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Adoption and Utilization of Improved Cookstove in Ghana

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Abstract:
Half of the world's population cooks with inefficient cookstove that run on biomass fuel such as wood, dung, and charcoal. These pose serious health risks to users because they emit excessive smoke due to incomplete combustion. Regardless of commitments by government and civil society organizations to scale up adoption and utilization of improved cookstove in Ghana, the market share is low, approximately 5% of the total cookstove market (GACC, 2012). One key challenge confronting actors in the cookstove program in Ghana is absence of empirical studies on factors that influence adoption and utilization and this study seeks to fill this gap. The study was cross-sectional nature based on primary data collected through a survey process at the study area. The study area comprised six towns in the Ejisu-Juaben Municipality, namely, Ejisu, Juaben, Asotwe, Besease and Anwomaso. A sample size of 400 households was used for the purpose of the study. It was evident that adoption of improved cookstove was negatively influenced by household size and positively by composition of adult females in the household. On the issue of utilization or frequency of use, the main influencing factors were income correlates such as household income, number of income-earning members in the household and the level of education of household head. All these factors reduced frequency of utilization because they facilitated households' ability to provide other improved means of cooking.

Keywords: *adoption, utilization, improved cookstove*

1. Introduction

Half of the world's population cooks with inefficient cookstove that run on biomass fuel such as wood, dung, and charcoal. These pose serious health risks to users because they emit excessive smoke due to incomplete combustion (Vahlne and Ahlgren, 2013). Poverty, reduction in quality of life, environmental degradation and pollution are some resultant effects of prolonged use of inefficient cookstove for simple but necessary activity of cooking (Levine et al., 2013). The worst effect associated with utilization of unimproved cookstove is increased life lost. It has been estimated that two million people die annually from cooking related illnesses worldwide (Bailis et al, 2009).

In sub-Sahara Africa and South East Asia, it is estimated that solid fuels are used in 90% of homes (Bailis et al, 2009). Specifically, in about eight countries of the West African sub-region, solid fuel accounted for 95% of fuel utilization. In effect, over 39 million people in these regions are affected by household air pollution, which results in more than 215,000 deaths annually (Kimble, 2012).

At the global level, various interventions have been employed to scale up utilization of improved cookstove to mitigate deforestation, domestic pollution and ultimately improve quality of life (Muneer and Mohamed, 2003;Vahlne and Ahlgren, 2013). These interventions are not new and could be traced to the 1970s when the relationship between household fuel use and deforestation was established, though in recent times the focus has been on the negative health effects of solid fuel utilization (Bailis et al, 2009).

Countries and organizations are gradually embracing adoption of improved cookstove as a way of reducing cooking-induced illnesses, mortality and environmental degradation (Bailis et al, 2009). There are at least 160 cookstove programmes on-going across the world (Kshirsagar and Kalamkar, 2014). These programmes differ in type of stove distributed, size, scope, design and financial mechanism. Some of the programmes were self-financed while others were financed through Clean Development Mechanism (CDM) and the Gold Standard (Ruiz-Mercado et al., 2011). Despite the plethora of programmes only a few households have adopted improved cookstove (Levine et al., 2013).

The slow adoption of improved cookstove has generated extensive interest in research all over the world (Fitzgerald et al, 2012). These include factors that influence adoption in the global south regions such as India, South America and Africa (Bielecki and Wingerbach, 2013; Aggarwal and Chandel, 2004; Muneer and Mohamed, 2003). Other studies have also focused on impact of cookstove in reducing indoor air pollution and its influence on sustainable use and distribution (Bailis et al., 2009) (Smith, 1994 ; Bruce et al, 2004; Dutta et al.,2007; Chengappa et al., 2007; Cynthia et al.,2008) (Ruiz-Mercado et al., 2011),

Regardless of the extensive research on improved cookstove, the question of adoption is an unsettled debate in the empirical literature. This could be attributed to preferential differences across various locations globally. For instance, in Mexico, payment structure for cookstove did not influence adoption however some socioeconomic household factors such as income positively correlated with adoption though age and educational variations did not (Troncoso et al (2007). In a similar study in rural Pakistan, it was concluded that education and household income were the most significant factors that affected adoption in 100 randomly selected households, (Jan 2012). Likewise, in Ethiopia adoption had increased considerably in urban towns for the *Mirte* and *Lakech*cookstove products, price, household income and household wealth were the most important factors affecting the rate of adoption (Beyene and Koch 2013).

