Household Solid Fuel Use and Associated Factors in Somaliland: A Multilevel Analysis of Data From 2020 Somaliland Demographic and Health Survey

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ABSTRACT: This study, utilizing data from the 2020 Somaliland Demographic and Health Survey, investigates the prevalence of household solid fuel use in Somaliland and the factors associated with this practice. Our analysis reveals that a staggering 97.2% of households rely on solid fuels like wood and charcoal for cooking, with only 2.8% utilizing clean energy sources. We employed multilevel logistic regression to examine the influence of individual and community-level variables on fuel choice. Results highlight the significant roles of education level, gender of the household head, wealth status, and location of cooking in shaping fuel selection. The study, aligned with Sustainable Development Goal 7: Affordable and Clean Energy, emphasizes the urgency of promoting clean energy alternatives, improving cooking practices, and addressing the health and environmental impacts of solid fuel usage to foster a more sustainable energy landscape in Somaliland.

KEYWORDS: Renewable energy, sustainability, Somaliland, cooking fuel, clean energy

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Background of the Study

Solid fuels are a type of fuel that includes coal, biomass, charcoal, wood or straw, animal dung, and crop wastes. They are used for cooking, heating, lighting, boiling water, and generating revenue at home.[1] Biomass fuel is a solid fuel found in wood plants, crop wastes, and animal manure, used for cooking and heating.[2] Access to clean, affordable, and efficient energy has become a challenge for the majority of households in low to medium-income countries.[3]

The reliance on solid fuels for cooking, heating, and other household needs remains a significant challenge in promoting sustainable development, particularly in less developed and developing regions. While global and regional estimation models provide valuable insights, field surveys offer crucial localized data that informs targeted interventions. This study addresses the critical need for a deeper understanding of household solid fuel use (SFU) in Somaliland, a region previously underrepresented in research on this topic.

Three billion of the world's poorest people continue to use solid fuels such as wood, animal dung, charcoal, crop waste, and coal.[1] Research indicates that households with lower incomes utilize bio-mass fuels like wood and dung, while those with higher incomes prefer cleaner energy sources.[4] Where the use of solid fuel is strongly associated with poverty.[5] Globally, the most significant direct health risk is the pollution produced by partial burning of solid fuels for cooking, and heating.[6] Solid fuels are inefficient and result in high levels of residential air pollution, creating health-harming pollutants such as microscopic soot particles that penetrate deeply into the lungs.[7]

Household air pollution (HAP) is responsible for around 3.5 million premature deaths worldwide, contributing to cataracts, and cardiovascular disease.[8] In 2012, WHO reported that outdoor air pollution (OAP) led to 4.3 million premature deaths worldwide, while outdoor air pollution caused 3.7 million fatalities.[9]

In Asia, low-grade fuel sources such as wood, agricultural waste, cow dung, and low-quality coal are used in rural and peri-urban areas. Three-stone stoves or simple open clay cookstoves are widely used in rural Asian countries. Because of their low efficiency, these stoves produce large amounts of incomplete combustion per unit of energy.[10-12]

The fuels most commonly used in this part of Africa include wood, charcoal, and agricultural residue, which influence the organic and black carbon in the released particles.[13] Solid fuel use is most popular in Africa and Southeast Asia, where more than 60% of families cook with solid fuels.[14] People from low-income countries use solid fuels because they are conveniently accessible at a lower price.[15,16] Several studies have shown several socio-economic factors, such as income, education, size and age of the households, ownership, education level, household size, and cooking culture influence household cooking fuel type.[4,17-19]

Somaliland, an autonomous territory in northern Somalia, has declared independence since 1991 but remains officially

unrecognized. Despite its unique status, Somaliland faces common challenges associated with energy access, including limited infrastructure and reliance on traditional fuels. This dependence on solid fuels, such as wood and charcoal, has severe consequences for public health, contributing to indoor air pollution, respiratory illnesses, and deforestation.

