

Domestic Energy Options and Household Health-Care Expenditures: Does Income-Driven Consumption Matter?



Motari, YO¹, Omweri. F. S.²

¹Department of Business and Economics, Kisii University, P.O Box 408-40200, Kisii, Kenya

²Lecturer, Kampala International University, Dept. Public administration and Development Studies- Western Campus, Uganda.

ABSTRACT: Many people who live in rural areas with low disposable income are unable to acquire clean energy. This means that they are exposed to respiratory diseases and are more likely to encounter unbearable healthcare expenditures. But when stakeholders are responsive, they create a healthcare system that offers affordable and accessible and encourages the use of clean energy. When health care expenditure is high, many poor households struggle to access the services, particularly for households not covered by health insurance. Therefore, the current study sought to examine the moderating role of income on the relationship between domestic energy options and healthcare expenditure. The study used a cross-sectional research design and collected data from a random sample of 384 households from Kisii County. The data was collected using a structured questionnaire. Data was analyzed using descriptive and inferential statistics. Findings show that most of the households were earning less than Ksh. 30,000 a month. Similarly, more than two-thirds of the households relied on solid biomass including firewood and charcoal for cooking. Findings show that domestic energy options have a significant relationship with healthcare expenditure for households in Kisii County. However, income does not moderate the relationship between domestic energy options and healthcare expenditure. The findings help policymakers to improve the uptake of clean energy options among households by subsidizing the cost of clean energy or removing tax on the products. The findings also encourage the uptake of universal healthcare among poor populations to reduce incidences of catastrophic healthcare expenditure.

KEYWORDS: Domestic energy options, Households, healthcare expenditure, consumption, income

1. BACKGROUND

Clean cooking energy is associated with healthy living and reduced healthcare expenditure. On one hand, this addresses nature loss by reducing the demand for firewood and ensuring that when new trees are planted, they are not cut down. This challenge can effectively be addressed at the household level, where cooking decisions are made. Thus, household units can be important players in the ongoing energy transition processes (Lekavičius, Bobinaitė, Galinis, Pažėraitė, 2020). Nearly two-thirds of the global population relied on solid fuels, including firewood and charcoal, in 2023 (Ritchie, H., Rosado, P., & Roser, M. (2024). Most of them come from 30 countries in the developing world with low disposable income to acquire clean energy. The situation is aggravated for those who stay in rural areas where logistical challenges and poor electricity connections hinder the acquisition of clean energy. As a result, the majority of rural households use rudimentary stoves as well as firewood which exposes them to pollution that leads to health risks.

The World Health Organization (WHO) indicated that as of 2021, about 7.3 billion people lived in a polluted environment and were exposed to unsafe average annual PM_{2.5} concentrations, 80 percent of whom live in low- and middle-income countries. The State of Air Quality and Health Impact study in Africa reported that in 2022, 5 countries including Niger, Nigeria, Egypt, Mauritania, and Cameroon had the highest levels of population exposed to pollution. Out of those who were exposed, 3.55 million deaths were reported in the same year with 1.1 million deaths occurring in Africa, Ali, Yousaf, Munir, and Wong (2021). Sadly, the dead were mostly women and children due to their higher exposure to domestic activities such as cooking.

The countries that bear the burden of respiratory diseases are mostly those in sub-Saharan Africa (Gyasi & Phillips, 2020); in Kenya, for example, the 2022 Household Demographic Survey revealed that 66 % of the population relies on solid biomass for cooking, with 24% using clean energy technology. Of those who use clean energy, 59% come from urban areas, compared to 6% of the population in rural areas. For the population that uses solid, 62% use firewood, and 48% use charcoal. In the report, 54% of the

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urban population falls in the highest wealth quintile, compared to 3% in rural households, who are most likely unable to meet high healthcare expenses. With the poor acquisition of clean energy, the members of the households may acquire life-threatening infections from pollution and spend their meager resources on medical expenses, worsening their economic conditions. This is because there is strong evidence that acute respiratory infections in children and chronic obstructive pulmonary disease in women are associated with indoor biomass smoke (Kamal, Srivastava, Kesavachandran, Bihari, 2022). Lung cancer, for example, in women has been associated with household coal use. Other conditions, such as chronic obstructive pulmonary disease in men and tuberculosis, could also be associated, although evidence is scarce (Carlos Torres-Duque, Darío Maldonado, Rogelio Pérez-Padilla, Majid Ezzati, (2008). For example, Apergis, Bhattacharya and Hadhri (2020) observes that a 1% increase in CO₂ emissions increased healthcare expenditure by 2.5%. Specifically, healthcare expenditure in the low-income, low-middle-income, high-middle income, and high-income groups increased by 2.9%, 1.2%, 2.312%, and 2.6% respectively. Despite the risks associated with indoor air pollution, its causal effect on health is severely understudied. Imelda (2019) attributes this to data and methodological challenges, as its effects are often confounded by unobserved health determinants associated with its exposure.

