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RESEARCH ARTICLE

Biomass to liquefied petroleum gas cooking energy: A solution to indoor pollution ailments in Temeke Municipality, Dar-Es-Salaam

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ABSTRACT

In 2010 World Health Organization estimated that three people per minute die prematurely in Sub-Saharan Africa from diseases attributable to Indoor Air Pollution (IAP). About 95% of Tanzanians still use biomass cooking fuels (BCF) which is the main source of IAP. Promotion of Liquefied Petroleum Gas (LPG) was done since mid-2000s to substitute BCF. However, the use of LPG accounts for only 7.2% of Tanzanians to date. Therefore this paper examined factors influencing use of LPG in Temeke municipality - Dar-es-Salaam. Data were collected from 160 respondents using questionnaires and analysed by using Probit regression model. Results revealed that education level of a household head, household income and time saved for cooking had significant effect on use of LPG at a probability level of $P<0.1$. The probability of using LPG increased by 3.4% with an increase of one more year of education for household heads attaining formal education. Moreover, the probability of using LPGs increased by 11% among household heads whose monthly income increased by 1million Tanzanian Shillings (USD 409). Surprisingly, the probability of using LPG decreased by 0.2% as households saved an additional minute compared to using biomass fuels. It is recommended that the government, private sector and development partners promote LPG use through awareness creation; incorporating LPG use in education and energy policy and conducting research on 'value engineering of LPG cooking facilities' to reduce costs for users.

Keywords: Indoor air pollution, liquefied petroleum gas, Temeke Municipality, cooking energy, Dar-es-Salaam

1. INTRODUCTION

To date 38% of the world population equivalent to 2.8 billion people and almost 50% of population in developing countries have limited access to clean cooking fuel [1, 2]. Developing countries account for more than 80% of total world biomass fuel consumption [3]. In Tanzania the situation is even worse because about 95% of households continue using traditional biomass fuels. However 20% of the households in Tanzania use a mix of cooking energy sources including biomass fuel and other modern fuels like LPG and electricity [4].

The use of biomass fuel has not gone without effect. Prevalence of Indoor Air Pollution (IAP) diseases is associated with the use of biomass fuels [5]. WHO (2014) [6] estimated that 4.3 million people die prematurely worldwide from diseases attributable to IAP; that is equivalent to the death of 4 people in every minute. The diseases include pneumonia, stroke, ischaemic heart disease, chronic obstructive pulmonary disease and lung cancer (These diseases account for 13% and 44% deaths among children below five years and adults respectively [6-8]. The IAP diseases derived from solid fuels ranks the eleventh overall risk factor mortality that accounts for 2.6% of the global burden of disease [9] and ranks third leading cause of disability-adjusted life years in the globe [10].

International Energy Agency and World Health Organisation projected 1.5 million deaths per annum in Sub-Saharan Africa whereby 4,000 people will die every day in 2030 due to health complications related to In house Air Pollution [11]. Bukarasa, 2011 [12] associated the cough/fever with the biomass cooking fuel in the country. The author discovered presence of

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cough/fever to stand at 10%, 21.3% and 28.1% among households using kerosene, charcoal and firewood respectively in Tanzania. Furthermore, Msafiri, 2009 [13] discovered higher rates of Carbon Monoxide (CO) and Suspended Particulate Matters (SPM) of 325 µg m^{-3} and 123,534 µg m^{-3} in Tanzania that exceeds World Health Organisation (WHO) recommended rates of 30 µg m^3 and 150 µg m^3 respectively for households using biomass cooking fuels. The high rates of CO and SPM imply health risks associated with IAP for the public especially women and children who spend about 76% of their time in the house. In fact Ndambuki and Rwanga, 2008 [14] estimated occurrence of cancer to stand at 48 adult cases out of 606,676 if exposed to Lead pollutant for 20 hours per day for fifty years; and 12 cases out of 476,746 among children if exposed to Lead pollutant for 20 hours per day for 10 years compared to the acceptable risk of 1 case out of 1,000,000 people. Moreover, the carcinogenic risk of pollutant Lead was higher among children ($18X10^{-6}$) and adult ($78X10^{-6}$) than acceptable limit of $1 X 10^{-6}$. In Tanzania, indoor air pollution from cooking accounted for an estimated 18,900 deaths in 2011 [15] that is equivalent to 52 deaths per day.

