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Research Article

Determinants of Life Expectancy in Nigeria: Auto Regressive Distributive Lag (Ardl) Model

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Abstract: This paper empirically investigated the determinants of life expectancy in Nigeria using Autoregressive Distributive Lag (ARDL) model as a tool of analysis for the period 1980 - 2018. The variables of choice are primary school enrolment, the prevalence of HIV/AIDS, household consumption, infant mortality rate, health expenditure, material wellbeing, energy consumption, electricity consumption and access to safe drinking water. The results of the study revealed that health expenditure, material wellbeing, access to safe drinking water, primary school enrolment, infant mortality rate and energy consumption are significant determinants of life expectancy in Nigeria both in the short run and long run with the exception of prevalence of HIV/AIDS and household consumption which are determinants of life expectancy in the short run. Therefore, the aforementioned determinants have an important role to play in improving life expectancy in Nigeria. Consequently, upon the findings of the research study, a number of recommendations are given which include: Health policymakers should pay special attention to the causes of high rates of mortality for some diseases at older ages, especially hypertension and diabetes mellitus, and therefore the legacy of smoking and alcohols drinking among other factors such as obesity and economic inequality have been suggested as possible causes of high mortality and consequently low life expectancy in Nigeria.

Keywords: *life expectancy, safe drinking water, household consumption, education, health, HIV, Mortality, energy, ARDL model, Nigeria.*

1. INTRODUCTION

The health of the population is influenced by both the type of health systems and the resources disposed to accomplish better health. The relationship between resources and health outcomes is important for life expectancy assessment, to uncover the performance of a country in terms of the health system which is apparently manifested in high life expectancy. Some countries have health system with a better performance in triggering life expectancy than other countries in the world, that is why for the same level of resources, some countries generate better health outcomes than others and whilst some generate the same outcomes but with fewer resources. However, life expectancy remains for the health dimension of human development and human development encompasses several variables and is determined by various factors, hence its comprehensiveness. Therefore, adequate health care facilities are presumed to see its reflections in stable high life expectancy at birth. Thus, this can be only accomplished if mortality is tackled from the root-cause. These root-causes of mortality are poor health care facilities, illiteracy, lack or inadequate access to safe drinking water, erratic power supply, malnutrition and poor energy intake (Muhammad and Sabo, 2018). However, low life expectancy in any country is attributed to so many factors apart from the aforesaid.

In addition, as a dimension of life, health stands for the existence of strength, vitality, and fitness which individuals can draw upon to pursue their goals and actions. In order to improve the health status of a country, it is vital to include and connect different organizational, socioeconomic and political elements and to provide adequate public health services. The public health care comprises a system of group and individual measures, services, and activities related to preservation and improvement of health, prevention of diseases, early detection of diseases, timely treatment and medical care and rehabilitation.

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Furthermore, attainment of 70 years life expectancy by 2020 is one of the millennium development goals in Nigeria. However, one of the pivotal goals of every government is to lengthen the life expectancy of its populace by reducing its mortality rate to the minimum possible level. That is the sole reason why economic development determines improvements in the socioeconomic conditions and an increase in life expectancy. Thus, residents of a country with high living standards live longer, on average, and have smaller mortality, both infant and maternal mortalities. Health and development require the promotion of human rights, political and civic, as well as economic, social and cultural rights. It can be deduced that there is a twofold relationship between development and health. Development is the process of improving health and quality of life, and health is a central component as well as a processing unit of the development process. The paper intends to answer the following question;

Do primary school enrolment, the prevalence of HIV/AIDS, household consumption, infant mortality rate, health expenditure, material wellbeing, energy consumption, electricity consumption and access to safe drinking water have a significant influence on life expectancy in both the long-run and short-run?

The paper is organized into five sections following this introduction is section 2 that contains conceptual as well as empirical literature reviews on life expectancy. Section 3 presents the method of data collection and methodology. The data analysis and discussion of results are presented in Section 4 and section 5 reports the conclusion and recommendation.

