



## ORIGINAL ARTICLE



# The feasibility and acceptability of clean fuel use among rural households. A pilot study in Central Ghana

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### Abstract

**Background:** 76% of the population in Ghana uses solid fuels as their primary source of cooking energy, including 41.3% firewood and 31.5% charcoal. Consequently, household air pollution (HAP) continues to be the leading risk factor for the majority of illness burden in the country. In the past, aggressive LPG distribution and adoption schemes have been implemented to reduce HAP in Ghana. Nevertheless, just 22% of Ghanaian households utilize LPG for cooking.

**Aims.** The purpose of this study was to determine the viability and acceptability of four clean fuels among rural households in central Ghana, both separately and in combination.

**Methods:** Quantitative and qualitative methods were used to conduct this study. The Kintampo Health Demographic Surveillance System was used to randomly pick ten homes who exclusively utilized biomass fuel. For each family (n = 10), we gave four stove and fuel combinations that were both clean. The stoves were utilized for two weeks, and free fuel was supplied. After each two-week trial period, interviews were conducted to gauge stove acceptance, with an emphasis on finding the specific energy requirements that each stove satisfied.

**Conclusions.** LPG and ethanol stoves were the most popular among rural families, according to our data. In comparison to Mimi Moto and electric induction stoves, the two stoves were favoured because they were easier to use and clean, cooked faster, were deemed safer, and enabled a variety of cooking styles. Participants' stove preferences appear to be primarily influenced by two domains: 1) realizing the benefits of clean stove technology and 2) overcoming early anxiety of clean stove use, particularly LPG.

Keywords: household energy, clean cookstove, feasibility and acceptability

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## INTRODUCTION

It is now widely proven that the use of solid fuels for cooking can have negative effects on both human health and the environment. An estimated 2.5 million people die too soon due to preventable causes each year as a direct result of household air pollution (HAP), which is linked to the usage of biomass fuels.<sup>1,2</sup> Being exposed to pollutants from HAP raises the possibility of contracting a variety of ailments, such as cardiorespiratory disorders, cognitive impairment, chronic respiratory diseases, pediatric pneumonia, ischemic heart diseases, and stroke.<sup>3–5</sup> The use of solid fuels, along with the pollution of the air that this results in, is a major contributor to climate change, and it is also one of the biggest causes of deforestation.<sup>7</sup> Recent studies have revealed that the use of solid fuel may lead to early childhood developmental impairments, especially in girls,<sup>8</sup> as well as an increased probability of perinatal mortality.<sup>9</sup>

About 76% of the population in Ghana relies on solid fuels as their primary source of energy for cooking, with 41.3% of them using primary firewood and 31.5% using primary charcoal.<sup>10</sup>

As a direct result of this, HAP continues to be a primary risk factor for the majority of the disease burden in the country.<sup>11</sup> In the past, efforts to minimize the prevalence of HAP in Ghana have included the implementation of extensive LPG distribution and adoption initiatives.<sup>12</sup>

Despite this, adoption rates are low, and just 22% of Ghanaian families cook with LPG.<sup>10</sup> In developing nations like Ghana, where clean cooking is primarily limited to LPG, there are considerable barriers to the adoption and exclusive use of clean cooking fuels and technologies, despite the fact that the diversity of clean cooking fuels and technology has increased.

Our research in Ghana<sup>13–15</sup> revealed that the percentage of households using LPG is low, and those households that do use LPG are quite likely to combine it with biomass fuels. Even though cost is the primary factor preventing the use of alternatives to biomass fuels, our research and the research of others<sup>15</sup> has shown that other factors and logistical barriers to the purchase of LPG all contribute to

continued use of biomass fuel in households that have access to LPG. This has led to a practice that is known as stove and fuel stacking and is widely reported from Ghana and across the world.<sup>16,17</sup>

We hypothesized, based on experiences from elsewhere,<sup>18</sup> that households that have access to a range of clean cooking options with different performance characteristics will meet a larger share of their cooking energy needs with clean fuels, holding cost constant. This was done in an effort to fully understand the potential for combinations of fuels and appliances to address these practices. In the long run, the adoption of LPG may be hindered by the economic obstacles that can be addressed with the help of these other alternative clean fuels.

Despite the fact that Ghana is exceptional among low- and middle-income nations in that it is a substantial producer of LPG, it is unlikely that rural Ghanaian families will be able to afford the cost of LPG for several decades if large-scale subsidies are not implemented.

