

## **Determinants of Life Expectancy in Nigeria**

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### ***Abstract***

*Life expectancy at birth is essential for evaluating a country's economic and social development. In Nigeria, life expectancy increased in the last decades, however, it is below the sub-Saharan Africa average of 60 years and 73 years global average. This study investigates the determinants of life expectancy in Nigeria. Data were obtained from World Bank database from 1980 to 2022. The 1 variables were tested for their time series properties, using Augmented Dickey-Fuller, and Phillip-Perron tests, the test of co-integrations among the series were examined using the Auto-regressive distributed lag (ARDL) bound test approach. The GDP per capita, adult literacy rate, total fertility and the effect of degree of urbanization have a positive and statistically significant relationship with life expectancy. The relationship between CO<sub>2</sub> emission (and life expectancy at birth is negative and significant. The coefficient of the error correction model) is negative and statistically different from zero. Although the study did not capture all key determinants of life expectancy, it recommends the measures geared towards formulating and implementing appropriate socio-economic policies and programmes to raise per capita income, increase literacy rate, improve medical care, promote urbanization and reduce CO<sub>2</sub> emissions in order to extend life expectancy in Nigeria.*

**Keywords:** Life expectancy, Autoregressive Distributed Lag, Nigeria.

**JEL Classification:** I11, P36

### **1. Introduction**

An indicator of a nation's health condition and human well-being is life expectancy. Improving life expectancy is necessary in achieving long-term sustainable economic development. Life expectancy is the average number of years remaining for an individual to live at a given age, which depicts the patterns of mortality for different age group. It is one of the four cardinal of

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the Human Development Index (HDI). Improved health and prolonged life increase productivity and support sustainable economic growth (Raffin and Seegmuller, 2014). Balani (2016) opined that life expectancy is multidimensional given that what influence it varies across regions which can be attributed to socioeconomic factor and state of the environment.

There has been tremendous improvement in life expectancy across the globe in recent times, however, there is wide variation between developed and developing countries, as well as divergence based on age group, that is, inequalities still persist in life expectancy. For instance, between 2005 and 2015 countries with low human development bridged the gap in life expectancy at birth, often driven by lessening infant mortality rates, but lagged behind in term of life expectancy at older age (Conceicao, 2019).

Life expectancy at birth expresses the number of years a new born child would live given that the patterns of mortality at the time of its birth remains unchanged through its period of life (Issaoui et al.,2015). Life expectancy is one of the main measures of a country's health status, which is a function of economic, social and environmental forces Miladinov (2020).

The variation in life expectancy at birth between low and very high human development economies is estimated to be 19 years with disparity expected in survival rate at every age. For example, the disparity in life expectancy at age 70 is about five years (Conceicao, 2019). This tends to suggest that people born in countries with high human development index would live more years (about 19 years) than individuals in countries characterized as low human development countries. Meanwhile, countries with better life expectancy at birth tend to have higher growth of the economy.

The disparities between countries can be attributed to cultural changes, changes in socioeconomic and environmental factors, as well as health system factors. Policymakers need to understand the factors that dictates the variation among countries (Delavari et al., 2016), given the fact that most developing countries are striving to achieve economic growth through investment in health and education sectors, provision of social safety nets, and environmental management. In addition, several efforts were made by policymakers to develop other factors that can improve the life expectancy of a country, such efforts were channel towards access to clean and safe water, improve nutrition and hygiene, reduction in poverty incidence, and to ensure significant decline in incidence and prevalence of diseases. Despite the various efforts, life expectancy in developing countries of the world are still

poor relative to that of developed countries (Kabir, 2008; Nkalu & Edeme, 2019).

Some studies argued that life expectancy in Africa is high relative to other continents as a result of factors such as environment free from contamination associated with industrialization, and good weather condition. On the other hand, some studies suggest that life expectancy in Africa is low in comparison to other continents. This was attributed to inadequate calorie intake, poor hygiene, widespread poverty, prevalence of diseases, and inadequate healthcare facilities (Effiong et al., 2021; Sunday & Adeleye, 2017; Rahman et al., 2022).

In Nigeria, life expectancy rises at an increasing rate from 36.73 years to 40.79 years in 1960 and 1970, respectively, it further rose to 46.56 years in the year 2000. The life expectancy for Nigeria was 54.49 years in 2019, representing about 0.58 per cent increase over 2018 figure. In 2020, the country recorded about the same percentage increase from 2019. The current life expectancy for Nigeria is 55.44 years, amounting to 0.57 per cent rise from 2021, it is projected to hit 56.36 years and 62.93 years in 2025 and 2050, respectively, therefore, recording annual percentage change of 0.54 per cent and 0.33 per cent, correspondingly. Hence, the life expectancy from birth (years) in Nigeria is increasing at a decreasing rate (United Nations, 2022). When compared with similar countries ranked by life expectancy, Nigeria has the third lowest life expectancy rate across the globe, and the lowest in West African region.

The low life expectancy in Nigeria can be partly attributed to the state of health in the country. The health system in Nigeria is characterized by diseases of all forms, such as HIV/AIDS, Malaria, and Tuberculosis among others. Nigeria has the second largest HIV epidemic in the world, with a prevalence rate of 1.4 per cent among adult. This is much less than what is obtainable in other sub-Saharan African countries like Zambia and South Africa having a prevalence rate of 12 per cent and 19 per cent, respectively, however, the population of Nigeria implies about 1.9 million people lives with HIV in 2019 (World Health Organisation [WHO], 2022). Similarly, Nigeria has the fourth largest incidence of Tuberculosis across the globe, with about 4 per cent of global tuberculosis cases (WHO, 2022). In 2020, Nigeria accounted for 27% of malaria cases across the globe and an estimated 24 per cent of all malaria deaths worldwide. Malaria accounted for about 11 per cent of maternal mortality, 25 per cent of infant mortality and 30 per cent of under 5 mortality (WHO, 2022). AIDS epidemic, Tuberculosis, and Malaria played

a significant role in the low life expectancy recorded in Nigeria. In addition, there are other preventable and curable diseases that are endemic in Nigeria with the associated high mortality rate.

