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Factors associated with sustained use of improved solid fuel cookstoves: A case study from Kenya

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ABSTRACT

Improved solid fuel cookstoves have been a focus of development efforts to address health and environmental problems caused by traditional cooking practices in Kenya. However, a review of Kenya's experience in promoting improved solid fuel cookstoves shows that the focus has been on (increasing) production and dissemination of improved cookstoves, overlooking the fact that some of the disseminated cookstoves are used less regularly or even abandoned. This study examines factors that influence the usage rate of improved solid fuel cookstoves, drawing on a survey of cookstove users conducted in Kenya through a project implemented by the African Centre for Technology Studies (ACTS) and The Energy and Resources Institute (TERI). The results show that sustained use of improved solid fuel cookstoves over time is significantly predicted by awareness creation activities and reputation of the new cookstoves among community members. These insights suggest that cookstove-disseminating organisations should pay attention to these two factors to ensure sustained use of improved solid fuel cookstoves in Kenya and perhaps other developing countries.

Introduction

Lack of affordable modern energy services is a key development challenge affecting a significant percentage of the global population. As of 2014, about 2.8 billion people worldwide (41% of the world's population) depend on rudimentary and inefficient cooking stoves burning traditional fuel sources, such as unprocessed firewood, cow dung, charcoal and crop residues (Shankar et al., 2014; Kumar et al., 2016). Unmanaged use of traditional cooking fuels has been known to result in adverse health and environmental consequences. Legros et al. (2009: 34) have reported that indoor air pollution (IAP) (mainly from burning traditional solid fuels) results in 2 million deaths every year, making IAP among the leading contributors to ill health and mortality in developing countries.

One way of addressing this challenge has been through large-scale dissemination of improved solid fuel cookstoves in developing countries. Kenya has been a typical example. Improved solid fuel cookstoves development and introduction in Kenya started in the 1980s (Karekezi and Walubengo, 1989). Since then, Kenya has implemented numerous improved cookstove projects, largely assisted or funded by development assistance. Most of these projects emphasised on development, installation and dissemination of improved cookstoves, with little attention to what happens (to the stoves) after initial acceptance by households.

As such, improved cookstove research in developing countries has emphasised on identifying factors that positively or negatively influence the willingness of project beneficiaries to initially accept improved cookstoves (see e.g. Jan, 2012; El TayebMuneer and Mukhtar Mohamed, 2003; Debbi et al., 2014; Lewis and Pattanayak, 2012; Rehfuess et al., 2014). A recent example in the Kenyan context is a study by Mtsami (2010) who has detailed constraints, which hinder adoption of improved solid fuel cookstoves in Wundanyi, Mwatate and Voi districts. Project interventions have often been aimed at meeting such constraints through provision of incentives, awareness campaigns and training of stove producers, and by doing so ensure initial acceptance and dissemination of improved solid fuel cookstoves (see e.g. Silk et al., 2012).

Unsurprisingly perhaps, there has been a historical tendency of measuring the success of cookstove projects by the number of cookstoves disseminated within a specified period, assuming that activities that lead to initial acceptance will also contribute to sustained use over time (Troncoso et al., 2013; Ruiz-Mercado et al., 2013; Pine et al., 2011; Lewis and Pattanayak, 2012). However, this has been indicated to be an unsuccessful strategy, since disseminating cookstoves does not equate with stove acquisition and continued use (Shankar et al., 2014; Ruiz-Mercado et al., 2011). In support of this, Pine et al. (2011:177) have stated that "… successful dissemination leading to widespread use of such stoves is not as easy as simply distributing them throughout communities; many programs to promote these fuel-efficient technologies have failed in the long run because they did not take variations in cultural preferences, local cooking needs, patterns of household fuel use, and other social and economic factors into account."

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Recent evidence suggests that, in the best-case scenarios, households often use their new cookstoves in conjunction with their traditional cookstoves, resulting in failure to reduce exposure to hazardous indoor air pollutants (Piedrahita et al., 2016; Hanna et al., 2013; Ruiz-Mercado and Masera, 2015). Others tend to try them but then abandon them (Hanna et al., 2013).

