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Empirical Analysis of the Impact of Public Health Expenditure on Life Expectancy: Evidence from Nigeria

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Abstract

Life expectancy at birth in Nigeria remains relatively low despite improvement in public health expenditure overtime. This research work examines the impact of public healthcare expenditure on life expectancy in Nigeria from 1990–2022. Autoregressive Distributive Lag model was used to achieve this objective while Fully-modified Ordinary Least Squares and Dynamic Ordinary Least Squares approaches were employed for robustness check. Findings of the study reveal that public health expenditure and per capita income exert positive long run impact on life expectancy in Nigeria. Moreover, carbon dioxide emissions comply with expectation by having negative impact on the dependent variable in the country. The study recommends enhanced public health expenditure to improve life expectancy of the citizens coupled with establishing and empowering relevant law enforcement agencies to ensure effective controls aimed at minimizing the effects carbon dioxide emissions for sustainable economic growth

Keywords: Public Expenditure, Life expectancy, Autoregressive Distributive Lag Model
JEL Classification: C22, H51, I19

Contribution to/Originality Knowledge
This research has contributed to the existing body of literature as it addressed issues with regard to the impact of Public health expenditure on Life expectancy in Nigeria. Also it used carbon dioxide emission (CO2) as control variable and employed FMOLS and DOLS to serve as robustness check to the ARDL method used which makes it

1.0 Introduction

Improvement in human capital is regarded as an indispensable catalyst to economic growth and development in any nation. Explicitly, the neoclassical endogenous growth model postulates that, growth in human capital in terms of education and health has a positive effect on workers' productivity in the long run (Novigon et al 2012). Similarly, Grossman (1972) theorized that quality health considerably influences human capital development by increasing working time and utility derived from good health. Improving healthcare investment through public expenditure remains very vital in every nation's development agenda, as well as the United Nation sustainable development goal (SDG 3), which focus key targets that boost the health of a country's overall population (Oladosu et al., 2022).

In addition, Bloom et al. (2003) stressed that healthier individuals contribute to the economy in the following ways: (i) they are more productive and thus generally earn a higher income in the work place, (ii) they take little or no sick leave as a result, they are able to spend longer time working, (iii) they enhances their productivity by investing in their education and training; and (iv) they are likely to invest more because of the expectation of longer life. Therefore,

health is an important aspect of sustainable development, and its improvement should be the key development agenda of any nation.

Life expectancy at birth (LE) is one of the important indicators of population's health which is commonly used as barometer of health status of a country. It is referred to as the number of years a new child is expected to live if all other fundamental survival variables concerning mortality rates at the time of birth remain unchanged throughout a child's existence (UNDP, 2015). According to Radmehr & Adebayo (2022) long life expectancy is indispensable required for its crucial worth and for the essential fulfillment in life of each person. It is among the most important components of the Human Development Index (HDI). Improving life expectancy has been the key focus of several scholars and stakeholders. Longer life expectancy is related to increased productivity which serve as indispensable stimulant for sustainable economic growth and development (Raffin & Seegmuller 2014; Bekun et al., 2019).

Improvement in the life expectancy rate and general public health require adequate and efficient Public health spending. Investment in health, at the macro level, is expected to improve health conditions and hence, human development of the population. According to Polcyn *et al.* (2023) improving citizen's health with adequate expenditure by government is the most important things a nation can embark for its labour force to be competitive in the world stage. In pursuing this, leaders in Africa converged in a session called "the Abuja Declaration of 2001" and committed to increasing domestic health expenditure to at least 15% of tier yearly budgets to health care (Ayipe & Tanko, 2023). This resolution is derived from an economic theory that advocates government involvement in the healthcare sector. The health is a public good that deserves the involvement of the government for its ideal production.

Following the Abuja 2001 declaration, many African countries have attempted to make their budgets centered on achieving health improvement by increasing the share of health spending. For instance, in 1970, Nigeria's health care current expenditure was ₦12.480M, the amount rose to ₦52.80M and ₦501M in the year 1980 and 1990 respectively. This increasing trend continued as the amount rose progressively from ₦15.20B in 2000 to ₦103B in 2010, and further rose to ₦236.1 billion in 2022. In the same vein government spending on social and community service – which include of capital spending on health and education has also been improved with the same period. For instance, in 1980 health expenditure (capital) was ₦1.80B. According to CBN (2022), the figure increased to ₦2.10B in 1990, and further increased to ₦28.0B, ₦151.80B and N168.0B in 1995, 2000 and 2022 respectively. This evidently indicates that Nigerian government had made remarkable effort in improving health care delivery over the years.

