



POLAC ECONOMIC REVIEW (PER)
DEPARTMENT OF ECONOMICS
NIGERIA POLICE ACADEMY, WUDIL-KANO



AN EVALUATION OF SOLID FUEL CONSUMPTION AND HEALTH EFFECTS IN NIGERIA

Idakwoji, Ojochogwu Blessing

Department of Economics, Prince Abubakar Audu
University, Ayingba Nigeria

Bernard O.A.

Department of Economics, Airforce Institute of
Technology, Kaduna, Nigeria

Saheed Zakaree

Department of Economics, Nigerian Defence
Academy, Kaduna, Nigeria

Dampome Moses

Department of Economics, Nigerian Defence
Academy, Kaduna, Nigeria

Abstract

The study examines the implication of household solid fuel consumption on health in Nigeria covering the period of 1971-2022. Data for the analysis were sourced from the World Bank's database while Autoregressive Distributed Lag (ARDL) and Granger causality test approaches were employed for the analysis. The dependent variable was life expectancy which proxied the health of users. The explanatory variables include solid fuel consumption (% of total energy) (SFC) proxied for household energy while complementary variables include; gaseous fuel consumption (GFC) (% of total energy), gross domestic product per capita (GDP), and rural population (RPOP). The bound test result reveals a long-run relationship among the variables captured in the model. The findings reveal that household energy consumption proxied by solid fuel consumption accounts for a decrease in life expectancy both in the long-run and short-run. The findings of the second objective show that there is unidirectional causation running from household solid fuel consumption to life expectancy. Based on these findings, the study recommends that the Nigerian government embark on a serious sensitization campaign about the importance of adopting health-friendly energy for household use. In collaboration with relevant stakeholders, the government must provide subsidized household cooking apparatus with no negative health implications.

Keywords: Household Energy, Solid Fuel Consumption, Health, Life Expectancy, ARDL Model

JEL CODES: Q40, Q43, Q49

1. Introduction

Energy plays a crucial role in human life and is essential for all elements of development (Akinola, Oginni, Rominiyi & Eiche 2017). Energy is an essential component required for a variety of home tasks including electricity, heating, cooking, transportation, and agricultural activities (Mensah 2015). Recent worldwide focus on increasing carbon dioxide (CO₂) emissions causing global climate change has raised sustainability worries regarding the impact of global energy usage on human health,

specifically concerning household energy consumption (Wang, Kwan, Zhou, Fan, Wang, & Zhan 2019).

Approximately 2.4 billion individuals globally still use solid fuels such wood, crop waste, charcoal, coal, dung, and kerosene in open fires and inefficient stoves (IEA, 2022). Most of these individuals are impoverished and reside in low and middle-income nations (UNSD, 2022). Household air pollution results from the utilization of ineffective and contaminating fuels and technologies within and near

the residence, releasing various harmful pollutants, such as tiny particles that can infiltrate the lungs and enter the bloodstream (World Bank, 2022). Women and children, who spend a significant amount of time close to the household fireplace, are especially at risk (IRENA, 2022). Dependence on harmful fuels and technology requires a substantial amount of time to cook on an ineffective appliance, along with collecting and preparing fuel.

Household energy is crucial for long-term health. Meeting global energy demand and ensuring access to clean, reliable, and cheap energy for everyone should be top worldwide goals (WHO, 2022). Energy itself encapsulates the numerous contradictions of modern life. Energy is necessary for economic progress, but using energy in an unsustainable manner leads to pollution, greenhouse gas emissions, and the exhaustion of nonrenewable resources. Access to energy is essential and should be a priority in any development plan, while also acknowledging the significant obstacles it presents. Climate change is not just present but also progressing at a faster pace than expected. Immediate and substantial measures are necessary to decrease our greenhouse gas emissions in order to mitigate environmental and health hazards (Oyedipo, 2012).

Developing countries continue to heavily rely on solid fuels, and it seems that intervention attempts are not keeping pace with population growth. The population predominantly utilizing solid fuel for cooking has consistently stayed at approximately 2.7 to 2.8 billion during the past thirty years. The population exposed to home air pollution in Sub-Saharan Africa increased from 333 million to 646 million between 1980 and 2010, and in the eastern Mediterranean, it increased from 162 million to 190 million. Throughout the period, the number of individuals in Southeast Asia exposed to home air pollution stayed consistent at approximately 1 billion people (Amegah & Jaakkola, 2016). In 2020, 125,000 persons in Nigeria died due to household air pollution from solid fuels, as reported in the 2020 State of Global Air. The World Health Organization (WHO) recently declared that efforts to tackle household air pollution have been historically sluggish, under-financed, and inefficient. Due to the health hazards linked to solid fuel usage, there is a likelihood that it

may decrease life expectancy, while also impacting the ecology and climate. This study aims to investigate the correlation between solid fuel use and life expectancy. The study aims to investigate the impact of solid fuel use on life expectancy in Nigeria using the autoregressive distributed lag (ARDL) model.