The policy issue in question should therefore be a little different. It should not only be interested in adoption of cookstoves as measured in terms of initial purchases or take up of an improved cookstove. Instead, the key issue is the degree of sustained use over time (Yadama, 2013). Whether a disseminated stove has been regularly used or abandoned and the factors contributing to such decisions are therefore key issues that need to be explored (Kumar et al., 2016). Whereas there are studies that have monitored cookstove use intensity over time using censor-based stove use monitors (SUMs) (see e.g. Ruiz-Mercado et al., 2011, 2013), socio-economic, institutional, technology and project-related factors, which explain variations in stove usage rates across households, have rarely been investigated.

The major purpose of this study is to provide insights into improved cookstove use patterns and factors that influence cookstove usage rates. It investigates the case of improved solid fuel cookstoves disseminated in Kenya by the African Centre for Technology Studies (ACTS) in collaboration with The Energy and Resources Institute (TERI) and other local partners.

The remaining sections of the paper are outlined as follows. The succeeding section provides a brief background to the study by reviewing the central activities of major stove projects in Kenya from a historical perspective. It also highlights a stove project implemented by ACTS and TERI under which a survey of improved cookstove users is conducted. Section 3 presents the methods of data collection and analysis. Section 4 provides results of the survey that include some descriptive statistics of household socio-economic and stove use characteristics as well as quantitative analyses of factors predicting stove usage rate among Kenyan households. Finally, the last section presents a brief summary of the key results and derives some conclusions.

Background to the survey

Historical overviews on major activities of selected improved solid-fuel cookstove projects in Kenya

Major improved cookstove projects in Kenya emerged in the 1980s, following recommendations of a wood-fuel consumption study in Kenya by the Swedish Beijer Institute. The Beijer Institute's study showed that Kenya's total wood-fuel demand was about 20 million tons per year in 1980, with 7 million tons of this being drawn from unsustainable sources. It also forecast a significant shortfall in the supply of wood-fuel (about 33 million tons) by the year 2000, providing a quantitative picture of the depleting biomass resources of Kenya over time (Hyman, 1985; Karekezi and Walubengo, 1989; O'Keefe et al., 1984). Table 1 summarises key activities of major cookstove projects in Kenya since the early 1980s.

The first major project was the Kenya Renewable Energy Development Project (KREDP), launched in September 1981 by the Ministry of Energy of Kenya. It was funded by the United States Agency for International Development (USAID) and the Government of Kenya. The major goal of the KREDP was to develop and disseminate affordable and simple renewable energy and energy-efficient technologies, such as improved solid fuel cookstoves, to Kenyan households (Jones, 1988).

The KREDP developed the Kenyan ceramic jiko model by adapting the Thai Bucket stove and the Kenyan charcoal-burning traditional stove (Kimani, 1991). Following field-testing of the Kenyan ceramic jiko prototype, the project focussed its attention on large-scale production and marketing of the Kenyan ceramic jiko (Karekezi and Gathoga, 1990).

Table 1
Summary of major improved solid-fuel cookstove projects in Kenya and their major activities.

Launch year	Name of project	Major project activities
1981	Kenya Renewable Energy Development Project (KREDP)	- Improved charcoal cookstove prototype development; - Training of artisans on manufacturing Kenyan ceramic jikos; - Creating public awareness about improved solid fuel cookstoves to entice adoption (stove promotion)
1983	Special Energy Program (SEP)	- Wood-burning cookstove prototype development; - Training of women groups on wood-burning cookstove manufacturing, installation and business management; - Public awareness creation (stove promotion)
1989	Rural Stoves West Kenya project	- Developing portable Jiko/"Maendeleo", a fuel-efficient stove to be used in rural areas: - Training of women to manufacture portable wood-burning cookstoves in rural areas
1995	Upesi rural stoves project	- Manufacturing, distribution, installation and commericalisation of "Upesi stove"; - Training of women on production and installation of "Upesi stoves"
2005	Energising Development Partnership (EnDev) stove Programme in Kenya	- Manufacturing and distribution of "Jiko Kisasa" and "Rocket stoves"; - Market development for efficient cookstoves; - Public awareness campaigning (stove promotion)

It trained selected artisans on Kenyan ceramic jiko production (Hyman, 1985), and undertook publicity campaign to sensitise the public on the importance of adopting improved solid fuel cookstoves (Opole, 1985). It distributed booklets with information on the importance of improved solid fuel cookstoves. The project also sensitized policymakers, district administrators, development workers, and school-teachers through workshops (Kimani, 1991). Simultaneously, the Ministry of Energy undertook demonstrations of Kenyan ceramic jikos at farmers' training centres, agricultural shows and market places (Namuye, 1990).