The 2030 agenda for sustainable development also calls for universal access to clean fuel technologies for cooking (SDG 7.1.2) and a significant reduction in the number of fatalities caused by the combined challenges of outdoor and indoor air pollution.[20] According to a 2007 study conducted by the Academy for Peace and Development, about 2.5 million trees are chopped and burned for charcoal in Somaliland each year.

According to the survey, each Somaliland household consumed the equivalent of 10 trees per month.[21] In Somaliland the 2020 Somaliland Health Demographic Survey (SLDHS) shows that firewood is the most common fuel used for cooking, followed by charcoal, with 47% and 42% of households using them, respectively. Firewood is the most common source of fuel used for cooking in nomadic and rural areas, with 94% of nomadic households and 66% of rural households using firewood whereas the most common fuel used in urban areas is charcoal with 69%.[22] While the prevalence of solid fuels was 90.3%, the prevalence of clean fuels was only 5.8%.[22] Therefore, this study aimed to investigate household solid fuel use and associated factors in Somaliland.

Novelty of the Study

This study stands out as the first of its kind to utilize the inaugural Somaliland Demographic and Health Survey (SLDHS) data, providing the first comprehensive analysis of household solid fuel use and its associated factors in Somaliland. This unique dataset allows us to offer valuable insights into the specific context and challenges of energy transition in Somaliland, a region previously underrepresented in research on this topic. Our multilevel analysis, examining both individual and community-level influences, contributes a deeper understanding of the complexities driving household fuel choices within Somaliland, filling a critical gap in existing knowledge and highlighting the need for targeted interventions to promote clean energy solutions in the region.

Main Contribution and the Research Gap

This study makes several key contributions to the understanding of household energy use in Somaliland. Firstly, it provides the first quantitative assessment of the prevalence of solid fuel use in the region, revealing the vast reliance on traditional fuels despite their detrimental health and environmental impacts. Secondly, by conducting a multilevel analysis, we identify the significant influence of individual-level factors such as education, household head's gender, and wealth status, alongside community-level factors like region and place of residence. This nuanced understanding is crucial for developing targeted interventions. Our findings also highlight the urgent need for a shift toward cleaner cooking fuels in Somaliland, particularly focusing on addressing the unique challenges faced by vulnerable populations in rural areas and those with limited access to education and financial resources.

Methods

Source of data

Somaliland, is an autonomous territory in northern Somalia, declared independence in 1991, following the fall of the Somali Republic due to civil war. However, it has remained officially unacknowledged until today. So, 2020 Somaliland Health Demographic Survey (SLDHS) is secondary data collected from 4 distinct questionnaires were employed in 2020, the Maternal Mortality, Household, Ever-married and Never-married Questionnaire. SLDHS was a nationally representative survey that provided information on the health and demographic features of Somaliland's population.

Sample size and sampling technique

SLDHS 2020 utilized a stratified multi-stage probability cluster sampling design. The sample design in urban and rural regions was a three-stage stratified cluster sample, whereas the design in nomadic areas was a two-stage stratified cluster sample. The primary sampling units (PSUs) were selected with a probability proportionate to the number of housing structures in the sample frame. The second-stage sampling units (SSUs) for rural and urban areas were selected with a probability proportional to the number of households mentioned in the frame. The ultimate sample units (USUs) for rural, urban, and nomadic areas were carefully selected from the cluster's listed households. Each administrative region was separated into urban, rural, and nomadic areas, giving a total of 18 sampling strata.[22]

In the SLDHS 2020, 5994 households were sampled utilizing Computer-Assisted Personal Interviewing (CAPI), which involved interviewers using smartphones to collect replies during the interviews. The United Nations Population Fund (UNFPA) national office created the CAPI data collection system for the survey, which uses a mobile version of the Census and Survey Processing System (CSPro). The SLDHS 2020 used 4 unique questionnaires: maternal mortality, household, ever-married, and never-married. Informed consent was requested at the beginning of the questionnaires, with a particular emphasis on type of solid fuel do they use, where enumerators described the nature of cooking fuel related questions to respondents and sought their informed agreement once more before proceeding.

