Correlates of Ghanaian households' use of clean cooking fuels: insight from the 2014 demographic and health surveys

Seth Sylvester Dadzie
Institute of Statistical, Social and Economic Research, University of Ghana https://orcid.org/0000-0002-4435-9803

Paul Lawer Kenney
Institute of Statistical Social and Economic Research, University of Ghana

Nakua Kweku Emmanuel
Kwame Nkrumah University of Science and Technology

Agboh Nuake Kofi Herman
Department of Social Work, University of Ghana

Duah Ofori Henry
Foundation of Orthopaedic and Complex Spine Hospital, Accra, Ghana

Dzomeku Millicent Veronica
Kwame Nkrumah University of Science and Technology

Agbadi Pascal (pascalagbadi@gmail.com)
Kwame Nkrumah University of Science and Technology https://orcid.org/0000-0001-5297-2512

Research article

Keywords: cooking fuel, clean fuel, biomass, dirty fuel, energy, Ghana

Posted Date: November 2nd, 2020

DOI: https://doi.org/10.21203/rs.2.21295/v3

Abstract

Background: Globally, about 2.9 billion persons, the majority of whom are from low and middle-income countries, depend on poorly combusted biomass and coal for cooking and heating. Using poorly combusted fuels have negative implication on people's health and quality of life. In Ghana, only about two out of ten households use clean fuels for cooking. Predictive models of associated factors of clean cooking fuels in Ghana are rare.

Objective: The study assessed the factors that influence Ghanaian households' use of clean fuels. In this paper, we define electricity, LPG, and natural gas as clean cooking fuels, and kerosene, coal, lignite, charcoal, wood, straw/shrubs/grass, and agricultural crop as dirty cooking fuels.

Methods: The study used the data of the cross-sectional demographic and health surveys conducted in 2014. Logistic regression was used to perform bivariate and multivariable analysis. We adjusted for the study designed and the household sampling weights.

Results: We found that the following factors were associated with a higher odd of a Ghanaian household to use clean fuels for cooking: rich households, male-headed households, households' headed by persons between 24years and 55 years, households with heads that were currently married or never married, households with heads that have attained at least a primary level education, households with less than eight members, households with at least two women, and households in Western, Central, Greater Accra, Volta, Eastern, Ashanti, Brong Ahafo, Upper East region. We further found that place of residence interacted with the relationship between study covariates and the uptake of clean cooking fuels.

Conclusion: In view of these findings, we recommend: a national effort to subsidize and make LPG and the stoves that burn it affordable; education on efficient and sustainable consumption must be intensified and incorporated in the basic school's curriculum to ensure the future generation are more health-conscious; creation of multiple LPG refilling outlets in all the regions in Ghana.

Background

Home cooking, an essential activity that primarily promotes human health and growth, is facilitated by the combustion of fuel. The type of fuel used in cooking can either support or obstruct its primary purpose. Fuels that are beneficial to human health, preferably, should undergo complete combustion process [1]. Globally, about 2.9 billion persons, the majority of whom are from low and middle-income countries, depend on poorly combusted biomass and coal for cooking and heating [2]. In Ghana, it is estimated that about eight out of ten households rely on biomass for cooking and heating [2]. These fuel types emit health destructive pollutants such as carbon dioxide, carbon monoxide, benzene, butadiene, nitrogen oxides, formaldehyde, polynuclear aromatic hydrocarbons, and fine particulate matter [3, 4].

Prolonged exposure to smoke from poorly combusted fuels is associated with high morbidity and mortality among the aged, adults, and children [1, 2, 5]. About 4 million persons, 54% of whom are women

and children, lose their lives annually from using poorly combusted fuels [2]. Incomplete combusted products can adversely affect household air quality, resulting in a myriad of adverse health effects such as pneumonia and bronchitis in children [1, 5], chronic obstructive cardio-pulmonary disease, cancer, and poor pregnancy outcomes such as low birth weight and neonatal deaths among women [1]. Given the negative effects the use of biomass fuels have on people's health and environment, the International Energy Agency, the United Nations (UN), the World Health Organization (WHO) and other international bodies are advocating for the use of clean cooking solutions in the interest of promoting good human health and environment sustainability [2].

Despite the progress made by governments, non-governmental organizations, and energy advocates to use clean fuels to meet household energy needs, the current estimate suggests that 4 out of 10 people worldwide do not have access to clean cooking energy sources [2]. Sub-Sahara Africa (SSA) has the largest clean cooking energy access deficit with only about 14% of its population having access. Although Ghana's estimate of 25% of the population having access to clean cooking energy sources is higher than the SSA average [2], it is undesirable and puts Ghana in a lagging position towards achieving the SDG 7 of universal adoption of clean cooking energy by 2030.