Other researchers were of the view that the outstanding factor that showed variation in adoption was fuel savings (Ruiz-Mercado et al. (2011). Another school of thought stated strongly that adoption would increase if the macro level triple benefit of preserving the ecosystem, improving the health of users and reducing greenhouse gases are adapted to include provision of heat and light (Bielecki and Wingerbach 2013). This could be attributed to the fact that stoves surveyed were found to have other very important use such as providing light and heat in the evening for social gathering.

Additionally, adoption of improved cookstove could facilitate achievement of Millennium Development Goals on child mortality, maternal health, gender equality, poverty eradication and environmental sustainability (Cordes, 2011). Several factors such as modernity, speed of cooking, convenience, compatibility with local cooking practices, pollution related issues, occupation, income and education were predictors of adoption (Ruiz-Mercado et al., 2011),

In a discussion paper on determinants of household choice of fuel in Ethiopia, it was established that family size affected the choice of fuel use at the household (Mekonnen and Köhlin 2008). They argued that the choice of non-solid fuels correlated negatively with family size and the square of the family size variable, which implied a probable non-linear relationship between fuel use and family size. The implication was that as family size increased, the probability of using non-solid fuels fell albeit disproportionately. They also established that the likelihood of choosing a fuel type did not depend on the composition of adult females in the household.

Efforts to introduce improved cookstove in Ghana dated back to the early 1990s with the *Ahibenso*cookstove programme initiated by the government of Ghana through the then Ministry of Mines and Energy in their quest to promote efficient cookstove (Atakora and Brew Hammond, 1999). It was estimated that by 1993 approximately 40,000 cookstove had been disseminated by the programme.

After the *Ahibenso* stove was rolled-out, a new cookstove brand called *Gyapa* was introduced in 2002 by Enterprise Works, a division of Relief International. By 2006, 200,000 units of the *Gyapa* stove had been sold out and the brand is still a favourite in Ghanaian households (Kemasour et al., 2011). Currently, Ghana is home to many improved cookstove producers that have each scaled to tens of thousands of cookstove annually (GACC, 2012).

1.1. Problem of the Study

Regardless of commitments by government and civil society organizations to scale up adoption and utilization of improved cookstove in Ghana, the market share is low, approximately 5% of the total cookstove market (GACC, 2012). One key challenge confronting actors in the cookstove program in Ghana is absence of empirical studies on factors that influence adoption and utilization and this study seeks to fill this gap.

1.2. Study Objectives

The study was addressed to investigating socio-economic and demographic characteristics of households and how they affect:

i. Adoption of improved cookstove
ii. Frequency of use of improved cookstove

2. Materials and Method

2.1 Type of Study

The study was cross-sectional in nature and it was based on primary data collected through a survey process.

2.2. The Study Area

The study area comprised six towns in the Ejisu-Juaben Municipality, namely, Ejisu, Juaben, Asotwe, Besease and Anwomaso. The Municipality was selected for the study because it is fast expanding as a result of growth spill-over from its adjoining Metropolitan city of Kumasi (the second largest city of Ghana). The population of the Municipality was 143,762 with females constituting 52.2 percent (GSS, 2013). Also the Municipality has a total of 33, 078 households with 70 percent been rural. The average household size per household was 4.3, which means that on the average a household was made up of four members. The Municipality was quite diverse in terms of ethnicity, urbanization, economic activity and infrastructure.