2. Literature Review

2.1 Conceptual Issues

Concept of Solid Fuel

Solid fuel is any solid material that may be burned to release energy through combustion, producing heat and light. Common solid fuels include wood, charcoal, peat, coal, hexamine fuel tablets, dried dung, wood pellets, corn, wheat, rice, rye, and other grains. Solid fuels are commonly utilized in rocketry as solid propellants. Solid fuels have been historically utilized for fire creation and remain commonly employed worldwide today (Adetayo et al 2020). Household energy refers to the energy consumed in homes to fulfill their requirements (Kadiri & Alabi, 2014; McGranham & Kaijser, 1993). Household energy sources can vary and may include wood, dung, agricultural wastes, charcoal, kerosene, liquefied natural gas, and electricity, depending on the specific usage. Emagbetere (2016) categorizes domestic energy into two types: solid and non-solid fuels. Kerosene, LPG, and electricity are examples of gaseous fuels. The residential sector is recognized as one of the world's biggest energy consumers (Wang et al., 2011).

Concept of Health

Health encompasses a condition of total physical, mental, and social well-being, rather than just the lack of disease or weakness. It includes different facets of a person's life, such as physical health, mental strength, emotional well-being, social relationships, and general well-being. Attaining and preserving good health requires a mix of elements including consistent physical activity, well-rounded diet, adequate sleep, stress control, pleasant social connections, and availability of healthcare services when necessary. Health is a complex notion that is impacted by environmental, socioeconomic, and

cultural factors, leading to variations among individuals and societies (Adetayo et al 2020).

Life expectancy at birth indicates the average number of years a newborn would live assuming mortality rates remained consistent throughout its life. Life expectancy is the anticipated average lifespan of an individual before their passing.

The "energy stack" and "energy ladder" models are frequently utilized in studies on energy selection. According to the energy stack theory, households favor a combination of energy sources and have the ability to transition between them. The energy ladder theory is a hierarchical relationship between household income, socioeconomic position, and the type of energy utilized for cooking and heating. The "energy ladder" is frequently utilized to assess the environmental impact, effectiveness, and expense of different types of fuel. Low-cost, ineffective, and highly polluting fuels like dry animal excrement, fallen branches, and grass are considered the lowest tier on the energy hierarchy. Households in the second tier depend on coal, kerosene, and charcoal. Third-tier high-income households are more inclined to utilize contemporary fuels like electricity and LPG. Advancement on this ladder is influenced by the increase in household wealth (Barnes & Floor 1999). Developed countries are moving away from biofuels and towards petroleum goods like kerosene, LPG, and electricity. In developing nations, households typically still rely on biomass even when cleaner and more advanced fuel options are available (Smith 1987). It is important to consider the harmful impacts of indoor pollution on human health, which are influenced by energy choices linked to household income and socioeconomic factors. Therefore, the energy ladder theory is the theoretical base for this study.

2.2 Empirical Review

Extensive literature exists on the impact of home energy on health. For instance, Muhammad, Michael, and Gazi (2022) studied the correlation between biomass fuel usage and life expectancy as well as infant and child mortality rates. The researchers employed a fixed effect model and instrumental variable regression to examine 13 years of cross-

country panel data from 105 countries spanning from 2000 to 2012. Solid fuel combustion has been found to elevate neonatal and child mortality rates while reducing life expectancy for both males and females. Based on a rough estimate, decreasing the disparity in solid fuel usage between low-income and lower-middle income nations by 50% results in a 16.5 and 29.8 per thousand decrease in infant and child mortality in low-income countries, respectively. It also leads to an increase in life expectancy of 1.0 and 1.5 years for males and females.

Özlem and Egemen (2021) studied the relationship between health status and indoor air pollution in Turkey resulting from households' energy choices. The study examined these impacts using random effects panel discrete ordered models with the Income Living Conditions Micro Longitudinal Data Set from 2014 to 2017. The investigation revealed that age, female gender, having dependent children, and indoor air pollution negatively impact health status. Education level and income level have a beneficial impact on health condition. An essential finding of this study is that affluent homes also suffer from indoor air pollution since they do not have access to renewable energy sources.

Adetayo, Adeyinka, and Agbabiaka (2020) investigated the impact of home energy consumption on the health of inhabitants in Ese-Odo and Okitipupa Local Government Areas (LGA) in Ondo State. The multiple regression analysis results indicate that environmental and socio-economic factors impact inhabitants' selection of domestic energy sources. The survey confirmed that burns, blindness, stroke, cataracts, and lung disorders were the most common self-reported health issues. There is a somewhat minimal link between home energy usage and ill-health among the population of selected Local Government Areas (LGAs) in Ondo State.

Nkalu and Edeme (2019) examined how environmental dangers impact life expectancy in Africa by using time series data from Nigeria from 1960 to 2017. The study utilized a generalized autoregressive conditional heteroscedasticity (GARCH) model with 58 years of observations to assure the accuracy and reliability of the estimation results. The analysis indicates that exposure to carbon

dioxide emissions from solid fuel usage decreases life expectancy by 1 month and 3 weeks, with a statistically significant outcome. Income, represented by GDP, increases life expectancy (LEX) by 1.5 years with little statistical significance. Population growth (POPG) increases LEX by 5.42 years due to the boost in human resources, leading to improved agricultural output in Africa.

Pokubo and Al-Habaibeh (2019) analyzed the present energy consumption mix in Nigerian households and its potential impacts on the environment and health using descriptive statistics. Empirical evidence indicates that electricity, firewood, charcoal, and liquified petroleum gas are the primary sources of home energy in Nigeria. The study reveals that fossil fuel-based energy and solid fuels are the primary alternative energy sources for generation and consumption.

