DETERMINANTS OF HOUSEHOLDS' PRIMARY COOKING FUEL IN NIGERIA: EVIDENCE FROM COUNTRY-WIDE STUDY.

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Abstract
Energy is critical to human survival. However, the consumption of energy, especially solid fuels, poses important health and environmental challenges that are harmful to well-being. Understanding the determinants of household choice of primary cooking fuel is an important step in designing policies that encourage clean cooking. This study therefore utilises the Nigerian General Household Panel Survey (NGHPS) data to examine the determinants of household primary cooking fuels in Nigeria. Findings from the Multinomial Logistic suggest that increasing access to electricity supply is key for clean cooking. It was also found that the stability of income flow and the infrequency of economic shocks significantly drive households' transition to clean cooking. These findings suggest the need to ensure not just increased access to electricity, but a more reliable supply of it. In adition, an insurance package that guarantees a stable and reliable flow of income will enable households to smoothen their consumption expenditure and prevent fallbacks on polluting fuel, having advanced to cleaner ones.

Keywords: Households, Primary Cooking Fuel, Economic Shock, Multinomial Logit, Nigeria
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Introduction

Solid fuels remain the primary source of cooking energy for most households in Nigeria. It is assessed that 68.3 per cent of all households rely on solid biomass in Nigeria (National Bureau of Statistics, 2020, p.24). Also, of the total energy consumed in the country, 85 per cent comes from biomass and waste, with 89.6 per cent of this consumption used to meet residential energy needs, predominantly cooking (Eleri, 2021; Oyeniran & Isola, 2023). Besides, this energy is often consumed in traditional, inefficient ways, posing profound adverse effects on health, the environment, and development. Exposure to indoor air pollution from incomplete combustion of solid fuels is documented as a major cause of acute respiratory infections (James, Shetty, Kamath & Shetty, 2020), burns (Heltberg, 2015; Elias & Victor, 2015) and even death (WHO, 2023).

Women and children are especially vulnerable, as they constitute the main source of cooking and wood collection labour (Masera, Saatkamp & Kammen, 2020). Deforestation, land degradation, Carbon emission (CO_2)and black carbon emissions have also strongly correlated with the increased use of solid fuels; threatening environmental sustainability and biodiversity (WHO, 2023). In addition, the reallocation of time, labour, and land resources to firewood collection has limited engagement in income-generating activities and stunted economic development (Eleri, 2021). To the extent that health creates wealth, solid fuel consumption also slashes labour productivity and worsens income and gender inequality (Alem, Beyene, Kohlin & Mekonnen, 2015; Adekoya *et al.* 2023).

To improve household welfare and ensure sustainable environments, it is important to design policies that enable households' transition to clean, efficient, affordable, and reliable cooking fuels. Understanding household fuel choice behaviour is a crucial first step in pursuing such policies. The energy ladder model has especially been adopted to explain household fuel choice behaviour in developing countries (Elias & Victor, 2015; Martey, Etwire & Yevu, 2021; Dongzagla & Adams, 2022; Adekoya *et al.* 2023). This model pictures a utility-maximising household that progressively moves along a hypothetical ladder defined by hierarchical ordering of ascendingly sophisticated cooking fuels as their socioeconomic outcomes improve (Mekonnen & Köhlin, 2009). Movement along the ladder is hypothesised as a simple, discrete, and unidirectionally linear process, involving replacing inefficient, cheap, and polluting fuels with efficient, costly, and clean ones (Swarup & Rao, 2015; Kroon *et al.*, 2013). An important underpinning of this model is the idea of fuel switching; where households shift to a more efficient fuel is simultaneously a shift away from a less efficient one (Eleri, 2021). By implication, the possibility of households' multiple fuel use at a time is theoretically impossible. Therefore, the focus of the study is to understand the determinants of household choice of primary cooking fuel in Nigeria.

Recent empirical findings are however pointing to the surprising complexity of household cooking energy transition and the interesting possibility of fuel stacking. The decision to use a particular cooking fuel is influenced by several internal and external factors such as household characteristics and market and institutional conditions. These factors intricately interplay to produce a rather complex, multidirectional, and nonlinear progression along the rungs of the energy ladder (Elias & Victor, 2015). This progression does not necessarily occur in a systematic and predictable pattern but involves surprising jumps along the rungs. For instance, Akpalu *et al.* (2011) found that Ghanaian households leaped from firewood to Liquefied Petroleum Gas (LGP), and in Vientiane, from biomass to electricity (Barnes, Krutilla & Hyde, 2004). These findings have interestingly been paralleled by a notable multi-fuel usage among households in developing countries. Households typically use two to four cooking fuels at a time (Link, Axinn & Ghimire, 2012; Muller & Yan 2016). For instance, several households in developing countries were found to simultaneously use firewood and LGP; firewood, kerosene, LGP, and electricity (Amoah, 2019; Dongzagla & Adams, 2022). Masera *et al.* (2020) formalise these discoveries into a multiple-fuel model and since then, the model has received impressive empirical support.

