Gas stove	72.19	36.64
Pressure cooker	40.39	91.73
Kerosene lamps	71.85	84.63

5.7. Awareness: Perceived costs and benefits

In Thiruvananthapuram, majority of the sample of households that used firewood for cooking stated that they were very satisfied with using it. Availability was the reason for why they preferred using it however almost half of these users were also bothered by the smoke emitted. In the case of LPG users, households preferred using it as it was easily available and easy to use. Households using electricity for lighting requirements were very satisfied with their current arrangement.

More than two-thirds of the sampled households using wood in Bijnor reported that they were not very satisfied using wood for their daily cooking needs. Majority of cow dung using households also did not report to be too happy using cow dung cakes. The main reason for not being very satisfied with wood and dung cakes was the smoke emitted by these fuels followed by blackening of utensils. Availability was the prime reason cited by households for still using firewood and cow dung cakes. Low price of these fuels, taste imparted to food, ease of usage and health benefits were the next commonly stated reasons. Most households using LPG seemed very satisfied with the fuel. Ease of usage was the most frequently stated reason for using LPG. Reduction in cooking time of the food was the reason given by households. However, households still complained regarding high price of LPG.

Majority of households using kerosene for lighting also did not state to be too satisfied with this fuel on due to the smoke emitted by it. However, they still continued using it as it was easily available.

5.8. Willingness to switch

In Thiruvananthapuram, households who did not currently use LPG and did not want to use it in future stated fear of bursting and high price of refilling as their reason for being unwilling to use it. However, as previously mentioned, a very small share of the sample did not use LPG. Households who did not want to use kerosene as a cooking fuel felt that there was sufficient firewood available therefore did not feel the need to use any additional fuel. Most of the households that did not use chimneys during the time of the survey did not want to use these in future.

In the sample from Bijnor, majority of households that did not use LPG as their main source of fuel did not wish to use it in future as well as they found LPG too expensive. It is worth noting that amongst those who wished to switch to LPG in future, most were willing to pay up to Rs 450 per cylinder refill. Households who were not willing to use kerosene cited unavailability as the prime reason for being unwilling to use. The odour emitted by kerosene was the other reason. Most households that did not have chimneys did not think that there was any need for it. Households not wanting to use pressure cookers stated reasons such as the bad taste it impart to food, fear of cooker bursting and gastrointestinal disorders caused by food cooked in pressure cooker, for disliking it.

Most households that used kerosene lamps did not wish to change to alternatives such battery operated LED lights as they did not think that there was any need to change.

5.9. Demographic characteristics of households

In Thiruvananthapuram , about 30 percent of households owned cultivable and homestead land. Among these, ten percent of households owned only homestead land. More than a third of the households stated that their households were included in the BPL (below poverty line) list. They also reported possession of BPL ration cards (pink colored).

53 percent of the sample owned cultivable and homestead land in Bijnor. As in the case of the sample from Thiruvananthapuram, only three percent of the total sample owned only homestead land. Only 20 percent of the sample stated that their households belonged to the BPL list. Even fewer reported to possess a BPL ration card (white coloured).

The religion and caste summary is provided in the table below.

Table 5: Demographic characteristics

Demographic Characteristics	Kerala	U.P.
Religion (%)		
Hindu	61.15	75.89
Muslims	9.12	23.88
Christians	29.73	0.24
Caste (%)		
Scheduled Castes	13.85	30.73
Scheduled Tribes	1.35	0

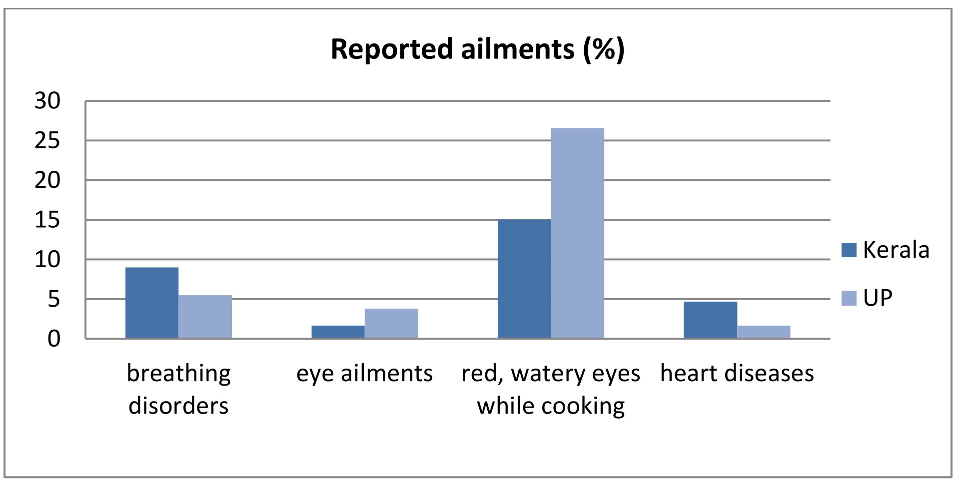
OBC	58.45	43.97

5.10. Reported health status and anthropometric measures

In Thiruvananthapuram, 21.67 percent of the surveyed woman said that they suffered from breathlessness while walking hurriedly on level ground. More than double of this share stated that they felt short of breath when they climbed a slight hill. More than half the sampled women experienced frequent headaches. Almost a third of sampled children below the age of 14 years suffered from headaches and cough. The average BMI (body mass index) for female respondents was 25.66. The mean lung power was 238 L/min. Lung power of at least 300L/min was recorded for 59 respondents. The median lung power was 250 L/min.

