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Health Effect of Biomass Fuel Pollutants to Women and Children in Kieni East Constituency Nyeri County, Kenya

By

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Abstract

According to World Health Organization (WHO) 2016 it is estimated that 3 billion people worldwide rely on wood, stubble, dung and leaves for cooking. Burning biomass fuels on open fires and use of inefficient stoves releases many harmful pollutants. Inhaling these pollutants result in excess respiratory morbidity and mortality in women and children. WHO (2016) states that over 1.6 million children die annually throughout in the developing countries from the consequences of exposure to biomass fuel smoke resulting to acute respiratory infections and chronic obstructive pulmonary disease. The data was collected from 90 women respondents sampled across Kieni East Constituency. The researcher also used control group of 90 men from the same households who were not exposed to biomass smoke in order to reject of fail to reject the hypothesis. The first objective of the study was to determine the effect of biomass pollutants to women and children. The second objective was to establish the best improved, most efficient and affordable cook stove and perceptions. The third objective was to understand in depth the household cooking characteristic of the vulnerable rural communities. The fourth objective was to determine policy interventions at county level that can help reduce morbidity and mortality associated with indoor pollution. The study identified key interventions that can motivate users of cook stoves through carbon credit gains. Key findings of the study established that household poverty is one of key factors that affect people attitude and perception to either adopt or embrace new technologies. The results showed that eighty per cent of rural women cooked indoors using biomass fuel with no ventilation. There was a positive correlation between use of ordinary cook stove and increase in respiratory diseases supported by the fact that a unit increase on use of improved cook stove indicated a unit decrease in respiratory diseases. Forty per cent of women interviewed report cases of respiratory complications, eye infection, asthma and lung problems affecting them and children. Eighty per cent of women were aware of the negative effect of smoke on their own health and were willing to change cooking practices but were unable to afford cleaner fuels or improved stoves as embedded in theory of social causation and human well-being. Innovations and incentives that increase rural households' access to modern energy sources can significantly reduce negative health impacts. The research recommended that educational and policy interventions should be used to increase the awareness of the health effects of indoor biomass cooking smoke to reduce mortality and illnesses related to smoke affecting women and children. This will help to achieve the sustainable development goal that ensures health lives and promotion of well-being for all at all ages.

Key words: Kenya, Nyeri, Indoor pollution, firewood, smoke, rural women, Children, perceptions, respiratory complications

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By

Paul Mwari Maina

Introduction

One third of the world's population uses the form of energy which is associated with high levels of indoor pollution, Smith & Peel (2010). According to World Health Organization (WHO) 2016, globally it's estimated that 3 billion people rely on wood, stubble, dung and leaves for cooking. Burning biomass fuels on open fires and use of inefficient stoves releases many harmful pollutants. Biomass is the main source of domestic energy in developing countries according to Ezzati Majid *et al.,* (2007). These health damaging pollutants include several carcinogenic compounds, Naeher *et al*., (2007). Inhaling these pollutants result in excess respiratory morbidity and mortality in women and children.

According to WHO report on burden of disease (2012), globally, 4.3 million deaths were attributed to household air pollution. According to Albalak, Bruce, McCracken (2001) study on particulate matter concentration from open fire found that irritation of the mucus membrane of the eyes, nose and throat, coughing and exacerbation of asthma were identified as the principal health effects associated with biomass fuel use. Over 1.6 million children die annually throughout in the developing countries from the consequences of exposure to biomass fuel smoke resulting to acute respiratory infections and chronic obstructive pulmonary disease (Rine & Rhoda 2008). In many developing countries, the poor still burn biomass energy biomass accounting for 78% of the total primary energy consumption in order to meet their household cooking needs. These open fires are fairly inefficient at converting energy into heat for cooking; the amount of biomass fuel needed each year for basic cooking can reach up to 2 tons per family. In addition, collecting this fuel sometimes can take an hour a day on average.