In response to this life threatening situation, various initiatives have been in place to address the use of biomass fuels worldwide and Tanzania in particular. Organizations such as International Energy Agency (IEA) and World Liquefied Petroleum Gas Association (WLPGA) initiated campaigns and projects like Universal Modern Energy Access Case (UMEAC) project, Global Clean Cooking Fuels Initiatives (GCCFI) project, cooking for life and Sustainable Energy for All (SE4ALL) since 2011 through 2012 and 2013 [7, 16, 17]. These campaigns targeted to increase the use of Liquefied Petroleum Gas (LPG) to 100 Million households by 2020 equal to 55% increase from 2005; and one billion by 2030. These efforts would lower the level of carbon monoxide (CO), hydrocarbons and Nitrogen dioxide (NO_2) nineteen times than traditional biomass energy [6, 7]. The above mentioned initiatives have led to increased use of LPGs in Tanzania. The use of LPG as cooking fuels have increased about four folds from 24,470 tons in 2010, to 107,083 tons in 2016 [18, 19] that was used by 0.8% of households in 2011 compared to its use in 2016 which was used by 7.2% of households. However the significant increased utilization of LPG for cooking energy in the country has been outmatched with increased use of firewood that grew by 5% from 66.3% in 2011 to 71.2% in 2016; and the Tanzanian per capita usage of LPG (1.4 kg $year^{-1}$) that is still far below the Sub Saharan Africa consumption of 2.3 kg $year^{-1}$ and Northern African countries whose per capita LPG consumption stood at 55 kg per annum [18]. Moreover, this consumption is far below that of our neighboring Kenya that is four times of Tanzania LPG use [18] regardless of the massive population of 53 million people versus Kenya's population of 45.4 Million people) [21, 22].

Considerable studies have been done in the country's energy subsector [23-29]. While some studies has focused on impacts of substituting clean energy sources to traditional biomass energy [23-24]; others have focused on estimation of costs associated with substituting LPG to biomass fuels in urban households [25] and examining the role of donors on supporting development of efficient renewable energy in Tanzania [26]. Recently, substantial studies have been made towards fuel consumption patterns in different parts of the country [27-29]. However, the studies on energy consumption in the country were done in relatively less urbanised areas with more homogeneous socio economic profiles. This paper contributes to the existing knowledge base by investigating socioeconomic factors affecting the use of LPG in Temeke municipality located in Dar es Salaam Metro-Politan city; where there are residents originating from almost all parts of the country with different socio economic backgrounds that would influence the choice of cooking energy.

2. METHODS

2.1. Theoretical Framework

Conceptually, decision of households to use or ignore LPG for cooking rests on various elements. Income is the main factor that has been hypothesized through Energy Ladder Theory and Energy Stack Theory [30, 31, 32]. Empirical findings in the country and elsewhere in the globe suggest that demographic and socioeconomic factors such as education level, efficiency of the gas in terms of time served during cooking and costs of acquisition & operations influence the LPG use. Household demographic and economic drivers of LPG use include age, gender & marital status of household heads [33]. Moreover, legal and regulatory framework like subsidy, tax wavering, rules and regulations governing the LPG business have been identified as influencers of LPG consumption [33, 34] as they influence LPG's price and eventually the purchasing power of users. Finally, the market development with availability of LPG on time and accessibility were also associated with the use of LPG [33].

Probit regression model has been adopted in this paper over logit regression models as it can be generalized to account for non-constant error variances. However, it is acknowledged that both logistic regression analysis and probit regression models yield similar results such that there is no significant scientific difference between the two models in making inferences to population. In this paper, the decision of household to use LPG fuel in cooking was hypothesized to be a latent variable Y* given demographic and economic characteristics of each individual household as displayed in Eq. (1) and Eq. (2). If Y* is greater than zero, the probability of actual observation given alternatives outcome is equal to one and vice versa.

$$Pr\left[\left(\frac{Y_i^*}{X_i}\right) > 0\right] = \Pr(Y_i = \frac{1}{X_i}) \quad (1)$$

if (Y^*/X_i >0) and

$$Pr\left[\left(\frac{Y^*}{X_i}\right) < 0\right] = \Pr(Y_i = \frac{0}{X_i}) \quad (2)$$

if (Y^*/X_i <0)

1 indicates the use of LPG as a cooking fuel and 0 is for otherwise.

Y_i= Observable outcome.