Studies have investigated the factors that explain household access, adoption and use of clean fuels across the globe [6-11]. These studies have identified the following as associated factors of uptake of clean cooking fuels and technologies: gender, marital status, household size and age of household head as well as socioeconomic factors including but not limited to household wealth status, level of education, place of residence (urban/rural), market development, programme and regulatory mechanisms significantly influence the access, adoption and use of clean cooking fuels among households in Asia, Latin America and Africa. In Ghana, Armah et al [11] conducted a study using DHS datasets from 31 sub-Sharan African countries including Ghana. Their paper, though included the same dataset we used for our study, is different in several ways. They created a new variable from merging household wealth and household head education level and treated it as one variable in the model. Given the cross-country nature of their study, their model excluded the region of residence and gave little attention to local context. Despite the similarity of factors across sub-Saharan Africa, a context-specific investigation to examine associated factors of clean cooking fuels in Ghana is imperative for national policy formulation and implementation. Given the gap in the literature, our study aimed to build a model of associated factors of uptake of clean cooking fuels in Ghana.

Methods

Design

The 2014 Ghana Demographic and Health Surveys (GDHS) data was collected in line with a cross-sectional survey design [12].The survey employed two-stage probability sampling, stratified by urban and rural areas of the ten administrative regions of Ghana [12]. The sampling frame for the survey was based on the updated sampling frame from the 2010 Ghana Population and Housing Census [12]. The first

stage of the probability sampling involved the selection of enumeration areas (EAs), which was stratified by place of residence [12]. A total of 427 EAs were selected, 216 in urban areas and 211 in rural areas [12]. The second stage of the probability sampling involved the systematic sampling of households [12]. The implementers of the survey undertook a household-listing operation in all the selected EAs from January through March 2014, and households to be included in the survey were systematically selected from the list [12]. Approximately 30 households were selected from each EA to constitute the total sample size of 12,831 households [12].

Data collection

Trained enumerators collected the data from early September to mid-December 2014 using paper-based questionnaires [12]. The selected sample size for the 2014 GDHS was 12,831 households, of which 12,010 were occupied [12]. Out of the occupied households, 11,835 were successfully reached, resulting in a 99% response rate [12]. In the GDHS, household heads provided information on their demographic characteristics and household characteristics such as household population and composition, housing structure, household assets, access to basic utilities, sources of drinking water, water treatment practices, access to sanitation facilities, and type of fuel used for cooking [12].

Study sample

The unit of analysis is households, and the dataset contains 11,835 households. The data were weighted using the household weight variable in the dataset. A sample of 513 households indicated that they cooked no food in the house, so they were excluded from further analyses. Therefore, the analytic weighted sample is 11,322.

Variables

Outcome variable:

In the dataset, the household head was asked to select the main source of fuel for cooking in the household from the following categories: electricity, LPG, natural gas, kerosene, coal, lignite, charcoal, wood, straw/shrubs/grass, and agricultural crop. Electricity, LPG, and natural gas was defined in our study as clean cooking fuels and all other sources of fuels as dirty fuels. Additional file shows the proportion of households using each of the fuel types for cooking in Ghana (See Additional file 1).

Covariates:

Ten sociodemographic characteristics variables were selected as potential covariates based on literature and availability of the variables in the DHS household datasets. Marital status was recoded as follows: never in union (as never married), married and living with partner (as currently married), widowed, divorced, and no longer living together/separated (as formally married). Age of household head was recoded as follows: 15-24 years, 25-34 years, 35-44 years, 45-54 years, and 55+ years. Household size was recoded as follows: 1 member, 2 members, 3 members, 4-5 members, 6-7 members, and 8+

members. Number of women or men in the household variables were recoded as follows: none, 1 woman/man, 2+ women/men. The household head's education and region of residence variable were used as available in the dataset and their categories are presented in the result tables. For the bivariate and multivariable analysis, household wealth was dichotomized as follows: poor (poorest, poorer, and middle) and rich (richer and richest). Household wealth index was already estimated and reported in the DHS data. This was created using household characteristics (source of drinking water, type of toilet, sharing of toilet facilities, main material for roof, and walls and floor materials amongst other household characteristics) and household possessions and assets (ownership of television, radio, vehicle, bicycles, motorcycles, watch, agricultural land, farm animals/livestock, and bank account amongst others). DHS used a principal component analysis (PCA) to assign weights to each asset in each household and cumulative score were calculated from the assigned weights. Households were ranked according to the cumulative scores from the household assets. The cumulative percentage distribution of the wealth score was estimated and the wealth score values that corresponded to the four cut point values of the quintiles (20th, 40th, 60th, and 80th percentiles) were determined. Households with values less than or equal to the 20th percentile score were assigned poorest, those greater 20% but less than or equal to 40th % were assigned poorer, those greater than the 40th % and less than or equal to the 60th % score were assigned middle, greater than the 60th % and less than or equal to the 80th % score were assigned richer and the richest household were those with scores greater than the 80th percentile score. Wealth index was thus ranked into quintiles: poorest, poorer, middle, richer, and richest [13].

Analytic procedure

We used STATA version 14 for the data analyses. Summary statistics, bivariate, and multivariate analyses were performed using logistic regression technique. After the bivariate analyses, we checked the interaction effect of urban-rural on the relationship of the covariates and the outcome variable. Following interaction effect results, we build separate models for rural sample, urban sample, and the full sample. We performed specificity and sensitivity analyses on the three models using Area under the ROC curve (AUROC). The analysis accounted for sampling design (cluster, strata) and household weights using the 'svy' command in a default mode. The Area under the ROC curve was performed on unweighed samples given that ROC doesn't work with population weights in STATA (see Additional file 2). Before performing the multivariable analyses, we check the assumption of multicollinearity and no violations were observed. The variance inflation factors of the covariates are all less than 2 (see Additional file 3), which are far less than the cut of points of 10 [14]. All variables were included in the model so long as they were not collinear with each other.