Afolayan and Aderemi (2019) utilize Dynamic Ordinary Least Square (DOLS) and Granger causality to analyze the correlation between environmental and health impacts and their significance for attaining sustainable economic growth in Nigeria from 1980 to 2016. Research shows that CO₂ emissions have a detrimental impact on mortality rates, although electric power use and fossil fuel consumption have a beneficial influence on mortality rates. Granger causality analysis indicates that life expectancy influences electric power usage, while fossil fuel consumption impacts death rates.

Matthew, Osabohien, Fagbeminiyi, and Fasina (2018) analyzed time series data from 1985 to 2016 in Nigeria to determine the lasting impact of greenhouse gas (GHG) emissions on health outcomes by employing the autoregressive distribution lag (ARDL) method. The study pinpointed CO₂ and the burning of fossil fuels as the primary sources of greenhouse gas emissions (GHGE), with human actions elevating GHG concentrations in the atmosphere. A study found that a higher level of GHGE leads to worse health outcomes, ultimately causing a substantial rise in mortality rate by approximately 146.6%.

Balani (2016) examined the correlation between environmental quality, indicated by CO₂ emissions,

and human health in 25 European Union (EU) member countries. The study included countries such as Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, Sweden, and the United Kingdom. Data from the Organization for Economic Cooperation and Development was utilized. The study analyzed population health by examining life expectancy at birth and CO₂ emissions through the usage of natural gas, petroleum, and coal from 1995 to 2013.

Agrawal and Yamamoto (2015) examined the impact of cooking smoke generated by solid fuel combustion on asthma cases reported among adult men and women in India through the use of multivariate logistic regression on cross-sectional data. Adult women residing in households that use biomass and solid fuels are at a higher risk of developing asthma, according to the findings. Duflo et al. (2008), Bruce et al. (2000), De Francisco et al. (1993), and Khalequzzaman et al. (2007) conducted research on the impact of cooking smoke on health. Boy et al. (2002) investigated the correlation between exposure to indoor air pollution from heating energy choices during pregnancy and low birth weight in rural Guatemala.

Amjad and Khalil (2014) in Pakistan utilized an autoregressive distributed lag (ARDL) model to analyze the influence of socioeconomic determinants on life expectancy in the Sultanate of Oman using time series data from 1970 to 2012. School attendance and food production have a notable and beneficial effect on life expectancy in the Sultanate of Oman, as shown by the findings. The results indicated that income per capita and population growth in Oman Sultanate have an insignificant and negative correlation with life expectancy. CO₂ has a detrimental and substantial short-term impact on life expectancy, but a beneficial and inconsequential long-term effect.

In 2013, Lakshmi and colleagues examined the correlation between indoor pollution and negative pregnancy outcomes such miscarriage and postnatal infant mortality by Poisson regression analysis. Both

investigations identified a significant association between stillbirths and low birth weight with indoor pollution. Morris et al. (1990) examined the impact of heating fuels on respiratory tract disorders by employing a multiple logistic regression analysis of self-reported health data. They determined that households using biomass for heating are at a heightened risk of respiratory illness.

Although there has been a theoretical rise in the utilization of transition fuels by Nigerian households since the early 2010s, biomass fuels like manure, straw, and wood remain the top choice for cooking and heating among the poorest and most vulnerable households. This preference is influenced by factors such as income inequality, high energy costs, and inadequate energy infrastructure. Air pollution is typically associated with outside environments, however inside spaces also have their own contaminants, often at higher levels than outdoor areas (Hoskins, 2003). Cooking stoves and heaters are frequently used indoors for extended periods each day, leading to high exposure effectiveness when people are present. This means that a significant percentage of the emissions from these sources reach people's breathing zones compared to outdoor sources (Agrawal 2012). This study establishes a null hypothesis based on a thorough examination of literature about health risks associated with solid fuel use: Solid fuel consumption does not have a substantial effect on health, as measured by life expectancy.

3. Methodology

The study collected data from secondary sources, including the Central Bank of Nigeria (CBN) and the World Bank's Development Indicators. The variables used in the analysis were life expectancy (proxy for health, dependent variable), solid fuel consumption as a percentage of total (independent variable), and other explanatory variables such as gaseous fuel consumption, GDP per capita, and rural population. The data was collected from 1971 to 2021 and analyzed using the autoregressive distributed lag (ARDL) technique and Pair-Wise Granger causality tests. Econometric diagnostic methods include the Breusch-Godfrey Serial Correlation LM Test, Heteroskedasticity Test (Breusch-Pagan-Godfrey).