In other words it can be explained that, if the probability of actual observation (Yi) given Xi, equals to one, the probability of latent variable is greater than zero. Vice versa is also true, such that Pr(Y_i=1,Y*/X_i<0) and Pr(Y_i=0,Y*/X_i<0).

Where Y_i, is given as Eq.(3),

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n \quad (3)$$

Thus the Probit model for the case of this study is given as Eq. (4).

$$Y_i = \beta_0 + \beta_j X_i + \mu_i \quad (4)$$

Whereby;

X_i = is a raw matrix representing factors influencing LPG use among households

β_j= is a column vector representing association of marginal effects on LPG use and

μ_i= independently and normally distributed random error terms.

Therefore the Probit model for desired outcome (Y*>0) is expanded in Eq. (5) and for alternative outcome (Y*<0) is in Eq. (6) respectively as follows

$$\Pr(\left(\frac{Y^*}{X_i}\right) < 0) = Pr(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n) = 0/X_i \quad (6)$$

Whereby;

X_i= Represent a set of social economics features and demographic characteristics influencing the use of LPG for cooking.

β_j = Representing coefficients of marginal effects of Probit model on LPG use for particular individual household and his/her characteristics

μ_i = independently and normally distributed random disturbance (errors) term.

β_0 = Intercept, representing households use of LPGs while X_i hold constants

Where i and j representing 1, 2, 3……….Nth, as a randomness of individual household and his/her characteristics influence on LPG use respectively.

Empirically, the econometrics model is expressed as Eq. (7) below,

$$Y_i = \beta_0 + \beta_1 I + \beta_2 T + \beta_3 E + \beta_4 AT + \beta_5 F + \beta_6 AV + \beta_7 AV + \beta_8 S + \beta_9 G + \mu_i \quad (7)$$

Where,

Y = Dependent variable of either household use LPG or not

β_0 = intercept/constant parameters representing LPG use while other variables fixed.

β_1 = Marginal effects of households' income (I) on LPG use

β_2 = Marginal effects for a minute saving in time (T) on LPG use

β_3 = Marginal effects of households' level of education of household head (E) on LPG use

β_4= Marginal effects for a minute spent to access LPG (AT) on LPG use

β_5 = Marginal effects for unit change in family size (F) on LPG use

β_6 = Marginal effects of LPG availability (AV) on LPG use

β_7 = Marginal effects of household awareness (AW) on LPG use

β_8 = Marginal effects of gender of household head (S) on LPG use

β_9 = Marginal effects of age of household head (G) on LPG use

μ_i = Random stochastic (disturbance) term (error) term.

Table 1. Variables and their measurements

Objectives	Variable	Description	Measurements	Expected sign
Demographic characteristics	Age	Age of household Head	Years	-
	Gender	Sex of household Head	Male/Female	-/+
	Household size	Number of members of household	Number of People	-/+ -
Social Economic characteristics	Income	Income of household head	TZs	+
	Education level	Informal& formal	Years of schooling	+
	Time saving	Time used to prepare meal using LPG Vs charcoal	Minutes	+
Accessibility characteristics	LPG accessibility	Time used to LPG shop	Minutes	-
	LPG availability	Availability of LPG shop in street of residence	Available/not available	+/-

2.2. Data Collection and Analysis

The study employed cross sectional study survey design and the use of multistage sampling technique. At stage one, Dar-es-Salaam city was purposively selected since it is the metropolitan city of the country that hosts about 10% of the national population; and accounts for 70% of the national revenue collection for a period between 1997 and 2011 [35]. This indicates that the use of LPG would be based in DSM since its use is associated with higher incomes of people from the Energy Ladder Theory. Moreover, the 91% of the national LPG storage is located in DSM [18] that renders the gas easily available to consumers for its consumption.

At stage two, Temeke municipal was selected purposively as the study case due to the fact that the main LPG storage facilities are located in the municipal and refining processes are carried out within the municipal. Since 2007 Dar es Salaam port which is also located in Temeke municipal imports more than 95% of Petroleum products; whereby Kurasini Oil Jetty (KOJ) is the major receiving and refining petroleum products point in the country [18, 36]. At stage three, three wards of Temeke, Taongoma and Chamanzi were selected based on population size of the wards.