2. LITERATURE REVIEW

Life expectancy at birth is the average number of years a newborn infant would be expected to live if health and living conditions at the time of birth remained the same throughout life. It reflects the health of a people, the quality of care they receive when ill as well as social, economic and environmental conditions which mitigate or predisposes to morbidity and mortality. Furthermore, life expectancy at birth is the number of years a newborn infant of either gender may be expected to live if prevailing patterns of mortality at the time of its birth stays the same throughout its lifetime (Muhammad and Sabo, 2018). Empirical studies investigating the determinants of life expectancy or the relationship between life expectancy and other relevant variables are abounded such as Muhammad and Sabo (2018); Ngwen and Kouty (2015); Monsef and Mehrjardi (2015); Sufyan, (2013); Sanda and Oyerinola (2014); Kunot *et al.,* (1994); Lokpriy (2013); Christensen and Vanpel (1996); Lin *et al.,* (2012); Bilas *et al.,* (2014); and Balan and Jaba (2011); but specifically there is no research on the determinants of life expectancy in Nigeria. They are as follows:

In Germany, Breyer and Felder (2006) assessed life expectancy and health care expenditures. The paper projected that at constant prices, per-capita health expenditures of Social Health Insurance would rise from €2596 in 2002 to between €2959 and €3102 in 2050 when only the age structure of the population changes and everything else remains constant at the present level, and to between €5232 and €5485 with a technology-driven exogenous cost increase of 1% per annum. Another projection only based on the age distribution of health care expenditures, but not distinguishing between survivors and decedents, yields values of €3217 and €5688 for 2050, respectively. Thus, the error of excluding the "costs of dying" effect is small compared with the error of underestimating the financial consequences of expanding medical technology.

For instance, Lokpriy (2013) applied multiple regression technique to examine the socio-economic determinants of life expectancy in ninety lower income countries with a per capita GNI below $4035 in 2011. The variables of interest are improved sanitation facilities, improved water sources, secondary school enrolment, GDP per capita, and health expenditure per capita. The study finds that a higher GDP per capita combined with access to sanitation and safe water sources as well as secondary school education have a positive impact on life expectancy; while the relationship between life expectancy and health expenditure per capita is found to be contradictory. It is recommended that non-medical interventions are more positively robust determining factors of life expectancy in comparison with medical intervention. Also, Christensen and Vanpel (1996) analyze the determinants of longevity in industrialized countries. The variables of choice are genetic, environmental and medical factors. It finds that high lifespan as well as mean lifespan increase substantially; there is a remarkable improvement in survival amongst people of eighty and above; genetic factor contributes one-quarter of the variation in lifespan; the impact of both genetic and environmental factors on longevity can potentially be modified by medical treatment, behavioral changes, and environmental improvements.

In Iranian study, Agheli and Emamgholipour (2015) examined the determinants of life expectancy at birth using a Johansen-Juselius cointegration method and Error Correction Model covering 1980-2012. The findings showed a positive relationship among life expectancy, per capita income vaccination and education level. While the result of Error Correction Model indicated that its coefficient is estimated at -0.022, which shows that the 2.2% of disequilibrium in life expectancy is adjusted in each period and is approached to its long-run equilibrium.

Using Autoregressive Distributed Lag (ARDL) Model, Muhammad and Sabo (2018) examined the impact of economic growth and access to safe drinking water on life expectancy in Nigeria from 1980 to 2014. The paper found the existence of cointegration among the variables under study. Hence, the result revealed that economic growth and access to safe drinking water exert a positive and statistically significant impact on life expectancy at birth over the period of the study. Similarly, Monsef and Mehrjardi (2015) surveyed the determinants of life expectancy in 136 countries for the period 2002–2010 using panel data analysis, fixed effects and random effect models. The results indicated that gross capital formation and gross national income have a positive impact on life expectancy.