A fundamental upshot of the multiple fuel model is the startling evidence that the role of income, as gestured by the ladder model, was excessively overplayed. Recent studies on household cooking energy diverge along two income-effect lines. Some studies have found income to significantly determine the transition to clean cooking (Barnes *et al.* 2004; Akpalu *et al.* 2011; Ouedraogo, 2006; Mekonnen & Köhlin, 2009). Others found its significance only after a certain threshold, which significantly differs across countries and between sectors (Mirza & Kemp, 2011; Swarup & Rao, 2015). In addition, non-income characteristics, as well as access to critical infrastructures, have also been found to significantly encourage households' transition to clean fuels (Nlom & Karimov, 2014; Alem *et al.*, 2015). However, the existing findings particularly from Oyeniran & Isola (2023) have generally shown mixed results with emphasis on patterns of household cooking fuel choice. Similarly, Adekoya et al. (2023) looked at household food insecurity and access to cooking energy. Generally, these studies mainly focused on examining the effect of the presence or absence of particular predictors on the likelihood of fuel switching. Again, these studies omitted important insights from the extent of the presence or absence of these predictors. In addition, while the effect of economic shocks and rising inflation on clean cooking has notably been alluded to, they have generally not been securitised as an empirical category. Therefore, this study sets out to fill these important empirical gaps.

This study also aims to examine the determinants of household primary cooking fuels in Nigeria. Early attempts at similar inquiry within the Nigerian context have been well documented. These attempts are nonetheless limited to a single selected state in the country (Bisu, Kuhe & Iortyer, 2016; Adeyemi &

Adereleye, 2016; Akomolafe & Ogunleye, 2017; Ozoh *et al.* 2018; Arowolo *et al.* 2018; Adekoya *et al.* 2023; and Oyeniran & Isola, 2023), though with a notable exception like Buba, Abdu, Adamu, Jibir and Usman (2017) which nonetheless, in addition to the aforementioned gaps, utilised the 2013 National Demographic and Health Survey data as against more recent versions. Salient findings from this study revealed that access to and reliability of power supply both significantly nudge households towards clean cooking. Also, the level and stability of households' income increase the likelihood of adopting clean primary cooking fuels. In addition, the frequency of economic shock on households was found to substantially decrease the likelihood of primarily adopting clean fuels, particularly electricity.

The remaining part of the study is organised as follows: section two provides a brief review of existing literature. Section 3 discusses methodological and data issues. Section 4 analyses the estimated results. Section 5 concludes and puts forward recommendations.

Review of Related Literature

Cooking fuels energy affects every sphere of living and its inadequate could be a major concern for households who largely rely on it for their daily meals. These, especially solid fuels, pose important health and environmental challenges that are harmful to the quality of living. Theoretically, the energy transition theory explains the change in the primary or conventional form of cooking fuel of households to alternative renewable energy (Campbell *et al*. 2003; Muller & Yan, 2016). The theory observed the historic transition from wood to coal and then to oil and gas. That is the shift from biomass fuels to commercial energy sources.

It is worthy of note that, among the theories that explain these exogenous factors that could determine primary cooking fuels is the transition approach. The model assumes that households gradually climb an energy ladder which begins with traditional biomass fuels, such as firewood, charcoal and saw-dust, moves through commercial fuels, namely, kerosene and natural gas, and culminates with electric stoves (Martins, 2005). In this model, the role of energy cannot be downplayed in any society because it enhances welfare and provides numerous health benefits (Alem & Demeke, 2020).