On realizing this danger, stakeholders continue to increase efforts to suppress or reduce indoor exposure, including subsidizing clean energy and distributing improved stoves. These changes primarily affect households that are sensitive to expenditure due to low income. One of the challenges of the clean energy transition is the attitudes and perceptions embedded in the households which depend on their disposable income which affects their behavior when seeking health services. Consequently, solutions are required through the commitment and active participation of governments, scientific societies, nongovernmental organizations, and the general community.

Focusing on this behavior helps to establish mechanisms to promote the acquisition of clean energy among rural households. Additionally, the study will contribute to improving consumer behavior theory. The study will use the consumer behavior model to show how families decide on cooking energy fuels. This will help to build evidence on the energy acquisition process. The paper is segmented into three sections. Section 1 describes the relevant literature on the antecedent role of energy options on health expenditure. Section 2 discusses the methodology used in data collection, sampling, and analytical approaches. Section 3 provides the findings, discussions, conclusion, contribution, and recommendations.

2. LITERATURE REVIEW

2.1 Domestic Energy options and Health care Expenditure

Approaches in domestic energy studies are twofold. The first type explores the use of the two major sources of energy including solid biomass or clean energy on health outcomes from a medical or public health perspective. This literature shows that solid biomass causes air pollution which is one of the most significant environmental health risks. As a result, households that use solid biomass expose themselves to noncommunicable diseases such as cardiovascular and respiratory diseases. The works of Konduracka and Rostoff, (2022); and Miller & Newby (2020) contain the link between cardiovascular disease and biomass use in households. While, Turner, Andersen, Baccarelli, and Diver (2020) as well as Pritchett and Spangler (2022) observed that solid biomass leads to lung cancer. The scholars also observed a striking convergence of the cases with the burden of diseases on households in low-income countries.

A study by Krutilla and Graham (2023) indicated that any unitary increase in pollution attracts double expenditure and burden in healthcare. It is estimated that the burden is much higher in low-income countries such as sub-Saharan Africa. Ali, and Minier (2021), for example, found that there was a 30% mortality rate from diseases caused by air pollution in Saharan Africa which is mainly attributed to cooking energy, as CO₂ emission particulate matter is estimated at (PM_{2.5}). The emission emerges from the use of kerosene and biomass (wood, charcoal, crop residues, and animal manure (Rosário, Urrutia-Pereira & Cecchi, 2021). The burden of air pollution in Africa falls on women and children whose life expectancy is lowered by 4-5 years (Mlambo, Ngonisa, Ndlovu, 2023).

2.2 Income-driven Consumption and Healthcare Expenditure

The second type of research is on the effect of domestic energy options on healthcare expenditure from social and economic perspectives. These research studies are focused on the contributory role of age, education, illness reporting, income, and head of households on expenditure. Other scholars have examined the role of household size. Literature also depicts a research trend where studies compare the expenditure of rural, semi-urban, and urban areas as studies have consistently shown a variance in the use of domestic energy between urban and rural demographics. Other studies observe that expenditure is driven by the changes in hospital care and preventive care costs, Vrutika Hasmukh Shah (2023) and Azorliade, Twerefou, and Dovie (2022).

The current study investigates the moderating role of income in the relationship between domestic energy options and healthcare expenditure. But integrates the perceptions of the semi-urban and rural populations. Income is perceived as a definitive factor of

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consumer behavior Khan (2020). Income refers to the monetary and natural value, which a person receives from other people or organizations for covering personal expenditures. It includes wages, salary, and other types of income from activity (after the tax payment); including transfers, net income from the business or agricultural activity, property (rent), dividends, and others. There are three major classifications of consumers based on class: Low-income, middle-income, and high-income customers (Kim, Hong, Park & Kim, 2020). Those in the lower-income class are characterized by low qualifications and are wage workers, unemployed, pensioners, and housewives. The middle class on the other hand are self-employed workers in the production and service sphere, farmers, students, and semiskilled wage workers. High-income consumers are business executives, chief executives, and other consumers who prioritize luxury, exclusivity, and quality spending

This strand of research arises from the realization that affordable healthcare is at the center of global development. Responsive health systems, therefore, strive to provide comprehensive healthcare systems that are affordable and accessible. Thus, the proportion of income spent on healthcare is of critical concern among scholars and practitioners (Adebisi, Umah, Olaoye & Lucero-Prisno, 2020). When health care expenditure is high, many poor households struggle to access the services, particularly for households not covered by health insurance. If the households are met with catastrophic expenditure, then they are likely to seek alternative ways of meeting the costs or avoid healthcare services. Therefore, the effect of income on the consumption of health services is not just a pressing issue for policymakers and marketers but also a crucial one in other fields including economics and psychology (Tanner, Vann & Kizilova, 2020).