Results

Sample Characteristics

In the dataset, 3040 (26.9%) households were using clean fuels for cooking. Majority of the households were headed by males (64.9%). Most of the household heads were currently married (62.9%). The

summary statistics for the remaining study variables are reported in Table 1.

Table 1: Summary statistics of study variables

Variables	n(%)
clean cooking fuels	
Using	3040 (26.9)
Not using	8282 (73.1)
Sex of household head (HH)	
Male	7347 (64.9)
Female	3975 (35.1)
Age of HH	
15-24	772 (6.8)
25-34	2707 (23.9)
35-44	2721 (24.0)
45-54	2165 (19.1)
55+	2954 (26.1)
Missing	3
Marital status of HH	
Never married	1618 (14.3)
Currently married	7123 (62.9)
Ever married	2576 (22.8)
Missing	5
The education level of HH	
None	2540 (22.4)
Primary	1547 (13.7)
Middle/JSS/JHS	4416 (39.0)
Secondary and above	2818 (24.9)
Missing	2
Size of HH	
1	2528 (22.3)
2	1828 (16.1)
3	1721 (15.2)
4-5	2976 (26.3)
6-7	1574 (13.9)
8+	694 (6.1)
Number of women (15-49) in HH	
0	3852 (34.0)
1	5862 (51.8)
2+	1609 (14.2)
Number of men (15-49) in HH	
0	7815 (69.0)
1	2868 (25.3)
2+	639 (5.6)
Household wealth	
Poorest	1585 (14.0)
Poorer	2149 (19.0)
Middle	2494 (22.0)
Richer	2503 (22.1)
Richest	2590 (22.9)
Urban/rural residence	
Urban	6161 (54.4)
Rural	5161 (45.6)
Region	
Western	1229 (10.9)

Central	1150 (10.2)
Greater Accra	2343 (20.7)
Volta	991 (8.8)
Eastern	1230 (10.9)
Ashanti	2049 (18.1)
Brong Ahafo	979 (8.6)
Northern	721 (6.4)
Upper East	372 (3.3)
Upper West	259 (2.3)
HH: Household Head	

Association between the outcome variable and the covariates

Results from the bivariate analysis revealed that sex, age, marital status, and education of HH, size of household, number of men in the household, household wealth, locality of residence, and region of residence were statistically significantly associated with the use of clean cooking fuels. Also, the place of residence (rural/urban) modifies the relationship between uptake of clean cooking fuels and the study covariates.

Table 2: Associated factors of uptake of clean cooking fuels and urban/rural interaction effect

		Urban/Rural interaction effect
	OR [95% CI of OR]	Adjusted Wald χ^2 test
Sex of HH (Ref: Female)		$F(3, 405) = 84.4, p \leq 0.01$
Male	1.39 [1.21, 1.59]	
Age of HH (Ref: 55+)		$F(9, 399) = 34.87, p \leq 0.01$
15-24	3.59 [3.01, 4.29]	
25-34	2.46 [2.01, 3.00]	
35-44	1.65 [1.36, 2.00]	
45-54	2.79 [2.20, 3.54]	
Marital status of HH (Ref: Ever married)		$F(5, 403) = 72.15, p \leq 0.01$
Currently married	1.85 [1.54, 2.22]	
Never married / never lived together	5.37 [4.43, 6.52]	
Education of HH (ref: No education)		$F(7, 401) = 106.25, p \leq 0.01$
Primary	2.82 [2.00, 3.97]	
Middle/JHS/JSS	8.41 [6.42, 11.01]	
Secondary/SSS/SHS/Higher	37.93 [28.43, 50.62]	
Size of HH (ref: 8+ members)		$F(11, 397) = 24.38, p \leq 0.01$
1 member	7.04 [4.75, 10.43]	
2 members	4.92 [3.12, 7.75]	
3 members	4.46 [3.02, 6.57]	
4-5 members	3.23 [2.11, 4.94]	
6-7 members	2.01 [1.29, 3.15]	
Number of women in HH (ref: None)		$F(5, 403) = 33.24, p \leq 0.01$
1 woman	0.99 [0.86, 1.12]	
2+ women	0.73 [0.58, 0.91]	
Number of men in HH (ref: none)		$F(5, 403) = 39.65, p \leq 0.01$
1 man	1.25 [1.12, 1.40]	
2+ men	0.72 [0.56, 0.94]	
Wealth status of HH (Ref: Poor)		$F(3, 405) = 220.85, p \leq 0.01$
Rich	34.98 [26.61, 45.99]	
Region (ref: Northern)		$F(19, 389) = 20.89, p \leq 0.01$
Western	10.17 [5.20, 19.91]	-
Central	8.37 [4.24, 16.55]	-
Greater Accra	34.60 [17.99, 66.54]	-
Volta	5.36 [2.66, 10.77]	-
Eastern	5.64 [2.82, 11.29]	-
Ashanti	12.38 [6.54, 23.42]	-
Brong Ahafo	4.42 [2.17, 9.01]	-
Upper East	1.89 [0.93, 3.86]	-
Upper West	1.93 [0.68, 5.47]	-
Place of residence (ref: rural)		-
Urban	6.63 [4.92, 8.93]	-
Strata	20	
Primary sampling units	427	
Observations	11362	
Population size	11315	

