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SURVEY ARTICLE

Predictors of Households' Adoption of Gas Cooking Stove in Some Rural Communities of Abia and Ebonyi States, Southeast Nigeria

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ABSTRACT

This paper aims at the factors that predict household's adoption of gas cooking stoves in selected rural communities of Southeast Nigeria. Leaning on theories of Knowledge gap, Groupthink, Technological determinism and Innovation Diffusion, it explores the theme of adoption as a selective process while interrogating the idea of an energy ladder. The paper probes the factors that accentuate poor energy choices in the face of availability of the better domestic energy source, gas. Based on data from 600 respondents, 300 from each of the southeastern Nigeria states of Abia and Ebonyi, an ordinal regression in the form of a Generalized Linear Model was used to predict the proportional odds of the dependent ordinal variables. Parameter estimates of the regression model predicting ordinal likelihood (odds) of using cooking gas indicate that none of the categories underage bracket were significant. The odds of households with male heads having very high usage of cooking gas stove were 1.563 (95% CI, .882 to 1.830) times more than that of households with female heads. The odds are against larger households; households with heads that are of lower education levels; households that regularly cook with fuelwood and those with lower income. The study recommends advocacy to bridge the knowledge gap and a subsidization regime that can overcome the income challenge.

Keywords: Gas stoves, Adoption, Southeast Nigeria, Energy

1 Introduction

Rural households in developing countries with particular reference to Southeast Nigeria are challenged by such financial and cultural difficulties that limit their options in energy sourcing and utilization. Nigeria's National Bureau of Statistics (NBS) posits that 72 percent of Nigerian people in rural areas are in multidimensional poverty (*Nigeria Multidimensional Poverty Index*, 2022). This is because they rely heavily on diverse forms of biomass: post-harvest residue, dried vegetal matter, saw dust, charcoal, wood logs, among others (Jekayinfa et al., 2020). Also of importance are such liquid fuels as Dual-Purpose Kerosene (DPK), Premium Motor Spirit (PMS) and Automotive Gas Oil (AGO), with relatively marginal role for electric power and gas due to high cost and supply issues (Edomah, 2019). These less dominant forms remarkably entail elaborate infrastructure and capital outlay apart from other socio-economic prerequisites even as they are more eco-friendly and sustainable.

A seeming public fixation on the dominant household energy forms has proved a major obstacle to governments' attempts at re-orientating the domestic energy market (Olujobi, 2020). Inertia on kerosene particularly has become an expensive energy habit. Whereas the product is competed for by the high-end aviation industry as aviation fuel, it has continued to serve particularly rural and also urban areas as fuel for lighting as well as cooking (Onyekuru et al., 2020). High cost is also increasingly noticed with fuelwood and

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charcoal; these financial costs hurt households as they claim increased percentages of their disposable income (Okereke et al., 2022). Of equally great significance is the effect of these energy sources on climate change scenarios. Gas utilization for cooking may entail environmental costs but these pale in significance when compared to environmental effects of charcoal and other fuelwood production and utilization.

Certain theoretical issues underpin the notion being espoused here. These include the Knowledge Gap, Group Think, Technological Determinism and Innovation Diffusion theories. The knowledge gap theory (Donohue et al., 1975) maintains that members of society vary in their acquisition of increased information. Higher social and economic status translates to better ability to acquire information. Hence there are two groups – the better educated that know more about things; and the less educated that know less. The advent of new ideas can extend the gap between people of lower and higher status as the increase in new ideas tends to accentuate the differences between social classes. It is however possible for the poor to get more of a certain type of new information and new ideas which the upper class may consider irrelevant or insignificant (Viswanath & JR., 1996). Knowledge Gap may therefore, as a broad thesis, suffer the effects of cognitive dissonance where the rich willfully ignore some new fads that have attracted the poor. Its realization as a theory may be subject to segregated public valuation of the import of new developments/ideas. In the case of gas stoves, knowledge gaps may keep the poor away. There could be areas of haziness in terms of safety of gas stoves, cost of equipment and cost of gas, procurement sources and cost differentials with extant domestic energy sources. While these forms of information are in the public domain, sundry filter systems ensure a knowledge gap endures.

Understanding how the poor may receive technological behaviour or otherwise may require focus on them as a unit of society. Can the poor operate under an invisible social bond that dictates their collective behaviour? Certain theories advance that thesis. One such thesis is the Groupthink theory (Janis, 1972). Groupthink captures the idea that when confronted with taking a stand on issues, for certain groups, maintaining cohesiveness and solidarity are more important than considering the facts in a realistic manner. A group makes faulty decisions because group pressures lead to a deterioration of mental efficiency, reality testing and moral judgment (Gyory et al., 2018). Group thinking tends to be mostly an affliction of cohesive, homogenous groups. Leading change usually has its most formidable obstacles in the moral ambivalence of conservative groups unsettled about uncertain change outcomes. This cohesiveness and homogeneity are essentially found among rural populations. Individual actions tend to be guided by peer influences as the population tends to resist or embrace change in a uniform manner. The diversity and heterogeneity of urban populations present a different scenario of diffusion sociology. Inertia can be reinforced by group lethargy. The opportunity for adoption with groupthink will however be the fact that where group leaders take to an idea, such as gas stoves, it might easily catch on across the population. Hence, the rural groupthink may become for extension workers, an ally and helper rather than the bulwark against marketing it is usually assumed to be.