Exposure to indoor air pollution has been linked with increased risk of acute respiratory infections, chronic obstructive pulmonary disease and lung cancer in women. Therefore, exposure to biomass smoke is therefore a major public health issue according to Bruce N, Perez –Padilla (2008). According to W. James Gauderman, Robert Urman *et al.*, (2015), air pollution has adverse effects on lung function growth in children. The study was triggered by the fact that the conditions of cooking in rural areas which represents eighty per cent of the population are poor, with women generally cooking indoors in non-ventilated areas with generally poor living conditions with limited access to clean energy.

The purpose of the study was to reject or fail to reject the hypothesis that biomass pollutants do not directly contribute to the health effects of women and children and that household cooking characteristic does not influence the health effects of women and children. The research was seeking to confirm whether attitude and perceptions influence adoption rate of improved cook stoves. Research has established that wood smoke particles pose different levels of health risks (Naeher *et al.,* 2007). Besides, the research aimed to reject or fail to reject the fact that policy intervention cannot in any way help to reduce morbidity and mortality associated with indoor pollution. The research is anchored in the Sustainable Development Goal (SGD 3) that aims to achieve the sustainable development goal to ensure health lives and promotion of well-being for all at all ages.

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Statement of the Problem

The conditions of cooking in rural areas represent eighty per cent of the population which is composed of poor women. The majority of the women cook indoors in non-ventilated areas with poor living conditions due to limited access to clean energy. Kenya has one of the largest populations that still rely on wood fuel as a primary source of energy for cooking. Women from rural traditional background with their children below five years suffer ill health from biomass burning during long hours of cooking. Poverty in rural household contributes to usage of biomass energy. The increase in challenges facing women and children due to the health effect of biomass fuel pollutants to necessitated this study which focused on the effect of biomass pollutants to women and children and the strategies to establish the best improved, most efficient and affordable cook stove. It's also imperative to understand in depth the household cooking characteristic of the vulnerable rural communities and the potential policy interventions to reduce morbidity and mortality associated with indoor pollution. Although women may be aware of the health and negative socio-environmental consequences of relying on biomass fuel pollutants, there may still be apparent inertia for dependence on the same due to lack of alternatives. The first objective of the study was todetermine the health effects of biomass pollutants to women and children. The second objective was to establish attitudes and perceptions based on cook stove adaptation based on efficiency and affordability. The third objective was to understand in depth the household cooking characteristic of the vulnerable rural communities. The fourth objective was to determine policy interventions at county level that can help reduce morbidity and mortality associated with indoor pollution

Research Theories

The study used Adam Smith theory of economic development which emphasis on saving to improve on livelihoods. Biomass in rural setting is relatively cheap compared to other sources of energy regardless of the health negative impacts. The research used the adoption of behaviour change and practice theory that aims to reduce the indoor air pollution significantly (Rachel Davis, 2015).

The Study Hypothesis

The study aimed to reject or fail to reject the hypothesis states that (i) Biomass pollutants do not directly contribute to the health effects of women and children (ii) Household cooking characteristic does not influence the health effects of women and children (iii) Altitudes and perceptions have no influence on the adoption rate of improved cook stoves (iv) Policy intervention cannot in any way help to reduce morbidity and mortality associated with indoor pollution.

Review of Relevant Literature

According to World Health Organization (WHO) 2016, about 3 billion people globally rely on biomass and coal burning for domestic use. The solid biomass fuels available locally are such as wood, charcoal, dung, and agricultural residues for cooking, heating, and other domestic basic needs (Boampong, & Phillips 2016). The emission emanating from these energy sources impacts negatively on human health and the environment (Dickinson *et al.*, 2015). Worldwide, more than have of the population and more than 90 per cent of rural people in developing countries rely on solid biomass energy for cooking, heating, and lighting purposes (Clark, Peel, Burch, Nelson, Robison, Conway, Bachand & Reynolds, 2009).

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According to Ndegwa, Breuer and Hamhaber (2011), 94 per cent of the African rural population and 73 per cent of urban population rely heavily on biomass energy especially for cooking and heating. It has been projected that there will be an increase of wood fuel consumers from 2.5 million in 2004 to 2.7 million in 2030 in Africa (Ndegwa, Breuer & Hamhaber, 2011). A study in Gonder, Ethiopia, comparing rural low and middle-income classes revealed that in low income household, cooking is done inside rooms that have poor ventilation (Edelstein, Pitchforth, Asres, Silverman & Kulkarni, 2008). Women from rural traditional background with their children below five years suffer ill health from biomass burning during long hours of cooking.