Predictive model of clean cooking fuels

Figure 1 presents the results for the AUROC of rural, urban, and full samples. It shows an area under the ROC curve of 93.4%, 86.6%, and 92.1% for the rural, urban, and the full samples, respectively. These results indicate a good predictive ability of the fitted models to predict uptake of clean cooking fuels.

In the multivariate model for the full sample, the following factors were associated with an uptake of clean cooking fuels among Ghanaian households: male-headed households, households' headed by persons between 24 years and 44 years, households with heads that were currently married or never married, households with heads that have attained at least a primary level education, households with less than eight members, households with at least two women, rich households, and households in Western, Central, Greater Accra, Volta, Eastern, Ashanti, Brong Ahafo, Upper East region. Few differences exist between the urban and rural populations in terms of the predictors of clean cooking fuel uptake. The number of women in the household and the gender of household head were significant predictors of uptake of clean cooking fuels in the urban sample but not in the rural sample. Details of the odd ratio estimates of each covariate in the model with its corresponding 95% confidence intervals are reported in Table 3.

Table 3: Adjusted Model of clean cooking fuels: rural, urban, and full sample (weighted)

	Rural sample	Urban sample	Full Sample
	AOR [95% CI of AOR]		
Sex of HH (Ref: Female)			
Male	0.95 [0.59, 1.53]	1.34 [1.07, 1.69]	1.25 [1.01, 1.54]
Age of HH (Ref: 55+)			
15-24	2.50 [1.44, 4.35]	1.45 [1.06, 1.98]	1.67 [1.27, 2.19]
25-34	1.49 [0.91, 2.43]	1.48 [1.14, 1.91]	1.49 [1.19, 1.86]
35-44	1.09 [0.61, 1.96]	1.44 [1.11, 1.87]	1.37 [1.09, 1.72]
45-54	1.11 [0.57, 2.17]	0.99 [0.58, 1.68]	1.03 [0.68, 1.56]
Marital status of HH (Ref: Ever married)			
Currently married	1.32 [0.75, 2.30]	1.54 [1.16, 2.03]	1.49 [1.16, 1.92]
Never married / never lived together	1.47 [0.63, 3.44]	1.74 [1.24, 2.44]	1.66 [1.20, 2.30]
Education of HH (ref: No education)			
Primary	0.80 [0.41, 1.58]	1.79 [1.18, 2.71]	1.45 [1.02, 2.06]
Middle/JHS/JSS	1.99 [1.15, 3.44]	2.72 [1.93, 3.84]	2.46 [1.82, 3.32]
Secondary/SSS/SHS/Higher	5.37 [3.05, 9.47]	7.71 [5.36, 11.09]	6.94 [5.11, 9.43]
Size of HH (ref: 8+ members)			
1 member	30.78 [3.95, 240.17]	3.39 [1.77, 6.49]	4.47 [2.56, 7.81]
2 members	13.84 [1.62, 118.43]	2.52 [1.32, 4.80]	3.00 [1.71, 5.25]
3 members	23.62 [3.02, 184.76]	1.94 [1.07, 3.52]	2.72 [1.63, 4.55]
4-5 members	11.70 [1.52, 89.77]	1.27 [0.67, 2.41]	1.64 [0.96, 2.83]
6-7 members	10.15 [1.28, 80.40]	0.94 [0.50, 1.78]	1.26 [0.73, 2.19]
Number of women in HH (ref: None)			
1 woman	0.86 [0.49, 1.49]	1.18 [0.91, 1.51]	1.11 [0.88, 1.39]
2+ women	1.18 [0.52, 2.66]	1.54 [1.02, 2.32]	1.47 [1.02, 2.12]
Number of men in HH (ref: none)			
1 man	0.91 [0.59, 1.40]	0.97 [0.78, 1.20]	0.96 [0.80, 1.16]
2+ men	1.39 [0.60, 3.21]	1.07 [0.71, 1.63]	1.10 [0.76, 1.58]
Wealth status of HH (Ref: Poor)			
Rich	16.46 [11.02, 24.58]	17.61 [11.68, 26.57]	16.91 [12.89, 22.19]
Region (ref: Northern)			
Western	5.99 [2.20, 16.34]	3.48 [1.57, 7.73]	4.03 [2.12, 7.68]
Central	5.98 [2.30, 15.56]	3.35 [1.42, 7.92]	3.96 [2.05, 7.64]
Greater Accra	9.20 [3.96, 21.41]	5.88 [2.83, 12.23]	6.53 [3.61, 11.82]
Volta	6.16 [2.35, 16.13]	3.55 [1.63, 7.75]	4.16 [2.21, 7.84]
Eastern	3.54 [1.38, 9.12]	2.26 [1.02, 4.99]	2.51 [1.33, 4.76]
Ashanti	5.34 [2.34, 12.18]	3.41 [1.62, 7.17]	3.76 [2.09, 6.79]
Brong Ahafo	2.30 [0.92, 5.77]	3.01 [1.30, 6.97]	2.92 [1.50, 5.69]
Upper East	2.16 [0.74, 6.28]	3.69 [1.50, 9.10]	2.90 [1.49, 5.62]
Upper West	3.91 [0.98, 15.62]	1.04 [0.46, 2.35]	1.82 [0.68, 4.84]
Place of residence (Ref: Rural)			
Urban			1.01 [0.78, 1.31]
Strata	10	10	20
Primary sampling units	211	216	427
Observations	5731	5631	11362
Population size	5161	6155	11315