The low life expectancy in Nigeria can be further attributed to high poverty profile, inequitable and inadequate healthcare financing. About 83 million Nigerians live in poverty in 2020 (Nigerian Bureau of Statistics [NBS], 2021). A substantial proportion of Nigeria population is poor with worse health status. Utilization of health care facilities is hampered by poor economic conditions and poor access to healthcare facilities and rising cost of medical care.

Also, the average health facility-population ratio is low and worse in rural areas. The national doctor-patient ratio was 1:5000, much lower than the WHO minimum standard of 1:600. While, there are private healthcare facilities, they are concentrated in the urban areas and characterised by high charges (Onisanwa et al., 2018). These tend to hamper the effective delivery of the health system in Nigeria.

Similarly, a high proportion of population of Nigerians lack access to clean source of water, thereby having a debilitating effects on life expectancy. The proportion of Nigerians using drinking water from an improved source that is readily accessible and available when needed as well as free from chemical contamination was 20.13 per cent in 2017. Similarly, only 29% of Nigerians have access to improved sanitation relative to the 71% that are lacking access. The aforementioned indicators are major health issues affecting life expectancy of Nigerians.

Other factors that can be associated with the low life expectancy in Nigeria are the relatively high infant mortality rate, and maternal mortality rate. The infant mortality rate for Nigeria in 2022 is 56.22 deaths per 1000 live births, while the maternal mortality rate in Nigeria is 814 out of every 100,000 live births. The lifetime risk of a Nigerian woman dying during pregnancy, childbirth, postpartum or post-abortion is 1 in 22, in contrast to the lifetime risk in developed countries estimated at 1 in 4900 (WHO, 2022).

In Nigeria, policymakers formulated policy and set goals such as access to quality health care via primary health care service, creation of the national health insurance scheme for public and private workers to help reduce the cost of procuring medical care, as well as commercialization policy aimed at

raising efficiency of the public health facilities. These measures are designed to improve the life expectancy at birth in Nigeria.

Although rising life expectancy are associated with economic development, the channels through which this is achieved still remain unraveled. While previous studies have examined factors influencing life expectancy globally or in other developing countries (Hassan et al., 2017; Luo and Xie, 2020; Wang et al., 2020; ), few studies have focused exclusively on Nigeria using recent national time series data spanning multiple decades. This is an important gap to address given Nigeria's uniquely low life expectancy compared to regional peers (like Tunisia, Mauritius, Morocco, Cabo verde, and Seychelles with a life expectancy that ranges between 75 years and 77 years ). Understanding determinants of life expectancy at the national level in Nigeria can support targeted policy interventions to improve health and longevity. The relationship between socio-economic factors, expenditure on health and life expectancy in Nigeria is therefore investigated. An understanding of the factors that influence a nation's life expectancy is important for the attainment of sustainable growth, because the prerequisite for a prosperous country is a healthy populace.

The knowledge of life expectancy at birth of Nigerian is paramount for the analysis of the depth of socioeconomic advancement of the country. This study investigates the determinants of life expectancy in Nigeria. The knowledge of factors affecting life expectancy over the past three decades could provide important insight and further evidence for policymakers to support governmental efforts to promote health status thereby increasing life expectancy.

The theoretical framework is premised on Grossman (1972) demand for health model. It explained the flows of inputs and outputs over a specified period. Output being measure of health status such as life expectancy, while inputs include environment, education, life style, and genetic factors among others. The study is based on data sourced from the World Bank (2022) database. The ARDL approach was used in the identification of the factors that influence life expectancy in Nigeria. The ARDL technique differentiates between the regressand and regressors and account for endogeneity among the explanatory variables Pesaran et al. (2001).

This study is structured into six sections, following the introduction is section two that provides a review of relevant literatures. The third section focuses on the research methodology and theoretical framework. Section four involves

the presentation of results, section five is the discussion of results. Lastly, section six, summarizes, concludes and gives the implications, the contribution and the limitations of the study.

## **2. Literature review**

Evidence of socioeconomic, environmental, and demographic determinants of life expectancy abounds in literature. Some factors such as per capita income, private and/or public health expenditure, number of physicians per 10,000 beds population, access to safe drinking water, urbanization, geographical location, educational qualification, fertility rate, misery rate ( Unemployment plus inflation rate) , and per capita calorie intake are found to be statistically significant in explaining life expectancy in previous studies.

Income per capita is found to be the foremost determinant of life expectancy in the bulk of existing studies. Most studies reported a direct relationship between per capita income and life expectancy in developing countries, the higher the income per capita, the higher life expectancy. This can be attributed to the fact that higher per capita income will facilitates the consumption of high quality goods and services, better housing, and enhance ability to seek medication in the face of illness, which brings about increase life expectancy (Fayissa & Gutema, 2005; Bayati et al.,2013; Delavari et al., 2016).

Meanwhile, there is a threshold level of per capita income at which the relation between living standard and life expectancy will no longer hold, at this point, per capiata income will no longer respond to changes in life expectancy. In a study conducted in Romania, Balan and Jaba (2011) found that per capita income proxy by wages has a positive relationship with life expectancy. In Iran, Delavari et al., 2016 found a positive and significant impact on life expectancy.

Hassan et al. (2017) found a positive relationship between income as proxy by gross domestic product and life expectancy. They argued that individuals that are richer have better access to health care, have higher calorie intake, and reside in clean environment, hence ability to nurture health evidenced by rising life expectancy. Similarly, Luo and Xie (2020) found that higher gross domestic product spurs life expectancy, while inequality in the distribution of income dampens life expectancy. Also, Wang et al. (2020) found that GDP growth increases life expectancy in Pakistan.

Monsef and Mehrjardi (2015) investigated the relationship between degree of economic development and life expectancy in a panel analysis by dividing countries into economies that have gross domestic product above global average income and the economies that have the gross domestic product below world average income. The findings revealed that the economies with income below the world average have a lower life expectancy by 6.377 years. On the contrary, the Indian state of Kerala was simultaneously experienced high life expectancy at birth and low income per capita (Beitz, 2000).