Primary data were collected with structured questionnaires to household heads or their representative (spouse or any adult daughter/son aged above 18 years). Although questionnaire was constructed in English, it was administered in Kiswahili by researchers. Appointments were made one day before the interview through ward officers and street representatives. Six streets of Matumbi, Temeke, Kongowe, Ponde, Msufini and Mwembebamia were randomly selected from each ward for the survey. Interviews were conducted at their homesteads during weekends since most of them were working far away from their homesteads in the city.

Descriptive statistics analysis was conducted with a focus on measures of central tendency and dispersion to depict features of respondents and LPG use as a cooking fuel in the study area. Moreover, Probit Linear Regression model "(7)" was employed to examine factors influencing the LPG usage among households. Then a number of tests were conducted to assess violations of basic assumptions of multiple linear regressions. Initially, the model specification error test was done by using Ramsey's test (Regression equation specification error test (RESET)). Given the results from RESET, the model was well specified. It was hypothesized that Ho: The model is well specified and Ha: The model is not well specified. A Link test command in (Statistical Analysis) STATA was used for model specification test and found that the probability of hat square (P>|t|) was 0.617 statistically insignificant at 10% level of significance. Therefore authors failed to reject the null hypothesis such that the model was well specified (Table 2).

Moreover, correlation and the volatility inflation factors (VIF) were used to test correlation and multicolinearity of variables respectively. However, neither multicolinearity nor correlation of variables were present because there were no variables whose VIF value was greater than 1.35, and mean VIF value was 1.21 (Table 3).

The correlation matrix showed the maximum correlation of 0.45 between LPG availability and LPG accessibility. In this regard correlation was less than perfect correlation (1) (Fig 1). So it was concluded that there was neither multicolinearity nor correlation of variables problems.

In addition to that, regression with standard errors robust was used to solve the heteroskedasticity problem. The probit regression with robust standard errors minimised standard errors and four variables became significant more than two variables that, were significant before using robust standard error. This signifies that, heteroskedasticity problem was causing large standard errors and insignificance of some variables. Income was transformed into natural logarithm to make somehow linear because had higher variations (Table 4).

Table 2. Linktest for model specification error test

LPG Use	coefficient	Standard errors	P. Value
Hat	1.085691	0.2674584	0.000
Hat square	0.0927219	0.1855415	0.617
constant	-0.0434388	0.2313056	0.851

Probit regression Linktest	Number of observations = 160
LR chi^2 (2)	= 41.60
Prob > chi^2	= 0.0000*
Pseudo R^2	= 0.2694
Log likelihood	= -56.414774
* = significant at 1%,	

Table 3. VIF test for multicolinearity

Variables	VIF	1/VIF
LPG available	1.35	0.7405
LPG accessibility	1.32	0.7569
Age	1.31	0.7647
Income	1.25	0.8007
Gender	1.22	0.8227
Family size	1.20	0.8301
Education	1.15	0.8704
Time saving	1.09	0.9156
Mean VIF	1.21	

	LPGuse	Age	sex	family~e	Edulevel	income	LPGAvail	LPGacc~s	Tsaving
LPGuse	1.0000								
Age	-0.0653	1.0000							
sex	-0.0303	0.2939	1.0000						
familysize	-0.0522	0.3381	0.1007	1.0000					
Edulevel	0.2626	-0.1772	0.1611	-0.0578	1.0000				
income	0.0472	0.1143	0.2586	0.2257	0.1864	1.0000			
LPGAvail	0.0605	-0.1008	0.1063	-0.0611	0.1413	0.1473	1.0000		
LPGaccess	-0.0967	0.0330	-0.0894	0.1014	-0.0580	-0.1713	-0.4540	1.0000	
Tsaving	-0.1007	-0.0238	0.0427	0.0300	-0.0617	0.1960	0.1699	-0.0173	1.0000

Fig 1. Correlation matrix

Table 4. Estimated coefficients with robust standard errors

Variables	Coefficients.	Robust Std. Err.	P > [Z]
Age	0.0022	0.0102	0.8320
Gender	-0.4943	0.4505	0.2730
family size	-0.0530	0.0435	0.2240
Edulevel	0.1474	0.0453	0.0010*
Time saving	-0.0103	0.0064	0.1060***
lnIncome	0.4964	0.2687	0.0650**
LPG Accessibility	-0.0031	0.0162	0.8460
LPG Availability	0.0901	0.3260	0.7820
_cons	-8.1114	3.3866	0.017
Number of observation			160
Wald $chi^2(9)$			30.46
Prob > chi^2			0.0004*
Pseudo R^2			0.2677
Log pseudolikelihood			-56.541002