Despite the substantial increase in public health expenditure over the years, it has not translated to improved life expectancy in Nigerian. For example, while life expectancy has been increasing moderately in the last two decades in several countries such as, China (76.9), Taiwan (80.7), India (70.5), Malaysia (73.2), Ghana (68.7), and South Africa (64.1); the average life expectancy in Nigeria has remained relatively unchanged as it is revolved around 56 years (UNDP, 2022). This implies that despite improvement in public health spending, the average life expectancy at birth in Nigeria has remained abysmally low.

From the empirical literature, numerous researches had, over time, reported conflicting result especially on the impact of Government health spending on health outcomes (Ogundari & Awokuse ,2018; Akinlo & Sulola,2019; Chireshe & Ocran, 2020; Ayipe & Tanko,2023) these studies reported positive relationship. On the contrary, studies such as Ojo *et al.* (2020), Osakede (2021) and Iyakwari *et al.* (2023) observed negative relationship between public health spending and health outcome indicators in Nigeria.

This empirical work is motivated by the above mentioned developments and attempts to re-examine the impact of public health expenditure on life expectancy in Nigeria. The remaining part of the paper is organized as follows: the second section dealt with the review of the conceptual and empirical literature. The third section is on the data, description of variables and econometric methodology used. The fourth part discusses the results and lastly fifths section summarizes the findings, concludes and offers policy recommendations.

2.0 Literature Review

2.1 Review of Conceptual Literature

2.1.1 Concept of Public Health Expenditure

Public health expenditure refers to the amount of money spent by government or its agencies on health care service delivery and other related programs aimed at boosting the health of the citizens. This include provision of health care infrastructure and its development such as Public dispensaries, clinics and Hospitals. Health care services, like treatment and diagnosis, supply of pharmaceutical products, health education, awareness campaigns and health promotion programs. Others include provisions of regulation and enforcement of health policies (Novigon et al., 2012; Ayipe & Tanko, 2023).

2.1.2 Concept of Life Expectancy

Life expectancy is the number of years that an individual is expected to live after they are born. Life expectancy is an integral component of Human Development Index (HDI). The HDI is the measure of human development that looks into three dimension of human development which include a long and healthy life, knowledge and a decent standard of living. According to UNDP (2015) Life expectancy is defined as the number of years a new child is expected to live if all other fundamental survival variables concerning mortality rates at the time of birth remain unchanged throughout a child's existence.

2.2 Review of empirical studies

The theoretical basis for analyzing the impact of public health expenditure on life expectancy in Nigeria is hinged on the Grossman (1972) theory. The fundamental proposition of this theory is that health is a long-lasting capital stock that yields an output of healthy time. It is believed that an initial stock of health was inherited by individual which depreciate with age and can be made better or improved through investment. In essence, health care expenditure is expected to translate into improvement in life expectancy and overall health status of a state. The Theory is relevant in the Nigerian context as it provides a framework for understanding the

relationship between health status, healthcare demand, health expenditure, and health outcomes.

On the empirical front findings from the previous studies on the contributions of public health care expenditure to health outcomes are mixed while some reported positive relationship others reported negative relationship and in some instances inconclusive findings were observed. For example, Using Fixed and random effect models, Rahman et al. (2018) examined the relationship between private, public and total health care and three selected health outcomes (life expectancy at birth, infant mortality rate and crude death rate) in SAARC-ASEAN region. It was found that public and private health expenditure improved life expectancy and significantly decreased infant mortality rates in the region. Similarly, positive relationships were reported by Ogundari & Awokuse (2018), Akinlo & Sulola (2019) and Chireshe & Ocran (2020) using SGMM, fixed effect and GMM methods respectively. The results revealed that health care expenditure decreased under 5 mortality rates and improvement in life expectancy in Sub-Saharan Africa. Also Ayipe & Tanko (2023) in their empirical works that investigated the relationship between public healthcare spending, mortality rate (under 5) and life expectancy in low-income countries of Sub-Saharan Africa, observed state health spending from domestic funds has a significant positive effect on the under-five mortality rate among the Sub Saharan African low-income countries.