In the Kerala State of India, Sauvaget, Ramadas & Sankaranarayanan (2009) investigated socio-economic factors and longevity using a cohort of 1,67,331 participants aged 34 years old and above. The findings showed that at 40 years, men and women were expected to live another 34 and 37 years, respectively. It also revealed that the gaps between categories were wider in men than in women and also a socio-economic disparity in longevity was observed: wealthy people a longer life expectancy. Also, Schnabel and Eilers (2009) analysed life expectancy and economic production using expectile frontier zones and discovered that the wealth of a country has a strong non-linear influence on the life expectancy of its inhabitants. Kunot *et al.,* (1994) empirically assessed whether life expectancy is to the detriment of happiness. The dataset on 5 countries over 6 years period from 1984 to 1989, using Sullivan Method. They addressed that life expectancies are not related to life satisfaction; because in Netherland, there is high life expectancy as well as a high level of life satisfaction; while Ireland has a high level of life satisfaction with low life expectancies; therefore, life satisfaction can be set up, in a country, irrespective of longevity; and in Greece and France, there are high life expectancies with the lowest number of years in happiness. They concluded that life at an old age is not as gloomy as indicators of physical health.

In a similar study, Sufyan, (2013) examines the impacts of socio-economic determinants of life expectancy across one-hundred and six countries. These countries are categorized into three categories namely, countries with low life expectancy as a group, countries with medium life expectancy as a group, and countries with high life expectancy as a group. Canonical discriminating analysis technique is used to discriminate the groups. The discriminating variables are population, living in urban areas (%), currently married or in-union women of reproductive age (%), GNI purchasing power parity, population density, rural population with access to improved water supply, infant mortality rate, total fertility rate, dependent population (%), and poverty. The study shows that infant mortality is the most influential variable in discriminating among the three groups, seconded by poverty. The other important discriminating factors are total fertility rate, the percentage of currently married or in-union women of reproductive age, the percentage of rural population with access to improved water supply, population density, and percentage of urban population. More so, infant mortality rate, poverty, and total fertility rate positively discriminate countries to belong to the group of low life expectancy at birth countries. While the percentage of population living in urban areas, currently married or in-union women of reproductive age, and rural population with access to improved water supply negatively discriminate a country to the group of high life expectancy at birth countries.

In Beijing, Lei, Li, Liu, and Mao (2009) studied socioeconomic determinants of life expectancy to predict future trends using linear stepwise regression model. The findings showed that floor space available per rural resident and GDP per capita have a positive impact on life expectancy, while the rural population proportion and illiteracy rate have a negative impact on life expectancy. In Nigerian studies, Sanda and Oyerinola (2014) examine the impact of life expectancy on economic growth in Nigeria over the period of 1980 – 2012. OLS and ARDL estimation techniques were used in the analysis. The finds revealed that life expectancy has a positive impact on economic growth in Nigeria. Similarly, Ogungbenle, Olawumi, and Obasuyi, (2013) analyzed the relationship among life expectancy, public health spending and economic growth in Nigeria using the VAR model. The findings revealed that there is no bidirectional causality between life expectancy and public health spending as well as life expectancy and economic growth but there is bidirectional causality between public health spending and economic growth. The method used is not in harmony with the findings of the study.

Ngwen and Kouty (2015) determined the impact of life expectancy on economic growth in developing countries using a dynamic panel of 141 countries over the period 2000- 2013. The results showed that life expectancy has a positive effect on economic growth. Using linear regression model Balan and Jaba (2011) examine the determinants of life expectancy in Romania by its region for the year 2008. The variables of interest under investigation are net nominal monthly salary(wages), number of readers subscribed to libraries, illiterate population aged ten and over (% from the total population), the ratio of the Roma population (%), number of beds in hospitals, and number of doctors. The study shows that wages, the number of beds in hospitals, the number of doctors and the number of readers subscribed to libraries are positively related to life expectancy. On the other hand, the ratio of the Roma population and the ratio of the illiterate population are negatively related to life expectancy. Therefore, it is clearly observed that

Romanian regions are homogeneous in terms of the level of life expectancy and its determinants.

Lin *et al.,* (2012) applied linear mixed models in examining the influence of four political and socio-economic factors on life expectancy at birth in one-hundred and nineteen less developed countries from 1970 to 2004. The four political and socio-economic determinants are economy, educational environment, over nutritional status and political regime measured by GDP per capita at purchasing power parity, the literacy rate of the adult population aged fifteen and over, the proportion of undernourished people in the population, and regime score, respectively. It finds that these determinants generally explain fifty-five percent to ninety-eight percent increase in life expectancy given a lag period of ten years. Specifically, the political regime has the least contribution to life expectancy in LDCs but it contributes to increasing rate; while other three determinants have the highest contribution but they contribute at decreasing rate.