Poverty in rural household contributes highly to usage of biomass energy. In the study of potential of agroforestry in provision of wood fuel in Sub-Saharan Africa Iiyama, Neufeldt, Dobie, Njenga and Ndegwa (2014) observed the annually growth rate consumption of wood fuel from 2000-2010. The rates were 1.01 per cent firewood and 2.96 charcoal which was higher than population rate 2.56% in the same time. Further, the studies outlined the projections for future trend of charcoal demand between years 2015 to 2050 were 2.8 per cent charcoal and 1.4 per cent firewood in Sub-Saharan Africa. The trend indicates chances of more deforestation leading to increased carbon pollution in the atmosphere. Kenya has one of the largest populations that still rely on wood fuel as a primary source of energy for cooking. Continuing reliance on wood fuel against the backdrop of burgeoning population poses huge threats to the country's declining forest cover, undermining capacity for climate change mitigation and adaptation.

Kenya's Vision 2030, launched at 2008 aims at providing adequate affordable energy to all populations in the country as socioeconomic strategy for development, an idea reflected in Kenyans Constitution (2010). Wood fuel is widely used in rural areas and urban slums often regarded as inferior energy for the poor. According to Jacobson (2007) wood fuel energy demand rates are doubling in Kenya as a whole, due to oil price rising and dry rainy season that has reduced hydropower performance. The principal energy supply sources in Kenya are biomass 68 per cent, petroleum at 22 per cent, electricity at 9 per cent and coal at less than 1 per cent (Ndegwa *et al;* 2011). The World Development (2007) reported that estimated 4.2 per cent of rural Kenyans who own a solar system have annual household incomes well above $2,000 per year are the rural middle class. This means the rural low class are left out by the solar energy sector due the cost, hence only left with the option of use of wood fuel which is an environmental concern.

As of 2007, biomass energy, firewood, charcoal, and agricultural wastes contributes approximately up to 70% of Kenya's final energy demand and provides for almost 90% of rural household energy needs, about one third in the form of charcoal and the rest from firewood. It is estimated that 80% of urban households' wood-fuel demand is met by charcoal (Boampong & Phillips, 2016), an indication of increased greenhouse gases (GHG) emissions. Wanjiru and Omendo (2016) have noted that most of Kenyans 2010 greenhouse emissions were from among others deforestation due to heavy reliance of firewood and charcoal as sources of fuel. Further their paper reports that Kenya's GHG emissions are expected to double from 73 Mt CO_2 in 2010 to 143 million tonnes of carbon dioxide in 2030. Marigi (2017) in his study opines that a typical family's firewood consumption annually is 4 tonnes which translate to 11kg of firewood daily and this means the burn would generate 20.57kg of carbon dioxide. Njenga, Mahmoud, Mendum, liyama, Jamnadass, Nowina and Sundberg (2017) reported that indoor air pollution dependents with cooking stove efficiency.

According to Kiplagat, Li and Wang, (2011) and Ndegwa, Breuer and Hamhaber (2011) in 2006 the biomass demand was estimated at 38.1 million tonnes against a sustainable

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supply of 15.4 million tonnes, creating a deficit demand of 60 per cent. The wood fuel demand was estimated to be growing at 2.7% per year while the sustainable supply was growing at a slower rate of 0.6% per year. This is caused by the principal drivers of wood fuel demand such as population growth, lack of access to biomass energy substitutes and the growing incidence of poverty among the population and to some extent by traditional three stone technology of which all these lead to environmental degradation. Kenya, like many African countries, experience severe impacts of climate change which is a major concern (Wanjiru & Omedo, 2016).

Study Methodology

Research design and method

The study followed exploratory research design. Quantitative research method was adopted to collect data from the study respondents. Consistent with the principles of quantitative research method, survey research approach was implemented to collect data from the study participants. Quantitative data included open ended and closed-ended information.