Study participants

Number of households selected for individual interview, after excluding missing values and duplicates, a total of 5283

of households interviewed for what kind of energy source do they use. this resulted in a sample size of all 5283 and aimed to investigate the household solid fuel use and associated factors in Somaliland: a multilevel analysis of data from 2020 Somaliland demographic and health survey after sampling weight was applied.

Study variables

Outcome variable. The outcome variable was the type of fuel utilized by Somaliland families to cook. This study divided these fuels into two categories based on their exposure to cooking smoke: "clean fuels" such as electricity, liquid petroleum gas (LPG), natural gas, and biogas, and "solid fuels" such as kerosene, coal/lignite, charcoal, wood, straw/shrubs/grass, and animal dung. Kerosene was included in the solid fuels group in this analysis based on prior household air pollution (HAP) investigations that identified kerosene as a polluting fuel,[23-26] Then, solid fuel was coded as "0," whereas clean fuel was represented by "1."

Explanatory variables. Explanatory variables employed as determinants and associate factors were selected based on causal theories obtained from the subject's knowledge. These included, marital status, education status, wealth index, household size, region, place of residence, electricity access, access to water, place of cooking, place of residence, sex and age of house hold head.

Statistical analysis. All statistical analyses were performed using Stata 17 software. The analysis began with generating a proportion table for the dependent variable (DV), with confidence intervals to assess distribution. This was followed by univariate analysis to examine the frequencies and percentages of all predictor variables. Bivariate analysis, using Chi-square tests, was then conducted to explore associations between the DV and independent variables (IVs). Subsequently, multilevel binary logistic regression was used to assess the impact of both individual- and community-level factors across 4 models: Model 0: A baseline model containing only the DV. Model I: Includes individual-level IVs. Model II: Focuses solely on community-level variables. Model III: A comprehensive model incorporating both individual and community-level variables. To compare these models, several evaluation metrics were applied: Akaike Information Criterion (AIC): Assesses model fit, penalizing for model complexity. A lower AIC indicates better fit. Bayesian Information Criterion (BIC): Similar to AIC but applies a stricter penalty for model complexity, favoring simpler models. Intraclass Correlation Coefficient (ICC): Reflects the variance explained by group-level differences, with higher ICC values indicating stronger group effects. Log-Likelihood: A higher (less negative) value suggests a better fit, showing how well the model explains the data. Variance: Indicates unexplained variability in the outcome, with lower values representing a better model. A significance threshold of 0.05 was applied throughout the analysis.

In the multilevel logistic regression analysis, the reference categories were: "Yes" for school attendance, "Male" for sex of household head, "Poorest" for wealth quantile, "In the house" for place of cooking, "Awdal" for region, and "Urban" for place of residence. All odds ratios are interpreted in comparison to these reference categories.

Results

Magnitude of solid cooking fuel

As shown in Table 1, "household cooking fuel" was categorized into 2 levels: "Solid" and "Clean." The proportion of households using clean cooking fuel was 2.8% (95% CI [2.4%, 3.3%]), with a standard error of 0.0023. In contrast, the proportion of households using solid cooking fuel was 97.2% (95% CI [96.7%, 97.6%]), also with a standard error of 0.0023. This indicates that the vast majority of households rely on solid cooking fuel, with only a small minority using clean fuel.

Descriptive statistics and frequencies

A shown in Table 2, univariate analysis of a variety of demographic and household characteristics are shown using frequencies and percentages. With respect to the Region variable, the highest percentage of participants lived in Woqooyi Galbeed (22.18%), succeeded by Togdheer (21.94%), Sanaag (20.86%), Sool (20.41%), were the least presented was Awdal region (14.61%). In terms of place of resident, the predominant group of respondents were nomadic people (43.33%), proceeded by those from rural areas (29.07%) and then those from urban settings (27.60%). In addition, the marital status of the respondents revealed that the majority were married (84.21%), with lesser proportions being widowed (8.71%), divorced (3.50%), abandoned (1.67%), or never married (1.91%). In relation to school attendance, results revealed that 73.82% of the participants did not attended school, whereas a substantial.