Everest Rogers Innovation Diffusion theory (Rogers, 1962) holds that ideas, products or innovations diffuse over time and across space. An idea or product diffuses through a population or social system and the result of diffusion is new adopters. Adoption signals change in the sense that a person begins to do or see something differently. Innovation is distinct for its novelty. Amenability to diffusion process will depend on a contagion factor which is about an individual's resistance; and proximity to the innovation source (Siyaya et al., 2022). The diffusion field is therefore not an isotropic plane. Probability for the occurrence of diffusion/adoption varies across the field. Across a population diffusion tends to follow a trajectory the shape of the normal curve reflecting few early adopters indicating early hesitance in adoption, later mutual reinforcement at attainment of mass market, and few hard to convert late adopters.

Adoption of innovation reflects the Herbert Blumer's (Blumer, 1969) theory of symbolic interaction following the work of George Herbert Mead. Following this theory, people inhabit a largely socially constructed world in which meaning of objects, events and behaviours come from the interpretation people give them. The interpretation given also varies from group to group. Hence rural people's adoption of gas stove will reflect their interpretation of its symbolic essence. The utilitarian appeal of artifacts may be secondary to aesthetic and social significance of ownership. A sense of social fulfillment may go with acquisition of such assets as gas stoves. Beyond symbolism, the current discourse offers an opportunity to further interrogate the World Health Organization (WHO)'s energy ladder (Figure 1) in improving standard of living in rural areas (World Health Organisation, 2006).