Another major stove project in Kenya was the Special Energy Program (SEP) that was implemented by the German Agency for Technical Cooperation (GTZ) in collaboration with the Ministry of Energy of Kenya. The major aim of the project was introduction of fuel-efficient rural woodstoves. The project carried out design development research that ultimately resulted in "Maendeleo woodstove" (Karekezi and Ranja, 2002). The program supported women's groups for manufacturing and installation of 'Maendeleo woodstoves'. It also provided basic training to women in business management and marketing to ensure the sustainability of commercial production of improved cookstoves (Karkezi and Ranja, 2002). The project also collaborated with the Ministry of Agriculture's extension officers in home economics and agriculture to promote improved solid fuel cookstoves in rural areas (Karkezi and Ranja, 2002).

A related project with the aim of promoting improved solid fuel cookstoves in rural areas was the Upesi rural stoves project. Supported by the Intermediate Technology Development Group (ITDG), the Upesi project focussed on training women in the production, distribution and installation of 'Upesi stoves' (another name for 'Maendeleo' stoves). Additionally, cookstove promoters were trained to carry out demonstrations and establishing linkages within rural communities. The promoters visited homes, churches, marketplaces, grain milling centres, schools and other public places with the aim of increasing awareness about rural improved solid fuel cookstoves. The project also

sponsored radio promotion in local languages aimed at creating awareness about the benefits of improved solid fuel cookstoves (Okello, 2005; Karkezi and Ranja, 2002).

Rural cookstove projects in the late 1980s and early 1990s resulted in instalment of numerous cookstoves in rural households. However, some households dismantled their cookstoves while others abandoned them (Khennas et al., 1995).

One of the prominent stove projects in Kenya in the 2000s is the Energising Development Partnership Programme (EnDev) rural cookstoves project (Djédjé et al., 2009). Funded by the Netherlands Directorate-General for International Cooperation (DGIS) and implemented by the German Federal Enterprise for International Cooperation (GIZ) (note that previously GIZ was called GTZ), the project commercially introduced improved solid fuel cookstoves to rural areas. The project focused on training women groups in manufacturing "Jiko Kisasa" and "Rocket stoves" (Ochieng and Makoloo, 2009). The program also undertook public campaigning activities through radio advertisement. It also prepared and distributed posters and newsletters regularly.

The brief historical overview shows that Kenya has a long experience of promoting improved solid fuel cookstoves. Early efforts emphasised on development and design of charcoal cookstoves whereas latter projects aimed at designing and introducing rural wood-burning cookstoves. The latter mainly included training of cookstove artisans and women groups and awareness creation about efficient cookstoves. While there has been a clear focus on increasing initial adoption of cookstoves through, for example, public awareness creation, this review suggests that earlier cookstove projects in Kenya did not pay sufficient attention to understand or influence what happens once cookstoves are in the hands of end-users. This is in line with the assessment of Ruiz-Mercado et al. (2011: 7558) who have reported that "… attention [of over 160 fuel-efficient stove programs globally] has concentrated in developing new stove designs, improving large-scale manufacturing process, marketing techniques and financial incentives for stove dissemination. Relatively few efforts have been devoted to understand how stoves are actually adopted and how to sustain their long-term use."

Piloting scalable models for clean energy access project

Above, the major fuel-efficient cookstove projects in Kenya from 1980s to 2015 have been briefly presented. However, Kenya's experience is also replete with smaller stove projects in terms of size of intervention and funding. One of these is a cookstove project implemented by the African Centre for Technology Studies (ACTS) in collaboration with The Energy and Resources Institute (TERI) and other local Kenyan partners from 2011 to 2015, under a DFID-TERI partnership initiative for clean energy access in India and Africa. The project piloted introduction of improved solid fuel cookstoves and lighting solutions among rural, peri-urban and urban Kenyan households. It aimed to increase community awareness and demand and thereby ensure large-scale adoption of improved solid fuel cookstoves by conducting information campaigns, demonstrations and field trials. The project also attempted to ensure cookstove quality by undertaking controlled cooking tests of a variety of cookstove models as well as training stove technicians and artisans in quality productions. The project also held cookstove stakeholder and end-user sensitisation workshops, in collaboration with international and local development organisations and private commercial partners. The project disseminated different types of improved solid fuel cookstoves, which include charcoal-burning stoves, wood-burning stoves as well as gasifier stoves[1] with fan, mobile phone charging and lighting components powered by a solar PV system—also called integrated domestic energy units (IDEUs).