30 percent of surveyed women from Bijnor felt breathless when walking on level ground. Similar number felt breathless while hurrying up a slight hill. 41 percent reported that they suffered from frequent headaches. A fifth of the sample also stated that symptoms such as headaches and watery eyes heightened when they spent time around the domestic hearth. Among the children below the age of 14 years from the sampled households, the most commonly cited ailment was fever. The BMI for the female respondents was 21.55. Mean lung power recorded was 206.29 L/ min. Only 30 respondents had a lung power that was at least 300L/min. The median lung power was 200 L/min.

Figure 1: Reported ailments



6. Intervention

The field experiments involved information campaigns in some of the chosen villages. Information campaign included information regarding monetary and health benefits (costs) of various fuel related alternatives. In each of the two states, four villages were subjected to extensive information campaign and another four villages received intensive information campaign. The remaining two villages were the control villages. Under the extensive campaign, surveyed households were given pictorial leaflets explaining the costs and benefits of different fuel related alternatives. These leaflets were stuck to walls within the dwelling with the respondent's permission. This was to enable repeated viewing of the leaflets. The intensive campaign involved one-to-one explanation of these leaflets. In addition, pictorial posters, similar to the leaflets were put around the villages. Information was given to only one individual in the household. Within the households receiving extensive and intensive type of information, half of the recipients were the female respondents and the rest were the male respondents.

In Uttar Pradesh, each village receiving information also received a workshop training households to make smokeless chimney chulhas. The workshops were taken by a master chulha craft-man who taught households to make these improved stoves using materials available locally, i.e., clay, bricks and a chimney. In Kerala, since the type of stoves were different, additional information about the smokeless stoves 'Parishad Chulhas' provided by the Grampanchayat was given.

In Bijnor, provision of information to women was difficult as women in the area were seldom allowed to talk to strangers. So it was made sure that the enumerators who interviewed these women also delivered information. This restriction on mobility also affected the attendance at the stove-making workshops. In addition, since some respondents were not comfortable with reading written material on leaflets, the information given on the leaflets was more pictorial in nature.

In Thiruvananthapuram, providing information was relatively easier as respondents in most cases were aware and able to understand the information regarding the deleterious effects of smoke.

7. Follow-up survey: *Projected timeline*

The findings based on the impact of the information dissemination and comparison of household behaviour will be studied using results from baseline and follow-up surveys. The follow-up surveys have been conducted in Uttar Pradesh and Kerala. The data needs to be digitized and cleaned for further analysis.

8. Potential policy significance of the findings

The findings from this project will help us to determine the most effective channel of information dissemination, both in terms of logistical and cost feasibilities. This will help to improve design of outreaching programs and information campaigns.

The findings will also determine the kind of fuels or alternatives to be promoted in these regions based on the price and availability data. Alternatively, this may help in identifying the supply constraints for fuel related alternatives faced by the households.

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Appendix

Table 5: The villages surveyed in Bijnor and Thiruvananthapuram are as following.

Villages and Gram-panchayats surveyed in Bijnor district	***Villages and Gram-panchayats surveyed in Thiruvananthapuram district***
Harchandpur, Harchandpur Grampanchayat	Ottasekharamangalam, Ottasekharamangalam Grampanchayat
Pundrikhurd and Barkatpur, Pundrikhurd Grampanchayat	Keezharoor, Aryancode Grampanchayat
Nagal Soti, Nagal Soti Grampanchayat	Velappil, Velappil Grampanchayat
Abul Fazalpur Tabela, Sadatpur Grampanchayat	Vilavoorkal, Vilavoorkal Grampanchayat
Rasolpur Sayyed, Rasolpur Sayyed Grampanchayat	Perumkadavilla, Perumkadavilla Grampanchayat
Bhaguwala, Bhaguwala Grampanchayat	Moongode, Malayinkeezhu Grampanchayat
Vijaypur, Vijaypur Grampanchayat	Amboori, Amburi Grampanchayat
Gauspur, Tayyabpur Gorwa Grampanchayat	Blaavatty and Vazhichal, Kallikad Grampanchayat
Padla, Padla Grampanchayat	Kulathummal (Killi), Katakada Grampanchayat
Bagumpur Saadi, Bagumpur Saadi Grampanchayat	Anchuthengu, Anchuthengu Grampanchayat
Tisotra, Tisotra Grampanchayat	

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