Discussion

The study sets out to do further analysis of the 2014 DHS data to build a predictive model of factors associated with uptake of clean fuels for cooking in Ghanaian households.

The findings reveal that less than a third of Ghanaian households were using clean fuels for cooking. A decade ago, the proportion of households that had access to LPG was estimated to be 18% [15]. Our result show that Ghana's progress regarding access to clean cooking fuels has been slow (26.9%). Since the early 1990, the government of Ghana has implemented Liquefied Petroleum Gas (LPG) program to encourage households to use (LPG) for cooking as a better alternative to the commonly used traditional biomass fuels [16]. The program has mainly undertaken safety awareness campaign, local production of cylinder and its accessories and increase LPG accessibility to the population by distributing free LPG gas cylinders [16]. The LPG cylinder distribution was further intensified in 2013. The objective of these programs is to ensure 50% of Ghanaian households depend on LPG for their cooking energy needs by 2015 [17], 2020 (revised timeline) [15], and 2030 (new timeline) [18]. The revision of the timelines was due to the failure of government to meet its target. Given the current estimate and the slow adoption rate for clean cooking solutions, it will be prudent for the government of Ghana to review and evaluate the LPG promotion programs.

The households' use of clean cooking fuels were also found to be positively associated with certain household head demographic factors, household characteristics, place and region of residence. To begin with, male-headed households were more likely to use clean fuels for cooking compared to female-headed households. Men have more economic advantage in most Ghanaian communities. This advantage positions men to purchase clean fuels that are generally considered expensive in Ghana. Even though some studies present similar results, others present contrary findings. For example, one study conducted in South Asia found that female-headed households were more likely to use clean cooking fuels [19, 20]. The authors mentioned the ability of clean cooking fuels to reduce the drudgery associated with cooking as a major influential factor for its adoption, hence the use by female-head households.

Again, households headed by persons between 24 years and 44 years were observed to have a higher odd of using clean cooking fuels. Conventionally, persons within this age group belong to the active working-age population, granting them easier access to economic opportunities. Therefore, these individuals are more likely to afford the usage of clean cooking fuels. Additionally, persons above 55 years may find it difficult and inconvenient to adopt clean fuels for cooking because they perhaps belong to a generation that predominantly relied on solid fuels for cooking [21]. Other scholars also explain that the tendency to experiment and to adopt efficient modern technologies and behaviour may be a contributing factor for the adoptions and use of clean cooking fuels among the younger generation [22].

Furthermore, we found that households with currently married or never-married individuals were more likely to use clean cooking fuels. In today's Ghana, it is trendy for couples to rely on LPG and electricity for cooking. Also, anecdotal evidence suggests that couples may be more likely to use clean cooking fuels because of its convenience. Even though undocumented in the literature, it is prudent to argue that

households with never-married heads were more likely to use clean cooking fuels due to its convenience and the high tendency of reducing exertion often associated with traditional cooking methods.

Moreover, we found education, one of the most frequently studied variables as another key contributing factor influencing adoption and use of clean cooking fuels among households. This is because the educated household head is more informed on the environmental and health benefits of cleaner cooking fuels which influence its adoption and use. One scholar in a similar study opined that educated household heads in urban communities are more inclined to use clean fuels [6]. In addition, it is instructive to reason that educated household heads may have more access to economically viable opportunities than their uneducated counterparts. This economic advantage provides educated households with high-income levels to purchase clean fuels which are relatively expensive but convenient to use.

Besides, the study revealed that household's with less than eight members have a higher likelihood of using clean cooking fuels. We attribute this phenomenon to the reduction in the financial burden in smaller households than larger households. Large households in Ghana are most often dominated by dependent individuals. The high demand for cooking energy uses due to the family size and the challenge of limited resources create the situation of treating the adoption and use of clean cooking fuels which are most often expensive as a periphery or less of a household need due to prevailing household welfare status. Other studies confirms this finding [23-25].

We also found that households with at least two women had a higher likelihood of using clean fuels. In Ghana, cooking activities are mostly a preserve of adult female household members. This exposes them, (especially women without clean cooking methods) to chronic obstructive cardio-pulmonary diseases (COPD) such as bronchitis, lung cancer, asthma etc than their counterparts who adopt and use clean fuels. We argue that in an attempt to avert the physical drain and negative health implications associated with the burning of solid biomass for cooking, households with 2 or more adult females are more likely to combine financial resources to adopt clean fuels which is more convenient, timesaving and healthy. Findings from a study conducted by some authors concur with this observation [25].