[1] A gasifier stove is a metallic stove that converts wood to combustible gas through intense heat.

At the end of the project, it became apparent that the project had taken essentially the same approach as most other past projects in Kenya, assuming not only adoption but also sustained use would result from project activities. In light of the increasing recognition that more effort is often needed to ensure sustained use of improved cookstoves (Kumar and Mehta, 2016), the project – as part of its overall evaluation activities in its final year – decided to investigate the usage rate of cookstoves amongst improved cookstove adopters in Kenya.

Methodology

A cross-sectional survey was conducted from April to June 2015 in rural, urban, and peri-urban areas of Kenya involving 80 respondents who were randomly selected from 8000 households that bought improved solid fuel cookstoves from the 'Piloting Scalable Models for Clean Energy Access project'.

The household was taken as a unit of analysis for the study. This is because household energy, in particular cooking, is an issue that concerns the entire household. The household head was taken as a respondent of the survey questions while recognising that many household heads in Kenya are men and are not directly involved in cooking activities. Nevertheless, household heads are well aware of their household issues, including cooking characteristics.

The dependent variable for the study was improved cookstove usage rate (in a one-year period before interview date). This variable was measured in a five-scale rating through a 'recall' questionnaire (as Never; Once per occasion; Once per month; Once per week; Regularly (More than once per week); see Table 2). Censor-based stove use monitoring could have been a preferred approach to provide an objective measurement of stove use frequency. However, there is evidence indicating that 'recall' surveys can also offer reasonably consistent data with SUMs (Ruiz-Mercado et al., 2013), suggesting that survey data on stove use intensity can provide useful insights in infrastructure and resource-poor research settings.

Several independent variables, which might predict where stove owners fall in any of the five categories of stove use rate, were included. These are household head gender, household head age, household estimated monthly income, household head education level, household location and household head occupation. Other predictor variables that were included are family size, reputation of the stove among villagers, and awareness creation. Table 2 summarises the definitions and measurement of the dependent and independent variables.

The ranges of intervals in the dependent variable are not equal. However, there is a clear order from the lowest to the highest alternative. In such situations, one of the appropriate econometric techniques to model the relationship between the dependent and independent variables is ordered logit model (Greene, 2003; Winship and Mare, 1984).

The formal ordered logit model specification shows that the ordinal response variable y is an expression of unobserved continuous random variable y^*. Note that in the case of this study, stove usage rate is reported in a scale of 0 to 4 (see Table 2), which may be seen as an approximate measure of actual usage rate y^* under a certain range. Thus the relationship between y and y^* can be specified as:

$$y = \begin{cases} 0 \text{ if } y^* \le 0, \\ 1 \text{ if } 0 < y^* \le \mu_1, \\ 2 \text{ if } \mu_1 < y^* \le \mu_2. \\ \quad . \\ \quad . \\ \quad . \\ j \text{ if } \mu_{j-1} \le y^* \end{cases}$$

where $\mu_1, \mu_2, \ldots, \mu_{j-1}$ are unknown parameters (cutpoints) and j represents response alternatives of the dependent variable.

Table 2
Variables, their definition and measurement.

Variables	Definition	Measurement
Stove usage rate	The rate at which a cookstove is used within a year.	Scale (0 to 4): Never = 0, …, Regularly = 4
Household head gender	This refers to whether a household head is a man or a woman.	Dummy: Female = 1, 0 otherwise
Household head age	The age of a household head in years.	Scale: Below 20 years = 1, …,above 50 years = 5
Household monthly income	Monthly income of a household estimated by the household head.	Scale (0 to 5): Below KES[a] 5000 = 0, …,Above KES 25,000 = 5
Household head educational level	The level of formal education a household head received.	Scale (0 to 4): Unable to read and write = 0, …,Tertiary school and above = 4
Household location	This refers to whether a household is located in urban, peri-urban or rural areas.	Scale (0 to 2): Rural = 0; semi-urban = 1; Urban = 2
Household head occupation	This refers to whether a household head is a salaried employee (having attended an academic study) or not.	Dummy, Non-professional = 0; Professional = 1
Family size	This refers to the number of people living in a household at the time of the survey.	Numbers
Reputation of stove	This refers to whether a stove is popular within a community in terms of its positive attributes, such as cooking speed, fuel efficiency and compatibility to cooking culture of the community.	Scale (0 to 3): Disliked = 0, …, Extremely liked = 3
Awareness creation	This refers to whether awareness creation activities about the benefits of improved stoves, including hazards of IAP, have or have not been conducted (as experienced by the household).	Dummy: Yes = 1; No = 0

[a] Note: 1 Kenyan Shilling (KES) on average equals 0.01 US Dollars during the study period.