3. RESULTS AND DISCUSSION

The study revealed that only 19% of respondents in the study area used LPG cooking fuel. The rest (81%) - were cooking with other energy sources. The low use of LPG for cooking can be associated with the risk perception on the energy that is unsafe. LPG cooking facility ranked the second unsafe fuel with 40% of respondents after electricity that accounted for 50% of the interviewed respondents. Firewood and charcoal were perceived safe since only 7.5% and 1.9% perceived them as dangerous cooking fuel types. However, proportion of households using LPG in the study area is relatively higher than the country statistics reported to account for only 7.2% [38, 39]. The difference might be attributed with the fact that the study was done in the urban areas where incomes of people are relatively high compared to overall country residents that would allow higher usage of LPG. Moreover, importation of LPG was first landed in the study area such that its price would be relatively cheaper due to the reduced transport costs.

Table 5 portrays demographic characteristics of respondents in the study area. The table shows that young headed families accounted for most users (66.6%) of LPG. The pattern indicated the negative association between age and the use of LPG. This would be due to the fact that young are ready to test the new things compared to the old. Similar results were found by Thadeo, 2014 [27] who discovered that 73.7% of LPG consumers are aged between 26 and 40 years old.

Furthermore, the study revealed presence of negative association between household size and LPG consumption since households with size 1-5 members accounted for 70% of all LPG users compared to households with more than 5 members (Table 5). The inverse association would be attributed by the fact that as household size increases burden of living also increase to reduce purchasing power of household heads such that they look for cheaper fuel sources biomass fuels. These findings are similar to results from other studies in the country [36] and elsewhere in Sub Saharan Africa such as [40] in Ghana; [41] in Uganda and [42] in Kenya.

Table 6 Shows results on the univariate analysis of socioeconomic factors influencing household LPG consumption. Households whose heads had primary and secondary education dominated consumption of LPG in the study area as they accounted for 40% each. The heads of households with tertiary education accounted for 16.7%. This could be attributed to the fact that most of Tanzanian population is dominated with people with primary followed by secondary school education. This implies that LPG is used by various groups in the society; hence any efforts geared towards promotion of consumption of LPG would yield significant results on lowering IAP associated diseases.

The income of households using LPG fuel was increasing with increasing of LPG use compared to households which do not use LPGs. When income rises between 300,000 to 700,000, the households which use LPG were 36.7% significantly bigger than 31.5% households of the same income which were not using LPG. Again 3.3% is bigger than 3.1% for households with the same income above 700,000 TZs. The results conform to the energy ladder theory which proposes as households income rises, switches from inefficient traditional cooking fuels to the most efficient modern fuels such as LPG and electricity.

Among households that were using LPG, 60% reported to save up to 30 minutes when compared to traditional charcoal fuels per meal than 53.1% who were not using LPG. Moreover 40% of LPG users reported to save a maximum 60 minutes than 38.5% that were not using LPGs. This implies that, households which use LPG used less time compared to the ones that were using charcoal fuels. Similar findings were reported by [2] that, women prefer cooking with LPG to traditional fuels because it saves up to two hours a day.

Results in Table 7 show accessibility of LPG in the study area. About 93% of household who were using LPG were able to access it within 15minutes walking time, while seven per cent accessed LPG within 16 to 30 minutes. This indicated that, accessibility for LPG is not a limiting factor for its use since it was almost found nearby shops in the study area. Similarly Kilahama [44] found that, about 67% of the respondents were using charcoal fuels in Dar es Salaam because it was accessible within five (5) minutes from their homes.

About 50% of households who used LPG reported that, the gas was available in their streets while 42% who did not use LPG reported the same.