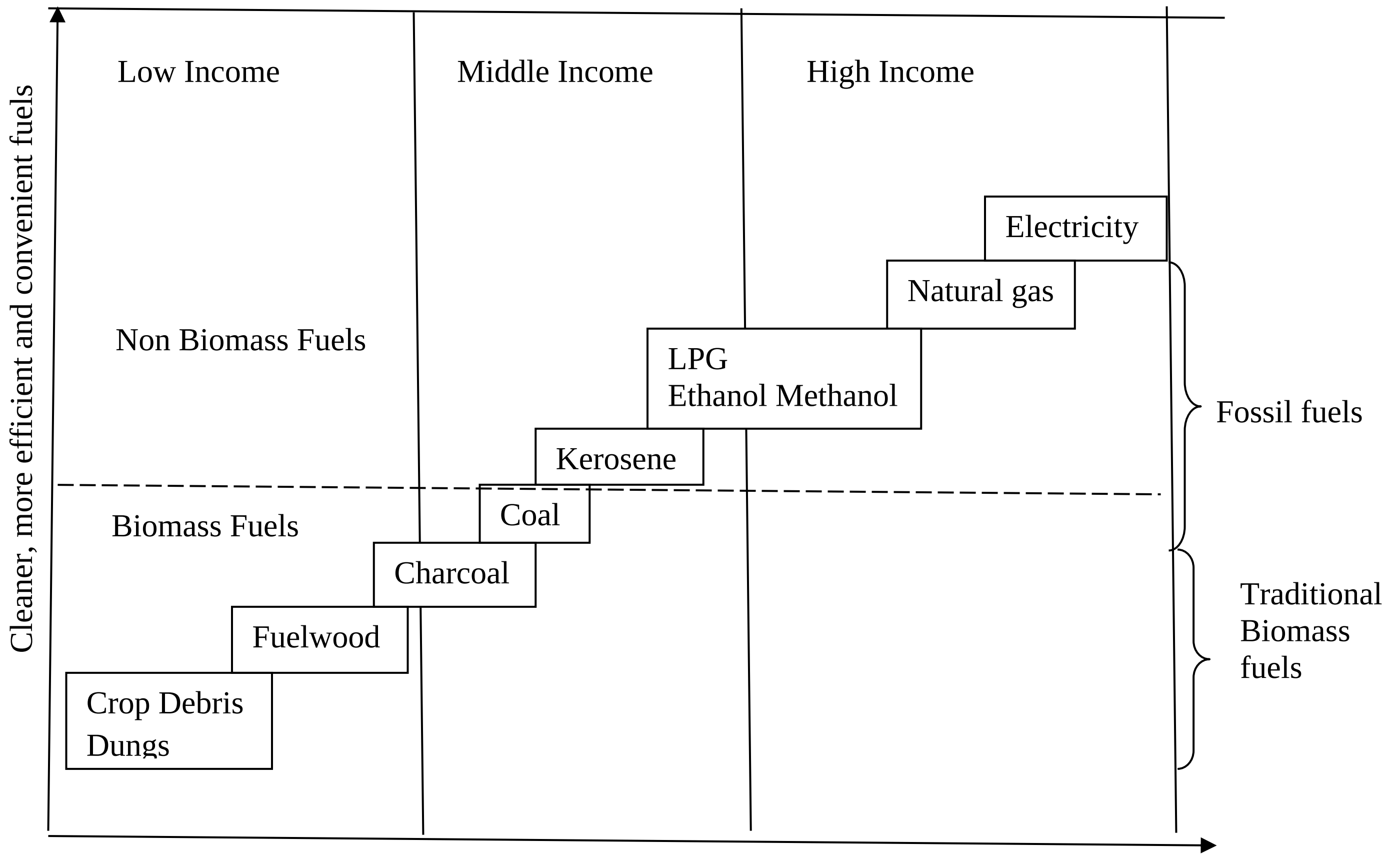

Figure 1: *WHO Energy Ladder Model*

In literature, a lot of work has been done on factors that promote or inhibit adoption of gas stove usage or Liquefied Petroleum Gas (LPG). Many of these works share the developmental setting of the study area. Clark et al. (2017) found on the Tibetan Plateau of China that household stove use was positively associated with reported cooking needs and negatively associated with age of the main cook, household socio-economic status and availability of substitute cleaner-burning stoves. Where the cook is advanced in age, making the domestic energy transition might prove difficult as gas stoves are essentially modern.

On the predictors of adoption, the findings in Guatemala by Thompson et al. (2018) seem to resonate across developing world contexts. They found that new technology should project the edge it has above the old; income does not predict acquisition but predicts sustained use; men are key decision makers, but are not targeted by gas stove messages; stoves seen as 'prize possessions may not be used; 'hearsay' fuels fear about gas stoves rather than experience; seasonal wood availability and retail shop practices hamper sustained use; and woodfuel collection is a socializing opportunity rather than drudgery. The issues of domestic gas usage can be seen to be largely sociological. Buy-in may be a function of proven functional superiority over wood stoves. Low-income groups can acquire gas stoves, but it is often only those with guaranteed income that can afford to sustain regular refilling. Men are not considered primary marketing targets but such capital investments as gas stoves have to be funded by men who happen to be the richer. While the stove may be seen as a celebrated status symbol, it may not be used for actual cooking. People may stay away from gas on account of shared unfounded stories of hazard rather than experience. Where free fuelwood can be accessed, even seasonally, households may switch off from gas. The rural sociology

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of energy sourcing in developing parts of the oriental world seems to show remarkable similarity. Gill-Wiehl et al. (2021) found that households are more likely to adopt improved stoves if they have had prior exposure to a trusted individual or organization promoting the product. Potential adopters may need assurances about their safety and cost-benefit advantages. This is also an important point for all forms of rural extension in diffusion of gas stove adoption.

Williams et al. (2020) analyzed predictors to uptake of gas stove usage and found that social and cultural barriers to exclusive LPG use can be overcome when LPG stoves and fuel are provided at no cost. Subsidization is therefore suggested by the authors to deepen usage and achieve mass market. Unraveling the factors that predict gas stoves acquisition and usage by households is critical to marketing this behaviour. This can also spur creation of a mass market and scale economies that will drastically improve the domestic energy market share held by gas.

The fact of continued utilization of these other energy sources despite campaigns against them and promotion of gas in the media hints at possible cultural, economic, social, technological inhibitions to the diffusion of gas stoves in these spaces (Akinbami et al., 2001). Planning agencies and concerned groups should be interested in knowing which conditions predispose households to adoption of gas stoves usage and which factors stagnate adoption if they are not to misdirect interventions in the course of facilitating the deepening of gas utilization in households. It has become necessary in the light of developments around climate issues and economic challenges to identify and explore factors that make households amenable to adoption of gas stoves. This is critical to all interventions in sustainable energy sourcing, (redirecting energy sourcing and utilization behaviour towards sustainability).

The paper is therefore aimed at the factors that predict household's adoption of gas stoves and relative influence of the predictors in the study area. The idea is that it is only when the influences on the adoption behaviour are known that the behaviour can be cultivated and propagated in pursuit of a mass market that will make gas usage and equipment, thereto, even friendlier in terms of cost. There is a certain leverage in scale economies that can be explored.

2 Methods

The two states of the study, Abia and Ebonyi are contiguous states in Southeastern geopolitical zone of Nigeria which is made up of five states, the others being Anambra, Enugu and Imo (see Figure 2).

Abia has a landmass of 6,320km^2 and ranks 32 in landmass among Nigeria's 37 units (36 states and Abuja FCT) while Ebonyi has 5670km^2 and ranks 33. Abia has a year 2020 Gross Domestic Product (GDP) of $7,078,540,953 ranking No. 14 of 37 in Nigeria with a GDP per capita of $1,799 while Ebonyi has a GDP of $2,888,378,681 and GDP per capita of $948 ranking 34 of 37 (*Nigeria Multidimensional Poverty Index*, 2022). The number of poor people is put at 1.12m for Abia and 3.66m for Ebonyi (National Bureau of Statistics, 2022). While Abia is ranked 8th in Nigeria on Human Development Indices (2021), Ebonyi is joint 12th (UNDP, 2021). Abia has a temperature range of 20 to 30^{o} Celcius while Ebonyi temperature range is 20 to 38^{o} celcuis. Annual rainfall is heavy and has a similar intensity at 2500mm for Ebonyi and 2400mm for Abia. The rainiest months are between April and October.