There is also a large and growing body of empirical literature investigating the factors that influence household cooking fuel choice. These factors have been extensively explored, especially following the multiple fuel model which hypotheses the importance of both income and non-income determinants. The significance of socioeconomic factors such as income, wealth, and prices in explaining the transition to clean cooking has impressively gained encouraging attention. Income (or expenditure) is found to encourage households' transition from a state of no-switching to full-switching (Mekonnen & Köhlin, 2009) and from biomass to clean fuels (Alem *et al.* 2015). It has also significantly correlated with the uptake of kerosene, LPG, and electricity (Nlom & Karimov, 2014; Akomolafe & Ogunleye, 2017). Interestingly, the income effect has closely mirrored those of household wealth. Measures of household wealth such as ownership of a dwelling, number of rooms in the dwelling, and ownership of farmland have been found to positively correlate with the uptake of modern fuels (Pope *et al.* 2018; Arowolo *et al.* 2018). In addition, though studies on the price effect of cooking fuels in developing countries are scanty, they have produced fairly consistent results. Wealthy, urban households were relatively more sensitive to changes in the prices of modern fuels, while poor, rural households responded inversely (Heltberg, 2014). Also, as the prices of traditional fuels increase, households become more likely to shift to more efficient fuels but observe the reverse with an increase in the price of the latter (Alem *et al.* 2015; Akpalu *et al.* 2011).

The strong, yet shockingly positive correlation between income and the persistent use of traditional cooking fuels has prompted extensive research into the effect of non-income factors on clean cooking. Interestingly, households and human capital characteristics have received surprising attention. Factors such as household size, number of female members, and age of household head increase the number of mouths to feed, available cooking labour, and conservativeness at the household level respectively. As such, these factors have generally increased the tendency of using traditional fuels (Kroon *et al.* 2013; Alem *et al.,* 2015; Amoah, 2019; Martey *et al.* 2021; Adekoya *et al.* 2023). Conversely, the level of household education increases the opportunity cost of time spent gathering wood as well as increases awareness of the negative health effects of unclean cooking. This factor has therefore unsurprisingly encouraged clean cooking (Nlom & Karimov, 2014; Malla & Timilsina, 2014). While Oyeniran and Isola (2023) have generally shown mixed results with emphasis on patterns of household cooking fuel choice; Adekoya *et al.* (2023) looked at household food insecurity and access to cooking energy.

The nexus between access to infrastructure and clean cooking has more recently been studied. Household access to facilities such as clean water, sanitation, and electricity can link them up with modernisation and enable quicker market penetration of modern cooking technologies (Joshi & Bohara, 2017; Dongzagla & Adams, 2022). These factors can therefore be understood as both ends in themselves as well as means to other ends. Available studies have generally suggested the encouraging effect of these factors on clean cooking (Alem *et al.,* 2015; Pope *et al.,* 2018; Arowolo *et al.,* 2018; Martey *et al.* 2021). However, it is still unclear if access to these facilities only correlates with or causes the uptake of clean fuels. This is important because findings from an evolving area of research are increasingly pointing to the significance of community-based access as triggers of cooking fuel transition (Link *et al.* 2012), thus casting causal doubt on preexisting results.

The effect of cultural factors on household cooking fuel choice is arguably one of the most compelling but unfortunately understudied in the literature. Factors such as food taste, preferences, caste, religion, and the multi-service nature of traditional cooking fuels have been found to explain culturally-induced behavioural inertia (Elias & Victor, 2015; Joshi & Bohara, 2017; Adekoya et al. 2023). For instance, Mesara and Navia (1997) found that households with LPG were willing to pay a premium to continue using fuelwood due to its convenience in cooking tortillas, a local delicacy in rural Mexico. A similar finding emerged in urban Ouagadougou, Burkina Faso, where even wealthy households preferred using firewood to cook (Ouedraogo, 2006). By extension, Swarup and Rao (2015) found Indian households practising Buddhism and Jainism to be more likely to completely switch to modern fuels, compared to those practising Sikhism, Christianity, and Islam. The scheduled caste also had a higher likelihood of exclusively cooking with LGP than other black castes (Swarup & Rao, 2015). Households have also been reported to be culturally and mentally committed to using certain fuels irrespective of income level. Masera *et al.* (2000), Pundo & Fraser (2006) and Alem, *et al.* (2015) found that households were unwilling to part with traditional cooking technologies even in the presence of efficient modern fuels. Akpalu *et al.* (2011) concluded that Ghanaian households were mentally committed to certain fuels; suggesting that the demand for cooking energy is not derived, as theory hypothesised. In Nigeria, Oyeniran and Isola (2023) emphasise patterns and determinants of household cooking fuel choice. The study further revealed that income, fuel accessibility, household size, and education are significant determinants of household cooking fuels. Adekoya *et al.* (2023) investigated food insecurity and access to cooking energy among households.