The purpose of this research was to determine whether or not rural households in central Ghana would use ethanol, processed biomass (Mimi Moto), liquid petroleum gas, or induction stoves and fuels, and to evaluate how feasible and acceptable these options would be.

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**Supplementary information** The online version of this article ([Figures/Tables](#)) contains supplementary material, which is available to authorized users.

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## MATERIALS AND METHODS

### Methods

This study was conducted in Asantekwaa of the Kintampo Municipality in the Bono East region using quantitative and qualitative methods. A total of ten households who were exclusive users of biomass fuel were randomly selected from the Kintampo Health Demography Surveillance Survey. For each household ( $n = 10$ ), we provided participants with four clean stove and fuel combinations (one after the other). These stoves were then used for two weeks and fuels were provided for free (zero cost to the household). After each two-week trial period, interviews were carried out to determine stove acceptability, with a focus on identifying the specific energy needs that a given stove met. All stoves were fitted with stove use monitors.

### Participant selection

Ten households who were exclusive users of biomass fuel were randomly selected from the Kintampo Health Demography Surveillance Survey (KHDSS) to be part of the study. The KHDSS routinely collects demographic data on age, sex, pregnancy, birth, death and migration, cooking practices, among others. The eligibility criteria for selection were that participants should: i) have access to electricity in the household, ii) not have participated in an earlier study – GRAPHS (where LPG and Biolite cookstoves were given to participants in the study), and iii) have regular preparation of meals in the household.

### Data collection

Data was collected from July 2020 to February 2021 using an electronic based survey questionnaire. The instrument, which was administered using Research Electronic Data Capture (REDCap) software, was designed to cover several rounds of surveys on household energy needs assessment, stove compliance, stove acceptability and stove use monitoring. During visits to the participating households, the questionnaires were administered by trained field staff and synched to KHRC servers daily. In order to protect participants' identities and ensure confidentiality, all participants were assigned unique study IDs. Again, access to the study's database was

restricted to only designated persons on the study team.

In addition to the use of questionnaires described above, one focus group discussion was conducted among the participants to understand the details of their lived experiences with clean fuel stacks.

### The intervention stoves

Because our goal to understand household-level energy needs in considerable detail using direct observation, in-depth interviews, and physical measurements, the small sample size notwithstanding its limited statistical power, was considered desirable. Four clean intervention stoves/fuels namely Mimi Moto (processed biomass), Electric Induction, Ethanol and LPG stoves (Figure 1) were deployed to participants. All fuels were provided at zero cost to participants. Households were given the four stoves (one after the other) to use for a period of two weeks.

After an initial assessment, two of participants' most preferred stoves were given back to them to be used concurrently for one month. To facilitate compliance assessments, all stoves were fitted with stove use monitors (SUMs) and a weekly assessment of stove use was done over a period of 12 weeks follow up. Study participants were reimbursed for the cost of electricity bills covering the period during which the devices were used. Similar arrangements were made to ease participants' access to LPG, which was also readily available within the Kintampo municipality.

### Data collection

The data were collected between July 2020 and February 2021 using REDCap software.<sup>20</sup> It was designed to cover several rounds of surveys on household energy needs and stove acceptability. A complementary tool – focus group discussion – was also conducted to understand participants' lived experiences with clean fuel stacks.

This study was approved by the KHRC Institutional Ethics Review Committee (2020-4). A written informed consent was sought from study participants, which detailed how privacy would be assured and encouraged voluntary participation.

### Data Analysis

Stata analytical software (StataCorp, USA) version 14.0 was used to analyze the quantitative data. De-

scriptive statistics such as frequencies, means, and graphs were used to describe the data. Thematic analysis was used to analyze the qualitative data.

### Ethics Approval

The study protocol was approved by the Kintampo Health Research Centre Institutional Ethics Review Committee. Prior to the study, all participants were adequately taken through informed consenting processes and participants were all aware that they could decline to respond to any questions if they felt uncomfortable and/or withdraw from the study at will. The study had no incentive or benefit packages for participants during the study. However, each participant was allowed to keep their most preferred intervention stove as a gift at the end of the study.

## RESULTS

### Study Sample and Household Characteristics

The primary cooks were married women, and were mostly older between ages 41 and 60 years. About half of the respondents had no education whereas the rest had basic level education. Compared with the national and the Bono East average household sizes of 3.6 and 4.1 persons respectively,<sup>21</sup> majority of our respondents reported larger household sizes ranging from 5 to 9. The main source of income for people in these households were trading and agriculture.