On the other hand, Oladosu *et al.* (2022) empirically examined the impact of public health expenditure on health outcomes in Nigeria and Ghana using linear regression analysis and reported negative effect of public health expenditure on health outcome in both countries. Further, Balkhi *et. al.* (2021) examined the impact of health expenditures on healthcare systems and health status in Middle East and North Africa (MENA) region and found out that there exist negative relationship in the sense that some countries spend more on healthcare but have shorter life expectancy was observed.

The panel techniques or estimators employed by previous studies do not consider the context specificities of the relationship between public health expenditure and life expectancy in a particular country. This shortcoming (in the panel approach) has led researchers to seek for time series estimators that account for unique characteristics of individual countries such Nigeria.

Consequent upon this, Hosokawa *et al.* (2020) examine the relationship among healthcare spending and healthy life expectancy at birth using descriptive statistics and correlation analysis across all Japan's secondary medical areas. The result revealed significant regional disparities and that the number of medical personnel support clinics for home healthcare delivery facilities and home visit treatments, also expenditure per capita (dentistry) has positive relation with both life expectancy and healthy life expectancy. This finding tallies with the work of Li *et al.* (2021) which revealed that an increase in the healthy diet score based on food expenditure by a 1-unit will result in 0.07% increase in life expectancy among men alone, women alone, and men and women combined, respectively in the US. More so, In Iran, Shahraki (2019) investigated the causality between public health expenditures and life expectancy in the short and long term from 2000 and 2017 using the Johansen Cointegration

and Vector Error Correction models. The result showed a bi-directional causal relationship between public expenditure and life expectancy in both short and long term.

In the specific context of Nigeria, Zubair (2018) empirically studied the impacts of government health expenditure on health status (life expectancy rate, under-five mortality rate and infant mortality rate) covering 1985 to 2015. Engel-Granger cointegration was employed and three models were estimated for each of the outcome as dependent variable. It was observed that private health expenditure, gross domestic product per capita, physician per 1000 population and population density significantly in explained the variations in under-five and infant mortality in Nigeria. Furthermore, government expenditure on health, GDP per capita along with population density significantly in explaining the variations in life expectancy. Also, the number of physicians per 1000 people, population density and GDP per capita are statistically significant across the models. The implication of the findings is that health expenditure improved the health status in Nigeria. Similar positive relationship is reported in the work of Ochiaka & Akuma (2021) that examined the effect of health care expenditure on health outcomes in Nigeria using data from 1980 to 2020. Employing descriptive statistics and correlational analyses, the study used two proxies to measures health care expenditure (Percentage of public health care expenditure to GDP and Total health care expenditure per capita,) while health outcomes are measured by infant mortality, maternal and adult mortality and life expectancy. It was found that increase in both health care expenditure has positive relationship with life expectancy and negative with infant, adult and maternal mortality rates respectively.

Owumi & Eboh (2021) examines the impact of healthcare expenditure on life expectancy at birth in Nigeria from 2000–2017. Robust least squares regression was employed to estimate the model. The results show that out-of-pocket expenditure, general government health expenditure (domestic), and external health expenditure had significant positive effects on life expectancy in the country.

On the contrary, Ojo *et al.* (2020) employed ARDL technique to examine the impact of health expenditure on life expectancy in Nigeria from 1981 to 2018. The result revealed that health expenditure had insignificant impact on life expectancy. It was concludes that health expenditure had insignificant impact in enhancing life expectancy in Nigeria. Similarly, Iyakwari*et al.* (2023) employ ARDL bound test to Cointegration methods to empirically investigate the effect of health expenditure on life expectancy in Nigeria using time series data from 1990 to 2021. The result revealed a negative relationship between health capital expenditure, health recurrent expenditure in the long run, while out-of-pocket health expenditure had a positive relationship with life expectancy.