Collectively, these studies have largely focused on examining the effect of the presence or absence of certain factors in explaining households' likelihood of switching cooking fuels. In addition, these factors are those more or less influence-able or at worst, predictable by households. However, the extent of the presence or absence of these factors has important implications for nudging households and designing effective transition policies and programs towards clean cooking. Besides, the effect of economic shocks on households' likelihood of adopting clean fuels has received little or no previous scholarly attention in the literature. Using the General Household Survey Panel (NGHPS) data for Nigeria, this study fills these important gaps. Unlike the studies of Adekoya *et al.* (2023), and Oyeniran and Isola (2023) that focused on fuel accessibility and ignored access to electricity, this study offers pioneering evidence on the effect of reliable power supply and frequency of economic shocks on households' likelihood of adopting clean cooking fuels. Secondly, it provides the first rigorous country-wide evidence on the determinants of household primary cooking fuel in Nigeria. Thirdly, the study of Oyeniran and Isola (2023) and Adekoya *et al.* (2023) lump all the incomes together as one, however, this study considered the effect of individual incomes, such as farm and non-farm incomes. Fourthly, considering the mixed socio-cultural and religious characteristics of Nigeria, the current study considers culture and religious influences, however, both Oyeniran and Isola (2023) and Adekoya *et al.* (2023) ignored this. Therefore, contrary to existing studies, the major contribution of this study is its integration of main drivers and economic shock factors into the cooking fuel choice modelling.

Methodology

The utility theory assumes that household members are rational, that is, they have preferences for the various cooking fuels and choose the one that maximises their utility subject to their income constraint. This suggests that a cooking fuel that maximises households' utility is revealed in their observed choice of fuel type. However, this choice is often influenced by socio-economic, demographic, and infrastructural factors, which in turn differs from one household to another.

Thus, the utility function of household i, for a particular primary cooking fuel type j is defined as:

$$U_{ij} = X_i'\beta_j + \varepsilon_{ij}, \qquad j = 0,1,2,3,4. \qquad (1)$$

Where X_i' is a vector of all possible primary cooking fuel determinantsβ_j is the vector of associated coefficients, ε_{ij} is the residual term that is assumed to be independently and identically distributed with extreme value distribution.

If the household chooses $j*$, where $j*$ is a subset of j, it is then assumed that $U_{ij*} > U_{ij}$. The observed choice set is defined as a vector of independent variables $Y_j = [Y_{ij}]$ that takes the value of 1 for the chosen fuel type and 0 for other fuels. Hence, the likelihood probability of choosing a fuel type j conditional on X_i' is:

$$P\left(Y_{ij} = j/X_i\right) = \frac{exp(\beta_j' X_i)}{\sum_{k=1}^{j} exp\,(\beta_k' X_i)}, \qquad j = 0,1,2,3,4 \qquad (2)$$

Equation 2 specifies the odd ratio of choosing a particular cooking energy as the primary cooking fuel for the household.

However, the β_j coefficients from this equation show the nature of the relationship, They do not offer insight into the probabilistic strength of the relationships.

Therefore, the marginal effects of the estimated odd ratios are computed as:

$$\delta_{ji} = \frac{\partial P_j}{\partial X_i} = P_j\left(\beta_j - \sum\nolimits_{j=0}^{4} P_j\beta_j\right) = P_j[\,\beta_j - \bar{\beta}\,], \;\; j = 0,1,2,3,4 \qquad (3)$$

Where δ_{ji} measures the probability of adopting a particular fuel type j given a change in the explanatory variables among households. Therefore, the determinants of primary cooking fuels considered by this study are access to electricity, both farm and non-farm incomes, education, household size, culture and religion.

Data type and sources

The paper utilised mainly the micro-data set from Wave 4 of the Nigerian General Household Panel Survey (NGHPS) conducted by the National Bureau of Statistics (NBS) in collaboration with the World Bank and the Bill and Melinda Gates Foundation. The 2018/2019 NGHPS is a nationally representative household panel survey that contains 5,048 households and 30,338 individuals drawn from the six geopolitical zones of the country and across rural and urban centers. The data also covers 36 states in Nigeria and Federal Capital Territory (Abuja). The survey collects welfare and socioeconomic data on household characteristics as well as their sources of primary cooking energy. In addition, data on households revealed economic shocks are documented. Herein, households are asked if they have been affected by any of the 22 specified shocks since 2017, and how often have they experienced it. These shocks are presented in the appendix.