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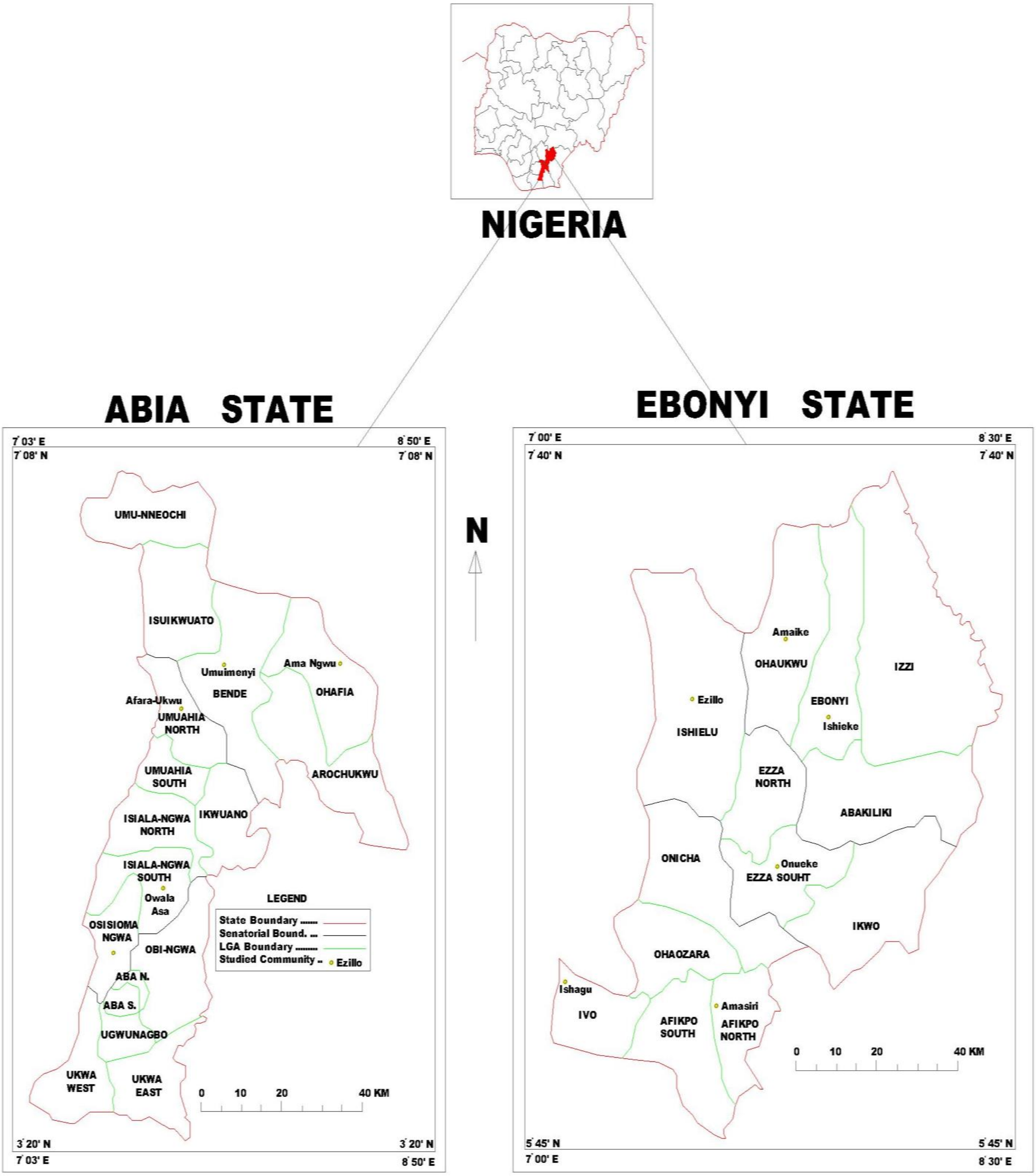

Figure 2: *Map of the study area*

Abia is drained by the Imo and Aba Rivers that empty into the Atlantic ocean while Ebonyi is drained by the Abonyi River, Cross River (River Aloma) Asu Eze Aku. The two states have largely agricultural economies. Ebonyi produces yams, rice, oil palm, cassava. Mining of lead, zinc, salt and limestone and quarrying of granites are major activities in Ebonyi. Abia also has minerals such as lead, zinc, limestone, oil and gas, salt, kaolin and limestone (Abia State Government). Two major environmental challenges for Abia are soil erosion and solid waste mismanagement. Ebonyi suffers intermittent flooding which sometimes proves beneficial to the paddy rice cultivated in parts of the state. Studied communities in the states are shown in Table 1.