Research Instrument

The survey instrument comprised demographic data items, Likert-scale survey items, dichotomous questions and checklists which were designed to collect data on the issues under investigation. Alpha obtained was 0.722 which is above the minimum threshold of 0.7 which implied the questionnaire tool used was reliable to make inference and generalize the results.

Study Participants

The target population for the study were women as they have primary responsibility for cooking in the household. The data was collected from 90 respondents out of the estimated 300 households sampled across Gakawa, Kiamathaga and Thegu ward in Kieni East Constituency using quota sampling method to select participants. Every ward identified 30 participants. The researcher then used the systematic or the nth method where every nth household had a chance to participate in the study, and in this case every 3rd household participated in the study and this helped to capture women of different social economic status. The researcher also used control group of 90 men from the same households where women were interviewed who were not exposed to biomass smoke in order to reject of fail to reject the hypothesis

Data Analysis

All the women interviewed live in the rural regions of the constituency. The 90 men interviewed were the husbands or men living in the same household. The survey respondents were women aged between 20 to 60 years, the average age of 41 years and a standard deviation of 9 years. This follows an approximately normal distribution because the quotient of the skewness (0.452) and standard error of skewness (0.427) was 1.06. About 16.7% of the respondents were single, 56.7% were married and 20% were windowed while the rest preferred not to disclose their marital status. The total number of households ranged from 1-9 with an average of 4 members.

Households' Cooking Characteristics

It was observed that 66.7% of respondents use wood, 20% use stubble and only 6.7% use Kerosene and cooking gas. None of the respondents interviewed use electricity for domestic cooking purposes.

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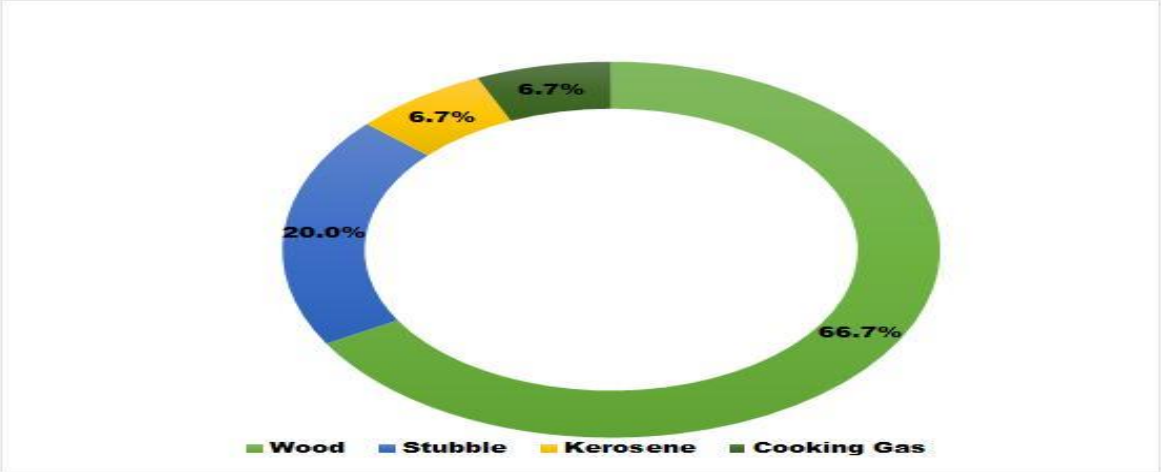

Figure 1: Households' Cooking Characteristics
Source: Author, 2014

The results show that 73.3% of respondents cook indoors out of whom 52.4% of their cooking places have no ventilations at all, 42.9% are poorly ventilated and only 4.8% of those cooking indoors have proper ventilation. When cooing, 86.7% reported that their children sit close to the fireplace and only 13.3% have their children sit at about five meters away. Majority of respondents have a poor impression of ordinary cook stoves due to their negative health implication on themselves and children. It was noted that 3% of those who reported to have good impression of ordinary cook stoves actually did not use them but instead relies on cooking gas. However, when asked about the how frequent an ordinary cook stove was used in the households, there was 100% response pointing to daily usage. The table below presents an analysis of public impression on the use of ordinary cook stoves in homes.