### Stove Use and Preferences

To assess the feasibility and acceptability of clean stove use, we performed a combined analysis of compliance and stove acceptability survey, focusing on frequency of stove use, and key attributes of participants' experiences and preferences. The compliance survey (Figure 2) revealed that eight and nine households used LPG stove in the first and second weeks of the study respectively.

The use of ethanol stove use also increased sharply from five to nine households in in the second week. Significantly, these frequencies differed from the proportion of households – four out of ten who used the Mimi Moto stove in the first week, before it dropped to two households in the second week; and those who used electric induction stove – three out of ten households over the period.

Across many indicators (Figure 3), ethanol and LPG stoves were found most acceptable to participants. Nearly all primary cooks (9 out of 10) households favored LPG and ethanol stoves because they cooked faster, are less complex to operate and are easy to clean. Our results also suggest that the majority of participants (9 out of 10 households) accepted ethanol stove for its production of enough heat (high firepower), followed by 8 out of 10 participants who also preferred LPG and electric induction stoves for similar attributes. We also observed a similar preference for LPG and ethanol stoves for their relative abilities to support multiple cooking tasks.

Regarding Mimi Moto and electric induction stoves, we noticed that operational challenges and perceived difficulties associated with the stoves decreased participants' preference for them. Most participants considered Mimi Moto to be difficult, because it didn't cook fast, and emitted smoke when fire is extinguished after cooking. A participant observed that:

*“Per its design [Mimi Moto pellet stove], you cannot use it to cook your meal to the end because when the pellets burn out, you always have to stop cooking and start another fire before you can continue cooking.” (FGD, study participant).*

Another respondent remarked that *“there is always a lot of smoke after you try to quench the fire”*. (FGD, study participant).

Similar reasons, including stove use difficulty and fear of possible fire outbreak were reported for participants' little use of the electric induction stove. Fear of fire-related incidents and the smaller-sized cooking utensils that were compatible with the electric induction were cited as major barriers to the stove use.

One respondent observed that *“the actual problem is that the electric socket in my house got burnt on my first use and so I was afraid to use it again”*. (FGD, study participant).

Another also recalled that: *“The first time I used the electric stove to cook rice, the food got burnt and it was not once so I stopped using it. I did not know how to control it. So, I think the electric stove is not meant for some of us, it is meant for the educated people.” (FGD, study participant).*

### Stove and fuel stacking

Despite participants' choice of their favored stoves, findings from a focus discussion showed continued use of traditional open fire stoves for at least twice daily. Nearly all respondents stacked their preferred clean stove with three-stone stove. Overall, the leading motivation for participants' fuel stacking practices was often a disparity between clean stove sizes and households' cooking pots – which tended to be too big. This constraint is articulated in the responses below:

*“We used the three-stone fires together with the clean stove because the number of people in some households are many. Sometimes you have to prepare tuo zaafi, banku and konkonte [local staple foods] but it's pretty difficult to cook the desired quantity with the clean stove; so, we would use the three-stone stove to prepare the banku or tuo zaafi and prepare the soup with the LPG cookstove”. (FGD study participant)*

Another respondent also explained that:

*“From the education you provided us, I concede that it is good for every woman or household to use clean fuels, but you cannot prepare abetie [local staple food] with it”. (FGD, study participant)*

### DISCUSSION

LPG and ethanol stoves are the most acceptable in rural households in central Ghana. The stoves were preferred because they were easy to use, cooked faster, easy to clean, considered safe and supported fairly different types of cooking. Basically, participants' stove preferences seem to be strongly influenced by factors that fall into two domains: 1) recognizing the advantages of clean stove technologies – including but not limited to time savings from fuel gathering; convenience and faster cooking; and 2) overcoming initial fear of clean stove use particularly LPG. This implies that future behaviour support interventions to promote LPG could be tailored to dispel fears about LPG use – which may hinder exclusive use of clean fuels as reported in a recent study<sup>22</sup>.

The wide use of ethanol stove among participants also has implications for Ghana's energy policy.

Unlike LPG stoves and fuels which are readily available in the country, ethanol stoves are virtually non-existent and even for purposes of this study, had to be procured from South Africa. Thus, it appears that participants preference for the stove may have been informed by its operational simplicity and design similarity with LPG stove.