Data Analysis and Findings

Descriptive statistics of the variables

Table 1 summarises the descriptive statistics of the variables used for estimation. The results show that nearly 55 per cent of households reported access to electricity in their dwellings. Several households (45% of sample households) still lack access to electricity. In terms of daily hours of electricity, 85 per cent of the sample households do not enjoy electricity for up to 9 hours daily. In addition, the proportion of sample households that reported more than three economic shocks between 2017 and 2019 is 6 per cent, while more than 26 per cent had experienced shock once. In addition, around 88 per cent of the sample household representatives do not have a first degree.

Table 1: Summary Statistics (Number of Reporting Households)

Variable	Category	Frequency	Percentage
Electricity Access			
No Access	0	2,294	45.45
Access	1	2,753	54.55
Daily Hours of Electricity:			
(5-9hrs, Average)	0	4,271	84.66
	1	774	15.34
(≥10hrs, Average)	0	4,521	89.58
	1	526	10.42
Economic Shock (since 2017-19):			
Once	0	3,691	73.13
	1	1,356	26.87
More than thrice	0	4,749	94.10
	1	298	5.90
Religion:			
Christianity	0	1,497	40.55
	1	2,195	59.45
Islam	0	2,239	60.66
	1	1,452	39.34
Traditional	0	3,647	98.81
	1	44	1.19
Highest Educational Qualification:			
At least Bachelor's degree	0	4,422	87.62
	1	625	12.38
Less than Bachelor's degree	0	625	12.38
	1	4,422	87.62
Non-farm income source	0	96	8.41
	1	1,045	91.59
Mean number of HH members		6.091767	
Mean monthly income (Naira)		65,897.37	
Type of primary cooking stove:			

3-stone/Openfire	2,208	43.95
Biomass (Charcoal, Wood, Crop residue)	1,338	26.63
LPG/natural gas	555	11.05
Kerosene stove	884	17.60
Electric stove	39	0.78

Source: Authors' computation (2023)

The average family size of the sample households is shown to be 6 with a mean monthly income of N65,897. About 91 per cent of these households' income comes from non-farm sources. Most of the sample households (44%) use three-stone and open-fire stoves, while 26 per cent depend on simple biomass (charcoal, wood, and crop residue) as their main energy source for cooking. The proportion of sample households who depend on kerosene, natural gas, and electric stove as primary cooking stoves in Nigeria are 17 per cent, 11 per cent, and 0.77 per cent, respectively.

Multinomial logit regression result

A Multinomial Logistic model was estimated using the full maximum likelihood estimation method. The result of these estimates is shown in Table 2. The model nested the cooking fuel choice of households within 5 different alternative fuels: 3-stone/open fire, biomass, kerosene, natural gas, and electric choices. However, kerosene was chosen as the base outcome.

From the result, access to electricity was negatively and significantly associated with the use of a three-stone/open fire stove as well as a biomass stove but positively and significantly associated with the uptake of electric stoves as primary cooking fuel. This transition pattern appears stronger when a reliable power supply is considered. Having access to a daily average power supply of between 5-9 hours and greater than 10 hours increases the likelihood of shifting away from biomass to cleaner fuels such as LPG and electricity. Of course, this is because access to a reliable power supply provides a household with an alternative and dependable fuel option but also links them up with modernization that in turn encourages clean cooking. This result is not surprising as Oyeniran and Isola (2023) and Adekoya *et al*. (2023) found that fuel accessibility is a significant determinant of household cooking fuel choice.

The effect of educational attainment on the transition to clean cooking is impressive. Households that have at least a first degree and higher have an encouraging likelihood of switching away from 3-stone/open fire and biomass stoves to LGP and electric stoves. This is intuitive because with education comes better awareness of the health dangers of solid fuels. Also, educated households tend to have a higher opportunity cost of time which in turn discourages the use of fuels requiring more labor-time inputs. This finding is also in line with Dongzagla and Adams (2022) and Oyeniran and Isola (2023) that education is key to household cooking fuel choice.

Again, the effect of household income level on clean cooking is as expected. Higher-income levels increase the likelihood of households moving away from biomass to more efficient fuels such as LPG. Interestingly, a less volatile income source does this better. Non-farm income sources which are expectedly less vulnerable to seasonal fluctuations appear to significantly increase the tendency for households to move from using 3-stone/open fire and biomass stoves to LGP and electric stoves. The study of Oyeniran and Isola (2023) also found the importance of household income.