2.3. Sampling and Sample Size Determination

Household, which constituted the sampling units for the study, is defined as the number of people living together under one roof and having the same catering arrangements (GSS, 2013).

In the case of this study, the research team could not obtain the list of households in the Municipality to serve as the sampling frame. For this reason purposive sampling was adopted. Six communities reflecting diversity in location, population size and function were carefully

selected. In each community, as many households who were interested and willing to participate in the study were interviewed until a sample size of 400 was obtained. The respondents were basically household heads or spouses and in some situations adult members of the households who have been part of the household for a period of at least six months were interviewed in the absence of household heads or spouses.

2.4. Data

Data collection was carried out by use of questionnaire. The Questionnaire was designed by the research team at various consultative sessions and was piloted at one of the suburb communities in the Municipality on one hundred households. After the pilot process, all shortfalls were corrected before its final adoption for the main data collection exercise. The data collection was conducted over a period of ten days at a time when it was possible to meet heads of household heads or at least their spouses at home. Direct interviews were conducted by the research team to elicit the data from the respondents.

Descriptive measures such as graphs, tables and frequencies and categorical-dependent regression models were used for the data analysis. Specifically, Binary Logistic and ordered logistic Regression models were used to explain adoption and frequency of use of improved cook-stove respectively. The variable of interest for adoption was based on the question "do you have a clean cook-stove at home?" with two level responses "yes" or "no". The predictors included educational level of household head, employment sector, availability of kitchen facilities, ownership of house, household size, and number of adult females above 15 years in the household and household average weekly expenditure. Apart from household size and number of adult females in the household, all the other predictor variables were nominal.

On frequency of utilization of improved cookstove, the dependent variable was based on the question "how often do you use your clean cookstove?" with three levels of responses "Everyday" "once a week" and "depending on the kind of meal". The explanatory variables were household characteristics, including household size, number of adult females in the household, kitchen facilities available, ownership of household accommodation, number of income earners in the household, weekly expenditure, level of education of household head, utility arrangement, and employment status.

3. Results

3.1. Descriptive Measures

Table 1 shows the status of the respondents interviewed within the households. Almost three-fifths were either heads of households or spouses whilst the remaining were other adult members of the households. The average household size was almost six (5.9), which were much larger than the municipal average (4.3) (GSS, 2010). Also, there was, on the average, three adult females per household. With regards to employment status of household heads, a little more than a quarter (27.25%) were employees of formal organizations in both the private and public sectors whilst a little over two-thirds (70%) were self-employed. On educational attainment of household heads, more than half (57.50%) had attained at most basic education and 38.25% had attained at least secondary-level education. The rest had not attained any formal education. A little over a quarter of households (27.32%) have improved cookstove and more than four-fifth of households of this population use them every day.

Category	Frequency	Percentage	Cumulative percentage
Status of respondents in household			
Household head	168	42.00	42.00
Spouse	125	31.25	73.25
Other adult members	103	25.75	99.00
Missing	4	1.00	100
Type of employment			
Formal employee	109	27.25	27.25
Others	280	70	97.25
Missing	11	2.25	100
Education			
Second cycle and above	153	38.25	38.25
Other	230	57.50	95.75
Missing	17	4.25	100
Availability of improved cook stoves			
Yes	109	27.32	27.32
No	290	72.68	100
Frequency of use of improved cookstove			
Everyday	93	80.67	80.67
Once a week	7	6.09	86.76
Depending on the type of food	10	8.69	95.45
Other	5	4.35	100

Table 1: Characteristics of Household and Respondents

Figure 1 showed that charcoal and LPG were dominant fuel-types in the area. Also Figure 2 showed fuel-use in relation to household size. It was evident that variations in household size affected fuel-use. For example, as household size increased from small to medium-size, the use

of firewood correspondingly increased, but as household size increased from medium to large, the use of firewood declines slowly. However, the use of all other fuel-types including LPG, charcoal and electricity fell as household size increased.