Table 1. Magnitude of solid fuel.

VARIABLE	LEVELS	PROPORTION	STANDARD ERROR	95% CONFIDENCE INTERVAL
Household cooking fuel	Clean fuel	0.028	0.0023	0.024–0.033
	Solid fuel	0.972	0.0023	0.967–0.976

Table 2. Univariate analysis.

VARIABLE	LEVELS	FREQUENCY	PERCENTAGE (%)
Region	Awdal	772	14.61
	Woqooyi Galbeed	1172	22.18
	Togdheer	1159	21.94
	Sool	1078	20.41
	Sanaag	1102	20.86
Place of residence	Urban	1458	27.60
	Rural	1536	29.07
	Nomadic	2289	43.33
Marital status	Married	4449	84.21
	Divorced	185	3.50
	Abandoned	88	1.67
	Widowed	460	8.71
	Never married	101	1.91
School attendance	Yes	1383	26.18
	No	3900	73.82
Sex of household head	Male	3612	68.37
	Female	1671	31.63
Age of household head	25 years or less	468	8.86
	26-35	1374	26.01
	36-45	1200	22.71
	46-55	966	18.29
	Above 56	1275	24.13
Wealth quantile	Poorest	3302	62.50
	Middle	575	10.88
	Richest	1406	26.61
Number of household size	1-3 Children	1094	20.71
	4-7 Children	2911	55.10
	More than 7 children	1278	24.19
Electricity	Yes	1419	26.86
	No	3864	73.14
Water	Water available	2043	38.67
	Water not available	3240	61.33
Place of cooking	In the house	1374	26.01
	In a separate building	1870	35.40
	Outdoors	1944	36.80
	Others	95	1.80

Further, 68.37% of the household heads were males, in contrast to 31.63% were females. The distribution of the age of the household head was as follows: 26.01% in the age group of 26-35. Where, 24.13% were above 56 years of age, 22.71% were within the 36 to 45 years age group, 18.29% were aged between 46 and 55 years, and 8.86% were 25 years old or younger. With respect to wealth quantiles, 52.47% of households were classified within the lowest wealth category, while the remaining households were distributed among the second (10.03%), third (10.88%), fourth (13.42%), and fifth wealth quintiles (13.19%). The composition of household size was predominantly characterized by families with 4 to 7 children, comprising 55.10% of the total, followed by families with more than 7 children at 24.19%, and those with 1 to 3 children accounting for 20.71%. In terms of electricity accessibility, a mere 26.86% of households reported having access to electricity, whereas a significant 73.14% lacked it. With regard to the availability of water, 38.67% of the surveyed population indicated that water was accessible, while 61.33% reported the contrary. Finally, in terms of the place of cooking, 36.80% of respondents cooked outdoors, 35.40% in a separate building, 26.01% inside the house, and 1.80% in other locations.

Chi-square results of bivariate results

The bivariate chi-square analysis in Table 3 examined the association between the categorical independent variables of the study and the dependent variable, which is the household's type of cooking fuel (solid vs clean). In terms of geographic distributions, a significant relationship was found between region and the type of cooking fuel. The highest proportion of clean fuel use was observed in Woqooyi Galbeed (4.86%), while Togdheer had the lowest proportion (0.78%). Solid fuel use was prevalent across all regions, ranging from 95.14% to 99.22%. In addition, urban residents were more likely to use clean fuel (8.71%), while nearly all rural (98.83%) and nomadic residents (99.78%) used solid fuels. In terms of marital status, the proportion of clean fuel use was similar across marital statuses, with married individuals using clean fuel at a rate of 2.88% and widowed individuals at 1.74%. Further, respondents who had attended school were more likely to use clean fuel (7.30%) compared to those who had not (1.26%). Where, female-headed households had a higher proportion of clean fuel use (3.65%) than male-headed households (2.46%). On the other hand, clean fuel use was highest among households headed by individuals aged 26-35 (4.44%) and lowest among those aged 56 or older (1.41%). Interestingly, clean fuel use was most common among the richest households (10.17%) and almost non-existent in the poorest quintile (0.12%). Furthermore, households with 1-3 children had the highest clean fuel usage (1.92%), while those with more than 7 children had the lowest (3.76%). In addition, households with electricity were much more likely to use clean fuel (9.80%) than those without electricity (0.28%). Households with water availability had a higher proportion of clean fuel use (4.65%) compared to those without water availability (1.70%). Further, clean fuel use was highest among those who cooked in a separate building (4.65%) or inside the house (4.15%) and lowest among those who cooked outdoors (0.26%). In summary, the bivariate chi-square analysis shows significant relationships between the type of cooking fuel used and most demographic and household characteristics, including region, place of residence, education, sex, age, wealth, household size, electricity, water availability, and place of cooking. However, marital status was the only variable that did not show a statistically significant association with cooking fuel type.