The continuous unobserved stove usage rate depends on certain measureable factors x and a residual ε, which can be modelled by a linear regression as:

$$y^* = x'\beta + \varepsilon \quad (1)$$

where x is a vector of explanatory variables, β is a vector of regression; and ε is an error term having a standard normal distribution, i.e. ε ~N (0, 1).

The probability of stove usage rate that a household reports for given values of x can be represented as:

$$Pr(y = j|x) = F\left(\mu_{j-1} < y^* \le \mu_j|x\right) = F\left(\mu_j - x'\beta\right) - F\left(\mu_{j-1} - x'\beta\right), \quad (2)$$
$$j = 0, 1, \ldots, 4$$

where F is the logistic cumulative density function.

A useful feature of interpreting results of an ordered logit model is determining how a marginal change in an explanatory variable causes a change in the distribution of the dependent variable or all the outcome probabilities (Boes and Winkelmann, 2006). The marginal effects of an explanatory variable x on the probability of choosing an alternative j can be specified as:

$$\frac{\partial\, Pr(y = j|x)}{\partial x_i} = \left\{F'\left(\mu_{j-1} - x'\beta\right) - F'\left(\mu_j - x'\beta\right)\right\}\beta_i \quad (3)$$

where x_i represents the i-th element in x.

The data were recorded and organised in Microsoft Excel spreadsheet and processed by Stata software (StataCorp, 2013).

Survey results and discussion

Household socio-economic and educational characteristics

Table 3 summarises descriptive statistics of household head gender, education, age, occupation, and household monthly income and location. It shows that women head nearly half of the surveyed households. About 39% of the household heads have educational qualifications of tertiary school and above whereas 20% cannot read and write. The remaining (41%) have received (some form of) formal education that ranges from basic literacy to secondary school. The data show that about 44% the surveyed households are residing in semi-urban areas whereas 33% and 24% of the households are located in rural and urban areas, respectively. It also shows that about 33% of household heads are over 50 years old while the remaining are in between 20 and 50 years of age. Table 3 also shows that all stove adopters have a monthly income of over KES 5000.

Stove usage rate and other characteristics

Before buying improved solid fuel cookstoves promoted by ACTS and TERI, about 64% of household heads reported that they were using traditional three-stone stoves that burn firewood while 33 respondents (41.3%) stated that they were using ceramic jikos, which burn charcoal. Nine households (11.3%) reported to have relied on paraffin stoves.[2] About 95% of the household heads reported that they buy their cooking fuel. From those who are buying fuel, 64% reported that the cost of charcoal and wood is 'too high' and is increasingly becoming unaffordable to them relative to their income and available resources. The respondents were also asked to characterise the type of stove they bought from the project. The results indicated that from the total of 80 stoves owned by the surveyed households, only 4 (5%) are gasifier stoves, equipped with an electric operated fan, lighting and mobile phone charging components. About 59% of fuel-efficient cookstoves burn charcoal alone, whereas 37.5% burn both charcoal and wood.[3] All households reported that their improved solid fuel cookstoves are in a working condition and have not been broken down since they acquired them.

Table 4 shows that 86% the surveyed households reported to have used their improved cookstove 'regularly'. The majority of household heads also reported that the stoves they are using are well liked among villagers. Additionally, 90% of household heads stated that there have been awareness creation activities about fuel-efficient stoves and their benefits.

Factors influencing usage rate of improved solid fuel cookstoves

An ordered logit regression was run to identify variables that are associated with the rate of improved cookstove usage among the surveyed households. Before variables were entered into the regression, a multicollinearity test was conducted to check the degree of correlation among the nine independent variables set out in Table 2. The analysis showed that household monthly income is highly correlated with household head occupation. Thus, household head occupation is

[2] Some households have indicated more than one option, so the cumulative percentage is greater than100%.

[3] Footenote 2 also applies here. Besides, it is assumed that each household has bought only one improved solid fuel cookstove.

Table 3
Summary statistics of demographic, geographic and socio-economic characteristics of surveyed households.