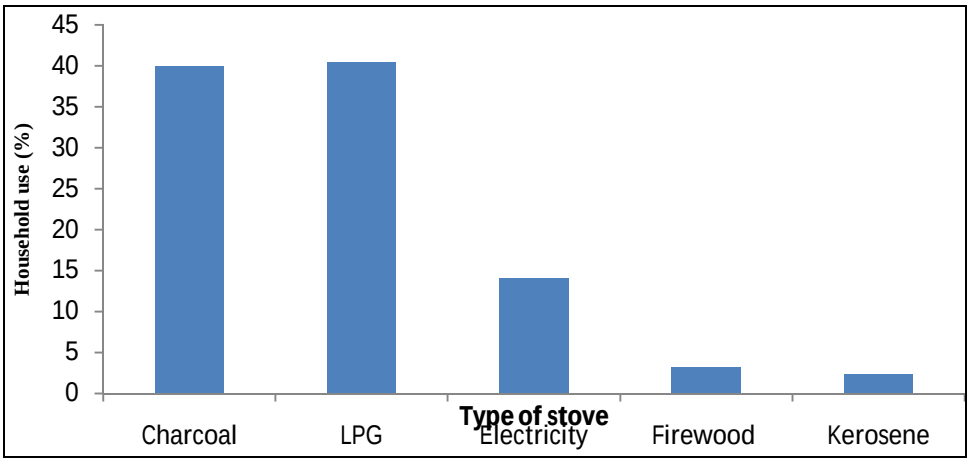

Figure 1 Fuel Use in Study Area

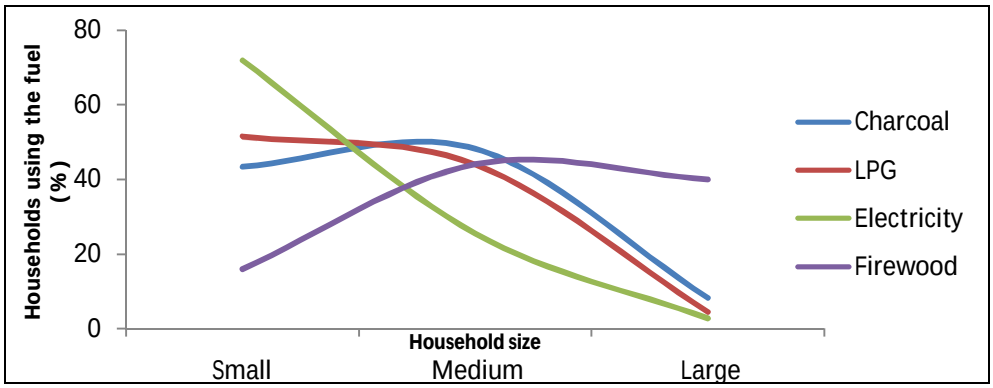

Figure 2: Household Sizes in Relation to Fuel-Use

Figure 3 showed that almost a third of households in the study area had improved cookstove. Further descriptive analysis of households' adoption of improved cookstove based on two key household characteristics such as education and employment of the head of household showed very interesting results. A higher proportion of households whose heads had higher education have improved cookstove as compared to households whose heads had a basic level education.