One noticeable gap from the literature reviewed is that very few empirical studies (Murthy et al. 2021; Radmehr & Adebayo, 2022) consider the impact of Carbon emission ($CO_{2)}$ on life expectancy in Nigeria. Carbon emission (CO_2) is considered as the key driver for environmental degradation which has adverse effects on health in several ways. It was reported that the Carbon emission (CO_2) and climate change exert negative effects on social and

environmental aspects of health such as clean air, safe drinking water, food, and shelter. Hence, increase in the mortality rate and ultimately negate life expectancy (WHO, 2020).

Nigeria's carbon emissions are relatively low compared to some other countries, particularly when considering its population and economic development. However, the country's economy is closely tied to oil and gas exports which contribute significantly to its greenhouse gas emissions and the emissions are likely to increase with government's desire to increase oil exploration and production. Nevertheless, the country has recognized the need to reduce its carbon emissions and has set a target to do so by 2030. Therefore, this study is aimed at providing improved empirical work by incorporating CO_2 in examining the impact of public health expenditure on life expectancy in Nigeria from 1990 and 2022.

3.0 Methodology

This section discusses the methodological techniques used to achieve the objective. It covers model specification, Source, definition and measurement of data, and estimation techniques.

3.1 Model Specification

The theoretical model adopted for this study is the Grossman (1972) health function that captures economic, social and environmental variables in the health function.

This is specified in equation 1 below:

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

H is a measure of individual health output and X is a vector of individual inputs to the health production function F. The above theoretical model was formulated for micro-level analysis but our aim is a macro-level analysis of the health function. Therefore, following the Fayissa & Gutena (2008) work that developed a macro level health production function based on the Grossman (1972) model. The model is then specified as follows:

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

Where, H Life expectancy at Birth (Health outcome), Y is the vector for economic input variables, S is for social input variables, and V stands for environmental variables.

For this research work, the economic variables include GDP per capita (GDPP), Public health expenditure (PHE), variables representing social factors include Education represented by Female literacy rate (FEMLIT) and variable representing environmental factors is carbon dioxide emissions CO_2.

The econometric model is specified in equation (3):

$$lnLEX_t = \alpha_0 + \alpha_1 lnGDPP_t + \alpha_2 lnPHE_t + \alpha_3 lnFEMLIT_t + \alpha_4 lnCO2_t + \mu_t \quad (3)$$

Table 3.1 Definition and Measurement of Variables

Variables	Definition	Measurement
Life Expectancy (LEX)	Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.	Life expectancy at birth, total (years)
Public Health Expenditure (PHE)	Public expenditure on health from domestic sources as a share of total public expenditure. It indicates the priority of the government to spend on health from own domestic public resources.	Domestic general government health expenditure (% of general government expenditure).
GDP Per capita (GDPP)	GDP per capita is gross domestic product divided by midyear population. Data are in constant 2015 U.S. dollars.	GDP per capita (constant 2015 US$)
Carbon dioxide emissions (CO_2)	Carbon dioxide emissions from liquid fuel consumption refer mainly to emissions from use of petroleum-derived fuels as an energy source.	Emissions CO_2 emissions from liquid fuel consumption (% of total)
Female Literacy Rate (FEMLIT)	Youth literacy rate is the percentage of people ages 15-24 who can both read and write with understanding a short simple statement about their everyday life.	Literacy rate, youth female (% of females ages 15-24)

Source: Word Bank (2022) World Development Indicators

3.2 Estimation Techniques

The estimation techniques used in achieving the objective of this work are in three steps. The first step involves conducting unit root tests to establish the stationarity property of the series by employing the Augmented Dickey-Fuller (1979) and Phillips-Perron (1989) unit root tests. In the second step, the study establishes the existence of a cointegration (long-run) relationship among the variables using ARDL bound testing procedure developed by Pesaran et al (2001).

The third step involves estimating the coefficients of the model using ARDL estimation technique developed by Pesaran & Shin (2001). The ARDL technique is applied because of its advantages over other cointegration methods such as estimating the long-run components of the model simultaneously addressing the shortcomings of omitted variables and autocorrelation and at the same time accepting variables irrespective of the order of integration (Abubakar & Kassim, 2016).