Model comparison

Table 4 presented the model comparisons. Based on the comparison of the 4 models, Model III, which includes both individual and community-level variables, provides the best overall fit according to multiple criteria: Model III has the lowest AIC (951.89), indicating it has the best fit among the models and shows the highest log-likelihood value (−452.95), which means it fits the data better than the other models. In addition, model III also has the lowest variance (0.39), indicating that it explains more variability in the outcome compared to the other models. While Model I have a slightly better BIC score (1082.27), Model III remains the most comprehensive, balancing both individual and community effects, and reducing unexplained variability the most. The ICC for Model III is also the lowest (0.11), indicating that the group-level differences account for a minimal proportion of variance, suggesting that individual and community variables explain most of the variability. Thus, results from Model III are used.

Multilevel binary logistic regression results

As shown in Table 5,Model III analysis revealed that households where respondents did not attend school are less likely to use clean fuel compared to the reference group of households where respondents did attend school, with an adjusted odds ratio (AOR) of 0.45 (95% CI: 0.29-0.68). This indicates a 55% lower likelihood of using clean fuel compared to the reference group. In addition, female-headed households are more likely to use clean fuel compared to the reference group of male-headed households, with an AOR of 1.66 (95% CI: 1.11-2.47), which indicates a 66% higher likelihood of using clean fuel compared to the reference group. Further, households in the richest wealth quintile are significantly more likely to use clean fuel compared to the poorest households, with an AOR of 52.12 (95% CI: 8.79-308.99), indicating a dramatically higher likelihood. Households in the middle wealth quintile are also more likely to use clean fuel compared to the poorest households, with an AOR of 5.38 (95% CI: 0.71-40.96), although

Table 3. Bivariate chi-square results.

VARIABLE	COOKING FUEL		DEGREE OF FREEDOM	CHI-SQUARE X^2	*P*-VALUE
	SOLID	CLEAN			
Region			4	35.55	.0000
Awdal	748 (96.89)	24 (3.11)			
Woqooyi Galbeed	1115 (95.14)	57 (4.86)			
Togdheer	1150 (99.22)	9 (0.78)			
Sool	1048 (97.22)	30 (2.78)			
Sanaag	1072 (97.28)	30 (2.72)			
Place of residence			2	254.66	.0000
Urban	1331 (91.29)	127 (8.71)			
Rural	1518 (98.83)	18 (1.17)			
Nomadic	2284 (99.78)	5 (0.22)			
Marital status			4	4.08	.3949
Married	4321 (97.12)	128 (2.88)			
Divorced	177 (95.68)	8 (4.32)			
Abandoned	86 (97.73)	2 (2.27)			
Widowed	452 (98.26)	8 (1.74)			
Never Married	97 (96.04)	4 (3.96)			
School attendance			1	135.31	.0000
Yes	1282 (92.70)	101 (7.30)			
No	3851 (98.74)	49 (1.26)			
Sex of household head			1	5.83	.0158
Male	3523 (97.54)	89 (2.46)			
Female	1610 (96.35)	61 (3.65)			
Age of household head			4	23.98	.0001
25 years or less	459 (98.08)	9 (1.92)			
26-35	1313 (95.56)	61 (4.44)			
36-45	1168 (97.33)	32 (2.67)			
46-55	936 (96.89)	30 (3.11)			
Above 56	1257 (98.59)	18 (1.41)			
Wealth quantile			2	373.57	.0000
Poorest	3298 (99.98)	4 (0.12)			
Middle	575 (99.48)	3 (0.52)			
Richest	1263 (89.83)	143 (10.17)			
Number of household size			2	7.28	.0262
1-3 Children	1073 (98.08)	21 (1.92)			
4-7 Children	2830 (97.22)	81 (2.78)			
More than 7 children	1230 (96.24)	48 (3.76)			