The concern for health expenditure falls at the center of sustainable development which human beings have long sought to meet increasing their health reserves. The empirical findings on the relationship between income and health expenditure are diverse although the causal relationship between the constructs remains unclear (Rana, Alam & Gow, 2020). As a result, several scholars have investigated the nexus between the constructs. Raghupathi (2020) and Zikidou and Hadjidema, (2020), for example, established that healthcare expenditure increases with personal income. However, Mulaga, Kamndaya, and Masangwi, (2021) observed that households with low income experienced lower levels of incidence of high health expenditure and had decreased risk of facing Catastrophic Health Expenditures (CHEs) compared to high-income households. Although the literature is rich on the nexus between domestic energy options and health expenditure, few scholars have explored the role of income in this relationship. Confounding factors affect mortality in epidemiological studies, particularly in health care expenditure.

2.3 Hypothesis Development

Health expenditure has been a matter of great concern in low-income countries. This is because health infrastructure in these countries is weak and affordability of health care is low. There are low levels of government health spending per capita in Kenya where expenditure is as low as 4.29% annually. Even as the health expenditure remains low, citizens particularly those from rural areas continue to suffer from respiratory diseases emerging from domestic air pollution. Stakeholders can use a two-pronged approach to deal with the problem at hand. Firstly, deal with the use of dirty energy among rural households by incentivizing the acquisition of clean energy. Secondly, increasing access to medical care through investment in healthcare.

To augment the approaches, stakeholders need to deal with the consumption behavior of households by countering attitudes, perceptions engrained in the families towards clean energy. This way, the uptake of clean energy is likely to increase among rural households. Therefore, in response to the interconnectedness of the three constructs, the study proposed two hypotheses:

H0₁: There is no statistically significant relationship energy pollution and household health care expenditure

The hypothesis deals with the direct relationship between domestic energy pollution and household expenditure in Kenya. The study will use correlation and simple linear regression to analyze data. The study will use P values to interpret results.

H0₂: Income-driven consumption does not statistically moderate the relationship energy pollution and household health care expenditure.

The study will seek to test an indirect relationship among the constructs. Income driven consumption is deemed as a moderating variable. The study will use hierarchical regression to analyze data. The study will use P values to interpret results.

3. METHODOLOGY

3.1 Population and Sampling Characteristics

The investigation was based on a cross-sectional research design. Using the design, the relationship among the three constructs: domestic energy pollution, healthcare expenditure, and income was established. The sample was drawn from the number of households declared in the 2019 Kenya population Census. According to the report, there are 308,054 households in Kisii County. Using Krejcie and Morgan's Table, the study sampled 384 households. A total of 9 enumeration areas were selected which were developed into clusters using a process of household listing and geo-referencing.

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3.2 Survey Instruments and Validation

The survey instrument was structured with questions dealing with population demographics. Questions on domestic fuels dealt with both clean i.e., liquefied petroleum gas, and dirty energy sources (i.e., charcoal and firewood). The income dealt with the sources and amount earned by the participants. The expenditure on the other hand was estimated by the costs incurred for respiratory diseases. The data collection process followed an established structure with a data enumerator, supervisor, and a driver. The supervisor coordinated field data collection activities, including activities such as management of the field teams, supplies and equipment, maps, finances, and listings, coordinating with local authorities concerning the survey plan, and making travel arrangements. Data was collected was sent to the central server on a real-time basis.

3.3 Data Management

Data were downloaded from the central servers and checked against the expected returns to account for all data. The software was used to generate field check tables to monitor progress and flag any errors, which were then communicated to the field teams for correction. Afterward, secondary editing was done by members of the central office team. The team resolved errors that were not corrected by field teams during data collection. After the preliminary checks, data was entered into the Statistical Package for Social Sciences (SPSS V21) for analysis. Of the 384 households selected for the sample, of which 201(52%) participated in the study. The data was analyzed using frequencies, means, standard deviation, simple regression, and hierarchical regression methods.