Table 5. The analysis of demographic characteristics on LPG use

Characteristics	Categories	Non-Use LPG		Use LPG	
		Frequency	%	frequency	%
Age	18-40 Years	86	66.2	22	73.3
	41-60 Years	34	26.2	7	23.3
	above 60 Years	10	7.7	1	3.3
Total		130	100	30	100
Family Size	1 – 5	92	70.77	21	70
	6 – 10	30	23.1	8	26.7
	Above 10	8	6.2	1	3.3
Total		130	100	30	100

Table 6. Distribution of LPG users in the study area

Characteristics	Categories	Not Use LPG		Use LPG	
		frequency	%	Frequency	%
Education	Informal Education	1	0.8	1	3.3
	Primary Education	93	71.5	12	40.0
	Secondary Education	33	25.4	12	40.0
	Tertiary Education	3	2.3	5	16.7
Total		130	100	30	100
Income	80,000 -300,000	85	65.4	18	60.0
	300,000 -700,000	41	31.5	11	36.7
	>700000	4	3.1	1	3.3
Total		130	100	30	100
Time Saving	1 - 30 min	69	53.1	18	60.0
	31- 60 min	50	38.5	12	40.0
	Above 60 min	11	8.5	0	0
Total		130	100	30	100

Table 7. The analysis of LPG accessibility characteristics on LPG use

Characteristics	Categories	Not Use LPG	Use LPG		
		frequency	%	Frequency	%
	Less 15 min	100	76.9	28	93.3
Accessible Source	16 - 30 min	28	21.5	2	6.7
	31 - 45 min	2	1.5	0	0
Total		130	100	30	100
LPG Availability	Not available	75	57.7	15	50
	Available	55	42.3	15	50
Total		130	100	30	100

3.1. *Estimation of Parameters and Post Estimation Tests*

Once parameters of the model were estimated with probit regression using Statistical Analysis (STATA) software program, only one variable (education) was statistically significant at 5% level of significant (Table 8). This prompted authors to test for violations of regression assumptions.

Table 9: Various tests for assumptions were done as clearly discussed in section three: data collection and analysis. Finally, the findings were based on Marginal effects of Table 9 as marginal effect gives the direct probability values of the predictor variables to the predicted variable in probit regression than coefficients parameters does. Therefore an additional insight is provided by analysing the marginal effects which is calculated as the partial derivatives of the non-linear probability function (dy/dx), evaluated for each variable sample mean given the objectives of the study.

The results in Table 9 reveal that level of education to have positive influence on LPG Use at 1% significant level. The probability of using LPG increased by 3.4% with an increase of one more year education for household head attaining formal education. This implies that increase of LPG use as a cooking energy can be attained through promoting more people to attain higher levels of education. This pattern can be associated with the fact that as people attain higher levels of education become aware of the hazards derived from usage of biomass fuel; and so opt alternative clean energy. The results are similar to the findings by [44] in India; [45] in Ethiopia; [46] in Kenya and [47] in Nigeria who also uncovered positive association between education levels and the use of cooking clean energy.

Table 8. Probit Regression before standard error robust

LPG Use	Coefficients	Standard errors	P. Values
Age	0.0021656	0.010788	0.841
Gender	0-.4942867	0.4175677	0.237
Household size	-0.0529795	0.0609838	0.385
Education	0.147438	0.0489108	0.003*
Time saving	-0.0102919	0.0074363	0.166
LnIncome	0.496432	0.3149989	0.115
LPG Accessibility	-0.0031421	0.022084	0.887
LPG availability	0.0901329	0.313859	0.774
Constants	-8.111426	3.949429	0.040

Probit regression Number of observations = 160
LR chi^2 (9) = 41.34
Prob > chi^2 = 0.0000
Pseudo R^2 = 0.2677
Log likelihood = -56.541002
* = significant at 1%

Table 9. Output of marginal effects

Variables	Marginal eff.	z	Robust Std. Err.	P > [Z]
Age	0.0005	0.2083	0.0024	0.8320
Gender	-0.0944	-1.3923	0.0678	0.1630
family size	-0.0122	-1.1961	0.0102	0.2320
Edulevel	0.0340	3.4343	0.0099	0.0010***
Time saving	-0.0024	-1.7143	0.0014	0.0930**
lnIncome	0.1144	1.8392	0.0622	0.0660**
LPG Accessibility	-0.0007	-0.1892	0.0037	0.8460
LPG Availability	0.0209	0.2743	0.0762	0.7840

***, **, and * = significant at 1%, 5% and 10%, respectively

Furthermore Table 9 portrays that incomes of household heads had positive effect on LPG use at 10% statistically significant level. The results indicated that probability of using LPGs increased 11% among household heads whose monthly income increased by 1million Tanzanian shillings (USD 409) provided that other factors remained constant. Therefore efforts towards rising people's income would lead to substitution of cheaper biomass cooking fuels by LPG. This can be done through tariff exemptions to LPG canals, and/or subsidization of the LPG to increase the purchasing power of users. This result is in line with the finding by Arogo [46] in Kenya that households spending promotes households to switch to the use of modern energy (electricity and solar) over wooden fuels and kerosene.