(Continued)

Table 3. (Continued)

VARIABLE	COOKING FUEL		DEGREE OF FREEDOM	CHI-SQUARE X^2	*P*-VALUE
	SOLID	CLEAN			
Electricity			1	340.32	.0000
Yes	1280 (90.20)	139 (9.80)			
No	3853 (99.72)	11 (0.28)			
Water			1	39.59	.0000
Water available	1948 (95.35)	95 (4.65)			
Water not available	3185 (98.30)	55 (1.70)			
Place of cooking			3	78.90	.0000
In the house	1317 (95.85)	57 (4.15)			
In a separate building	1783 (95.35)	87 (4.65)			
Outdoors	1939 (99.74)	5 (0.26)			
Others	94 (98.95)	1 (1.05)			

Table 4. Model comparison metrics.

CRITERIA	MODEL 0 *(EMPTY MODEL)*	MODEL I	MODEL II	MODEL III
AIC	1146.18	970.54	1057.97	951.89
BIC	1159.33	1082.27	1110.55	1103.06
ICC	0.62	0.20	0.30	0.11
Log-Likelihood	−571.09	−468.27	−520.98	−452.95
Variance	5.39	0.82	1.42	0.39

Abbreviations: Key: AIC, Information Criterion; BIC, Bayesian Information Criterion; ICC; Intra-Cluster Correlation.

this result is not statistically significant. Moreover, households that cook outdoors are less likely to use clean fuel compared to the reference group of households that cook inside the house, with an AOR of 0.31 (95% CI: 0.10-0.93), indicating a 69% lower likelihood of using clean fuel compared to the reference group. In terms of community level variables, households in Togdheer region are less likely to use clean fuel compared to the reference group of households in the Awdal region, with an AOR of 0.23 (95% CI: 0.09-0.60), indicating a 77% lower likelihood compared to the reference group. Finally, rural households are less likely to use clean fuel compared to the reference group of urban households, with an AOR of 0.44 (95% CI: 0.22-0.86), indicating a 56% lower likelihood compared to the reference group. Therefore, these results highlight the significant factors influencing the likelihood of using clean fuel in households, with key determinants including respondent education, sex of the household head, wealth status, and location of cooking.

Discussion

The of households using clean cooking fuel was 2.8% (95% CI [2.4%, 3.3%]). while households using solid cooking fuel was 97.2% (95% CI [96.7%, 97.6%]). This indicates that the vast majority of households in Somaliland use solid cooking fuel, with only a small minority using clean fuel.

Based on the comparison of the four models, Model III, which includes both individual and community-level variables, provides the best overall fit according to multiple criteria: Model III has the lowest AIC (951.89), indicating it has the best fit among the models and shows the highest log-likelihood value (−452.95), which means it fits the data better than the other models. So according to the model III, the type of fuel used by Somaliland households were influenced by the school attendance, sex of household head, age of household head, wealth quantile, place of cooking, region and residence.

School attendance was found to be significantly associated with type of fuel use in Somaliland households which is

Table 5. Multilevel binary logistic regression.