The study also used traditional stationarity tests such as the Augmented Dickey-Fuller (ADF) test developed by Dickey and Fuller in 1979. The ARDL bounds test is utilized to analyze the short- and long-term impacts of explanatory variables on health, using life expectancy as a proxy. It is considered superior to other estimation techniques when working with a small sample size, as noted by Pesaran and Shin (1998) and Pesaran et al. (2001). Hence, following Pesaran and Shin (1998), we specify the following generalised ARDL model:

$$Y_t = \gamma_{0i} + \sum_{i=1}^p \delta_i Y_{t-1} + \sum_{i=0}^q \beta'_i X_{t-i} + \varepsilon_{it} \quad (1)$$

Where Y_t is the dependent variable being explained by its lag, the current and the lagged values of its regressors. The lags are denoted with p and q , the p is associated with the lags of the dependent variable while the lagged values of the regressors take the q . β'_i is also a vector which implies that all the variables that make up this model can also be used as a dependent variable. The variables in X_t are allowed to be purely $I(0)$ or $I(1)$ or cointegrated; and γ_{0i} are coefficients: γ_{0i} is the constant: i can range from 1 to k : p, q are optimal lag orders: ε_{it} is the vector of the error terms – unobservable zero mean white noise vector process (serially uncorrelated or independent). The dependent variable is a function of its lagged values, the current and lagged values of the other exogenous variables in the model. The lag lengths for p, q , may not necessarily be the same. To perform the bounds test, the conditional ARDL ($p, q_1, q_2, q_3, q_4, q_5$) is specified below the foregoing hypotheses to be tested.

$H_0 : \beta_{1i} = \beta_{2i} = \beta_{3i} = \beta_{4i} = \beta_{5i} = 0$ (i.e., there is no cointegration).

$H_1 : \beta_1 \neq \beta_{2i} \neq \beta_{3i} \neq \beta_{4i} \neq \beta_{5i} \neq 0$ (i.e., there is cointegration).

Hence, using the F-test suggested in Pesaran and Shin (1998) and Pesaran et al. (2001), the estimated ARDL test statistics will be compared with the two asymptotic critical values in Pesaran et al. (2001) as against the conventional critical values. Therefore, if the estimated test statistic is higher than the upper critical value, we will reject the null hypothesis of no long-run relationship, but if it is

lower than the lower critical value, we will accept the null hypothesis. However, if the estimated test statistic lies between the two critical values or bounds, then the result is inconclusive. Thus, following Pesaran and Shin (1998) and Pesaran et al. (2001), the reduced form model to be estimated in this study is specified as:

$$\begin{aligned} \Delta LEX_t = & c + \alpha_1 LEX_{t-1} + \alpha_2 Y_{t-1} + \alpha_3 Y_{t-1}^2 + \\ & \alpha_4 SFC_{t-1} + \alpha_5 GFC_{t-1} + \alpha_6 + \\ & \alpha_7 RPOP_{t-1} \sum_{i=0}^{q1} \beta_{1i} \Delta LEX_{t-1} + \\ & \sum_{i=0}^{q2} \beta_{2i} \Delta Y_{t-1} + \sum_{i=0}^{q3} \beta_{3i} \Delta Y_{t-1}^2 + \\ & \sum_{i=0}^{q4} \beta_{4i} \Delta \ln SFC_{t-1} + \sum_{i=1}^{q5} \beta_{6i} \Delta GFC_{t-0} + \\ & \sum_{i=1}^{q6} \beta_{6i} \Delta GDP_{t-0} + \sum_{i=1}^{q7} \beta_{7i} \Delta RPOP_{t-0} + \varepsilon_t \quad (2) \end{aligned}$$

Where Δ is the first difference operator, represents the drift, are the short-run dynamic coefficients of the underlying ARDL model, represents the long-run multipliers, t is the time index, and is the white noise error term. LEX represents life expectancy and it is the proxy for health effects; SFC represents Solid fuel consumption; GDP represents the Gross Domestic Product per capita; GFC represents the gaseous fuel consumption as % of total and $RPOP$ is the rural population.

4. Results and Discussion

Table 1: Descriptive Statistics

	LEX	SFC	GFC	GDP	RPOP
Mean	47.59	0.38	16.36	0.75	4.74
Median	46.10	0.12	14.00	1.47	4.74
Maximum	55.08	2.07	36.43	12.46	5.85
Minimum	41.39	0.01	1.09	-15.45	4.03
Std. Dev	3.66	0.52	10.06	5.45	0.54
Skewness	0.64	1.80	0.25	-0.67	0.43
Kurtosis	2.45	5.10	2.07	4.08	2.13
Jarque-bera	4.10	36.91	2.37	6.28	3.17
Probability	0.13	0.00	0.31	0.04	0.21

Source: Extract from E-view 10 output, 2022

Table 1 showed that all the variables have a positive mean. The maximum growth rate of LEXP is 55.08, while the minimum is 41.39. The maximum SFC is 2.07, while the minimum is 0.01. The maximum GFC, GDPPC, and RPOP is 36.43, 12.46, and 5.85 while the minimum is 5.97, 1.09, -15.45, and 4.03 respectively. Most of the variables were positively skewed, which implied that the variable has more

increases than falls and vice-versa. The variables of LEXP, GFC, and RPOP have kurtosis values less than 3, which validate the property of normally distributed variables while SFC, and GDP have kurtosis values above 3. The Jarque-Bera for SFC, GDP and RPOP demonstrated that the data were not normally distributed.

Table 2: Summary of Stationarity Test Results

Variables	Augmented Dickey Fuller			
	Level 1	1 st Diff	Decision	Order
LEX	-3.332793**	-7.776703***	Level	I(0)
SFC	-2.390944	-4.465809***	1 st diff	I(1)
GFC	-1.332793	-4.776703***	1 st diff	I(1)
GDP	-3.390944**	-5.465809***	level	I(0)
RPOP	-3.760627***	-7.860897***	level	I(0)

Notes: ***, ** and * denote 1%, 5% and 10% significance levels respectively.