The ARDL model is specified as follows:

$$lnLEX_t = \alpha_0 + \alpha_1 lnLEX_{t-1} + \alpha_2 lnPHE_{t-1} + \alpha_3 lnGDPP_{t-1} + \alpha_4 lnFEMLIT_{t-1} + \alpha_5 lnCO_{2_{t-1}} + \sum_{t=1}^{p} \beta_1 \Delta lnLEX_{t-1} + \sum_{t=0}^{q} \beta_2 \Delta lnPHE_{t-1} + \sum_{t=0}^{r} \beta_3 \Delta lnGDPP_{t-1} + \sum_{t=0}^{s} \beta_4 \Delta lnFEMLIT_{t-1} + \sum_{t=0}^{t} \beta_5 \Delta lnCO_{2_{t-1}} c + \mu_t \quad (4)$$

In equation (4), "*ln*" stands for the natural logarithm of the variables; α_0 denotes the intercept or constant term; α_1, α_2, α_3, α_5, α_2 are the parameters that signify the magnitude and direction of the impact each variable has on Life Expectancy (LEX) and μ_t is the error term, representing the unobserved factors affecting Life Expectancy (LEX) that are not explained by the included independent variables.

After establishing the long-run relationship among the variables, an error correction model (ECM) is estimated to obtain the short-run coefficients. The ARDL specification of the ECM is presented below:

$$\Delta(lnLEX)_t = \beta_o + \sum_{i=1}^{P} \beta_1 \, lnLEX_{t-i} + \sum_{i=0}^{q} \beta_2 \, lnGDPP_{t-i} + \sum_{i=0}^{r} \beta_3 \, lnFEMLIT_{t-i} + \sum_{i=0}^{s} \beta_4 \, lnCO_{2_{t-i}} + \theta_I ECT_{t-1} + \varepsilon_t \quad (5)$$

In order to check the robustness of the result, Fully-modified ordinary least squares (FMOLS) and Dynamic ordinary least squares (DOLS) were employed. Pedroni (2001) developed the FMOLS estimation technique, it is a residual-based test that gives efficient results for cointegrated variables. Additionally, FMOLS is regarded as a reliable estimate, especially when dealing with small sample sizes, and it helps alleviate other issues related to serial correlation endogeneity (Merlin & Chen, 2021). On the other hand, Stock and Watson (1993) developed the DOLS to handle endogeneity (correlation between the independent variables and the error term) and serial correlation (correlation between error terms across time) issues often encountered in time series data.

4.0 Results and Discussion

4.1 Results of Unit Root Tests

Table 1 displays the result of the Augmented Dickey-Fuller (1981) and Phillips-Perron (1989) unit root tests. The results reveal that, with the exception of *ln*FEMLIT that is stationary at

level, the remaining variables exhibit unit roots at their levels, indicating non-stationarity. However, upon implementing first-order differencing, these variables attain stationarity [I (1)]. As a result, the null hypothesis proposing the non-stationarity of the variables was rejected.

Table 4.1: ADF and PP Unit Root Tests Results

	Level		First Difference		Status
Variables	ADF	PP	ADF	PP	
lnLEX	-1.737	-2.248	-3.468**	-3.439**	I(1)
lnPHE	-3.087	-1.119	-8.882***	-3.439***	I(1)
lnGDPP	-1.693	-1.795	-2.968**	-15.446***	I(1)
lnFEMLIT	-3.567**	-2.869**	-	-	I(0)
lnCO2	-2.516	-2.601	-6.101***	-6.700***	I(1)

Note: The Akaike Information Criterion (AIC) was used to arrive at the optimal lag length in the ADF test, and ***, ** indicates statistical significance at the 1% and 5% level respectively.

Based on the results of the unit root tests, it is concluded that the variables are integrated of mixed order i.e [I(1)] and [I(0)]. Consequently, this study employs ARDL bound testing procedure advanced by Pesaran & Shin (2001) to explore the existence of a cointegration relationship.

The results of the ARDL bounds test for cointegration reported in Table 4.2 indicate that the computed F-statistics (7.405) is higher than the upper bound critical value at 1% significant level. This implies that there is a cointegration (long-run) relationship among the variables in the model. Consequently, the null hypothesis of no cointegration is rejected in favour of the alternative, establishing a cointegration (long-run) relationship among the variables in the model.