Sede and Ohemeng (2015) found that current per capita income does not exert significant influence on life expectancy in Nigeria. In a similar study, Nkalu and Edeme (2019) found a positive but insignificant relationship between income and life expectancy.

High investment expenditure in health and education is seen as a medium of developing the human capita status of a country, which can help a country attains sustainable development. Therefore, education can be consider another major determinant of health status that has both indirect and direct effects on life expectancy. An increase in literacy rate increases the knowledge of the causes and dangers of malnutrition, as a result, household will reduce the factors associated with malnutrition (Rogers & Wofford, 1989). Education promotes labour productivity and brings about growth in individual's income, creates opportunity for improvement in the welfare of children when women are educated. Similarly, educating women will raise the productivity of household, this will in result improve health status in the household, and increase the survival rate of child at birth (kabir, 2008). In Omar, Ali and Ahmad (2014) found that education has a direct and significant influence on life expectancy despite that per capita income has an inverse and insignificant impact on life expectancy. Delavari et al., 2016 found that better life expectancy is associated with literacy rate. Also, in a study conducted by Hassan et al. (2017), education index was found to be a significant determinant of life expectancy in some selected developing countries. Aligning with the view that educational status is a significant determinant of life expectancy, Siegel et al. (2022) concluded that population's educational attainment is a key determinant of population health status in industrialised societies.

Another prominent determinant of life expectancy examined in the reviewed literatures is urbanization. Urban households generally has access to better health care facilities and high standard of living, improved education, and better social amenities, which help raise the standard of health outcomes in

general, and prolong life expectancy in particular. Effiong et al. (2021) found that urbanization in Nigeria exerts a direct and significant influence on life expectancy at birth. In a country level analysis, Kim & Kim (2016) found that urbanization has a positive influence on life expectancy. Evidence suggested that degree of urbanization is an important factor that brings about improved life expectancy in the Romania state.

On the contrary, Rogers & Wofford (1989) showed that the level of urbanization in developing countries has less than expected influence on life expectancy at birth due to unhealthy practices in most cities. In a similar study, Kabir 2008 revealed that urbanization is not often an influential determinant of life expectancy in less developed countries. Delavari et al. (2016) found a positive but insignificant relationship between degree of urbanization and life expectancy in Iran. Nathaniel and Khan (2020) result tends to suggest that urbanization dampens the quality of life in Nigeria though not statistically significant in the short run. Meanwhile, urbanization significantly reduces life expectancy at birth in the long run, intuitively, urbanization is not good for a quality in Nigeria. Halicioglu (2011) found that urbanization had an adverse impact on life expectancy in Turkey.

An increasing number of empirical works examine the extent to which health care expenditure influence life expectancy in developed and developing countries. Public and private health expenditure are assumed to have significant effect on life expectancy through direct reduction in mortality and morbidity Kabir (2008), however, some studies hold a different opinion. Nathaniel and Khan (2020) found that government expenditure on health does not meaningfully contribute to life expectancy in Nigeria. This is similar to the findings of Akinlo and Sulola (2019) that argued that public health spending in Nigeria tends to influence infant mortality rate negatively, by intuition, a poor or low life expectancy. Another study found that health care spending is not a significant determinant of life expectancy among European countries (van den Heuvel & Olaroju, 2017).

However, it is expected that health care expenditure would have a direct relationship with life expectancy supposing rising resources means improved health facility and better health system in the country. Meanwhile, there is a possibility of diminishing returns to investment in the health sector above certain level of health care spending. Sunday and Adeleye (2017); and Murthy et al. (2021) found a direct and significant relationship between government spending on health and life expectancy. Also, Jaba et al. (2014)



finding reveals that rising per capita health care spending significantly increases life expectancy in developed country.

Access to safe and clean water is another determinant of life expectancy in some less developed countries. According to Macfarlane et al. (2000) some African and Asian nations experienced improvement in life expectancy in the mid-twentieth century owing to improved access to clean drinking water among other factors. Similarly, Gulis (2000) found that access to clean water significantly affect life expectancy using 156 countries data. However, Kabir (2008) found that access to clean water is not statistically significant in explaining life expectancy in some selected 91 developing countries.

Other factors found to influence life expectancy are calorie intake, diseases burden, CO<sub>2</sub> emission or greenhouse gas, and gender. Studies such as Bayati et al. (2013), found a positive relationship between calorie intake and life expectancy. But their findings show no significant relationship between CO<sub>2</sub> emission and life expectancy. In a similar study, Ali & Ahmad (2014) reported a positive but insignificant relation between CO<sub>2</sub> emission and life expectancy in the long run, while in the short run the result revealed a negative and statistically significant influence between CO<sub>2</sub> emission and life expectancy. Delavari et al. (2016) result suggests that a positive but insignificant relationship exists between CO<sub>2</sub> emission and life expectancy in Iran.

However, Murthy et al. (2021) found an inverse but significant relationship. In a similar study, Erdoğan et al. (2019) result reveals that rising carbon emission in Turkey reduces life expectancy at birth. This is identical to the findings of Nkalu and Edeme (2019) that found that environmental hazard has a negative impact on life expectancy by reducing it by seven weeks. In addition, Matthew et al. (2018) found that 1% increase in the emission of greenhouse gas brings about reduction in life expectancy by 0.0422% in Nigeria . Sede and Ohemeng (2015); Onwube et al. (2021) found that exchange rate has a negative effect on life expectancy in the short run but the influence was positive in the long run.

The reviewed literature on the determinants of life expectancy shows that determinants of life expectancy at birth are many and comprises direct life expectancy -related issues and indirect forces that may be socioeconomic in nature and occasionally environmental. Second, the degree to which these factors influence life expectancy vary across nation, time and regions.

Third, most of the studies are global or national in scope, with some focusing on developed countries or carried out across regions. .

This study is one of very few studies which have investigated the effects of per capita income- economic factors, urbanization (as social factor) and CO<sub>2</sub> emission (as environmental factor) on life expectancy using time series data that spans four decades in Nigeria.