Table 1: *Sampling frame of studied communities in Abia and Ebonyi States*

Senatorial Zone	Local Government Areas	Communities	Population Sample
Abia Central Senatorial Zone	Umuahia North	Afara-Ukwu/Mbaocha	50
	Isiala Ngwa South	Owala Asa/Ntighauzo	50
Abia North Senatorial Zone	Ohafia	Amangwu	50
	Bende	Umuimenyi	50
Abia South Senatorial Zone	Osisioma Ngwa	Okpu Umuobo	50
	Ugwa West	Obuzor	50
Ebonyi Central Senatorial Zone	Ezza South	Onueke	50
	Ishielu	Ezillo	50
Ebonyi South Senatorial Zone	Ivo	Ishagu	50
	Afikpo North	Amasiri	50
Ebonyi North Senatorial Zone	Ohaukwu	Amike	50
	Ebonyi	Ishieke	50
Total			**600**

The sample population has been randomly selected from household heads based on a quota of 50 per community. Household heads are preferred for being at a vantage position in the household to have and make decisions on gas stoves usage. On the roadways houses are numbered and so are households living in them. Odd number households are surveyed to the selected maximum of 50. Interview schedule has been used in data gathering with field assistants filling out responses, given rural areas with large illiterate population. In addition, ethical considerations were made in terms of informed and voluntary consent, non-injury and confidentiality, during data collection.

Study Respondents: Demographic Characteristics

The populations are essentially rural coming from communities preoccupied with primary production. As is customary with rural households, authority figures are usually allowed to speak for households, and these are the household heads. Household heads are incidentally usually male where adult males are part of households. Aspects of the demographic characteristics of the study population are shown on Table 2.

Table 2: *Demographic characteristics of the study respondents*

Variable		Ebonyi n(%)	Abia n(%)	Total n(%)	p-value
Gender	Male	273 (91.0)	171 (57.0)	444 (74.0)	.000
	Female	27 (9.0)	129 (43.0)	156 (26.0)	
Age bracket	18-28	1 (0.3)	11 (3.7)	12 (2.0)	.000
	29-39	7 (2.3)	55 (18.3)	62 (10.3)	
	40-50	82 (27.3)	142 (47.3)	224 (37.3)	
	51-61	200 (66.7)	59 (19.7)	259 (43.2)	
	More than 61	10 (3.3)	33 (11.0)	43 (7.2)	
Education	Informal	53 (17.7)	11 (3.7)	64 (10.7)	.000
	Primary	133 (44.3)	45 (15.0)	178 (29.7)	
	Secondary	87 (29.0)	124 (41.3)	211 (35.2)	
	Tertiary	27 (9.0)	120 (40.0)	147 (24.5)	
Household Size	1 – 5 persons	19 (6.3)	133 (44.3)	152 (25.3)	.000
	6 – 10 persons	180 (60.0)	117 (39.0)	297 (49.5)	
	11– 15 persons	101 (33.7)	37 (12.3)	138 (23.0)	
	16– 20 persons	-	11 (3.7)	11 (1.8)	
	More than 20 persons	-	2 (0.7)	2 (0.3)	

Household heads are more in the 40 to 61 age brackets. This group makes up 80.5 percent of household heads. The household heads are also 74 percent males. Heading households usually require breadwinning role and the most active breadwinners are usually workers of pre-retirement age. About 50 percent of households are made up of between 6 and 10 persons and of remarkable note is the 21 percent of households having 16 persons and more. The fact of primary production, largely manual agriculture dominant in the surveyed rural communities promote large households for mobilization of adequate farm labour. Also, all the demographic characteristics were statistically significant, in terms of respondents' location.

Prediction of usage of cooking gas stove in respondents' households from zero usage to very high usage relied on ordinal logistic regression based on proportional odds. The exercise is based on six independent predictor variables: (1) head of household's gender, (2) head of household's age, (3) households' size, (4) head of household's education, (5) household's primary cooking fuel and (6) household's monthly income category. Certain assumptions have been made in putting the variables forward:

1. The head of household's gender is considered significant since catering services in the domestic environment have gender nuance. Females, under extant household labour division, are usually assigned food preparation roles and are therefore primary users of cooking fuels/energy. It is therefore important that energy mixed decision-making in the household can be affected by the gender of the person that usually takes decisions. Male-headed households have decision makers that do not directly superintend the kitchen where cooking facilities are installed. Female-headed households have energy decision makers doubling as the major decision maker of their households. These households do not have the burden of layers of decision making unlike male-headed households.
2. Head of household's age is considered important for the fact that gas stoves are relatively a new technology and therefore might be generation sensitive. Some generations have had to pass through woodstoves that are very poor in efficiency usually modeled after stone or metal tripods; liquid fuel stoves have followed such as the kerosene stoves before the coming of gas stoves and electric stoves. Hence fixation to earlier generations of stoves might lie with older persons while young household heads least exposed to earlier cook-stone versions may readily settle for the more modern gas stove. Other attributes such as exposure and work life critical to gas stove usage may also be associated with age.
3. Household size is assumed to be associated with level of exposure, age of household head and other factors. Larger households tend to be less informed and more conservative with greater poverty index than smaller households. They also have higher dependency rates. These characteristics may affect their ability to scale up to newer technologies considered to have high cost implications.
4. Head of household's education level is considered to play a determining role in exposure, readiness to receive extension service and media information ability to source capital and upgrade to higher technologies and more efficient ways of doing things.
5. Household's primary cooking fuels are considered an influence on households' readiness to use gas stoves. Those that use wood stoves may be more inclined to use the kerosene stove while those that use electric stoves may readily use the gas stove as an alternative. This assumption considers the energy spectrum a sustainability gradient of energy types in which energy users tend to adopt as default the next to their favourites on the spectrum.
6. Household income is considered critical to taking the decision to acquire gas stoves. Where income is large the decision just as it is for other household investments may come more easily than where it is poor. This is particularly because in rural areas, fuelwood for cook stoves may come at zero cost from post-harvest and fallow fields. The open access nature of these resources may prove a disincentive to a switch to gas stoves.