VARIABLE	MODEL I AOR (95% CI)	MODEL II AOR (95% CI)	MODEL III AOR (95% CI)
School attendance			
Yes	Ref		Ref
No	0.47 (0.31-0.71)*		0.45 (0.29-0.68)*
Sex of household head			
Male	Ref		Ref
Female	1.64 (1.10-2.45)*		1.66 (1.11-2.47)*
Age of household head			
25 years or less	Ref		Ref
26-35	2.27 (1.03-5.01)*		2.20 (0.99-4.87)*
36-45	1.43 (0.62-3.33)		1.44 (0.61-3.35)
46-55	1.53 (0.66-3.59)		1.58 (0.67-3.71)
Above 56	0.96 (0.39-2.37)		0.94 (0.38-2.33)
Wealth quantile			
Poorest	Ref		Ref
Middle	2.51 (0.49-12.82)		5.38 (0.71-40.96)
Richest	22.51 (5.83-86.8)*		52.12 (8.79-308.99)*
Number of household size			
1-3 Children	Ref		Ref
4-7 Children	1.09 (0.63-1.90)		1.04 (0.60-1.81)
More than 7 children	0.93 (0.51-1.70)		0.89 (0.48-1.63)
Electricity			
Yes	Ref		Ref
No	0.49 (0.21-1.16)		0.50 (0.19-1.30)
Water			
Water available	Ref		Ref
Water not available	1.00 (0.68-1.48)		0.92 (0.62-1.37)
Place of cooking			
In the house	Ref		Ref
In a separate building	1.09 (0.74-1.59)		1.20 (0.82-1.75)
Outdoors	0.43 (0.15-1.19)		0.31 (0.10-0.93)*
Others	0.40 (0.05-3.21)		0.27 (0.03-2.29)
Region			
Awdal		Ref	**Ref**
Woqooyi Galbeed		1.07 (0.46-2.50)	1.15 (0.56-2.35)
Togdheer		0.18 (0.05-0.56)	0.23 (0.09-0.60)*
Sool		1.76 (0.71-4.38)	1.95 (0.89-4.29)
Sanaag		1.14 (0.50-2.64)	1.40 (0.66-2.96)

(Continued)

Table 5. (Continued)

VARIABLE	MODEL I AOR (95% CI)	MODEL II AOR (95% CI)	MODEL III AOR (95% CI)
Place of residence			
Urban		Ref	Ref
Rural		0.40 (0.19-0.87)*	0.44 (0.22-0.86)*
Nomadic		0.02 (0.01-0.05)*	3.18 (0.47-21.80)

Abbreviation: CI, Confidence interval.
*p-value < 0.05.

corroborated by additional research conducted in the area.[1-4] This demonstrates how families may learn about the benefits of switching to cleaner fuels and the issues with solid fuel type through education. Alternatively, promoting awareness of clean energy, non-polluting fuels, improved cook stoves, and the health risks associated with using solid fuels for cooking requires access to education.[5]

Simultaneously, the sex of the head of the household is linked with the type of fuel used in Somaliland households; households headed by men are more likely to use non solid fuel than households headed by women, and solid fuel use seems to be more common in female-headed households than in male-headed households. This result was consistent with research conducted in Ouagadougou, which demonstrated that homes led by men have a higher socioeconomic position than those led by women.[6,7] When it comes to making decisions about cooking in the home, female heads of households typically hold a major role.[8]

The age of the head of the household was significantly correlated with their preference for solid fuel as their main cooking fuel. This suggested that as age increased, the likelihood of using solid fuels increased.[9,10] respondents in the youngest age group utilize less solid fuel than those in the oldest age group.