Moreover, our findings highlighted not only the underlining motivations of participants' preferences, but the barriers that led to reluctance in the use of some stoves. Prominent among the reasons for participants least preference for stoves included perceived difficulty in stove use, complexity, slow cooking, emission of smoke and intermittent need for refueling of stove with pellets during cooking. A mismatch between clean stove burner sizes and households' cooking utensils was also identified as hindrance to exclusive use of clean stoves, leading to fuel stacking practices. These findings are consistent with a growing body of literature<sup>13,17,23,24</sup> that describe fuel stacking practices in comparable settings around the world.

### LIMITATIONS

A major limitation for this study is that it had a very small sample size. Thus, our findings may not be generalizable to other settings. More extensive studies in multiple settings would be needed to fully understand the nuances of household energy needs and stove preferences.

### CONCLUSION

It is observed that participants had a high preference for LPG and ethanol stoves. Compared with Mimi Moto and electric induction stoves, these two were preferred and used more frequently in preparing households' meals. The strongest influences on stoves preferences included ease of use, faster cooking, easy to clean, safety and relative ability to support fairly different types of cooking. It also emerged from the findings that difficulty in stove use, mismatch between cooking utensils and burner sizes, slow cooking, emission of smoke from stove

and intermittent need for refueling of stove during cooking were likely to hinder readiness to use clean stoves.

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**Conflict of interest.** The authors declare no potential conflict of interest

**Poster presentation.** An E-poster presentation of this paper was featured in the 33<sup>rd</sup> Annual Conference of the International Society for Environmental Epidemiology (ISEE21).

Intervention stove 1: Mimi Moto stove



Intervention stove 2: Ethanol stove



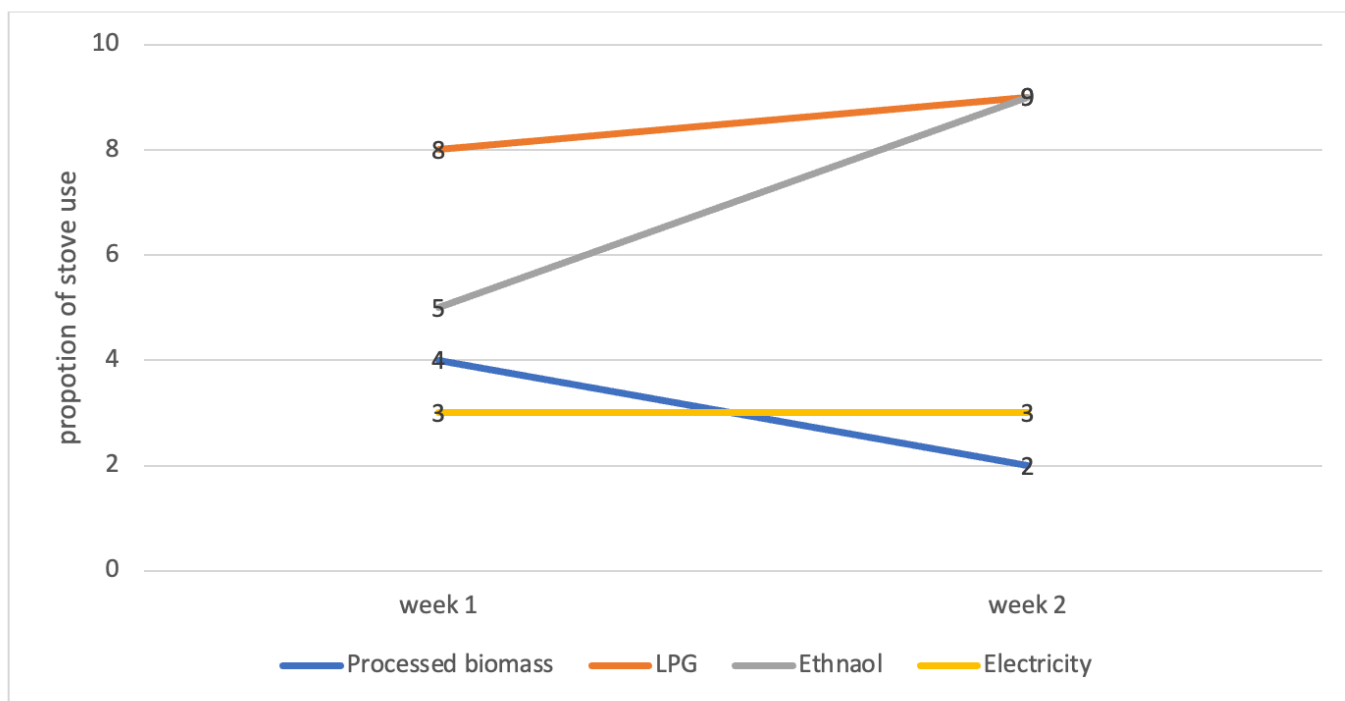
Intervention stove 3: Electric Induction stove