Table 1: Impression Of Ordinary Cook Stove (Dependent on biomass, mainly firewood)

Efficiency	Good	4.0%
	Poor	76.0 %
	Very Poor	20.0%
		100%

Source: Author, 2014

From the above table, we can conclude that 96% of respondents have a poor impression of ordinary cook stoves and only 4.0 % have a good impression of ordinary cook stove despite ranking them as having poor efficiency. Lack of alternative means of cooking could be the reason why 4.0 % of respondents could still claim a good impression on something they consider inefficient. To further probe the reason why all the respondents use ordinary cook stove on a daily basis despite their inefficiency, the researcher asked them whether they have ever used an improved cook stove and also find out if they are willing to change their current cook stove. From the study, 83.3% of the respondents have never used an improved cook stove and only 16.7% have ever used.

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Household Health Characteristics

To assess the health conditions of the households using ordinary cook stove for domestic purposes, the researcher identified severely coughing, severe nasal irritation and frequent chest congestions key indicators of respiratory complication among children. From the study, it was observed that 45% of women interviewed reported to have observed their children.

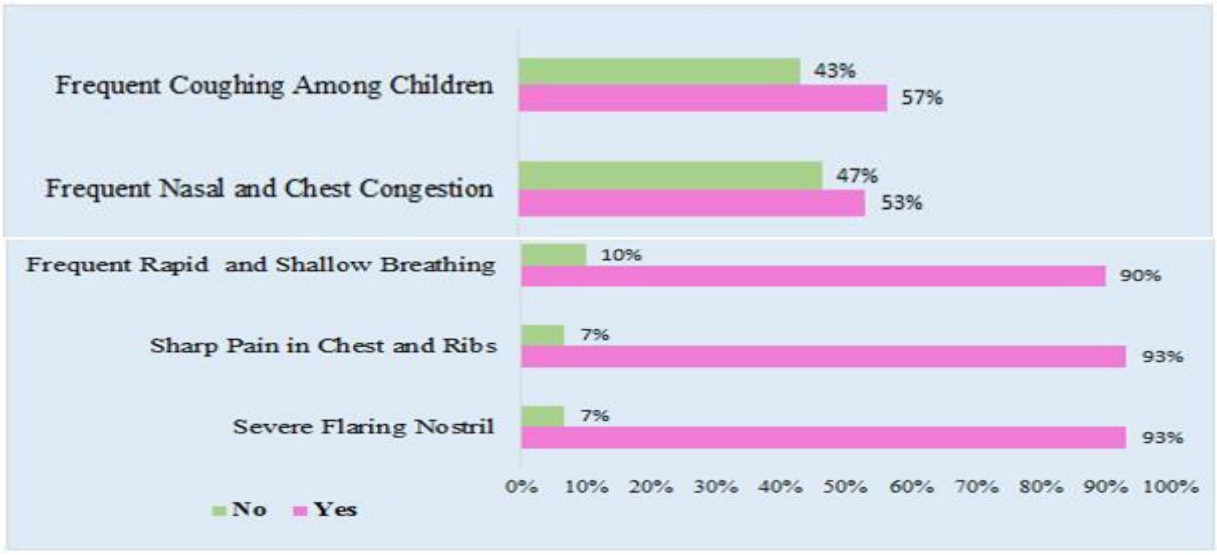

Figure 2: Results of Children Respiratory Health Conditions in the Study
Source: Author, 2014

The researcher identified three independent variables namely; frequent rapid and shallow breathing, sharp pains in the chest and ribs and severe flaring nostril as indicators of presence of either respiratory complications, asthma or lung problem. Given that these indicators are independent by the fact that respiratory complication, asthma and lung problems are not necessarily mutually exclusive, the set theory was applied on the responses from the three variables in the graph below to minimize response bias. Majority of women and children were reported to have respiratory complication, asthma and lung problems.

Control Group on Household Health Characteristics

Out of the 90 men interviewed, none experienced flaring of nostrils, chest congestion or ribs complications. The men sample size had 20 percent who were smokers and this confirmed the hypothesis that exposure to biomass smoke had adverse effects on human health.