Source: Extract from E-view 10 output, 2022

The result in Table 2 reveals that LEXP, GDP, and RPOP achieved stationarity at level [that is $I(0)$] while the series of SFC and GFC were stationary at

level [that is, $I(0)$]. At this point, the variables in the model are ready for bound cointegration tests and this is presented in Table 3.

Table 3: ARDL Bounds Test Result

Model: $LEX = f(SFC, GFC, GDP, RPOP)$		
F-Statistics	9.857335***	
Significance level	Lower Bound $I(0)$	Upper Bound $I(1)$
1%	3.93	5.23
5%	3.12	4.25
10%	2.75	3.79

***& ** Stands for 1% and 5% significance

Source: Extract from E-view 10 output, 2022

From Table 3, the bounds tests for the cointegration relationship for the model revealed that the estimated F-statistic value of 9.857335 was higher than the lower and upper bounds values at a 1 percent level of

significance. Meaning that there is a presence of cointegration relationships among the variables in the model.

Table 4: Results of the nexus between household solid fuel consumption and health

Panel A: Long run estimates	Coefficient	Std. Error	T-Stat.	Prob.
SFC	-0.540891	0.203469	2.658353	0.0112
GFC	0.028473	0.011793	2.414392	0.0204
GDP	0.008506	0.005764	1.475551	0.1479
RPOP	-0.072702	0.056654	-1.283266	0.2068
Panel B: Short run estimates				
Constant	6.193657	1.381505	4.483269	0.0001
	-0.341239	0.098637	-3.459548	0.0013
	0.017963	0.005989	2.999448	0.0046
	0.005366	0.003796	1.413492	0.1652
	-0.045866	0.036435	-1.258860	0.2154
	-0.630883	0.077342	-8.157022	0.0000

Source: Extract from EViews 10 Output

The long-run and short-run results revealed that the coefficient of solid fuel consumption (SFC) exhibited a negative impact on life expectancy and was statistically significant at a 1% level of significance implying that the variable has a significant negative impact on the life expectancy in Nigeria. Specifically, an increase change in solid fuel consumption by 1 percent level will bring about 0.541 percent and 0.341 decreases in life expectancy in the long run and short run.

However, gaseous fuel consumption exerts a positive impact and significant correlation with life expectancy. This implies, that a unit change in GFC

will bring about a 0.028 percent increase in life expectancy (improved health quality), which is in line with the finding of Ubuoh and Nwajiobi (2018), Ibrahim and Cudjoe (2021) that gas usage is less harmful to health and environment. The long-run and short-run coefficients of gross domestic product per capita (GDP) demonstrate positive impact and insignificant correlation with Life expectancy. Precisely, changes in GDP one percent are associated with 0.008 in the long run and 0.005 and in the short run increases life expectancy. The long-run and short-run results of rural population revealed that the coefficient of rural population (RPOP) exhibited a negative impact on life expectancy and was

statistically significant at a 1% level of significance implying that the variable has a significant negative impact on the life expectancy in Nigeria.

The coefficient of ECM reported at -0.630883 is correctly signed and statistically significant at 1 percent. This implies that it will take a 25 percent time horizon for the short-run dynamics to equilibrate in the long run. The adjusted R-square value of 0.667719 signifies that 67% variation in health quality can be jointly explained by the explanatory

variables in the model and only 33 percent variation in life expectancy is explained by the error term. The Durbin Watson value of 2.405618 implies that the model is free from first-order serial correlation as the value is within the range of 1.50 to 2.50. The F-statistic which is the test for the overall significance of the model indicates the value of 25.61633 which is highly significant at a 1 percent level of significance, meaning that the explanatory variables in the model were jointly significant in explaining the changes in life expectancy which is the proxy for health.

Table 5: Result of Correlation Matrix

	LEX	SFC	GFC	GDP	RPOP
LEX	1.00	-0.75	0.82	0.02	-0.45
SFC	-0.75	1.00	-0.64	0.09	0.19
GFC	0.72	-0.64	1.00	-0.02	-0.35
GDP	0.02	0.09	-0.02	1.00	-0.15
RPOP	-0.45	0.19	-0.35	-0.15	1.00

Source: Extract from EViews 10 Output

From the correlation matrix in Table 5 above, we can confirm that there is no pair-wise correlation coefficient that is in excess of 0.80 (Gujarati and Porter, 2006). Hence, the variables cannot be said to

be collinear. SFC is -0.75, with GFC, GDP and RPOP having 0.72, 0.02 and -0.45 respectively. Therefore, we conclude that there is no multicollinearity among the regressors.

Table 6: ARDL Diagnostic Test Results

Diagnostic Tests	F-statistic	Probability
Serial Correlation Test	2.300366	0.1140
Heteroskedasticity Test	2.25695	0.0378

Source: Extract from EViews 10 Output

A serial correlation test using Breusch-Godfrey serial correlation LM test was employed on the study to test for the presence of serial correlation. The null hypothesis for no serial correlation was not rejected since the p-value is greater than five percent.

Heteroscedasticity was also estimated using the Breusch-Pagan-Godfrey test and from the test result reported in Table 6, the null hypothesis of variance is constant (homoscedasticity) because the probability value is greater than five percent.