Table 4.2: Results of ARDL Bounds Test for Cointegration

F-Statistic	k	Significance	Lower(bound)	Upper(bound)
		10%	3.03	4.06
7.405***	4	5%	3.47	4.57
		1%	4.4	5.72

Note: *** indicate 1% statistically significant level and k represent the number of independent variables. Unrestricted Constant and Unrestricted Trend are included in the test and the optimum lags selected by Akaike info criterion are (2, 0, 3, 3, 3).

With the cointegration (long-run) relationship among the variables confirmed, the next task is to estimate the long-run coefficients for the model using ARDL estimation procedure while Fully Modified OLS (FMOLS) and Dynamic Ordinary Least Squares (DOLS) are serving as robustness checks.

The results of the ARDL, FMOLS and DOLS as reported in Table 4.3 are consistent in all the instances. The methods reveal comparable coefficient estimates and significance levels,

indicating robustness of the findings. The results show that public health expenditure (lnPHE) exhibit positive and statistically significant coefficients. This implies that improved health status in Nigeria proxied by life expectancy at birth is associated with increased government expenditure.

Table 4.3: **Results of Long-run Estimated Coefficients**

	ARDL		FMOLS		DOLS	
Regressors	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
lnPHE	0.010***	2.969	0.013***	5.135	0.016***	4.468
lnGDPP	0.057***	3.898	0.138***	6.439	0.088**	2.400
lnFEMLIT	0.043	1.305	-0.011	-0.273	0.080	0.948
$lnCO_2$	-0.013***	-5.016	-0.028**	-1.827	-0.287**	-2.330
C	1.437***	4.335	2.171***	6.102	2.365***	4.835
R^2	0.912		0.977		0.987	

Note ***, ** and * indicate statistical significance at 1%, 5% and 10% respectively. The Akaike Information Criterion (AIC) indicated the optimal lag length of (2, 0, 3, 3, 3).

Specifically, the result indicates that a 1% increase in per capita public health expenditure is associated with, on the average, 0.010% to 0.016% increase in life expectancy at birth. . This lends credence to some previous studies (Ogundari & Awokuse 2018; Akinlo & Sulola 2019; Chireshe & Ocran 2020) which revealed that public health expenditure has significant and positive impact on life expectancy. However, the finding of this study is contrary with that of Iyakwari *et al.* (2023); Arthur and Oaikhenan (2017) which showed negative relationship between public health expenditure and life expectancy.

The coefficient on GDP per capita is positive and significant at the 1% level. It indicates that a 1% increase in per capita income will, on the average, lead to 0.057% to 0.088% increase in life expectancy at birth in Nigeria ceteris-paribus. This implies that higher levels of income will lead to improved public health infrastructure (such as, access to clean water and sanitation, improved education, better nutrition and the ability to pay for health care services and product) which will ultimately increase life expectancy. This finding is consistent with the work of Owumi and Eboh (2021) and Radmehr and Adebayo (2022) who reported positive relationship between Per capita income and Health status indicators in Mediterranean Countries and SSA respectively.

Education proxied by Female Literacy showed statistically insignificant relationship with life expectancy across all the models. This, perhaps, may not be unconnected with the social and economic barriers that prevent Girl-child from accessing education in Nigeria. According to UNICEF (2022) 7.6 million girls are not attending schools which represent 60% of out-of-school children in the country.

Table 4.4: Results of Short-run Estimated Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.438***	0.206	6.972	0.000
@TREND	0.001***	0.000	6.442	0.000
D(LNLEX(-1))	0.333***	0.101	3.307	0.006
D(LNGDPP)	0.009	0.013	0.727	0.480
D(LNGDPP(-1))	0.029*	0.014	2.123	0.054
D(LNGDPP(-2))	-0.033*	0.013	-2.573	0.023
D(LNFEMLIT)	0.026***	0.007	3.869	0.002
D(LNFEMLIT(-1))	-0.003	0.007	-0.415	0.685
D(LNFEMLIT(-2))	-0.026***	0.006	-4.227	0.001
D(LNCO2)	-0.008*	0.005	-1.790	0.097
D(LNCO2(-1))	-0.006	0.004	-1.426	0.177
ECT_{t-1}	-0.522***	0.005	-4.615	0.001
R^2	0.912			
F-statistic	14.600			0.000

Note ***, ** and * is an indicator of statistical significance at 1%, 5% and 10% respectively. The optimal lag length of (2, 0, 3, 3, 3) was selected using Akaike Information Criterion (AIC).