Furthermore, rich households were more likely to use clean fuels compared to poor households. The adoption and use of cooking fuels like other graded commodities are highly influenced by the purchasing power of the household. The finding agrees with the Energy Ladder Theory that explains the direct relationship between rise in household income and the adoption of clean cooking energy sources [26]. The mean annual non-food and housing expenditure for households in Ghana is GHC 4,682 [27]. Averagely, 14.5kg of LPG which is about GHC 80/USD 13.8 (GHC 960/USD 166 annually), representing about 21% of annual non-food-and-housing expenditure should suffice to meet a household's cooking and heating need. The average annual gross income for poor households is GHC 18,191, which is 2.5 times lower than that of the rich households (GHC 44, 933) [27]. This means, allocating one-fifth of non-food-and-housing expenditure to clean cooking fuel will be much easier for the rich households than the

poor. Again, apart from the ability to purchase clean fuels, the luxury and prestige attached with the adoption and use of clean fuels could explain why rich households associate with it [24].

We investigated whether regional variations influenced the likelihood of a Ghanaian household to use climate-friendly and health-promoting fuels for cooking. The study observed that households within some political administrations in Ghana had a higher probability of using improved cooking methods than others. For example, we observed that households in the Greater Accra, Ashanti, Brong Ahafo, Central, Western and Eastern regions were more likely to use clean fuels than traditional biomass. Possible explanation for this observation can be attributed to the urbanized nature of these regions. Greater Accra region, for example, is the political head and administrative region of Ghana. It is the most urbanized region with about 87.4% of its population living in urban centres with access to viable economic and political resources for an improved standard of living [28]. This implies that households within these regions are more likely to utilize the available economic and political advantage to adopt or adapt climate-friendly and health-promoting fuels for cooking than their counterparts in the other rural regions of the country. Moreover, there is easy access to clean cooking fuels in the urban regions than the rural regions [29]. Illustratively, compared with the Northern region which has only 12 LPG gas refilling stations, Greater Accra (179 outlets), Ashanti (95 outlets), Brong Ahafo (70 outlets), Central (76 outlets), Western (66 outlets) and Eastern (66 outlets) regions have more refiling outlets making it easier for households in these regions to have access to LPG for their household needs [30]. These finding shares some similarities with findings of one other study [31].

Of particular interest in the above finding was the higher probability of households in the Upper East region to use climate and health-promoting fuels for cooking. This is quite revealing because households in the Northern regions of Ghana are the poorest across the country. However, the likelihood of households in the Upper East regions identified in this study to use clean cooking fuels suggests some qualitative explanations. In 2013, Ghana launched The Rural LPG Promotion Program (RLP) in the Upper East Region with the aim to create access to households in rural areas to use LPG for cooking [30]. The RLP involved the distribution of free gas cylinders to households [30]. It is therefore prudent to argue that many households in the region had a higher chance to benefit from the free cylinders compared with the Northern region.

The study has certain strength and limitations that are worth mentioning. It employed the cross-sectional analysis which did not permit the researchers to derive causal relationships between covariates and the outcome variable. It is also worth mentioning that few households were excluded from the analysis because they did not cook at home and therefore did not use any domestic cooking energy. Close to four decades, the GDHS program has been conducting its survey every five years, and this has improved the quality of the sampling methodologies, data collection procedures, and the development of the questionnaires. Given that the study used the GDHS dataset that is nationally representative and large, the estimates from the analyses can be generalized for the entire Ghanaian population.

Conclusions

The adoption and sustained use of clean cooking fuels are important in enhancing good health for nearly half of the world's population, mostly women and children in developing countries and to help protect the global environment. Our study finds household characteristics and region of residence as influential factors in the adoption of clean cooking fuels in Ghana. The level of education, wealth status, age and marital status of household heads positively influenced the use of clean cooking fuels. It became evident in this study that male-headed households were more likely than female-headed households to adopt clean cooking fuels, which contrary to most narratives in the literature. Additionally, having two or more adult females in a household positively influences the chances of using clean cooking energy. Large family size (above 8 individuals) and residence in the Upper West region of Ghana were found to negatively influence the adoption of clean cooking fuels.

To increase the adoption and use of clean cooking fuels to advance Ghana's pursuit towards achieving the SDGs, we recommend a national policy to subsidize LPG and promote the creation of LPG refilling outlets across the country. Education on efficient and sustainable consumption must be intensified and incorporated in the basic school's curriculum to ensure the future generation are more health-conscious.

Abbreviations

GDHS: Ghana Demographic and Health Surveys

COPD: chronic obstructive cardio-pulmonary diseases

HH: Households

HAP: household air pollution

SDG: Sustainable Development Goals.