### 3. Research methodology

Information about a country's health status is often sourced from its health production function. The health isoquant depicts the relationship between inputs and output for a specified period. The output comprises indicators of state of health such as infant mortality, and life expectancy among others. On the other hand, flow of inputs include health care spending, social factor, economic factor, biological factor, behavioral factor, and/or environmental factor. The health production function can be conceptualized using Grossman's (1972) model for health, hence, the theoretical underpinning for this study is based on the Grossman (1972) health model.

Grossman's model attributes increase in an individual's stock of health to a rise in his inputs to the health production function. The model opined that household produces health based on their preferences, lifestyles, and their demand for medical care. The outcome of these decisions is the health status or longevity of lifetimes (Halicioglu, 2011).

Meanwhile, household ability to maximize opportunities in order to produce better health outcomes is limited by physical and mental health endowments, economic constraints, social and environmental constraints, as well as time constraints. Grossman (1972) developed a theoretical health model, used by Fayissa\* and Gutema (2005) and specified as follows:

$$H = f(X) \quad (1)$$

Where  $H$  is a measure of household health output (life expectancy) and  $X$  a vector of household flow of inputs in the health production function,  $f$ .

The Grossman's health model was developed for analysis of health production function at the micro level. However, analysis of the determinants of life expectancy in Nigeria, in this study is a macro analysis, therefore, there is a need to switch from micro analysis to macro analysis. To move from micro analysis to macro analysis, and still preserve the theoretical ground, the

component of the input vector  $X$  were measured using per capita variables (Fayissa & Gutema, 2005)

The elements of the input vectors can be classified into social, economic, and environmental factors, denoted as:

$$H = f(E, S, V) \quad (2)$$

Where  $H$  is the household's state of health proxy by life expectancy.

$S$  is a vector of per capita social variables,  $E$  is a vector of per capita economic variables, and  $V$  denotes vector of per capita environmental variables, that may affect life expectancy, which represent health status.

This study estimates the determinants of life expectancy in Nigeria based on the Grossman (1972) theoretical model. The main importance of identifying the determinants are to obtain estimates of the aggregate influence of health care usage on the life expectancy of household. The findings will assist policymakers in making cost efficient choices and allocates health resources in an attempt to optimize health spending. The Grossman (1972) health model was adapted in line with the econometric approach.

Different factors have been employ in explaining life expectancy in literature. Income per capita determines the state of people economic, and a major socioeconomic determinant of life expectancy. Some of the studies that argued that income is one of the determinants of life expectancy are Fayissa and Gutema (2005); Bayati et al. (2013); Delavari et al. (2016). Education is another important determinant (Ali & Ahmad, 2014; Delavari et al., 2016; Hassan et al., 2017). It influences life expectancy in many ways, educated people tend to have access to better jobs, attract higher earnings, and be engage in less risky activities.

Calorie intake contributes to lifespans of an individual, the quality and quantity of food consumed influence health status (Bayati et al., 2013; Hassan et al., 2017). Health expenditure defined household access to health care and also determines the level of resources allocated to healthcare in an economy (Jaba et al., 2014; Sunday & Adeleye, 2017; Murthy et al., 2021). Another important determinant of life expectancy is the degree of urbanization which has both positive and negative. While urbanization increases access to health facilities and raises health care awareness on one side, it can also bring about pollution and environmental degradation (Bayati et al., 2013). The

determinants of life expectancy in Nigeria chosen in this study is based on the reviewed literatures and available data.

This study extends the frontier of knowledge in this germane by providing a better understanding of the determinants of life expectancy in Nigeria using time series data that span 1980-2022 to account for a large percentage influence of socio, economic, and environmental factors on life expectancy at birth in Nigeria. This would allow for a more robust and reliable findings.

Based on the theoretical framework presented above, this sub-section specifies a model to examine the determinants of life expectancy in Nigeria. The life expectancy at birth can be express as a function of social, economic, and environmental factors as expressed in functional form (equation 2).

The elements of the economic factors of life expectancy in this study include per capita income. Social factors of life expectancy for this research are educational attainment (adult literacy as percentage of total population), degree of urbanization, and total fertility rate.

The environmental determinants of life expectancy considered in this study is carbon ( $CO_2$ ) emission.

The dependent variable is the life expectancy at birth reflecting the number of years a new born infant would live given that the prevailing state of mortality at its time of birth remains unchanged through its livetime. It is a proxy for health status in an economy.

Given the aforementioned element of vectors  $E, S$ , and  $V$ , equation 2, can be rewritten as

$$le = f(pc, ed, tf, CO_2, ur) \quad (3)$$

Equation 3, states that life expectancy is a function of per capita income ( $pc$ ), educational attainment ( $ed$ ), total fertility rate ( $tf$ ), carbon emission ( $CO_2$ ), and degree of urbanization ( $ur$ ). The chosen variables were in line with theory and in conformity with reviewed literatures.

The effect of per capita health care expenditure on life expectancy is ambiguous. Higher health care expenditures could lead to increase provision

of health facilities, which enhances longevity, provided the increase in medical spending has no negative effect on the individual's health condition.

**Table 1: Definition of Variables used in the Model**

Notation	Meaning & measurement	A prior
<i>le</i>	Life expectancy at birth, years, 2022	-
<i>pc</i>	Per capita GDP in purchasing power parity (PPP) US dollar, 2010	Positive
<i>ed</i>	Adult literacy rate, that is, percentage of people ages 15 and above that can both read and write and understand simple statement about their everyday life	Positive
<i>f</i>	Total fertility rate (births per woman)	Ambiguous
$CO_2$	CO2 emission (metric tons per capita) indicates the effect of air pollution on life expectancy. Carbon dioxide emissions emanates from burning of fossil fuels and manufacturing of cement. It include carbon dioxide produced during the consumption of solid, liquid, gas fuels, and gas flaring.	Negative
<i>ur</i>	Urban population as percentage of total population, 2022	Ambiguous

Degree of urbanization is measured as the percentage of the population that lives in cities and towns. The impact can be negative or positive on life expectancy, it comprises factors that influence health such as access to health care facilities, health awareness, pollution, and congestion.