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Public Awareness on Health Hazards of Biomass Smoke

The researcher identified indicators to test how familiar the respondents were with regard to effects of smoke on health of women and children. From the study, 90% of the respondents reported knowledge that most of respiratory and eye complications are caused by exposure to smoke especially cooking in a smoky place. All the respondents (100%) were willing to use better cooking technology such as improved cook stoves. A large proportion of women (84%) interviewed reported that they were not able to afford improved stove. Chest complication, breathing difficulties and eye problems were identified as major problems associated with using ordinary smoke cook stove in homes for cooking as summarized below.

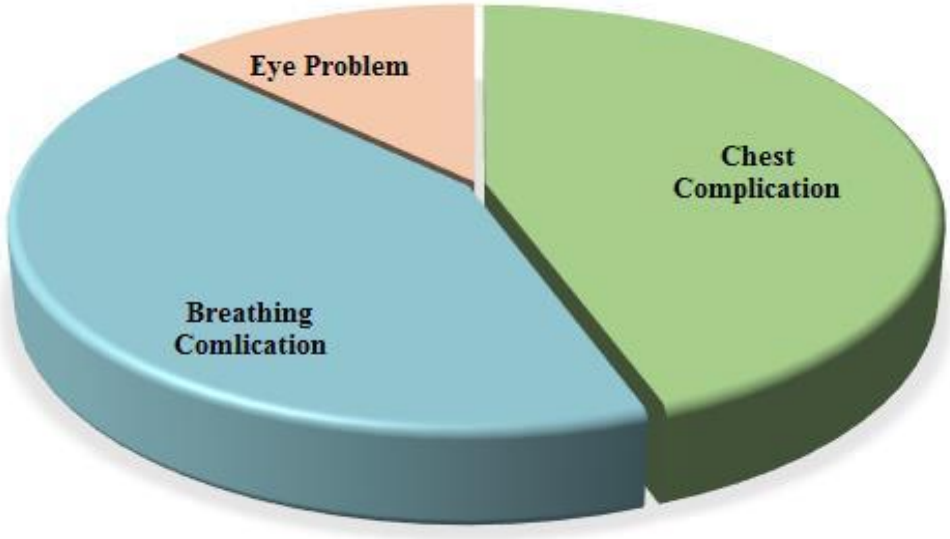

Figure 3: Public Awareness on Health Hazards of Biomass Smoke

Source: Author, 2014

5.4 Correlation Analysis

The researcher used correlation analysis to evaluate the nature and strength of relationship among a set of independent and dependent variables. In this study, health effects of biomass such as respiratory complications, eye problems, and asthma and lung problems were identified as dependent variables while all household cooking characteristics were identified as independent variables. From the table below, the study noted that there was positive correlation among all the seven variables listed which indicated that a unit increase in independent variable led to a proportional increase in the dependent variable. The table below shows the summary of correlation analysis of seven variables with their respective significance indices.

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Table 2: Correlation Analysis

		1	2	3	4	5	6	7
1	What do you use for cooking	1	.699**	.388*	0.3	0.264	0.167	0.189
2	How Far do your children sit from cooking point?		1	0.288	.681**	0.196	.400*	.421*
3	Ever experience flaring nostril?			1	.464**	0.356	0.272	0.287
4	Sharp Pain in Chest and Ribs				1	0.356	0.272	0.287
5	Rapid and shallow Breathing					1	0.223	0.239
6	How Often Do children complaint of nasal and chest congestion?						1	.982**
7	How Often do you see children coughing abnormally?							1
	** Correlation is significant at the 0.01 level (2-tailed).							
	* Correlation is significant at the 0.05 level (2-tailed).							

Source: Author, (2014)

Perceptions About Adoption of Improved Cook Stoves

The research sought to examine the reasons why there is no paradigm shift among women adopting the use of improved cooking stoves. The following figure presents a summary of findings as challenges, and misconception women have or experience concerning improved cooking stoves.