Table 7: Granger Causality test

Null Hypothesis	observations	F Statistics	probability
SFC does not Granger cause LEX	49	3.53449	0.0377
LEX does not Granger cause SFC		0.19230	0.8257
GFC does not Granger cause LEX	49	2.59000	0.0864
LEX does not Granger cause GFC		9.16716	0.0005
GDP does not Granger cause LEX	49	5.78768	0.0059
LEX does not Granger cause GDP		0.01269	0.9874
RPOP does not Granger cause LEX	49	1.37040	0.2646
LEX does not Granger cause RPOP		2.75559	0.0746

Source: Authors design 2022

The results of the causality analysis indicate the hypothesis that solid fuel consumption does not granger cause life expectancy is rejected because the P-value of the f statistics is below 0.05 but we cannot reject the hypothesis that life expectancy does not granger cause solid fuel consumption. The results of the causality analysis indicate a unidirectional causality running from solid fuel consumption (SFC) to life expectancy proxied for health effects in Nigeria. This is in line with the finding of Adetayo, Adeyinka, and Agbabiaka (2020). This implies that SFC is a viable determinant of LEXP in Nigeria but not the reverse. This implies that SFC is a viable determinant of LEXP in Nigeria but not the reverse.

The results of the causality analysis indicate the hypothesis that Gaseous fuel consumption does not granger cause life expectancy is not rejected because the P-value of the f statistics is above 0.05 but we reject the hypothesis that life expectancy does not granger cause Gaseous fuel consumption. The results of the causality analysis indicate a unidirectional causality running from life expectancy to Gaseous fuel consumption (GFC). Also, unidirectional causality was found between GDP and Life expectancy where the hypothesis that GDP does not granger cause life expectancy is rejected because the P-value of the f statistics is below 0.05 but we cannot reject the hypothesis that life expectancy does not granger cause GDP. The results of the causality analysis indicate a unidirectional causality.

Finally, the results of the causality analysis indicate the hypothesis that Rural Population does not granger cause life expectancy is not rejected because the P-

value of the f statistics is above 0.05 also, we do not reject the hypothesis that life expectancy does not granger cause Rural population because the p-value of the f statistics is above 0.05. The results of the causality analysis indicate an independent causality.

5. Conclusion and Recommendations

This study looks at the implication of household solid fuel consumption on health quality (proxied by Life expectancy) in Nigeria, which is hinged on energy ladder hypothesis. The study covers the period of 1971 to 2021 using data obtained from World Bank's database while the estimation technique is the ARDL and granger causality test approach. The preliminary test of stationarity test exhibit mixed order of integration [that is I(0) & I(1)], necessitating the use of the ARDL bound approach. The finding of the first objective reveals that household energy consumption proxied by solid fuel consumption account for a decrease in life expectancy both in the long-run and short-run. The outcome of the second objective demonstrates that there is unirectional causation running from household solid fuel consumption to life expectancy. This implies that continuous usage of household energy particularly from fuel wood, and coal that makes up solid fuel energy is detrimental to the health status of Nigeria's households. Based on these findings, this study, therefore, concludes that there is still a high level of dependence on solid fuel energy consumption among Nigeria's households and if not addressed through the adoption of efficient energy, it will take the Nigerian government many years to curtail the consequence of health hazard from using solid fuels.

References

- Adetayo, O.D., Adeyinka, S.A. and Agbabiaka, H.I. (2020). Domestic energy usage and its' health implications on residents of the Ese-Odo and Okitipupa local government areas of Ondo state, Nigeria. *Environmental Quality Management*, 2020;1–10 doi:10.1002/tqem.21681
- Afolayan, O.T. and Aderemi, T.A. (2019). Environmental quality and health effects in Nigeria: implications for sustainable economic development. *SSRG International Journal of Economics and Management Studies*, 6(11), 44-55
- Akpan, G. E., and Akpan, U. F. (2012). Electricity consumption, carbon emissions and economic growth in Nigeria. *International Journal of Energy Economics and Policy*, 2(4), 292-306.
- Alege, P.O., Adediran, O.S. and Ogundipe, A.A. (20216). Pollutant Emissions, Energy