Declarations

Ethics approval and consent to participate

The Ghana Health Service Ethical Review Committee and the Institutional Review Board of ICF International reviewed and approved the 2014 GDHS protocol. Enumerators obtained informed consent from mothers between 15-49 years with children under-five years before interviewing them [12]. The GDHS did not obtain assent from parents or guardians of childbearing women who were either 15 or 16 years because they already had children and were independent of their guardians or parents. The GDHS is publicly available upon a simple, registration-access request, so no further ethical clearance was sought

Consent for publication

Not Applicable

Availability of data and materials

The 2014 Ghana DHS dataset supporting the analysis of this study is available in the DHS repository. The DHS datasets are available for free after a simple registration process.

Competing Interests

The authors declare no competing interests.

Funding

Authors did not receive any funding.

Authors' contributions

DSS, AP and PLK conceptualized the study. AP and DOH performed data analysis. NKE validated the analysis. DSS, PLK, NKE, DMV, ANKH, DOH and AP wrote the paper. AP supervised the study. All authors read and approved the final manuscript.

Acknowledgments

Not Applicable

References

1. Smith, K.R., A. Woodward, D. Campbell-Lendrum, D.D. Chadee, Y. Honda, Q. Liu, J.M. Olwoch, B. Revich, and R. Sauerborn, *Human health: impacts, adaptation, and co-benefits. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability.*, in *Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, C.B. Field, et al., Editors. 2014, Cambridge University Press: Cambridge, United Kingdom and New York, NY, USA. p. 709-754.
2. IEA, IRENA, UNSD, WB, and WHO, *Tracking SDG 7: The Energy Progress Report 2019*. 2019: Washington DC.
3. Smith, K.R., *Health impacts of household fuelwood use in developing countries.* UNASYLVA-FAO-, 2006. **57**(2): p. 41.
4. Organization, W.H., *Health in the Green Economy: Co-Benefits to Health of Climate Change Mitigation Household Energy Sector in Developing Countries.* World Health Organization. http://www. who. int/hia/green_economy/en, 2011.
5. Tielsch, J.M., J. Katz, R.D. Thulasiraj, C.L. Coles, S. Sheeladevi, E.L. Yanik, and L. Rahmathullah, *Exposure to indoor biomass fuel and tobacco smoke and risk of adverse reproductive outcomes, mortality, respiratory morbidity and growth among newborn infants in south India.* International journal of epidemiology, 2009. **38**(5): p. 1351-1363.

6. Oyekale, A.S., *Assessment of households' access to electricity and modern cooking fuels in rural and Urban Nigeria: Insights from DHS data.* Life Science Journal, 2012. **9**(4): p. 1564-1570.
7. Malla, S. and G.R. Timilsina, *Household cooking fuel choice and adoption of improved cookstoves in developing countries: a review*. 2014: The World Bank.
8. Lewis, J.J. and S.K. Pattanayak, *Who adopts improved fuels and cookstoves? A systematic review.* Environmental health perspectives, 2012. **120**(5): p. 637-645.
9. Rehfuess, E.A., E. Puzzolo, D. Stanistreet, D. Pope, and N.G. Bruce, *Enablers and barriers to large-scale uptake of improved solid fuel stoves: a systematic review.* Environmental health perspectives, 2014. **122**(2): p. 120-130.
10. Puzzolo, E., D. Stanistreet, D. Pope, N. Bruce, and E. Rehfuess, *Factors influencing the large-scale uptake by households of cleaner and more efficient household energy technologies.* 2013.
11. Armah, F.A., B. Ekumah, D.O. Yawson, J.O. Odoi, A.-R. Afitiri, and F.E. Nyieku, *Predictive probabilities of access to clean cooking: evidence from the demographic and health surveys in 31 countries in sub-Saharan Africa.* Environmental Justice, 2019. **12**(3): p. 118-131.
12. Ghana Statistical Service (GSS) and Macro International Inc. (MI), *Ghana Demographic and Health Survey 2014*. 2015, GSS and MI.: Calverton, Maryland.
13. Rutsein, S.O. and J. Kiersten, *The DHS wealth index. DHS comparative reports no. 6*. 2004, ORC Macro.: Calverton, Maryland, USA.
14. Hair JFJ, Anderson RE, Tatham RL, and Black WC., *Multivariate data analysis*. 3 ed. 2014, New York: : Macmillan.
15. Energy Commission-Ghana, *2016 Energy (Supply And Demand) Outlook for Ghana*. 2016, Energy Comission, Ghana: Accra.
16. Acharibasam, J.B. and G. Apatinga, *Ghana and the liguidified petroleum gas dilemma critical analysis of Ghana's LPG policy.* International Journal of Energy and Environmental Research, 2014. **2**(2): p. 1-8.
17. Ministry of Energy, *Energy Sector Strategy and Development Plan*. 2010, Ministry of Energy: Accra.
18. Commission-Ghana., E., *2020 Energy (Supply And Demand) Outlook for Ghana*. 2020, Energy Comission, Ghana: Accra.
19. Action, P., *Gender and livelihoods impacts of clean cookstoves in South Asia.* Washington (DC): Global Alliance for Clean Cookstoves (http://cleancookstoves. org/binarydata/RESOURCE/file/000/000/363-1. pdf, accessed 17 February 2016), 2014.
20. Mekonnen, A. and G. Köhlin, *Determinants of household fuel choice in major cities in Ethiopia.* 2009.
21. Clark, S., E. Carter, M. Shan, K. Ni, H. Niu, J. Tseng, S. Pattanayak, M. Jeuland, J. Schauer, and M. Ezzati, *Adoption and use of a semi-gasifier cooking and water heating stove and fuel intervention in the Tibetan Plateau, China.* Environmental Research Letters, 2017. **12**(7): p. 075004.
22. Onyeneke, R., C. Nwajiuba, C. Mmagu, J. Aligbe, C. Uwadoka, C. Igberi, and M. Amadi, *Impact of adoption of improved cook-stove on different components of household welfare in rural*