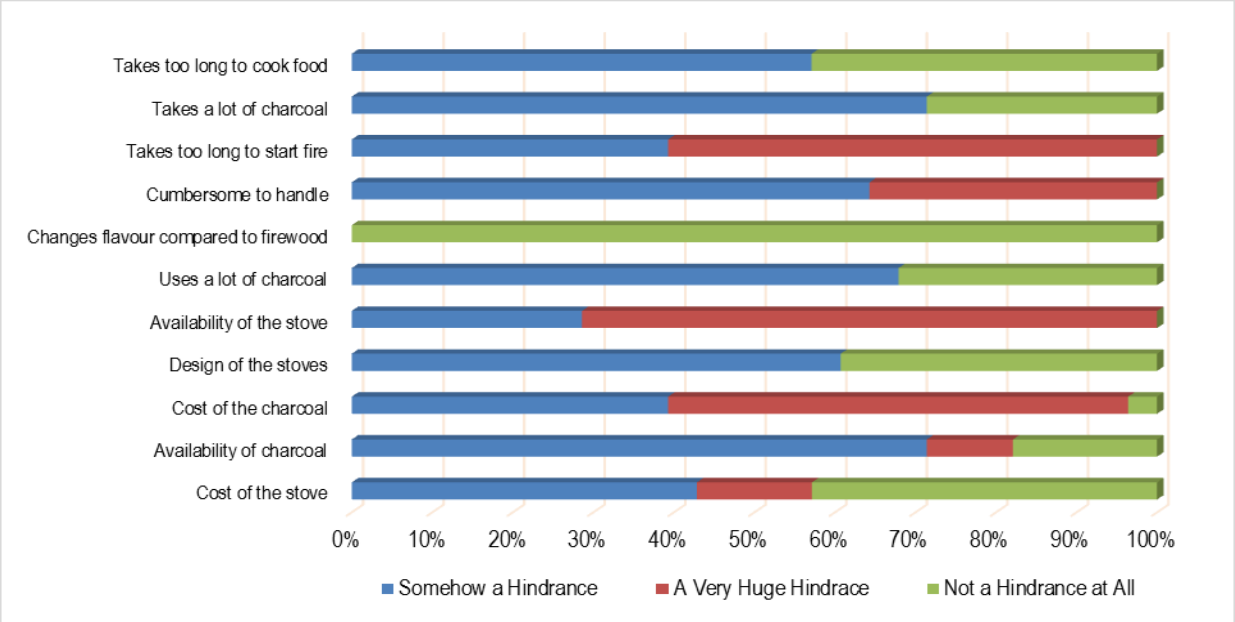

Figure 4: Perceptions About Adoption of Improved Cook Stoves

Source: Author, (2014)

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Among some of the factors that hinder adoption and appreciation of improved cooking stoves include the perception that they take a lot of charcoal at 70%, unavailability of charcoal (70%), cumbersome to handle at 66%, complicated design of improved stove and perception that they take too long to cook food. The study noted that the cost of the improved cook stove was a major hindrance.

Conclusion and Recommendation

Increasing the awareness of the health effects of indoor biomass smoke is the first step to reduce exposure. The research concluded that use of biomass fuel as a primary source of cooking fuel is wide spread in rural areas. Key findings of the study established that household poverty is one of key factors that affect women's attitude and perception on either adoption or embracing new technologies. Innovations and incentives can increase rural households' access to modern energy sources and can significantly reduce negative health impacts. Use of improved cook stoves significantly reduces levels of indoor air pollution.

The research recommended that policy interventions at county level can help reduce morbidity and mortality associated indoor pollution. This can be achieved by introducing wide range of affordable improved cook stoves that vary in cost, technology and efficiency and every household encouraged to acquire at least one. Capacity building on uptake and acceptance of new cook stoves should be enhanced and creation of awareness of problems associated with exposure to indoor pollution. This will help to achieve the sustainable development goal that ensures health lives and promotion of well-being for all at all ages. The research findings therefore have direct relevance for policy and practice. Future research should develop synergies to address factors that significantly play a role in women attitude and perception towards enhancement and adaptation of improved cook stoves. Future research should go beyond analysing health effects and go beyond describing the complex mechanisms of impact and measures for reducing negative health effects.

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