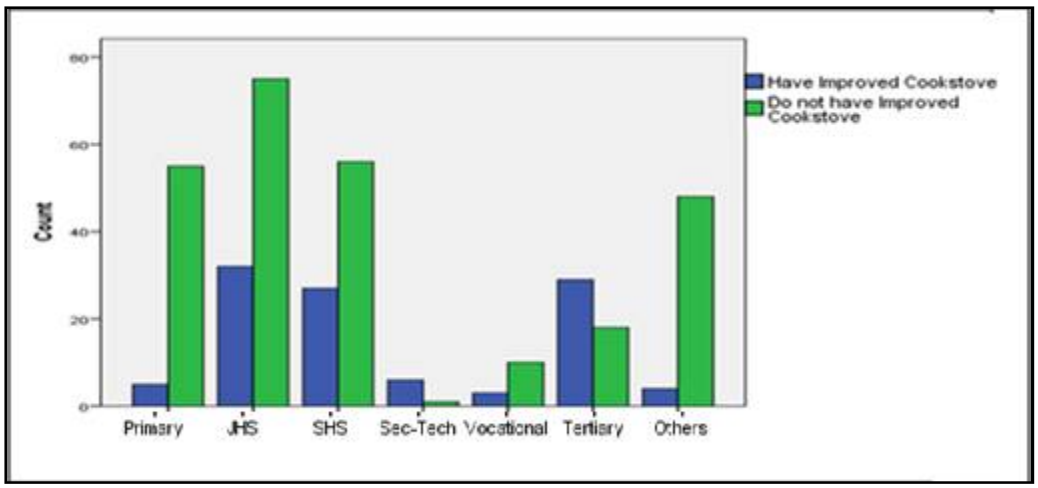

Figure 3: Educational Level and Cookstove Ownership

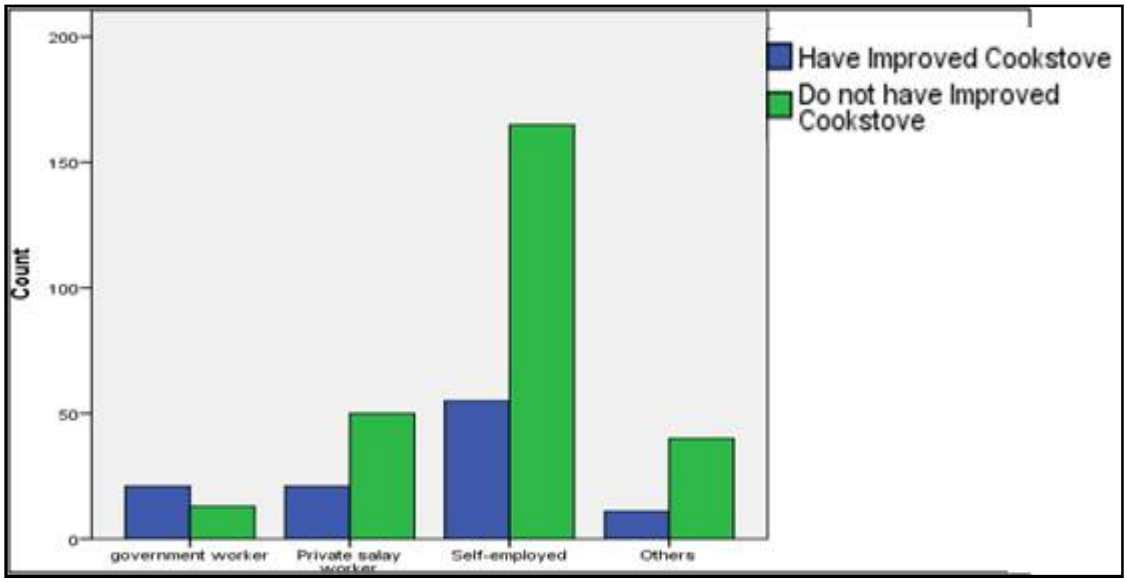

Figure 4: Employment Status of Household Head and Possession of Cookstove

Ownership of improved cookstove was high among government workers and private salary workers. The proportion of the "haves" among salary workers was relatively higher than among the self-employed. The type of employment of the household head did improve ownership of improved cookstove as indicated in (Figure 4).