Modern healthcare facilities are often available in town and cities, thereby enhancing access to improved medical facilities that leads to longevity. However, pollution and congestion tend to pose adverse consequences on health that ultimately reduces life expectancy.

Therefore, the influence of degree of urbanization on life expectancy is a function of which of the of the two contradictory forces outweigh the other.

The used of environmental factors as part of the determinants of life expectancy in Nigeria is borne out of the growing degree of urbanization, the position of Nigeria in the Environmental Performance Index (EPI) and her Global competitive Index (GCI). For instance, Nigeria was ranked 168 out of 180 countries in Environment Performance Index.

Equation 3, can be expressed in mathematical linear regression form as

$$le = \beta_0 + \beta_1 pc + \beta_2 ed + \beta_3 tf + \beta_4 CO_2 + \beta_5 ur \quad (4)$$

An estimable explicit econometric model of equation 4, is expressed below

$$le_t = \beta_0 + \beta_1 pc_t + \beta_2 ed_t + \beta_3 tf_t + \beta_4 CO_{2,t} + \beta_5 ur_t + \varepsilon_t \quad (5)$$

Where  $\beta_0$  is the intercept,  $\beta_1$  to  $\beta_5$  are the coefficients of the explanatory variables, and  $\varepsilon_t$  is the stochastic error term with zero mean and constant variance

$$lle_t = \beta_0 + \beta_1 Ipc_t + \beta_2 Ied_t + \beta_3 Itf_t + \beta_4 ICO_{2,t} + \beta_5 Iur_t + \varepsilon_t \quad (6)$$

Given that the variables used in this study are of different units, there is a need to log- transform the series in order to minimize the scale such that the degree of differences among the variables become smaller than the initial value, thereby reducing the chances of having unequal variance of the error terms and stabilize the unit of the time series data (Bayati et al. 2013; Hassan et al. 2017). The study used a double-log model, hence the coefficients can interpreted as percentage change, that is, the coefficients reveal that the percentage change in life expectancy is due to one per cent change in the corresponding explanatory variable. This implies  $\beta_1$  to  $\beta_5$  measure the elasticity of life expectancy to changes in the corresponding explanatory variable.

The estimated model is drawn from the Autoregressive Distributed Lag (ARDL) bounds test approach developed by Pesaran and Shin (1999) and later advanced by Pesaran et al. (2001). ARDL model describes the procedure of estimating time series data with different order of integration. The technique is robust for finite sample, both in the face of changes in regime and shocks phenomena (Fuinhas & Marques, 2012)

Equation 6, could be converted to its Autoregressive Distributed Lag, if the series are cointegrated, the model can be further converted to an unrestricted error-correction model (VECM). The model does not only test for existence of a long relationship but also estimate both short and long run coefficients for the study. A dynamic error correction model (ECM) is further determine from the ARDL via linear transformation. The ECM relates the short run dynamics with the long run without losing ground of the long run information (Shrestha & Chowdhury, 2005; Hoque & Yusop, 2010).

For estimation, following Pesaran et al. (2001), the life expectancy equation (6) can expressed in the ARDL model form as

$$\begin{aligned} \Delta(Ile)_t = & \beta_0 + \sum_{i=1}^{n1} \beta_{1i} \Delta(Inle)_{t-i} + \sum_{i=0}^{n2} \beta_2 \Delta(Ipc)_{t-i} + \sum_{i=0}^{n3} \beta_3 \Delta(Ied)_{t-i} + \sum_{i=0}^{n4} \beta_4 \Delta(Itf)_{t-i} \\ & + \sum_{i=0}^{n5} \beta_5 \Delta(ICO_2)_{t-i} + \sum_{i=0}^{n6} \beta_6 \Delta(Iur)_{t-i} + \beta_7 \Delta(Ile)_{t-1} + \beta_8 \Delta(Ipc)_{t-1} \\ & + \beta_9 \Delta(Ied)_{t-1} + \beta_{10} \Delta(Itf)_{t-1} + \beta_{11} \Delta(ICO_2)_{t-1} + \beta_{12} \Delta(Iur)_{t-1} + \varepsilon_t \end{aligned} \quad (7)$$

Where  $\Delta$  is the first difference operator,  $\beta_0$  is the constant term, and  $\varepsilon_t$  is the white noise error term assumed to be normally distributed. The parameters  $\beta_i (i=1,2,\dots,6)$  denotes the short run dynamic coefficients, while the  $\beta_i (i=7,8,\dots,12)$  measures the long run multipliers of the model.

The error correction version of the ARDL model for equation (6) is expressed as follows:

$$\begin{aligned} \Delta(Ile)_t = & \beta_0 + \sum_{i=1}^{n1} \beta_{1i} \Delta(Ile)_{t-i} + \sum_{i=0}^{n2} \beta_2 \Delta(Ipc)_{t-i} + \sum_{i=0}^{n3} \beta_3 \Delta(Ied)_{t-i} + \sum_{i=0}^{n4} \beta_4 \Delta(Itf)_{t-i} \\ & + \sum_{i=0}^{n5} \beta_5 \Delta(ICO_2)_{t-i} + \sum_{i=0}^{n6} \beta_6 \Delta(Iur)_{t-i} + \alpha ECM_{t-1} + \varepsilon_t \end{aligned} \quad (8)$$

$\alpha$  measures the speed of convergence from short run disequilibrium to a state of long run equilibrium.

### Diagnostic Test

Diagnostic and stability tests was conducted for the reliability and robustness of the estimated model. The tests include serial correlation, heteroscedasticity and normality. The CUSUM and CUSUMQ tests was also carried out.

### Data Source

This study investigates the social, economic, and environmental determinants of life expectancy in Nigeria. Data for the present study were

sourced from World Bank (2023) database spanning 1980 to 2022 for efficient and robust results.

#### 4. Research findings/results

The result of the descriptive statistics of growth of life expectancy, per capita income, adult literacy rate, carbon dioxide emissions, total fertility rate, and degree of urbanization is presented in Table 2.