Meanwhile Table 9 shows that time saving had negative influence on LPG Use at 10% statistical significant levels. Suprisingly, probability of using LPG were decreasing as household save additional minute from cooking with LPG over charcoal fuels by 0.24 %. The results differ from the expectation and general rule of wisdom. The results implies that time saving is not the only fact considered by LPG users; but rather the perception risk among the society. This was revealed by the fact that 40% of respondents perceived LPG as the riskiest cooking fuel followed by electricity. The result was similar to findings by Kilabuko and Nikai [48] who found that 80% of the respondents in Dar es Salaam faced the challenge to abandon charcoal fuels despite cooking with LPG were saving time than charcoal fuels. However, the result is contrary with that of [2, 49] who found that time saving was the motive drive for households to use LPG over traditional biomass fuels in third world developing countries and India respectively.

4. CONCLUSIONS

Based on the findings of the study it can be established that the key driving factors for consumption of LGP in Temeke Municipality, Dar-es-Salaam can be grouped into two categories. The first category is to do with risk perception where there is fear that LGP gas can cause hazardous explosions when used for cooking. This perception is linked with limited level of education and older age. So the greater the age with limited level of education the more the perceived risk of using LGP gas for cooking. The second category of driving factors is the level of income. The higher the income the higher the consumption of LPG gas at household level. This is also linked with family size where the income level seems to be affected by the energy demands of the family size. The bigger the family size the greater the demands for basic needs that lessen ability to afford LPG at a given fixed level of income. It is also a fact that most users of biomass energy for cooking are low income earners.

In order to increase consumption of LPG gas at household level; five initiatives need to be done by various stakeholders as a solution for in-house air pollution associated ailments.

First, undertaking of LPG user knowledge campaign on its benefits over biomass fuels is critical to harness the negative perception of current and potential users on the risks of its use in their homesteads. Would the use of LPG be well articulated and adopted, it could serve as a tool to lessen diseases that are attributed to In-house Air Pollution that are more prevalent among children and mothers.

Secondly, adding practical lessons in the curriculum at primary and secondary school levels on the use of LPG for cooking would also help because it matches well with the findings of the study that those with low level of education perceive that there is a high risk of using LPG for cooking.

Thirdly, at policy level the government needs to consider special attention and commitment in promotion of use of LPG at household level. This needs to be incorporated in the energy policy and programmes where objectives and targets regarding LPG promotion should be clearly articulated. This includes the incorporation of LPG use for cooking in the primary and secondary schools curricula and devising an LPG subsidy mechanism to reduce cost of acquiring gas packaging facilities, cookers and the gas itself for low income households. This is against the background of the existing national energy development policies. For example, the Five Year Development Plan II (2015/16 – 2020/21) advocates for promotion of LPG to be done through the development of policy and institutional capacity [50]. However, the National Energy Policy 2015 has put more emphasis on electricity generation such that LPG promotion is not well articulated with clear objectives and targets. Moreover, even in the previous energy programmes and strategies such as EWURA strategic plan 2012/13 – 2016/17 LPG for household use did not receive special attention.

Moreover, the limited attention to LPG prevailed further even in the programmes that came later such as the Power Master Plan 2016 [50] and EWURA strategic plan 2017/18 – 2021/22 [51] where there are no specific objectives for promotion of LPG as cooking energy at household level.

Lastly but not least there are two areas that need attention for further research. First, further research needs to be done on Demand and Supply of the LPG gas for cooking at national level. Currently there is limited information as to how much LPG gas is demanded for cooking at household level and how much is supplied. It is hard to establish whether there is demand gap or a supply gap exists. Information from such studies will be useful to establish the level of promotion required if the demand is short of supply or the supply is short of demand. This will build up a good basis for promotion of the cooking energy by various stakeholders ranging from the government, the private sector, Non-governmental organizations to other development partners as they strive to save lives of people from indoor air pollution ailments.

Another potential area for further research is value engineering of LPG gas facilities. This is to do with finding out possibilities of reducing cost of packaging materials of the gas or increasing efficiency of cookers by cooking more foodstuffs by using less amount of gas.

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