3.2. Regression Models

Table 2 shows the results of the binary logistic model on the relationship between adoption of improved cookstove and household characteristics. Adoption was measured by availability of an improved cookstove in the household. The full model was significant ($prob>Chi^2 = 0.0022$; $p<0.05$). The outcome of the analyses revealed that family expenditure and level of education of household heads did not influence adoption of improved cookstove. However the number of adult females in a household was directly related with the adoption of improved cookstove. That is as the number of adult females in the household increased, the probability of adoption increased by 4 percent, all things remaining the same ($p<0.040$; Table 3).

The size of household negatively correlated with adoption of improved cookstove. An increase in the the size of household by one additional member reduces the likelihood of adoption of improved cookstove by a probability of 3.1 percent ($p<0.031$, Table 3).

Also employment in the formal sector was positively related with adoption of improved cookstove. Employment in the formal sector by a household head increased the likelihood of adoption of improved cookstove by a probability of 10.1% as compared to working in non-formal employment all other variables remaining unchanged ($p<0.101$, Table 3).

Finally households living in their own houses were more likely to adopt improved cookstove as compared to their non-owner occupied households. That is, owner-occupied households was more likely to adopt improved cookstove by a probability of 9.6% as compared to non-owner occupied households, all other things remaining unchanged ($p<0$ .09605, Table 3). .

Variable	Coeff	Std Error	Z	*P>z*	95% CI	
Household size	-0.17334	0.073184	-2.37	0.018	-0.3168	-.029909
Number of Adult females	0.22145	0.10636	2.08	0.037	0.01298	0.429917
Weekly household expenditure	-0.01201	0.144361	-0.08	0.934	-0.29495	0.270936
Level of education	-0.00511	0.011952	-0.43	0.669	-0.02853	0.018316
Formal employment	0.560156	0.276182	2.03	0.043	0.018849	1.101464
Residence ownership	0.531728	0.263201	2.02	0.0158	0.015863	1.047594
Constant	-1.02499	0.443885	-2.31	0.021	-1.89499	-0.154994

Table 2: Binary Logistic Model on Household Adoption of Improved Cookstove
$Prob>chi^2 = 0.0022$; LR Chi^2 (6) = 20.52

Variable	Marginal effect	Std Error	Z	*P>z*	95% CI	
Household size **	-0.03131	0 .01290	-2.43	0.015	-0.05660	-0.00602
Number of Adult females **	0.04001	0.01884	2.12	0.034	0.00308	0 .07693
Weekly household expenditure	-0.00217	0.02608	-0.08	0.934	0.05328	0.04894
Level of education	-0.00093	0.00216	-0.43	0.669	-0.00515	0 .00331
Formal employment **	0.10119	0.04888	2.07	0.038	0 .00539	0 .19699
Residence ownership **	0 .09605	0.04662	2.06	0.039	0.00468	0.18741

Table 3: Marginal Effects of Household Adoption of Improved Cookstove

3.3. Utilization of Improved Cookstove

Results of ordinal logistic regression of how characteristics of households explained the frequency of use of improved cookstove was shown in Table 4. The was a direct relationship between household size and frequency of use of improved cookstove. However, number of income earners and educational level of household heads were negatively related with frequency of use.

Specifically, the results showed the following, that all things remaining the same:

i. an increase in household size by an additional person favored the odds of using improved cookstove frequently by 120%.
ii. when the number of income earners in the household increased by one additional income earner, the odds of using improved cookstove frequently reduced by almost 24%,
iii. households whose heads have levels of education above basic education were 52% less likely to use improved cookstove frequently than their counterparts with basic education and below