**Table 2. Descriptive statistics**

	GLE	PC	CO2	ED	TF	UR
Mean	0.500256	6.142821	0.699231	93.60029	6.181026	35.438
Median	0.410000	4.640000	0.670000	93.31004	6.150000	34.304
Maximum	1.200000	149.3400	0.930000	113.0788	6.760000	50.344
Minimum	-0.030000	-43.37000	0.460000	78.66348	5.420000	21.970
Std. Dev.	0.448274	29.95087	0.109770	8.269038	0.397934	8.3014
Skewness	0.039130	2.666396	0.099605	0.744798	-0.075998	0.1735
Kurtosis	1.466381	14.57943	2.502535	3.110232	1.949413	1.9176
Jarque-Bera	3.831930	264.0979	0.466629	3.625455	1.831108	2.0995
Probability	0.147200	0.000000	0.791904	0.163208	0.400295	0.3500
Observations	39	39	39	39	39	39

Source: Authors' computation

#### Unit root test results

The unit root test results from Augmented Dickey–Fuller (ADF) and Phillip Peron (PP) across two-equation test options are presented in Table 3. The results revealed a mixed order of integration, as such the probable existence of a long-run relationship is investigated.

**Table 3: Unit root tests of the variables**

	Augmented Dickey-Fuller (ADF)			Phillip Perron (PP)		
	Level	First Difference	I(d)	Level	First Difference	I(d)
LE	-1.578 <sup>b</sup>	-6.202 <sup>***b</sup>	I(1)	-1.578 <sup>b</sup>	-6.247 <sup>***a</sup>	I(1)
PC	-5.243 <sup>***a</sup>	-3.308 <sup>***a</sup>	I(0)	-5.159 <sup>**b</sup>	-10.979 <sup>***a</sup>	I(0)
CO <sub>2</sub>	-3.343 <sup>**a</sup>	-4.383 <sup>***b</sup>	I(0)	-2.020	-15.497 <sup>***a</sup>	I(1)
ED	-2.384 <sup>a</sup>	-4.364 <sup>***a</sup>	I(1)	-1.998 <sup>a</sup>	-4.817 <sup>***a</sup>	I(1)
UR	0.597 <sup>a</sup>	7.166 <sup>***b</sup>	I(0)	1.528		

Source: Authors' computation

Note: \*\*\*, \*\* and \* imply statistical significance at 1%, 5% and 10% levels respectively. Also, "a" denotes model with constant, and "b" is for model with constant and trend



**Determination of lag structure**

In Table 4 below, the lag order of the 5% level of criteria is presented

**Table 4: VAR lag order selection criteria result.**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-294.5845	NA	0.720334	16.69914	16.96306	16.79125
1	-17.18977	446.9137	1.11e-06	3.288320	5.135759*	3.933126
2	23.8915	52.4927*	9.99e-07	3.006030	6.436988	4.203526
3	77.1705	50.3191	6.35e-07*	2.046085*	7.060562	3.796272*

**Note:** \* indicates lag order selected by the criterion

**Table 5: F-Statistics for testing the presence of long-run cointegration**

Model	F-statistic
LE= f(PC, CO <sub>2</sub> , ED, TF, UR)	6.152*** (n= 35, k=5)

**Narayan (2005) Critical Value Lower Bound I(0) Upper Bound I(1)**

1%	3.06	4.15
5%	2.39	3.38
10%	2.08	3.00

**Note:** \*\*\* depicts 1% level of significant.

**Determinants of Life expectancy**

This study examined the significance of the variables using ARDL model approach. The result is presented in Table 6.

**Table 6: ARDL regression results**

Long-run results		Short-run results	
variable	coefficient	Variable	Coefficient
PC	0.0172 (0.0011)	DGPCI	0.0043(0.0000)
ED	0.0289 (0.0024)	DEDU	0.0072 (0.0927)
CO <sub>2</sub>	-1.1885 (0.0717)	DTFR	3.6423(0.0738)
TF	1.5939 (0.0659)	D(TFR(-1))	-3.7201(0.0010)
UR	0.1095 (0.0292)	CoinEq(-1)**	-0.6235 (0.0000)

Source: Authors' computation

## Diagnostic test result

**Table 7: Results of the diagnostic test**

Test Statistics	Probability
Breusch–Godfrey LM test (Serial Correlation)	0.5276
Heteroskedasticity (ARCH)	0.9729
Linearity (Ramsey Reset)	0.2124
CUSUM Test	Stable

**Source:** Authors' computation

## 5. Discussion

The trend representation of the series are presented in Appendix. The graph revealed an upward trend for urbanization, on the contrary, TF experienced a downward trend all through the period under reviewed. The plot shows that GLE was relatively stable between 1983 and 1993, thereafter it experience upward trend for three years, constant growth between 1994 and 1998, after which it increases over the studied period with occasional fluctuations. The plots show that PC, ED, and CO<sub>2</sub> emissions were characterize by zigzag pattern through the entire duration.

The descriptive statistics is presented in Table 2. The statistics reported include the mean, minimum and maximum values for the respective series. Others are skewness, kurtosis, and the Jarque-Bera statistics. The deviation of the series from their respective mean value is high as shown by the standard deviation coefficients, this indicates variation in the series. The skewness statistics reveal that all the variables have positive statistics value, except total fertility rate with a negative value. However, the statistics did not differ substantially from Zero which is the threshold value for normal distribution, except in the case of the growth of per capita income that is positively skewed.

Table 2 further shows that, all the variables have Kurtosis values that are not substantially different from the threshold value 3, except for the growth of per capita income whose distribution is peaked (leptokurtic) relative to the normal.

The growth of life expectancy, carbon dioxide emission, total fertility rate, degree of urbanization, and education are normally distributed, while growth of per capita income as shown by the probability value of the Jarque-Bera test is not normally distributed. Therefore, we conclude that all the series are normally distributed except growth of per capita income as evidence by the

probability of the Jarque-Bera test, and confirmed by the Skewness and Kurtosis values.