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In carrying out ordinal regression, dummy variables which are dichotomous co-efficient that can fit into the regression model were created for both dependent and independent variables. The ordinal regression applied in the study is the Generalized Linear Model (GENLIN) which predicts the proportional odds of the dependent ordinal variables (Ezedike et al., 2020). The GENLIN can be described as general multivariate regression model Hypothesis tests with the GENLIN model can go the multivariate way where columns of Y (dependent variable) are tested together or as several independent univariate tests where columns of Y are tested independently (Harrell Jr, 2015). The model is simply a compact way of simultaneously writing several multiple linear regression models in the form of

$$Y = XB + U$$

Where Y is a matrix with series of multivariate measurements

X is a matrix of observation on independent variables

B is a matrix containing parameters that are usually to be estimated and

U is a matrix containing errors (noise)

The GENLIN relate some number of continuous and/or categorical predictors to a single outcome variable.

3 Results

A GENLIN ordinal regression of proportional odds was used to determine the effect of six independent variables: (1) head of household's gender (2) head of household's age (3) household size, (4) head of household's education (5) household's primary cooking fuel and (6) household income, on the level of usage of cooking gas stove in respondent's households (from "zero usage" to very high usage).

Table 3 indicates that test of multi-collinearity was acceptable given that all the tolerance values for the independent variables were above .500. This implies that there was no collinearity between the variables in the logistic regression model. The Variance Inflation Factor (VIF) shows values slightly above 1.0 (VIF values between 1 and 5 show that variables are only moderately correlated; those above 5 show high correlation while 1 indicates absence of correlation among variables).

Table 3: *Test for multicollinearity between the predictors in the regression model*

Model Predictors	Collinearity	Statistics
	Tolerance	VIF
Head of household's gender	.885	1.130
Head of household's age	.869	1.151
Household size	.910	1.098
Household head's education	.875	1.143
Household's primary cooking fuel	.927	1.078
Household's monthly income	.946	1.057

Study results in Table 3 show that regression model predicting use of cooking gas stove in respondents' households based on gender, age category, household size, education level, primary cooking fuel and monthly income, fitted appropriately because goodness-of-fit-test for deviance ($\chi 2(1001) = 932.506$, $p = 0.397$) and Pearson ($\chi 2\ (1001) = 2335.285$, $p = 0.102$) were both non-significant.

Furthermore, the final model statistically significantly predicted use of cooking gas stove in respondent's households, as shown by the Omnibus test result in Table 4, $\chi 2\ (19) = 340.067$, $p < .001$. Akaike

Information Criterion (AIC) value of 1037.638 has provided a measurement that can be used in linking the parameters in the present model with other comparable models.

Table 4: *Goodness of fit tests for the ordinal logistics regression in model*

	Value	Df	P-value
Omnibus Test: Likelihood Ratio Chi-square	340.067	19	.000
Deviance	932.506	1001	.940
Pearson chi-square	2335.288	1001	.102
Akaike Information Criterion (AIC)	1087.638		

Effect of each variable in terms of their contribution to the regression model, are shown in Table 5. While five of the variables were significant with respect to model effects (gender, household size, education, primary cooking fuel and household income), only one of them was non-significant (age).

Table 5: *Test of model effects for each variable in the regression*

	Wald Chi-square	Df	P-value
Gender of head of household	8.414	1	.004
Age of head of household	4.668	4	.323
Household size	22.332	4	.000
Household head's education	19.144	3	.000
Primary energy of household	126.445	3	.000
Household income	9.591	4	.048

Parameter estimates of the regression model predicting ordinal likelihood (odds) of using cooking gas stove in respondents' households are shown in Table 6. The results indicate that none of the categories under age bracket were significant in the model. The odds of households with male heads having very high usage of cooking gas stove were 1.563 (95% CI, .882 to 1.830) times more than that of households with female heads, $\chi 2$ (1) – 8.414, p = .004. The odds of households with between 11 – 15 occupants having very high usage of cooking gas stove was 2.031(95% CI, .802 to 2.493) times less than that of households with more than 20 occupants, an effect that was statistically significant, $\chi 2$ (4) = 22.332, p < .000.

Also the likelihood of household heads with secondary level education having very high usage of cooking gas stove was 0.536 (95% CI, .345 to .832) times less than that of household heads with tertiary level education, $\chi 2$ (3)) = 19.144, p < .000. In addition, the odds of households with fuelwood as their primary energy source having very high usage of cooking gas stove were .696 (95% CI, .405 to 1.194) times less than that of households with liquid fuel as their primary energy source, $\chi 2$ (3) = 126.445, p < .000. In the same vein, odds of households with income of between 100,001 Naira and 150,000 Naira having very high usage of cooking gas stove was 1.386 (95% CI, .310 to 1.580) times less than that of households with income greater than ₦200,000, $\chi 2$ (4) = 9.591, p < .048.