- Consumption and Economic Growth in Nigeria. *International Journal of Energy Economics and Policy*, 2016, 6(2), 202-207
- Andreoni, J. and Levinson, A. (2001). The simple analytics of the environmental Kuznets curve. *Journal of Public Economics*, 80(2), 269-286.
- Balan, F. (2016). Environmental Quality and its Human Effects: A Causal Analysis for the EU-25. *International Journal of Applied Economics*, 13(1), 57-71.
- Chafe, Z.A., Brauer, M., Klimont, Z., Dingenen, Z.V., Mehta, S., Rao, S., Riahi, K., Dentener, F. and Smith, K.R. (2014). Household cooking with solid fuels contributes to ambient PM_{2.5} air pollution and the burden of disease. *Environmental Health Perspectives*, 122(12), 1314-1320.
- Cheremisinoff, N.P. (2008). *Responsible Care. The Chemical Process Industries*, 143–235. doi:10.1016/b978-1-933762-16-6.50007-4
- Dasgupta, S., Laplante, B., Wang, H., and Wheeler, D. (2002). Confronting the Environmental Kuznets Curve. *Journal of Economic Perspectives*, 16(1), 147-168
- Dinh H. L. and Shih-Mo L. (2015). Dynamic causal relationships among CO₂ emissions, energy consumption, economic growth and FDI in the most populous Asian countries. *Journal of Advance Management & Applied Economics*, 5(1), 1-5
- Dinh H. L., and Shih-Mo L. (2015). Dynamic causal relationships among CO₂ emissions, energy consumption, economic growth and FDI in the most populous Asian countries. *Journal of Advance Management & Applied Economics*, 5(1), 1-5
- Emagbetere, E; Odia, J; Oreko, BU (2016). Assessment of household energy utilized for cooking in Ikeja, Lagos State, Nigeria. *Nig. J. Technol.* 35(4): 796 – 804.
- Eregba, P.B. and Mesagan, E.P. (2017). Energy consumption, oil price and macroeconomic performance in energy dependent African countries. *Applied Econometrics*, 46:74-89.
- European Environment Agency (2022). Environment and health.
- Food and Agriculture Organisation of the United Nations [FOA] (2015). *Global Forest Resources Assessment 2005*; FAO Forestry Paper 147; 2006.
- Geweke, J., Meese, R. and Dent, W. (1983). Comparing alternative tests of causality in temporal systems. Analytic results and experimental evidence. *Journal of Econometrics*, 21, 161–94.
- Gujba, H., Mulugetta, Y. and Azapagic, A. (2015). The Household Cooking Sector in Nigeria: Environmental and Economic Sustainability Assessment. *Resources* 2015, 4, 412-433
- Ibrahim, A.S. and Cudjoe, D. (2021). The Environmental Impact of Energy Consumption in Nigeria: Evidence from CO₂ Emissions. Research Square, <https://doi.org/10.21203/rs.3.rs-420727/v1>
- IEA (International Energy Agency). (2006). *World Energy Outlook*. Paris: OECD 38(4), 247-257.
- Kadiri, KO; Alabi, OA (2014). Household energy consumption pattern in Offa City, Kwara State, Nigeria. *J. Sci. Research & Report*, 3(11): 1499- 1506.
- Kasman, A., and Duman, Y. S. (2015). CO₂ emissions, economic growth, energy consumption, trade and urbanization in New EU member and candidate countries: A panel data analysis. *Economic Modelling*, 44(2), 97–103.
- Le, T., and Nguyen, C.P., (2019). Is energy security a driver for economic growth? Evidence from a global sample. *Energy Policy*, 129, 436-451.
- Lin, B., and Raza, M.Y. (2019). Analysis of energy related CO₂ emissions in Pakistan. *J. Clean. Prod.*, 219, 981-993.
- Maina, Y.B., Kyari, B. and Jimme, M.A. (2020). Impact of household fuel expenditure on the environment: the quest for sustainable energy in Nigeria. *Central Asian Journal of*

- Environmental Science and Technology Innovation*, 2 (2020) 109-118
- Matthew, O., Osabohien, R., Fasina, F. and Fasina, A. (2018). Greenhouse Gas Emissions and Health Outcomes in Nigeria: Empirical Insights from ARDL Technique. *International Journal of Energy Economics and Policy*, 8(3), 43-50.
- Matthew, O., Osabohien, R., Olawande, T. and Urhie, E. (2019). Manufacturing Industries and Construction Emissions in Nigeria: Examining the Effects on Health Conditions. *International Journal of Civil Engineering and Technology*, 10(01), 2401-2414.
- McGranahan, G. and Kaijser, A. (1993). Household Energy - Problems, Policies and Prospects. Stockholm Environmental Institute, Box 2142, S-10314, Stockholm, Sweden.
- Mensah, J.T., and Adu, G., (2015). An empirical analysis of household energy choice in Ghana. *Renewable and Sustainable Energy Reviews*, 51, 1402-1411.
- Mesagan, E. and Ekundayo, P. (2015). Economic Growth and Carbon Emission in Nigeria. *IUP Journal of Applied Economics*, 3(2), 44-56.
- Mesagan, E.P. and Nwachukwu, M.I. (2018). Determinants of environmental quality in Nigeria: assessing the role of financial development. *Econometric Research in Finance*, 3, 55-78
- Mohammed, A., Ismat, A., Jeroen, B., & Guido, V.H. (2012). Energy consumption, carbon emission and economic growth nexus in Bangladesh: Cointegration and dynamic causal analysis. *Energy Policy Journal*, 45(2) 217 – 225.
- Mohammed, Y.S., Mustafa, M.W., Bashir, N. and Ibrahim, I.S., (2017). *Existing and recommended renewable and sustainable energy development in Nigeria based on autonomous energy and microgrid technologies*.
- Nasiru, I.M. (2015). Desertification in the Dry Lands of Nigeria and its Consequences. Available online: http://fab.utm.my/wp-content/uploads/2011/10/cStudents_student3Seminar200708.pdf (accessed on 30 July 2022).
- Ochada, I.M. and Ayadi, F.S. (2020). Energy consumption, air pollution and economic growth in Nigeria. *Journal of Economic Studies*, 17(1), 2020.
- Oguntoke, O. and Adeyemi, A. (2017). Degradation of Urban Environment and Human Health by Emissions from Fossil Fuel Combusting Electricity Generators in Abeokuta Metropolis, Nigeria. *Indoor and Built Environment*, 26(4) (2017) 538-550.
- Onakoya, A.B., Onakoya, A.O., Jimi Salami, O., and Odedairo, B.O. (2013). Energy consumption and Nigerian economic growth: An empirical analysis. *European Scientific Journal*, 9(4), 25-40
- Oseni, M.O., (2012). *Households' access to electricity and energy consumption pattern in Nigeria*.
- Oyedepo, S.O. (2014). Towards achieving energy for sustainable development in Nigeria. *Renewable and Sustainable Energy Reviews*, 34, 255-272.
- Pesaran, M.H. and Shin, Y. (1998). An autoregressive distributed-lag modelling approach to cointegration analysis. *Econometric Society Monographs*, 31, 371- 413.
- Pesaran, M.H., Shin, Y., and Smith, R.J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), 289-326.
- Pokubo, D. and Al-Habaibeh, A. (2019). An investigation into the current household energy consumption mix in Nigeria. International Conference on Energy and Sustainable Future, Nottingham, UK, 9-11 September 2019.
- Schlag, N. and Zuzarte, F. (2008). Market barriers to clean cooking fuels in sub-Saharan Africa: a review of literature.
- Shaaban, M., and Petinrin, J.O. (2014). Renewable energy potentials in Nigeria: Meeting rural energy needs. *Renewable and Sustainable Energy Reviews*, 29, 72-84.