Using a VAR and VECM models Sede and Ohemeng (2015) studied socio-economic determinants of life expectancy in Nigeria. The results revealed that the conventional socio-economic variables such as per capita income, education and government expenditure on health are very effective in determining the life expectancy of developing countries yet are insignificant in the case of Nigeria. Bayati, Akbarian, and Kavosi (2013) explored determinants of life expectancy in 21 Eastern Mediterranean countries over the period of 1995 – 2007 applying Fixed-effect-model to estimate the parameters based on Hausman test. The paper found that income per capita, education index, food availability, level of urbanization, and employment ratio determined health status, proxied by life expectancy at birth.

Similarly, Bilas *et al.,* (2014) investigate the determinants of life expectancy at birth in twenty-eight European countries from 2001 to 2011 using panel data analysis approach. The variables used in the study are GDP growth rate, level of education attained, education enrollment, GDP per capita, and life expectancy. The finds reveal that GDP per capita and level of education have a positive and negative influence on life expectancy, respectively; these are the leading variables explaining between seventy-three and eighty-three percent of differences in life expectancy. Therefore, the negativity of educational level might be due to lifestyle factor of people with higher education that incorporate more stress as a result of more complex responsibility at work, bad nutrition habits, long working hours, less physical activities, etc

3.0 METHODOLOGY

3.1 Source of Data and Description of Variables

This paper employs the Autoregressive Distributed Lag (ARDL) Model to examine the determinants of life expectancy. The data covers twenty-nine years i.e. 1990 to 2018. Therefore, the period was justifiably selected based on the availability of data in Nigeria. The paper measured education as primary school enrolment; access to safe drinking water is measured as the percentage of the population using an improved drinking water sources such as piped water on premises, public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection (WDI, 2015); electricity consumption is measured as the average annual electric energy usage per person in kilowatt/hours; energy consumption is measured by the fossil fuel energy consumption. Material well-being is measured by real GDP per capita in the U.S. dollar on the 2000 constant price.

3.2 Model specification and Estimation Procedure

Following the work of Pesaran *et al.,* (2001), the ARDL model is given as:

$$LEXPECTCY_{t-1} = \beta_0 + \beta_1 \sum_{i-1}^{m} PRISCHENR_{t-1} + \beta_2 \sum_{i-1}^{m} PREVLHIV_{t-1} + \beta_3 \sum_{i-1}^{m} HHCONS_{t-1} + \beta_4 \sum_{i-1}^{m} IMORTALITY_{t-1} + \beta_5 \sum_{i-1}^{m} HEALTH_{t-1} + \beta_6 \sum_{i-1}^{m} GDPPERK_{t-1} + \beta_7 \sum_{i-1}^{m} FFENGY_{t-1} + \beta_8 \sum_{i-1}^{m} ELCOENG_{t-1} + \beta_9 \sum_{i-1}^{m} ASDWATER_{t-1} + \mu_t \quad (3.1)$$

Although ARDL model consists of two parts, the first part of the equations with β1 to β9 stands for the short-run dynamics of the models, while the coefficients α1 to α3 represents the long-run relationship. The null hypothesis of the above model is defined as

H0: β1 = β2 = β3 = β4 = β5 = β6 = β6 = β7 = β8 = β9 = 0 which tell us that there is no evidence of long-run relationship (Pesaran et al., 2001).