Table 6: *Parameter estimates in the ordinal regression model.*

Parameter		B	Std. Error	P-value	Exp(B)	95% Wald CI for Exp (B)	
						Lower	Upper
Threshold	(Gas Usage: Nil vs. (ref))	-4.388	1.5840	.006	.012	.001	.277
	(Gas Usage: low vs. (ref))	-3.570	1.5810	.024	.028	.001	.624
	(Gas Usage: moderate vs. (ref))	-1.940	1.5762	.218	.144	.007	3.157
	(Gas Usage: high vs. (ref))	-.765	1.5746	.627	.465	.021	10.186
	[Gender: Male vs (ref 1*)]	.574	.1978	.004	1.563	.882	1.830
	[Age Bracket: 18-28 vs. (ref2*)]	-.517	.6751	.444	.596	.159	2.239
	[Age Bracket: 29-39 vs. (ref2*)]	-.173	.4018	.667	.841	.383	1.849
	[Age Bracket: 40-50 vs. (ref2*)]	.074	.3395	.827	1.077	.554	2.095
	[Age Bracket: 51-61 vs. (ref2*)]	-.351	.3455	.309	.704	.358	1.385
	[Household size: 1-5 vs. (ref3*)]	-2.701	1.4066	.055	.067	.004	1.057
	[Household size: 6-10 vs. (ref3*)]	-3.039	1.4021	.030	.048	.003	.748
	[Household size: 1 1-15 vs. (ref3*)]	-3.475	1.4119	.014	2.031	.802	2.493
	[Household size: 16-20 vs. (ref3*)]	-1.141	1.4991	.447	.320	.017	6.034
	[Education: Informal vs. (ref4*)]	-1.181	.4105	.004	.307	.137	.686
	[Education: primary vs. (ref4*)]	-1.093	.2689	.000	.335	.198	.568
	[Education: secondary vs. (ref4*)]	-.624	.2245	.000	.536	.345	.832
	[Energy: fuelwood vs. ref5*)]	-.363	.2755	.188	.696	.405	1.194
	[Energy: gas vs. (ref 5*)]	2.068	.2668	.000	7.908	4.688	13.341
	[Energy: electricity vs. (ref5*)]	-2.335	1.0600	.028	.097	.012	.773
	[Income: < 50K vs. (ref6*)]	-.633	.5422	.243	.531	.184	1.537
	[Income: 50. 1K-100k vs. (ref6*)]	-.850	.5503	.122	.427	.145	1.257
	[Income: 100.1K-150K vs. (ref6*)]	-1.471	.5997	.014	.230	.071	.744
	[Income: 150.1K-200K vs. (ref6*)]	-.953	.6865	.165	1.386	.310	1.580

Note: ref = very high, refl = female, ref2 = >60, refi = >20, ref4 = tertiary, ref5 = liquid fuel

4 Discussion

Findings on the role of age of head of household which stood out among the variables as the only non-significant variable predicting household usage of gas stoves agrees with the findings on age of household heads made by Muszynska & Wedrowska (2021). They found that the age of the household head has a limited effect on the extent of overall inequality in income distribution. Rather household composition and other factors have impact on surveyed households' economic situation. Hence households do not vary in income along the lines of age of their heads. While older age may confer advantages on some heads, under economic transitions such as has characterized the digital revolution, youthful household heads may in fact have advantages. In a sense the Digital Divide known better for its geography is also intergenerational in favour of younger people. However, the Statistics Bureau of Japan (2020) found greater household saving capacity among older household heads. It found that household heads under 30 and in their 30s have liabilities exceeding their outstanding savings. The income and savings differentials among generations of peoples may emerge as a regional and temporal variable linked to specific industrial and social policy circumstances. These circumstances are influential in determining which generations may have higher income to procure cleaner domestic energy.

Findings show that the likelihood of a male headed household having very high usage of cooking gas stove is 1.563 times higher than that of a female headed household. The odds are against female headed households. The matter of the comparative impoverishment of female headed households is replete in literature. It is also a concern that has prompted advocacy for some affirmative action for female headed households. In their study of the nexus of gender and malnutrition, Ashagidigbi et al. (2022) found that most malnourished children were males in female-headed households living in rural areas in the northeast zone of Nigeria. The male headed households are, usually in patriarchal societies more financially empowered as females in such circumstances seem to suffer sundry structural disadvantages. The fact of stigmatization of female headed households in single-parent family settings is also a significant reinforcing issue for income inequality. This pattern may however not be universalized as some literatures seem to paint the picture of more enhanced agency of female heads in providing for households. The findings here seem to detract from Food and Agriculture Organization report (*Household Structure, Living Standards Incomes and Savings*, n.d.) on female-headed households exhibiting a higher standard of living than male-headed households measured by living standards indicators such as per capita expenditures. However, it observed that when assets, capacity to borrow and labour resources are considered female-headed households emerge more vulnerable on the long term. The difference might be a gendered differentiation in home economics skills in favour of females. Klu et al. (2022) based on the experience of households in Ghana found that anaemia and its severity is higher among children living in male-headed households. This might be indicative of better, resourcefulness of females in culinary and dietary skills in settings where catering and kitchen services are essentially dominated by females.