Intervention stove 4: Three Burner LPG stove

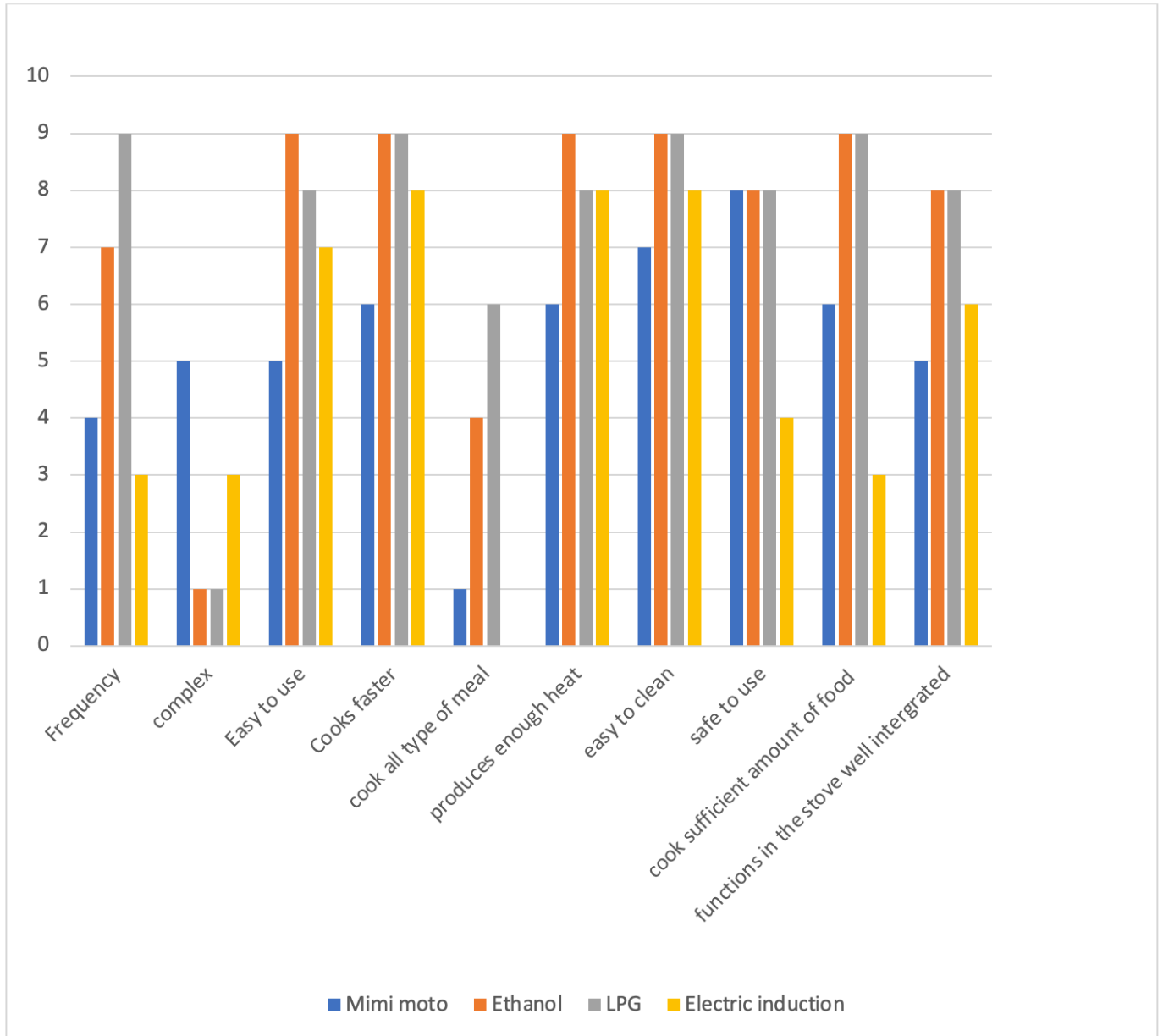


**FIGURE 1:** Intervention Stoves.



**FIGURE 2:** Stove use monitoring.





**FIGURE 3:** Comparison of stove attributes.

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