More over the wealth index statistically significantly affects the choice of cooking fuel which is supported by many studies carried out in the field.[1,11,12] When it comes to place of cooking households with separate buildings were more likely to use solid fuel type compared those use in the house this is aligned with a previous study.[2]

Region is also found to be connected with type of fuel utilized in Somaliland households similarly, the results of the research showed a statistically significant correlation between the type of fuel utilized and the residence. Living in an urban area raises the likelihood of using clean fuels. This conclusion was in line with other comparable research conducted around the world that looked at the relationship between residential location and the type of cooking fuel chosen.[13-15] This finding could be explained by the usage of solid fuels for cooking in rural areas where access to alternative, clean fuels is limited. Additionally, certain biomass fuels, like wood, straw, animal dung, and crop residue, are widely available across the country.[16]

While the SLDHS data does not provide information on the exact amount of fuel consumed, it is clear that there is significant variation in fuel consumption patterns. Future research should collect quantitative data on fuel consumption to understand this variability and inform more targeted interventions.[17-19]

Beyond the overall prevalence of clean vs. solid fuels, it is also important to analyze the proportions of different fuel types within each category. While the data shows a high prevalence of solid fuel use, further investigation into the specific types of solid fuels, such as the prevalence of wood vs. charcoal, is crucial for understanding the unique challenges and opportunities associated with each fuel source.[15,16]

The study provides valuable insights into the complex factors influencing household energy choices in Somaliland. The high reliance on solid fuels and the identification of key associated factors, such as education, household head's gender, wealth status, and location, provide a strong foundation for designing targeted interventions to promote clean energy transitions in the region.

In conclusion this study discovered to 2.8% (95% CI [2.4%, 3.3%]) households using clean cooking fuel, while 97.2% (95% CI [96.7%, 97.6%]) of the households using solid cooking fuel. Model III which is the addition to both individual and community level variables become the best fitting model in the multilevel analysis and factors associated with solid fuel use in Somaliland households are school attendance, sex and age of household head, wealth quantile, place of cooking, region and residence.

Main message

This study underscores the critical need for targeted interventions to promote clean energy alternatives and improve cooking practices in Somaliland, directly aligning with Sustainable Development Goal 7: Affordable and Clean Energy. Addressing factors such as education, poverty, infrastructure, and access to clean energy technologies is crucial for achieving a sustainable energy transition and improving health outcomes, ultimately contributing to a more sustainable and prosperous future for Somaliland.

Conclusion

The findings of this study highlight the urgent need for a shift toward cleaner and more sustainable cooking fuels in Somaliland. The widespread reliance on solid fuels for cooking poses significant health and environmental risks, contributing to indoor air pollution, respiratory illnesses, and deforestation. Targeted interventions, focused on promoting education, improving socioeconomic conditions, and increasing access to clean energy technologies are essential for achieving a more sustainable energy landscape in the region and improving the well-being of Somaliland households.

Policy Implications

1. Prioritize Education and Awareness: Policymakers should prioritize education initiatives that promote awareness about the health and environmental consequences of solid fuel use and the benefits of transitioning to cleaner energy options.
2. Invest in Clean Energy Infrastructure: Investing in infrastructure development, including the expansion of electricity grids and clean energy generation, is essential for increasing access to clean fuel alternatives in both urban and rural areas.
3. Promote Sustainable Cooking Practices: Policies should encourage the adoption of efficient cookstoves and sustainable cooking practices, reducing fuel consumption and minimizing harmful emissions.
4. Target Vulnerable Populations: Specific interventions should be tailored to address the needs of vulnerable populations, including those in rural areas, female-headed households, and low-income communities, to ensure equitable access to clean energy solutions.
5. Develop Financial Incentives: Financial incentives, such as subsidies or tax breaks, can encourage the transition to clean fuels by reducing the cost barrier for households.
6. Strengthen Partnerships: Collaborating with NGOs, private sector companies, and international organizations is crucial for developing comprehensive and sustainable energy programs.

By implementing these policy recommendations, Somaliland can effectively address the challenges associated with solid fuel use, paving the way for a healthier and more sustainable future for its people.[27–41]

Author Contribution

All authors contributed equally to this manuscript.

Ethical Disclosures

Authors got permission from Demographic and Health Surveys (DHS) Program and downloaded data from this link (https://microdata.nbs.gov.so/index.php/catalog/50). As this data is publicly available and has no personal identifiers, Ethical approval was not necessary.

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Data Availability

The data used in the study will be available from the corresponding author upon reasonable request.

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