Findings show that odds are against larger households in the use of gas stoves. Smaller households are more likely to use gas stoves than larger ones. This speaks to other household variables that are correlates to smaller household size such as higher education and income. The theme of household size in energy sourcing resonates in the findings of Danlami et al. (2015), Arowolo et al., (2018) and Egunjobi (2020). Large households in rural areas are essentially farming households that substitute capital for labour. They make up for lack of mechanization by increasing household labour on the farms. High household population is therefore the norm and may accentuate poverty condition rather than bring relief. These households manifest a debilitating dependency ratio that may detract from households' ability to invest in such 'luxuries' as gas stoves. Having large households may also indicate high availability of labour for gathering openly sourced fuelwood for household use. Large households usually possess farmlands (the abinitio impetus for the large population). Arowolo et al., (2018) found that farmland possession was among the variables that determine cooking energy source. Farmlands yield fuelwood, post-harvest residue and other forms of biomass that may encourage their owners to cook with fuelwood or to include fuelwood in their energy portfolio.

The odds are against households with heads that are of lower education levels. They are less likely to be found in very high usage of gas stoves than those with tertiary level education. Ownership of gas stoves remarkably may not translate to usage of gas stove or regular usage. There may be circumstances in which people see artifacts such as gas stoves as a prize and fail to derive utilitarian value from possessing them. This may come with poor education. The findings here agree with those of Gill-Wiehl et al. (2021) on

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exposure. They found that households are more likely to adopt improved stoves if they have had prior exposure to a trusted individual or organization promoting the product. Where a household head is educated, the household can easily pick up critical development information. Thus Bilenkisi et al., (2015) found a negative association between the probability of a household being poor and the education level of the household head. Poverty at times comes down to information access which is graduated along the lines of levels of education received.

The odds in high usage of gas stoves are against fuelwood users but favour liquid fuel users such as those households that primarily cook with kerosene stoves. This agrees with World Health Organisation, (2006) energy ladder theory. It is further proof that energy transition is really stepwise with households graduating from the most basic of solid fuel all the way to electric energy. Along the line of stepwise ordering of energy typology on energy ladder, (Thompson et al., 2018) found that new technology has to project the edge it has above the old to secure a market. Households as this study has found seem not to skip rungs on the energy ladder but are most likely to advance to progressively next-in-line energy types as their socio-economic indices improve or deteriorate. The advantages of the next higher energy technology above the extant one in use have to be the clear positive business case for adoption of the new technology where adoption is governed by economic or other rationale.

The odds in gas stoves usage are against lower income households. Income is a major index as it tends to predict most other socio-economic variables of households. Household stove use in the study carried out by (Clark et al., 2017) was negatively associated with household socio-economic status and availability of substitute cleaner burning stoves. While suspending the factor of economic cost, (Williams et al., 2020) found that providing LPG stoves and fuel at no cost overcomes social and cultural barriers to exclusive LPG use. This is suggestive of the likelihood of success in subsidization efforts. (Soltani et al., 2020) in the same vein while holding other factors constant, found that income may lead to variation in LPG and electricity consumption in Mahabad, Iran African setting has socio-cultural nuances that may obfuscate the role played by income differentials. Wassie et al., (2021) found that higher income level and grid connection have not led households to completely forgo the use of traditional cooking and lighting fuels. The idea in many households may therefore be about an energy portfolio characterized by an energy mix rather than income restricted household energy stereotypes. Some types of cooking may be done in open fuelwood fires outdoors even where concerned households have higher forms of energy. Dietary tastes and cultural milieu of cooking are influences that may sometimes suspend the clear role of income as determinant of energy choice.

5 Conclusion

There are variables that predict households' behaviour of adopting gas stoves. Rural households in developing countries with particular reference to those in parts of Abia and Ebonyi, South East Nigeria are being encouraged to scale up to gas stoves usage from lower solid fuel energy forms which are harmful to their health, the environment and lately their finances. There persists a knowledge gap and groupthink which stifle diffusion of gas stoves usage. Success with extension efforts at making gas stoves a mass market and encouraging a switch to the more environment-friendly gas has to factor variables of importance. Predictors of household adoption of gas stoves usage are diverse. They include gender of household head, household size, household head's education, primary cooking energy form in use and household income. Under the GENLIN ordinal regression while these variables were found to significantly impact adoption, age of household heads was found to be insignificant. The odds in gas stoves adoption favour male-headed households; smaller households; households with educated heads; households using liquid fuels and households of higher income. Efforts will have to focus on creation of awareness through advocacy to bridge the knowledge gap and introduce gas stoves to the poorly educated while subsidization will have to address the income challenge.

6 Declarations

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6.2 Competing Interests

The authors declare no competing interests.

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