This is expected because efficient cooking fuels usually require a higher upfront cost, and higher household income becomes an important incentive to purchase modern cooking technologies. However, especially for LGP which seldom requires refilling, a stable and reliable income source is important for ensuring continuity of use and preventing household relapse to traditional polluting fuels.

Demographic factors such as family size influence households' choice of cooking fuels in fundamental ways. Firstly, because affordable modern cooking technologies are usually not designed for large-scale cooking, they are often incompatible with large family-size required cooking utensils. Secondly, large family members may mean more cooking labour inputs and less opportunity cost of time. The result confirms that large family size significantly increases the likelihood of adopting fuels that allow for mass cooking such as 3-stone/open fire and biomass stoves. Both Oyeniran and Isola (2023) and Adekoya *et al*. (2023) also found the same result.

While the nexus between culture and clean cooking has impressively been previously explored, their effect can be difficult to reconcile. Religious inclination and clean cooking have especially produced mixed findings. Compared to Islam, this result ambiguously suggests that practicing ancient traditional religion can increase the likelihood of adopting any of the four fuels as a primary source of cooking energy.

Table 2: Determinants of primary cooking stoves (Base outcome: Kerosene stoves)

Variables	3-stone/Openfire	Biomass	LPG/Natural gas	Electric Stove
Access	-1.9756***	-1.2018***	.2715	10.9049***
	(.3302)	(.3686)	(.5653)	(.9196)
DlyHrs(5-9hrs)	-.3122	-1.1180***	.9113***	2.0425**
	(.3024)	(.3850)	.2686	.9855
DlyHrs(≥10hrs)	-.0085	-.0360	.7938***	2.0792**
	(.3765)	(.3973)	(.3257)	(1.0271)
Education(≥Bchl.)	-.9865***	-.6436*	1.3215***	1.3649*
	(.3061)	(.3310)	(.2481)	(.7403)
Log Income	-.0675	-.2355***	.3355***	-.0952
	(.1014)	(.1006)	(.1253)	(.2973)
Non-FarmY	-.9298**	-1.0220***	1.6887***	13.2257***
	(.4491)	(.4785)	(.7856)	(.9682)
HHmember	.1892***	.1936***	-.0151	-.0810
	(.0417)	(.0439)	(.0562)	(.1864)
Christianity	-.4009	-.4301	.3536	-.0549
	(.3324)	(.3517)	(.3178)	(.6873)
Traditional	15.4855***	16.3128***	16.6390***	15.5768***
	(1.1169)	(.8979)	(1.0545)	(1.1284)
Ec. Shock(=1)	.3854	.3852	-.1226	-13.7499***
	(.2719)	(.2917)	(.2784)	(.4405)
Ec. Shock(≥ 3)	-.5976	.0783	-1.0533	-13.7693***
	(.4968)	(.4886)	(.6476)	(.6393)
North East	.9106	1.7859***	-.1027	-13.8652***
	(.5840)	(.6085)	(.8602)	(.8623)
North West	-.1103	-.4720	.1857	-.1631
	(.4271)	(.5015)	(.4350)	(.9228)
South East	-.9879***	.0578	-.6304	-1.1981
	(.4118)	(.4722)	(.4049)	(1.1576)
South South	-1.2397***	-1.2789***	-.2081	-15.1247***
	(.4065)	(.4755)	(.3896)	(.7578)
South West	-2.1206***	-1.6869***	.8249***	-.9761
	(.4289)	(.5254)	(.3494)	(1.0837)
Constant	3.3520***	3.7622***	-6.9532***	-26.6202***
	(1.1938)	(1.2248)	(1.5740)	(3.9717)

*Wald Chi^2 (64): 1317.58, Prob>Chi^2: 0.0000, Pseudo R^2: 0.2818. Where ***,**,* indicate statistical significance at 1%,5%, and 10% respectively. Parentheses show robust standard errors*. Source: Authors' Computation, 2023

Table 3: Marginal Effect of Determinants of Primary Cooking stoves (Base: Kerosene stove)