In order to determine the optimal lag that will give rise to a non-spurious regression, this study utilized a combination of lag selection criteria that include Final prediction error (FPE), Akaike information criterion (AIC), and Hannan-Quinn information criterion (HQ). The selection criteria reveal that Lag 3 is the optimal lag, although Schwarz information criterion (SC) suggested otherwise.

Table 5 shows the computed value of F-statistics as 6.152, which is more than the upper bound value of Narayan (2005) critical value at 1 percent level of significance; this depicts a long-run cointegration relationship among GLE and its determinants (per capita income, literacy rate, carbon dioxide emission, total fertility rate, and urbanization). Hence, we reject the null hypothesis of no relationship and conclude that all the variables have long run relationship.

The estimated coefficients have expected signs and statistically significant. The results reveal that the growth of per capita income, literacy rate, total fertility rate and urbanization have a positive and significant relationship with the growth of life expectancy at birth. The results further reveal that CO<sub>2</sub> emissions has a negative relationship with the growth of life expectancy at birth.

The findings that the growth of per capita income has positive and statistical relationship with the growth of life expectancy as shown in column 2 of Table 6, can be justified on the ground that improved per capita income implies more resources for the purchase and consumption of high quality goods and services, improving housing, and access to better medical facilities, which prolonged life, hence better life expectancy. Rising per capita income is also associated with higher education attainment of the people, hence per capita income is a core determinant of life expectancy in Nigeria. The study showed that higher economic growth tends to raise the life expectancy of Nigerians. This empirical result is in conformity with the work of Delavari (2016) for Iran, Nkalu and Edeme (2019) for Africa, who found that per income increases life expectancy by one year and six months. The result is also in line with the findings of Rahman and Khanam (2022) for most polluted counties. However, the finding did not conform to the work of Nathaniel and Khan (2020) that found a positive but insignificant relationship in the case of Nigeria.

In the case of education, more educated persons tend to attract better job and earn greater wages. A higher wage is tandem to greater per capita income, thereby facilitating consumption of improved goods and services as well as rising demand for healthcare. In addition, better educated individuals are more aware and conscious of sanitation quality, calorie intake, and preventive measures for illness as well as formal healthcare services. This result agreed with the outcomes of Nathaniel and Khan (2020) empirical work for Nigeria, Delavari et al. (2016) for Iran, and Siegel et al. (2022) for Germany.

The result further reveals that the degree of urbanization influence life expectancy positively and significantly. The positive relationship can be justified on the ground that urban households tend to have more access to healthcare facilities than rural dwellers. Similarly, urbanization avails access to education and information that create awareness among individuals on what needs to be done to enable them live longer and improved living standard. This result is in agreement with the outcomes of Delavari et al. (2016); Effiong et al. (2021) who reported a positive and significant impact of urbanization on life expectancy in Iran and Nigeria, respectively. On the contrary, this finding did not conform to the result of Nathaniel and Khan (2020).

As expected CO<sub>2</sub> emissions has a negative and significant impact on life expectancy in Nigeria. Given the growing degree of urbanization in Nigeria, there is increase in CO<sub>2</sub> emission from industrial activities, transportation, natural gas, and other fossil fuels. This could significantly reduce life expectancy in Nigeria. This contradict the suggestions of Nathaniel and Khan (2019) who found a negative but insignificant relationship between life expectancy and CO<sub>2</sub> emissions. Also, Delavari et al. (2016) found a positive and significant relationship between CO<sub>2</sub> emissions and life expectancy at birth. Meanwhile, our empirical finding corroborates that of Effiong et al. (2021); Rahman et al. (2022); Sunday and Adeleye, (2017) who found a negative and significant relationship between life expectancy and CO<sub>2</sub> emissions in their respective studies.

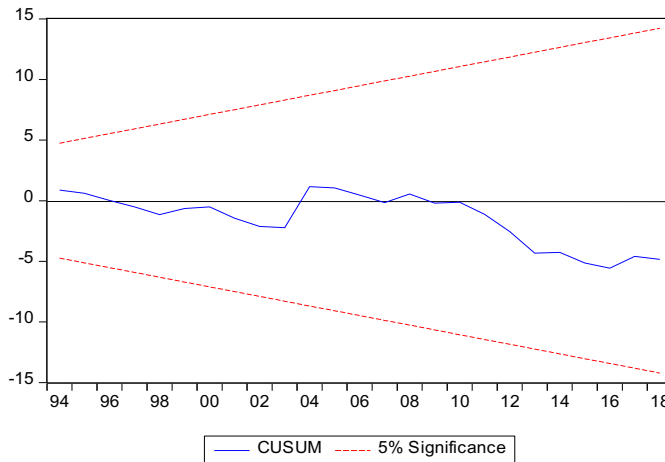
The total fertility rate has a positive and statistically significant influence on life expectancy in Nigeria. The idea is that higher fertility can be said to be an evidence of improved healthcare system and rising standard of living which bring about health and longevity. This finding did not conform to the studies of Delavari et al. (2016).

The coefficient of the ECM is negatively signed and statistically significant in line with theory. The coefficient (- 0.6235) of the ECM suggests that the

model converges back to equilibrium in the long run after the short run disturbance at the speed of 62.35 per cent. The adjustment will take roughly one year and six months, a relatively high speed of convergence, owing to the high ECM's coefficient. That is, the lower the coefficient of the error correction model, the longer will be the duration of adjustment back to equilibrium and vice versa. This further established the existence of a long run relationship among the series.

**Diagnostic Test Result**

The diagnostic tests revealed that the long-run model is statistically valid over time. The model has the correct specification, there is neither serial correlation nor heteroscedasticity among the residuals as revealed by the non-significant probability statistics of the respective tests. Furthermore, the plot of CUSUM statistics stay within control bounds (see the figure below).



**6. Conclusions and policy implication**

This study investigates the social, economic, and environmental factors that influence the growth of life expectancy at birth in Nigeria. This study is based on the Grossman's (1972) health model. The theory opines that household produces health based on their preferences, lifestyles, and their demand for medical care. The results show that growth of per capita income, education (literacy rate), total fertility rate, and degree of urbanization are positive and statistically significant in explaining the growth of life expectancy at birth in Nigeria. On the contrary, CO<sub>2</sub> emission has a negative and statistically significant effect on growth of life expectancy at birth.