- Sharma, S. (2017). Climate Change and Sustainability. *SSRG International Journal of Economics and Management Studies*, 4(6) (2017) 21-26.
- Sinha, A. (2014). Carbon Emissions and Mortality Rates: A Causal Analysis for India (1971-2010). *International Journal of Economic Practices and Theories*, 4(4) (2014) 486-492
- Staton, D.M. and Harding, M.H. (2011). Health and environmental effects of cooking stove use in developing countries. 2000. Cited 22-11-2011.
- Stern, D.I. (2004). The Rise and Fall of the Environmental Kuznets Curve. *World Development*, 32(8), 1419-1439
- Ubuoh, E.A. and Nwajiobi, B. (2018). Implications of Different Household Cooking Energy on Indoor Air Quality in Urban and Semi-Urban Settlements in Imo, South Eastern Nigeria. *J. Appl. Sci. Environ. Manage*, 22 (5), 725 – 729 May 2018
- Uddin, G. A., Salahuddin, M., Alam, K., and Gow, J. (2017). Ecological footprint and real income: Panel data evidence from the 27 highest emitting countries. *Ecological Indicators*, 77(2), 166–175.
- Unicef, (2019). Silent Suffocation in Africa Air Pollution is a Growing Menace, Affecting the Poorest Children the Most.
- Vermeulen, S.J., Campbell, B.M., and Ingram, J.S. (2012). Climate change and food systems. *Annu. Rev. Environ. Resour.*, 37(1), 195-222.
- Viegi, G., Simoni, M., Scognamigli, A., Baldacci, S., Pistelli, F. and Carrozzi, L. (2004). Indoor air pollution and airway disease. *Int J Tuberc Lung D*, 8(12),1401- 15.
- Wang, Q., Kwan, M., Zhou, K., Fan, J., Wang, Y. and Zhan, D., (2019). Impacts of residential energy consumption on the health burden of household air pollution: Evidence from 135 countries. *Energy Policy*, 128, 284-295.
- Wang, S., Li, G. and Fang, C. (2018). Urbanization, economic growth, energy consumption, and CO2 emissions: empirical evidence from countries with different income levels. *Renew. Sustain. Energy Rev.* 81, 2144–2159. July 2017.
- Wang, Z; Zhang, B; Yin, J; Zhang, Y (2011). Determinants and policy implication of household electricity saving behaviour: Evidence from Beijing China. *Energy Policy* 39, 3550-3557.
- WDI, (2019). World Bank's world development indicators. Available at: <http://www.worldbank.org/>.
- WHO (2006). Fuel for Life: Household Energy and Health.
- World Health Organisation (2015). Indoor Air Pollution: National Burden of Disease Estimates 2007. Available online: http://www.who.int/indoorair/publications/indoor_air_national_burden_estimate_revised.pdf (accessed on 30 July 2022).
- World Health Organization, WHO., The 10 Leading Causes of Death by Broad Income Group. Available from: www.who.int/mediacentre/factsheets/fs266/en/index.html; last accessed 30 July 2022.
- Wuyuan, P., Zerriffi, H. and Jihua, P. (2008). Household level fuel switching in rural Hubei.
- Zhixin, Z. and Xin, R. (2011). Causal relationships between energy consumption and economic growth. *Energy Procedia Elsevier Ltd.*, 5 (2) 2065–
- IEA, IRENA, UNSD, World Bank, WHO. 2022. Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC. © World Bank. License: Creative Commons Attribution—NonCommercial 3.0 IGO (CC BY-NC 3.0 IGO). Available from: <https://trackingsdg7.esmap.org/downloads>
- Puthumana JS, Ngaage LM, Borrelli MR, Rada EM, Caffrey J, Rasko Y: Risk factors for cooking-related burn injuries in children, WHO Global Burn Registry. *Bull World Health Organ*. 2021 Jun 1;99(6):439-445.