Variables	3-stone/Openfire	Biomass stove	LPG/Natural gas	Electric Stove
Access	-.3711***	-.0188	.1428***	7.89e-07**
	(.0541)	(.0412)	(.0351)	(.000)
DlyHrs(5-9hrs)	-.0699	-.1539***	.1958***	2.56e-07
	(.0570)	(.0359)	(.0489)	(.000)
DlyHrs(≥10hrs)	-.0498	-.0322	.1251**	2.69e-07
	(.0665)	(.0460)	(.0577)	(.000)
Education(≥Bchl.)	-.2432***	-.0852**	.2927***	1.24e-07
	(.0436)	(.0349)	(.0488)	(.000)
Log Income	-.0174	-.0416***	.0537***	-4.84e-09
	(.0188)	(.0120)	(.0160)	(.000)
Non-FarmY	-.1684**	-.1187*	.1595***	1.94e-07***
	(.0692)	(.0608)	(.0281)	(.000)
HHmember	.0308***	.0179***	-.0175**	-1.12e-08
	(.0077)	(.0050)	(.0073)	(.000)
Christianity	-.0789	-.0497	.0750**	7.37e-09
	(.0611)	(.0450)	(.0340)	(.000)
Traditional	-.0649	.1582***	.2329	-6.97e-09
	(.2467)	(.2136)	(.2938)	(.000)
Ec. Shock(=1)	.0671	.037119	-.0452	-1.89e-06***
	(.0506)	(.03763)	(.0307)	(.000)
Ec. Shock(≥ 3)	-.0946	.0803	-.0852*	-1.27e-07***
	(.0831)	(.0824)	(.0465)	(.000)
North East	.0287***	.2630***	-.1012**	-4.00e-07***
	(.0779)	(.0849)	(.0480)	(.000)
North West	-.0083	-.0647	.0454	-4.64e-09
	(.0760)	(.0506)	(.0584)	(.000)
South East	-.1756***	.0897	-.0380	-3.96e-08
	(.0581)	(.0757)	(.0406)	(.000)
South South	-.1803***	-.1049**	.0647	-9.94e-07***
	(.0603)	(.0462)	(.0558)	(.000)
South West	-.3429***	-.1473***	.3012***	-2.03e-08
	(.0434)	(.0420)	(.0695)	(.000)
Predicted y	.3439	.1904	.1525	6.184e-08

*Where ***,**,* indicate statistical significance at 1%,5%, and 10% respectively. Parentheses show robust standard errors.*
Source: Authors' Computation, 2023

Further, economic shocks, which typically reflect shocks to household income and source of wealth have important implications for smoothening households' consumption expenditure, substitution between their basic needs, and depletion of their resilience reserve (Jessel, Sawyer & Hernández, 2019). With a persistent shock to income, households can be compelled to reallocate income between competing needs. Relapse to less costly but inefficient cooking fuels becomes much more probable in such circumstances. The result shows that even a single economic shock has the likelihood of hindering the adoption of clean fuels, especially electricity. This is equally true for shocks greater than three.

The marginal effects concerning the explanatory variables are presented in Table 3. These statistics measure the probability of adopting a fuel type given a change in the explanatory variables. Notably, the nature of the relationship or statistical significance is not necessarily the same as those presented in Table 2. This is customary with marginal effects computed from multinomial logit models (Greene, 1993; Ouedraogo, 2006).

For those cases where the nature of the relationships is retained, in addition to the explanation provided in Table 2, Table 3 summarises the exact likelihood strength of the relationships. For example, access to electricity reduces the likelihood of adopting 3-stone/open-fire as primary cooking fuel by 37 per cent but increases the likelihood of adopting LGP by 14.3 per cent. Similarly, educational attainment of a bachelor's degree or higher reduces the likelihood of adopting 3-stone/Open fire and biomass stoves by 24 per cent and 9 per cent respectively but increases the probability of adopting LGP by 29 per cent. A similar interpretation applies to the other results in the table.

One surprising outcome of the marginal result is the probability of adopting electricity as primary cooking energy conditional on the explanatory variables. These probabilities are unexpectedly low. While the result may cast significant doubt, it is not implausible, especially in the short term. Adopting electricity as a major cooking fuel in developing countries, especially in Nigeria where the access rate is woefully discouraging, is practically improbable. Aside from cultural factors that condition individuals' preferences towards unclean cooking fuels, poverty and market-related factors such as low purchasing power, intermittent supplies, and low power voltage may worsen the chance of primarily adopting electricity for cooking. In a related study, considering important income parameters, Ouedraogo (2006) show that it will take about 300 years for households to exclusively adopt clean fuels in Ouagadougou, Burkina Faso. Others have shown the unfeasibility of households to completely switch away from biomass even in the long term (Heltberg, 2014; Elias & Victor, 2015). This evidence not only suggests the difficulty in exclusively using electricity as cooking fuel but also highlights the uncertainties related to doing so.