4. FINDINGS

4.1 Demographics

The study described how the population was structured in terms of income, choice of domestic energy, and their expenditure on healthcare. Their frequencies are presented in Table 1.

Table 1: Demographical Distribution of the Population

	F	%
Monthly Income		
<5000	71	36.6
5001-10,000	34	17.5
10001-15000	20	10.3
15001-20,000	19	9.8
20,001-25,000	9	4.6
25001-30,000	16	8.2
>30,000	25	12.9
Total	194	100.0
Domestic Energy Options		
Clean Energy	38	19.6
Dirty Energy	156	80.4
Total	194	100.0
Health Care Expenditure		
<500	77	39.7
501-1000	63	32.5
1001-2000	32	16.5
2001-5000	18	9.3
>5000	4	2.1
Total	194	100.0

Source: Survey Data (2022)

Sources of income were measured from earnings obtained from business, permanent employment of casual labour. Findings show that slightly more than one-third (36.6%) of the participants indicated that they earn below Ksh.5000 monthly to support their households, followed by 17.5% who were earning between Ksh.10,001 and Ksh. 15,000 and 12.9% earning above 30,000. Those earning between Ksh.15,001 and Ksh.20,000 were 10.3%. Few (4.6%) participants were earning between Ksh. 20,001 and Ksh. 25,000. The use of domestic energy varied between liquid petroleum gas which is described as clean energy and biomass which is described as dirty energy (i.e., charcoal & firewood). Less than one-fifth (19.6%) of the participants used clean energy for domestic cooking while more than two-thirds (80.4%) used dirty energy

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for cooking. Majority (39.7%) of the participants had incurred less than Ksh. 500 for outpatient services while 39.7% had spent between 501 and Ksh 1000. 16.5% of the participants incurred between Ksh. 2001 and Ksh. 5000. Those who spent above Ksh. 5000 were 2.1% albeit a government subsidy for outpatient expenditure for children and the elderly in Kenya.

4.2 Correlation Results

The study examined the association between domestic energy options, income and healthcare expenditure as shown in Table 2.

Table 2: Correlation Analysis

		1	2	3
1. monthly income	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	194		
2. Energy Option	Pearson Correlation	-.718**	1	
	Sig. (2-tailed)	.000		
	N	194	194	
3. Health Care Expenditure	Pearson Correlation	.219**	-.288**	1
	Sig. (2-tailed)	.002	.000	
	N	194	194	194

Source: Survey Data (2022)

The results show that income negatively but significantly correlated with domestic energy options ($r=-.718$, $P<0.05$). It was however observed that it was positively and significantly correlated with healthcare expenditure ($r=.219$, $P<0.05$). The positive correlation between income and health expenditure was also observed in an empirical assessment of OECD countries for the period 1995-2015 by Raghupathi (2020). Energy options, on the other hand, negatively but significantly correlated with healthcare expenditure ($r=-.288$, $P<0.05$). These findings however differ from those of Rosário, Urrutia-Pereira (2021) where a positive correlation was established.

4.3 Hypothesis Testing Results

Hierarchical regression was used to determine the influence of income, domestic energy options and healthcare expenditure. Hierarchical regression establishes how much of each predictor variable has to do with the regression (Tabachnick & Fidel, 2013). Using this regression analysis, the contribution of income and domestic energy on healthcare expenditure were measured in the model summary table (Table 3) whereas, the predictive power of the constructs is presented in Table 4. The significance levels of the relationship were measured using the coefficients which are presented in Table 3.

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.288 ^a	.083	.078	1.01810
2	.289 ^b	.084	.074	1.02019

Source: Survey Data (2022)

The results in Table 3, show that domestic energy options explain 8.3% (R square 0.083) of the changes in healthcare expenditure. When household income was introduced in the relationship, the contribution was enhanced slightly by 0.1% (R Square; =0.084 - .083). The strength of the relationship was however weak according to the results, nevertheless, there was a relationship among the constructs. When Rana, Alam, and Gow (2020) tested the relationship between income and healthcare expenditure, the study observed that income contributes 43% to the healthcare expenditure. Rana and colleagues also observed that expenditure was low among low-income countries compared to the developed nations.

Therefore, the study proceeded to test the predictive power of income, and domestic energy options on healthcare expenditure among households. ANOVA table was used as presented in Table 4. Its coefficients were used to show the predictive strength of domestic energy options on healthcare expenditure as represented by F coefficients and significance levels.