		Obs.	Percent
Household head gender	Male	41	51.2
	Female	39	48.8
	Total	80	100.0
Household head education	Unable to read and write	16	20.0
	Basic literacy	5	6.3
	Primary school	17	21.3
	Secondary school	11	13.8
	Tertiary school and above	31	38.8
	Total	80	100.0
Household location	Rural	26	32.5
	semi-urban	35	43.8
	Urban	19	23.8
	Total	80	100.0
Household head age, years	Below 20	0	0.0
	20 to 30	12	15.0
	30 to 40	24	30.0
	40 to 50	18	22.5
	above 50	26	32.5
	Total	80	100.0
Household head occupation	Non-professional	52	65.0
	Professional	28	35.0
	Total	80	100.0
Household monthly income, KES	Below 5000	0	0.0
	5000–10,000	37	46.3
	10,000–15,000	11	13.8
	15,000–20,000	5	6.3
	20,000–25,000	7	8.8
	above 25,000	20	25.0
	Total	80	100.0

omitted from the regression. This left 8 independent variables that were included in the final model. Since (the 'standard') ordered logit is a proportional odds (PO) model, the parallel lines assumption should also be checked for unbiased estimates (Long, 1997). By using a user-written 'omdel' command in Stata statistical software (Wolfe, 1997), 'approximate likelihood-ratio test of proportionality of odds across response categories' is undertaken. The results show that the chi-squared test is not significant at *0.01* level ($\chi^2 = 22.64$, $P = 0.54$), suggesting that the parallel lines assumption is not violated, and ordered logit model is reasonably appropriate to analyze the data.

Table 5 shows that the ordered logit model's chi-squared is 22.64 with 8 degrees of freedom, which is also highly significant. It also reveals that despite a significant overall model, only two variables are statistically significant predictors of the rate of fuel-efficient stove use at *0.01* level. These variables are 'reputation of stove' and 'awareness creation'.

The analysis suggests that high level of reputation or popularity of cookstoves is likely to lead to regular use of fuel-efficient stoves. This result can be justified by the fact that popularity of stoves depends on their social acceptance by meeting expectations and needs of local communities. Responses to questions about the positive attributes of stoves, which may have increased their popularity, reveals that 78% of household heads believe that their stoves are 'very attractive' while 74% believe that their stoves' cooking speed is 'very fast'. Nearly all household heads also indicated that their cookstoves are 'compatible' to local cooking practices and culture. Reputation of new technologies and practices may also be positively influenced by favourable opinions among community members, especially from opinion leaders (Rogers, 1995). This is related to the role of 'word of mouth communication', which has been shown to be a key factor in technology diffusion in marketing research (Lang and Hyde, 2013). Word of mouth communication is a situation in which community members communicate about a new technology, practice or service without a commercial motive (Lang and Hyde, 2013).

Awareness creation activities are also positively associated with the rate of cookstove use. This supports the view of Goodwin et al. (2014:9) who have stated that 'behaviour changing techniques', such as 'shaping knowledge' through promotion, can contribute to achieving the goals of improved cookstove interventions, i.e. acceptance, continued and consistent use of fuel-efficient cooking technologies.

Table 4
Summary statistics of stove use level, reputation of stoves and promotion.

		Obs.	Percent
Usage rate	Never	1	1.3
	Once per occasion	2	2.5
	Once per month	2	2.5
	Once per week	6	7.5
	Regularly/more than once per week	69	86.3
	Total	80	100
Reputation of stove	Disliked	3	3.8
	Less liked	2	2.5
	Liked	31	38.8
	Extremely liked	44	55.0
	Total	80	100.0
Awareness creation	No	8	10
	Yes	72	90
	Total	80	100

In addition to coefficient estimates, a marginal effect of independent variables on each category of stove use level is estimated (Table 6). The results show that a unit increment in reputation of a cookstove among villagers (e.g. an increase from disliked to less liked) would be associated with a 9% increase in the likelihood of a new stove being used 'regularly'.

On the other hand, a unit increase in the awareness creation variable (i.e. promoting stoves through awareness campaigns, demonstrations, field trials etc. as compared to not conducting such activities) would be associated with a 21% increase in the likelihood of improved solid fuel cookstoves being used 'regularly'. This result suggests that cookstove promotion activities, which are a prominent feature of major cookstove projects in Kenya to entice initial uptake, also have a positive influence on regular use of improved solid fuel cookstoves. This finding is also in line with a recent enthusiasm about promotion as an important activity in relation to sustained adoption of improved solid fuel cookstoves and its measurement (Kumar and Mehta, 2016).