To the extent that this study finds important household income and non-income characteristics as significant determinants of transition to clean cooking fuels, this study corroborates the works of Nlom and Karimov (2014), and Malla and Timilsina (2014), Amoch (2019), Martey *et al.* (2021), Adekoya *et al.* (2023), and Oyeniran and Isola (2023). Also, it provides further support to studies highlighting the significance of access to basic infrastructures as a crucial determinant of clean cooking (see Pope *et al.* 2018; Arowolo *et al.* 2018). It however does not claim causality in the estimated result or inference.

The key implication of these findings concerning the realities of Nigeria's high current dependence on unhealthy cooking is that, the countrywide clean cooking fuels are slow and lacking. The results revealed that access to electricity, both farm and non-farm incomes, education, household size, culture and religion are all significant in determining household cooking fuel choice. It was also indicated that economic shocks such as rising inflation and high cost of living pose negative effects on the use of modern cooking fuels. Therefore, policymakers could target these factors to reduce the negative effects of traditional cooking fuels in Nigeria.

Conclusion and Policy Recommendations

Access to clean, efficient, and affordable cooking energy is important for a healthy and productive workforce. Solid fuels such as firewood, charcoal, and dung remain the major source of cooking energy for most households in developing countries. Aside from the hazardous health effects from incomplete combustion of these fuels, they consume considerable time in addition to widening gender and income gaps.

Unfortunately, women and children are especially vulnerable. More worrisomely, such fuels are often the primary source of cooking energy. As such, exposure becomes continuous; heightening associated risks. Addressing the associated adversities of unclean cooking requires designing effective intervention policies that minimise or discourage the primary use of solid fuels. Understanding the factors that determine households' choice of cooking energy is a crucial first step in pursuing such policies.

This study investigates the factors that determine household adoption of primary cooking fuels in Nigeria. It uses the 2018/2019 Nigerian General Household Panel Survey (NGHPS) data, which is the latest publicly available data set on household socioeconomic and cooking energy statistics. Important findings from the study reveal that access to a reliable power supply is important in encouraging household adoption of clean fuels such as LGP and electricity. In addition, income levels also appeared to encourage the adoption of clean fuels. However, a reliable income source tends to nudge households even more. Interestingly, exposure to frequent economic shocks significantly reduces the probability of adopting clean energy, particularly electricity, as the primary cooking fuel. While educational attainment, especially a bachelor's degree and higher, increases the likelihood of moving away from polluting fuels towards clean fuels, household family size does the exact opposite.

Important policy implications from this study's findings relate to the need to ensure not just increased access to electricity, but a more reliable supply of it. Also, an insurance package that guarantees a stable and reliable flow of income will enable households to smoothen their consumption expenditure and prevent fallbacks on polluting fuel, having advanced to cleaner ones. In addition, similar insurance would also hedge households against the risk of frequent economic shocks while ensuring the continuity of clean cooking. In sum, de-risking households' income from frequent shocks and fluctuations remains an important means of ensuring the adoption of clean sources of energy as primary cooking fuel in Nigeria.

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Appendix I

Economic Shocks*

1. Death or disability of an adult working member of the household
2. Death of someone who sends remittances to the household
3. Illness of income-earning member of the household
4. Loss of an important contact
5. Job loss
6. Departure of income-earning member of the household due to separation or divorce
7. Departure of income-earning member of the household due to marriage
8. Nonfarm business failure
9. Theft of crops, cash, livestock or other property
10. Destruction of harvest by fire
11. Dwelling damaged/demolished
12. Poor rains that caused harvest failure
13. Flooding that caused harvest failure
14. Pest invasion that caused harvest failure or storage loss
15. Loss of property due to fire or flood
16. Loss of land
17. Death of livestock due to illness
18. Increase in price of inputs
19. Fall in the price of output
20. Increase in price of major food items consumed

21. Kidnapping/Hijacking/robbery/assault
22. Other (specify)

*While the questions appear myriad, summary statistics of the various respondents show that an increase in the price of food items consumed was the most reported shock by households (18.5%). This is followed by an increase in the price of inputs (6.8%), flooding that caused harvest failure (6.6%), theft of crops, cash, livestock or other property (6.6%) and Death or disability of an adult working member of the household (6.0%). Other factors were only marginally reported.