Table 4: ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	17.938	1	17.938	17.306	.000 ^b
	Residual	199.015	192	1.037		
	Total	216.954	193			

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2	Regression	18.165	2	9.082	8.727	.000 ^c
	Residual	198.789	191	1.041		
	Total	216.954	193			

Source: Survey Data (2022)

The first model of the ANOVA table shows that domestic energy options had a predictive power on healthcare expenditure ($F=17.306$, $P<0.05$). In the second Model, findings revealed that income could also predict healthcare expenses ($F=8.727$, $P<0.05$). The findings provided room for the study to test the hypothesis as shown in Table 5.

Table 5: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.398	.340		9.987	.000
	Domestic Energy Option	-.766	.184	-.288	-4.160	.000
2	(Constant)	3.169	.598		5.297	.000
	Domestic Energy Option	-.677	.265	-.254	-2.556	.011
	monthly income	.023	.049	.046	.466	.642

Source: Survey Data (2022)

In the first model, the results ($\beta = -.766$, $t=-4.160$; $p<0.05$) show that there was a significant relationship between domestic energy options and healthcare expenditure, therefore, the null hypothesis was rejected. Vrutika Hasmukh Shah (2023) as well as Azorliade, Twerefou, and Dovie (2022) also observed that there was a significant relationship between domestic energy options and healthcare expenditure among Chinese and Ghanian participants respectively.

In the second model, the results ($\beta = .023$, $t=.466$; $p>0.05$) show that the income of households does not moderate the relationship between domestic energy options and healthcare expenditure. Therefore, the study failed to reject the null hypothesis. The findings however differ from those of Azorliade, Twerefou, and Dovie (2022) who observed that households with low income experienced lower healthcare expenditure and likelihood of catastrophic health expenditure.

5. RESEARCH IMPLICATIONS

5.1 Implication to Theory

Given the erratic economic condition globally, high health expenditure is bound to occur. This strains poor households who have to meet other basic needs. This implies that healthcare expenditure is a major concern to poor households. Policymakers and academia are also concerned about healthcare expenditure. There are instances when policies have been developed to avert catastrophic healthcare expenditures. However, few have tried to deal with the causative nature of diseases such as respiratory diseases. The findings of the current study trace the expenditure of poor households to energy options. This helps to build up the existing theory of the causation of healthcare expenditure.

Expenditure in healthcare depends on household disposable income. It is anticipated that income creates demand for goods and service and increases uptake as well as expenditure for healthcare services as held by consumer theory. However, the study refutes this long-held claim as their relationship between the constructs was not established. This then, depicts healthcare services as inelastic. This means that those who seek the services have limited options than to look for funds to meet the costs when they arise. On this basis, there is a need to cushion the population from catastrophic expenditure which is bound to occur.

5.2 Implication to Practice

The current research offers insightful implications for practitioners. The findings provide evidence to help managers adopt clean energy options to reduce the occurrence of respiratory diseases which effectively reduces healthcare expenditure. Additionally, the study demonstrates that income does not affect healthcare expenditure which essentially indicates that the burden of healthcare on poor households continues regardless of their disposable income. Therefore, policy choices should focus on the use of cleaner fuel options including sustaining and extending the access of the rural and poor populations to liquefied petroleum gas, solar, and electricity. It offers the basis for enhancing programs meant to promote the use of clean energy and discourage the use of dirty fuels. Policymakers can also strengthen universal healthcare among the poor population to cushion them against high healthcare expenditures.

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6. CONCLUSION

Findings show that the majority of the participating households were of low income and relied on solid biomass including firewood and charcoal for cooking. Although most of the households incurred less than Ksh. 500 in their outpatient healthcare expenditure there were cases where expenditure was high. The study also observed that domestic energy options drive healthcare expenditure. However, income does not moderate the relationship between domestic energy options and healthcare expenditure.

7. RECOMMENDATIONS

Based on the findings the study makes the following recommendations:

1. Policymakers should seek to improve the uptake of clean energy options among households in Kenya. This can be achieved by subsidizing the cost of clean energy or removing tax on the products
2. There should be a sensitization program on the hazards of dirty cooking energies to the population.
3. The government and other players can encourage the uptake of universal healthcare among poor populations to reduce incidences of catastrophic healthcare expenditure.

8. LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Although it offers several theoretical and practical implications, it experienced limitations. For instance, the study adopted a cross-sectional research design with a structured questionnaire which may have not produced accurate results about healthcare expenditure, domestic energy options, and household income. Further still, the study collected data from urban and rural households. The differences espoused by the rural and urban populations could have distorted the findings. To overcome this limitation, the study recommends future research on a population that is homogeneous.

9. ACKNOWLEDGMENTS

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10. CONFLICT OF INTEREST

The authors declare that there is no conflict of interest

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