We begin the estimation by conducting cointegration test. The calculated F-statistics is compared with the Critical Value as tabulated by Pesaran *et al.,* (2001). If F-statistics exceeds or supersedes the upper critical value, then the decision rule will be to reject the null hypothesis of no long-run relationship (no cointegration) irrespective of whether the underlying order of integration of the variables is zero or one i.e. I(0) or I(1), whereas if F-statistics falls below a lower critical value, then the null hypothesis cannot be rejected and if F-statistics falls within these two critical bounds, then the result is inconclusive (Pesaran et al, 2001). Accordingly, the Error Correction Model of the ARDL approach is specified as:

$$LEXPECTCY_{t-1} = \beta_0 + \beta_1 \sum_{i-1}^{m} PRISCHENR_{t-1} + \beta_2 \sum_{i-1}^{m} PREVLHIV_{t-1} + \beta_3 \sum_{i-1}^{m} HHCONS_{t-1} + \beta_4 \sum_{i-1}^{m} IMORTALITY_{t-1} + \beta_5 \sum_{i-1}^{m} HEALTH_{t-1} + \beta_6 \sum_{i-1}^{m} GDPPERK_{t-1} + \beta_7 \sum_{i-1}^{m} FFENGY_{t-1} + \beta_8 \sum_{i-1}^{m} ELCOENG_{t-1} + \beta_9 \sum_{i-1}^{m} ASDWATER_{t-1} + \mu_t + \beta_{10} ECM_{t-1} + \mu_t \quad (2)$$

Where ECM is the error correction representation of equation (1). However, before estimating equation (1), the study conducted a unit root test through the use of Augmented Dickey-Fuller and Dickey-Fuller Generalized Least Square.

4.0 RESULTS AND DISCUSSIONS

Even though ARDL does not require stationarity test, but this study decides to determine the stationarity level of the variables under investigation before running the ARDL bound test. This is because ARDL bound test is not capable of handling any series that go beyond first difference i.e. I (1) order of integration. Table 1, Show the results of the ADF and KPSS unit root tests and none of the series goes beyond I(1) order of integration. Based on the ADF stationarity test, the results show that life expectancy, the prevalence of HIV/AIDS, and infant mortality rate are stationary at level while primary school enrolment, household consumption, health expenditure, GDP per capita proxy for material wellbeing, energy consumption, and electricity consumption are stationary at first difference. Meanwhile, the result from the KKPSS shows that access to safe drinking water is stationary at level value.

Table 1: Unit Root test (ADF and DF-GLS)

Variables	ADF		KPSS	
	Level	First Diff.	Level	First Diff.
Life Expectancy	-4.0265***			
Primary School Enrolment		-4.2282***		
Prevalence of HIV/AIDS	-6.2334***			
Household Consumption		-8.6523***		
Infant Mortality Rate	-5.6278***			
Health Expenditure		-6.0196***		
Material Wellbeing		-3.9060***		
Energy Consumption		-4.8882***		
Electricity Consumption		-6.0142***		
Access to Safe Drinking Water				0.1454*

Note: ***, **, and * indicating significant at 1%, 5% and 10% respectively.
Source: *Authors computation using Eviews Version 9.*

However, after the unit root test, there is also a need to know the value of F-statistics in order to determine the presence or existence of cointegration or otherwise among the variables underestimation. This has been carried out using ARDL bounds test and the result reveals the evidence of cointegration among the variables. From Table 2, F-statistics is 17.19505. This shows that the null hypothesis of no cointegration can be rejected at one percent significance level. This is because the value of F-statistics is greater than the upper bound critical value of 3.93 and 2.79for lower critical bound value.

Table 2: ARDL Bounds Test for Cointegration

F-statistics value = 17.19505		
Critical Value of Bounds		
Significance	I(0) Bound	I(1) Bound
1%	2.79	3.93
5%	2.3	3.33
10%	2.05	3.02

Source: *Authors Computation Using Eviews Version 9.*

However, the ARDL long-run coefficients are presented in Table 3. The results indicate that there is a negative and statistically significant relationship among primary school enrolment, infant mortality rate, energy consumption, and life expectancy. On the other hand, it also reveals that there is a positive relationship among health expenditure, GDP per capita proxy for material wellbeing, access to safe drinking water and life expectancy in Nigeria throughout the study period; while the prevalence of HIV/AIDS, household consumption, and electricity consumption are found to be statistically insignificant. This implies that a percentage increase in health expenditure, economic growth and access to safe drinking water lead to 3%, 0.4% and 44% increase in life expectancy, respectively. Contrariwise, a percentage increase (decrease) in primary school enrolment, infant mortality rate, and energy consumption is associated with the 1.19%, 9.62 and 2.11% decrease (increase) in life expectancy, respectively. In another development, the results show that access to safe drinking water is the best determinants of life expectancy in Nigeria as a percentage increase in access to safe drinking water will lead to about 44% increase in life expectancy over the period of the study.