Concluding remarks

Governmental and non-governmental organizations have been promoting improved solid fuel cookstoves in Kenya since the 1980s. A review of selected improved cookstove projects shows that the emphasis has been on developing new cookstoves, building the capacity of local stove manufacturers and creating public awareness to ensure dissemination of stoves. However, there is an increasing awareness among clean cooking sector practitioners that ensuring regular use

Table 5
Ordered logit estimation of the predictors of stove usage rate.

	Coef.	Std. err.	P > z	95% Conf. interval	
Household head age	0.11	0.41	0.80	−0.70	0.92
Household head gender	−1.90	1.19	0.11	−4.24	0.44
Household monthly income	−0.64	0.40	0.11	−1.43	0.15
Household head education	−0.08	0.45	0.86	−0.96	0.81
Household location	−0.07	0.65	0.92	−1.33	1.20
Family size	0.29	0.17	0.09	−0.05	0.62
Reputation of stove	1.75	0.57	0.00	0.63	2.87
Awareness creation	4.29	1.33	0.00	1.68	6.89
/cut1	1.58	2.72		−3.76	6.91
/cut2	2.80	2.59		−2.28	7.88
/cut3	3.42	2.58		−1.64	8.49
/cut4	4.61	2.63		−0.56	9.77
Number of obs	80.00				
LR chi2(8)	22.64				
Prob > chi2	0.00				
Pseudo R2	0.25				

Table 6
Marginal effect estimates of variables on stove usage rate.

	Never	Once per occasion	Once per month	Once per week	Regularly
Household head age	0.00	0.00	0.00	0.00	0.00
Household head gender	0.01	0.01	0.01	0.06	−0.09
Household monthly income	0.00	0.00	0.00	0.02	−0.02
Household head education	0.00	0.00	0.00	0.00	0.00
Household location	0.00	0.00	0.00	0.00	0.00
Family size	0.00	0.00	0.00	−0.01	0.01
Reputation of stove	0.00	−0.01	−0.01	−0.07	0.09*
Awareness creation	−0.01	−0.03	−0.03	−0.14	0.21*

Note: Marginal effects are estimated at the mean values of all independent variables.
* Statistically significant at *0.05* level.

of improved cookstoves—and thereby attaining their maximum environmental and health benefits—is as important as ensuring their initial acceptance and commercialisation (Kumar and Mehta, 2016). While existing research provides insights into the determinants of initial uptake of improved cookstoves, it is becoming increasingly clear that such factors that enable or hinder 'short-term' adoption are likely to be different from those influencing sustained use over time (Rehfuess et al., 2014). It is therefore important to understand the degree of stove use intensity and its influencing factors. It is with this objective that a survey was conducted involving 80 randomly selected improved cookstove users of a stove project implemented by the African Centre for Technology Studies (ACTS) and The Energy and Resources Institute (TERI) in Kenya.

The survey collected data mainly on nine socio-economic and other factors, which were expected to influence stove usage rate. Ordered logit regression analysis of these factors showed that reputation of stoves among villagers and awareness creation activities are statistically significant factors. Contrary to expectations, the remaining variables turned out being statistically insignificant. There might be other factors, such as cost and availability of fuels, which are not included in this study. Yet, the results – in and of themselves – raise interesting insights for researchers, policymakers and cookstove practitioners to move from initial acceptance to sustained use of improved cookstoves.

Estimated marginal effects of a unit increase of undertaking awareness creating activities and increasing the reputation of improved solid-fuel stoves would increase the likelihood of regular stove usage rate by 21% and 9%, respectively. It is therefore vital that stove-promoting organizations ensure high level of awareness and positive reputation of improved solid fuel cookstoves among community members to ensure sustained use of improved cookstoves. Specifically, improved cookstove promoters should raise community awareness about the benefits of adopting improved cookstoves and continued use through, for example, targeted messages on fuel-efficiency and associated economic and environmental benefits as well as hazards associated with IAP from traditional stoves. Practitioners may also focus on increasing the popularity of stoves by maximizing the 'aggregate' effect of positive-attributes of cookstoves, such as high fuel efficiency, high cooking speed and cultural compatibility. Besides, improved cookstove promoters may work with local influential individuals to leverage on their role as opinion leaders and by doing so increase the reputation of cookstoves.

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