The results are in line with theory and conform to the outcomes of some studies such as Delavari et al. (2016); Nathaniel and Khan (2019); Effiong et al. (2021); Siegel et al. (2022); and Rahman and Khan (2022), which established that social, economic, and environmental factors indeed influenced life expectancy at birth.

The results from the ARDL model show that life expectancy at birth in Nigeria is influenced by social and economic advancements in the country, as well as improvement in the environmental factor (CO<sub>2</sub> emissions). Intuitively, as the social and economic indicators in the country are improving, and CO<sub>2</sub> emission is reducing, the people tend to enjoy prolonged life.

The results tend to suggest that growth of per capita income, improve literacy rate, fertility rate, and degree of urbanization are important determinants of life expectancy in Nigeria. Also urban development is expected to be an important investment for the health sector.

The study was not able to capture some important determinants of improved life expectancy such as access to safe drinking water, smoking rate, calorie intake, crime rate, and per capita health expenditure, as well as other factors. This is as a result of dearth of these data in time series form and/or owing to the fact that the variables are missing over long periods, which would have constrained the study period. Future study could go a step further by capturing other key factors that influence growth of life expectancy by sourcing data from surveys. Also, future research can consider the use of non-numerical variables that enables the use of qualitative methodological approach.

All the variables considered in this study proved to be statistically significant in influencing life expectancy, that is, the socio-economic determinants such as growth of per capita income, literacy rate, urbanization, and fertility rate as well as environmental factor proxy by CO<sub>2</sub> emissions can be regarded as factors that influence life expectancy in Nigeria.

In the words of Grossman (1972) if investment in health brings about rising economic growth for a developing country, then health is a human capital. Therefore, people tend to spend more on education in order to earn higher income, a fraction of the higher income can be spent on health care (Hassan et al., 2017). There is need for more research in order to fully comprehend the

interplay between measures of health and forces that necessitate investments in health in an attempt to increase life chances of the individuals in Nigeria.

There should be emphasis on measures geared towards formulating and implementing appropriate socio-economic policies and programmes to raise per capita income, increase literacy rate, improved medical care and promote urbanization by the government. Also, policymakers should formulate policies that are environmental friendly in order to reduce the production of CO<sub>2</sub> emissions to the minimum and mitigate its effect on the environment so as to extend life expectancy.

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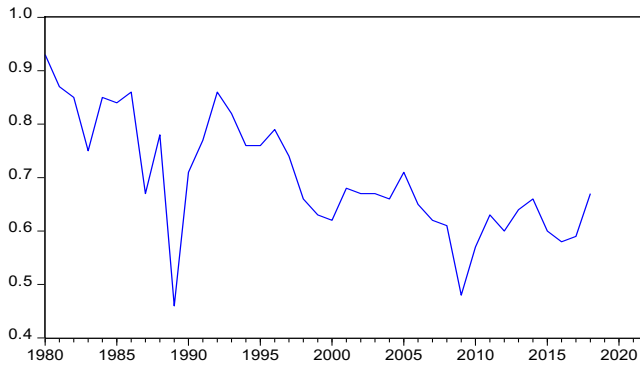


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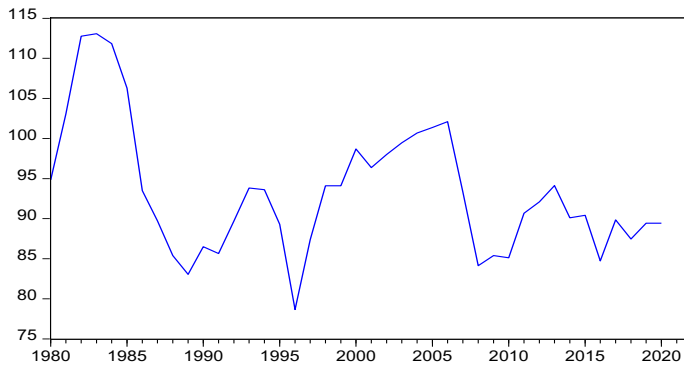
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Appendix

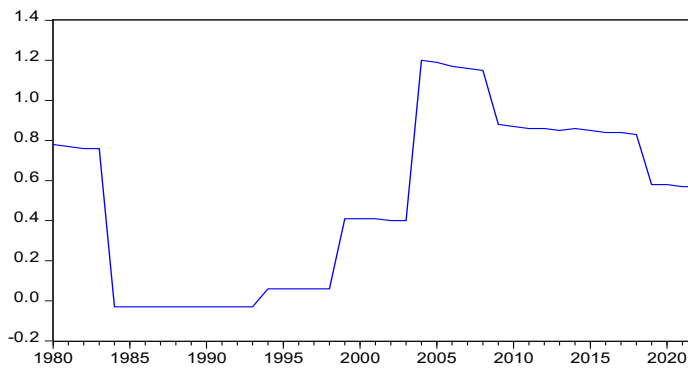
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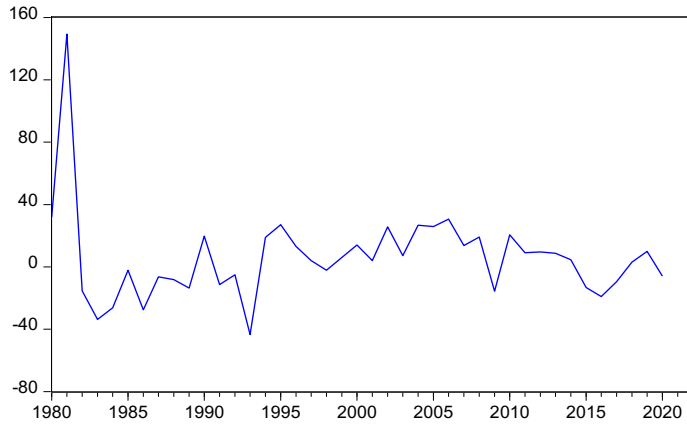
EDU



GLE



GPCI



TFR