Frequency of use of improved cookstove	Odds Ratio	Std. Err.	z	P>z	[95% Conf. Interval]	
Household accommodation						
Owner-occupied household	0.637	0.197	-1.46	0.145	0.347	1.168
Household population						
Household size**	1.298	0.123	2.76	0.006	1.079	1.562
Adult females	0.871	0.099	-1.21	0.226	0.696	1.089
Number of income earners**	0.763	0.095	-2.18	0.029	0.598	0.973
Education						
Higher education**	0.476	0.149	-2.37	0.018	0.257	0.879
Weekly expenditure						
51-100 cedis	0.981	0.327	-0.06	0.955	0.511	1.885
101-200 cedis	1.734	0.763	1.25	0.211	0.732	4.106
Above 200 cedis	0.545	0.320	-1.03	0.301	0.172	1.724
Employment status						
Private salaried	2.420	1.194	1.79	0.073	0.919	6.365
Self employed	2.172	1.004	1.68	0.093	0.877	5.376
Others	2.751	1.734	1.61	0.108	0.800	9.459
Type of kitchen facility	1.366	.574	0.74	0.459	0.599	3.113
Share utilities	0.776	.258	-0.76	0.446	0.404	1.489

Table 4: Ordinal Regression on Frequency of Use of Improved Cookstove
Prob>Chi sq = 0.00003; LR Chi Sq (14) = 39.79; Pseudo R sq = 0.092

4. Discussion

The study indicated that less than a third of households (27.3%) in the Municipality have improved cookstove at home. This reflected a low level of adoption considering the merits of saving fuel, minimizing health risk and preserving the environment offered by improved cookstove.

The main factors that influenced adoption were household composition, characteristics of household head, employment-type and wealth status of households. Household composition was measured by household size and composition of adult females in the household. Characteristics of the household head were measured by type of employment whilst household wealth was measured by household housing ownership.

Household size negatively affected adoption of improved cookstove. That is, when household size increased, the probability of using improved cookstove fell, all things remaining unchanged. This was not consistent with (Meakonnen and Köhlin 2008) who argued that an increase in the size of household reduced the choice of non-solid fuel. The difference here was that the study did not query the type of cookstove and associated fuel-type that households were prepared to use in place of improved stove.

Although no study in the empirical literature was cited as proffering concrete explanations for the relationship between household size and fuel-type utilization; this study could attribute it to traditional cultural antecedent that over the years have shaped the traditional practices associated with cooking to feed large households. These antecedents may include the mode and volumes of cooking for a large number of people as well as rigidities associated with adapting to new cooking practices. If improved cookstove on the market were not large enough to optimize process of cooking for large households, it may affect adoption negatively. That is if cookstove sizes would compel large households to cook in batches, then it would not be worthy for large households to adopt it.

Secondly, the study established that as the number of adult female in a household increased, adoption of improved cookstove also increased all things remaining the same. This was in contrast with the findings of the study, that the adult female composition of the household was not a significant predictor of fuel use (Mekonnen and Köhlin 2008). In Ghana, cooking is a culturally determined responsibility of adult females in the household. In effect factors that would reduce the drudgery associated with cooking like improved cookstove would facilitate adoption

when there is considerable proportion of adult females in the household. Although culturally, male heads provided resources for feeding, nevertheless decisions associated with the process of food preparation, including kitchen utensils and wares were considered properties of female spouses or adult females. This observation held true even for other societies also (Muneer and Mohamed, 2003).

The study showed a positive relationship between employment status of household head and adoption of improved cookstove. That is, adoption of improved cookstove was high among households in the formal sector where incomes were regular and averagely higher as compared to the informal sector. This implied that improved cookstove was a superior commodity such that as income of households improved adoption also increased. Similarly households living in their own houses adopted improved cookstove implying that adoption correlated positively with household wealth.

The results also indicated that income correlates such as number of income-earning household members and highly educated household heads reduced the frequency of use of improved cookstove in the household. This may be as a result of competing substitutes to improved cookstove in high income households. This was consistent with (Muneer and Mohamed 2003).

5. Conclusion

The study concludes that adoption of improved cookstove was influenced by household characteristics. That is, adoption was negatively influenced by household size and positively by composition of adult females in the household. On the issue of utilization or frequency of use, the main influencing factors were income correlates such as household income, number of income-earning members in the household and the level of education of the household head. All these factors reduced frequency of utilization because they facilitated households' ability to provide other improved means of cooking.

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