communities in Nigeria: The case of Save80 cook-stove in Kaduna. Environmental Progress & Sustainable Energy, 2018. **37**(4): p. 1327-1338.

23. Miah, M.D., H. Al Rashid, and M.Y. Shin, *Wood fuel use in the traditional cooking stoves in the rural floodplain areas of Bangladesh: a socio-environmental perspective.* Biomass and Bioenergy, 2009. **33**(1): p. 70-78.
24. Nepal, M., A. Nepal, and K. Grimsrud, *Unbelievable but improved cookstoves are not helpful in reducing firewood demand in Nepal.* Environment and Development Economics, 2011. **16**(1): p. 1-23.
25. Owusu, E.S., J.X. Ribeiro, E. Ayesu, E. Antwi, J.C. Ahiakpor, and E.C. Bensah, *Adoption and Utilization of Improved Cookstove in Ghana.* International Journal of Innovative Research and Development, 2015. **4**(9).
26. van der Kroon, B., R. Brouwer, and P.J. Van Beukering, *The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis.* Renewable and Sustainable Energy Reviews, 2013. **20**: p. 504-513.
27. Ghana Statistical Service, *Ghana Living Standards Survey Round 6 (GLSS 7): Main Report*. 2019, Ghana Statistical Service (GSS). Accra.
28. GSS, *Ghana Living Standards Survey Round 6 (GLSS 6): Main Report.* 2014, Ghana Statistical Service (GSS): Accra.
29. Songsore, J., *The urban transition in Ghana: Urbanization, national development and poverty reduction.* University of Ghana, Legon–Accra, 2009.
30. Asante, K.P., S. Afari-Asiedu, M.A. Abdulai, M.A. Dalaba, D. Carrión, K.L. Dickinson, A.N. Abeka, K. Sarpong, and D.W. Jack, *Ghana's rural liquefied petroleum gas program scale up: A case study.* Energy for Sustainable Development, 2018. **46**: p. 94-102.
31. Mensah, J.T. and G. Adu, *An empirical analysis of household energy choice in Ghana.* Renewable and Sustainable Energy Reviews, 2015. **51**: p. 1402-1411.

Figures

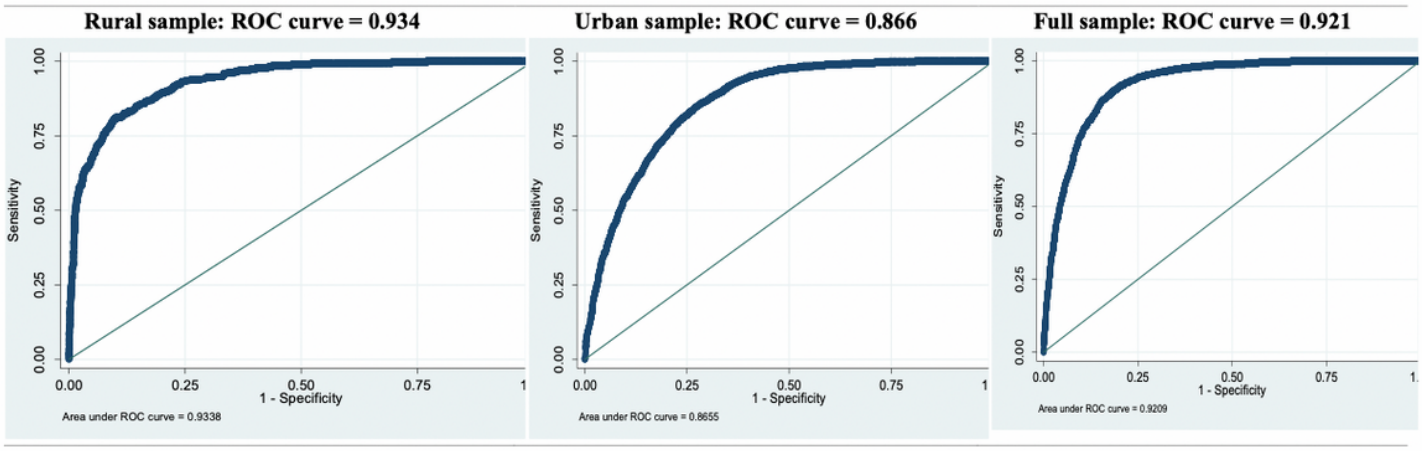

Figure 1

Area Under ROC curve for rural, urban, and full sample

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Additionalfile1.pdf
- Additionalfile2.docx
- AdditionalFile3.docx