Table 3: Result of the Estimated Long-Run Coefficients of the ARDL

Dependent Variable: LLIXP		
Variables	Coefficients	t-Statistics
Trend	-0.3587	-5.8169***
Primary School Enrolment	-0.0119	-4.0296***
Prevalence of HIV/AIDS	0.1600	0.4518
Household Consumption	0.1425	1.2292
Infant Mortality Rate	-0.0962	-6.1863***
Health Expenditure	0.0334	2.0139*
GDP Per Capita	0.0004	3.7683***
Energy Consumption	-0.0211	-3.0096**
Electricity Consumption	-0.0019	-1.1266
Access to Safe Drinking Water	0.4430	13.0404***
R^2 = 0.99, Adj. R^2 = 0.99, AIC = -3.9601, SIC = -3.0338, HQC = -3.7032, DW = 2.3297		
Significant at 1% (***), 5% (**) & 10% (*)		

Source: *Authors Computation Using Eviews Version 9.*

Moreover, once the variables under study are cointegrated, then there is a need to go further to test error correction model (ECM) that expresses the short-run nexus among the variables. The reason behind this ECM is that it expresses the speed of adjustment from the short-run to the long-run equilibrium in case of any distortion in the economy. The results as depicted in Table 4 show that ECM coefficient is -0.999931 and statistically significant at 1% level. This shows a high speed of adjustment to equilibrium level after a shock. For the other explanatory variables, the short-run analysis reveals the existence of a positive and statistically significant relationship with the dependent variable.

Table 4: Error Correction Estimate of the ARDL Model (Short-Dynamics)

Dependent Variable: Life Expectancy		
Variables	Coefficients	t-Statistics
Primary School Enrolment	-0.005081	-5.33989***
Prevalence of HIV/AIDS	-0.125810	-2.25023*
Household Consumption	0.139752	3.9830***
Infant Mortality Rate	0.504622	22.9054***
Health Expenditure	0.025465	5.7119***
Material Wellbeing	-0.000007	-0.2249
Energy Consumption	-0.021653	-7.3104***
Electricity Consumption	-0.000405	-0.8644
Access to Safe Drinking Water	0.039889	2.7348*
Constant	42.318240	28.4767***
ECM(-1)	-0.999931	-28.5294***
Significant at 1% (***), 5% (**) & 10% (*)		
Source: author's computation using Eviews version 7.0.		

5.0 CONCLUSION AND RECOMMENDATION

The paper titles "determinants of life expectancy in Nigeria" examines factors that influence life longevity. Thus, Augmented Dickey-Fuller and KPSS were employed in testing the unit root properties of the variables under investigation. The paper further used Autoregressive Distributed Lag (ARDL) Model in estimating variables under investigation. The paper reveals that health expenditure, material wellbeing, access to safe drinking water, primary school enrolment, infant mortality rate and energy consumption are significant determinants of life expectancy in Nigeria both in the short run and long run with the exception of prevalence of HIV/AIDS and household consumption which are determinants of life expectancy in the short run. Therefore, the aforementioned determinants have an important role to play in improving life expectancy in Nigeria. The research work recommends that in order to improve the health status of Nigerians, health policymakers should focus on the factors which lie outside the healthcare system. These factors are mainly associated with economic growth and development level. Thus, the economic stabilization policies with the aim of increasing productivity, economic growth, and reducing unemployment play significant roles in the health status of the people of the region. Health policy makers should pay special attention to high rates of mortality for some diseases at older ages, like hypertension and diabetes mellitus, and therefore the legacy of smoking and alcohols drinking among other factors such as obesity and economic inequality have been suggested as possible causes of high mortality and consequently low life expectancy in Nigeria.

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