The effect of CO_2 emissions on life expectancy is negative and statistically significant in the ARDL, FMOL and DOLS results, suggesting that a rise in CO_2 emissions dampen the life expectancy. Specifically, a 1% increase CO_2 emission will, on average, lead to reduction in life expectancy by 0.013% to 0.029 % in Nigeria. This finding is in tandem with the work Murthy et al. (2021) on the link between life expectancy and CO_2 emissions that revealed that an increase in energy consumed is leading to increase in CO_2 emissions and consequently decrease life expectancy in the countries covered by the work. This outcome following the expectation, since carbon monoxide causes blood clotting and failing of the respiratory system (Radmehr & Adebayo, 2022).

The R-Squared (R^2) for the models ranges from 0.91, 0.95 to 0.97. This suggests that the independent variables jointly explain over 91% of the variation in the dependent variable and the model is fit and reliable for policy formulation and forecasting. The coefficient of the error correction term lagged by one period (ECT_{t-1}) is statistically significant and negative as expected. Thus, confirms the existence of conitegrating relationship between the variables. It also means that 52% of the deviations from the long-run will be corrected within one year.

4.4 Results of Diagnostic Tests

Diagnostic tests result is reported in Table 4.5. It shows that the ARDL model passed all the tests.

Table 4.5: ARDL-ECM model diagnostic tests

Test Statistic	Results
Serial Correlation: CHSQ(2)	1.8595[0.1977]
Functional Form: Reset F-stat(1,25)	0.1530[0.6990]
Normality: Jarque-Bera	0.9269[0.6129]
Heteroscedasticity: CHSQ(16)	0.8666[0.6123]

Source: Authors Computation (2024).

The Brown, Durbin & Evans (1975) test was conducted to check the stability of the estimated parameters. The (CUSUM) and (CUSUMQ) plots are within the critical bounds at 5% level of significance (see Figure 1 and Figure 2).This is implying that the coefficients of the estimated model are stable in the period covered by the study.

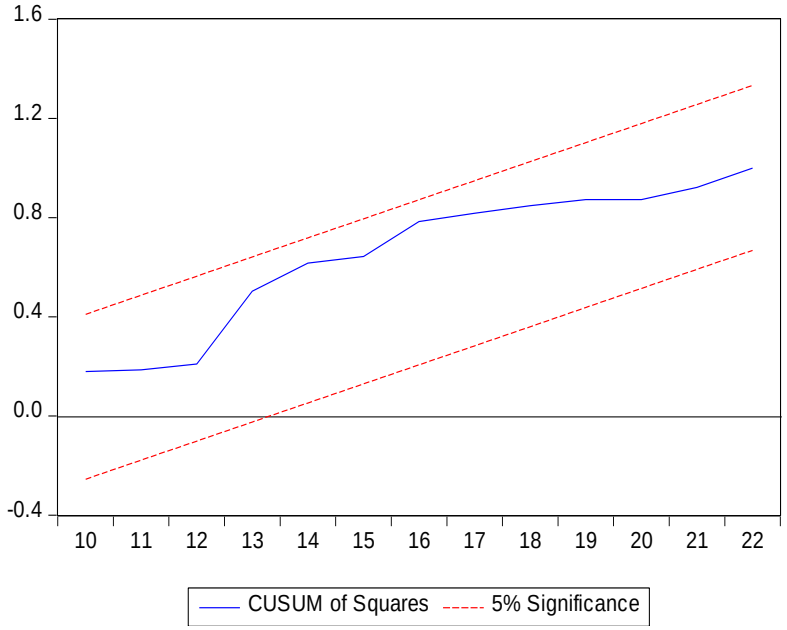

Figure 1. Plot of CUSUM of Square residual

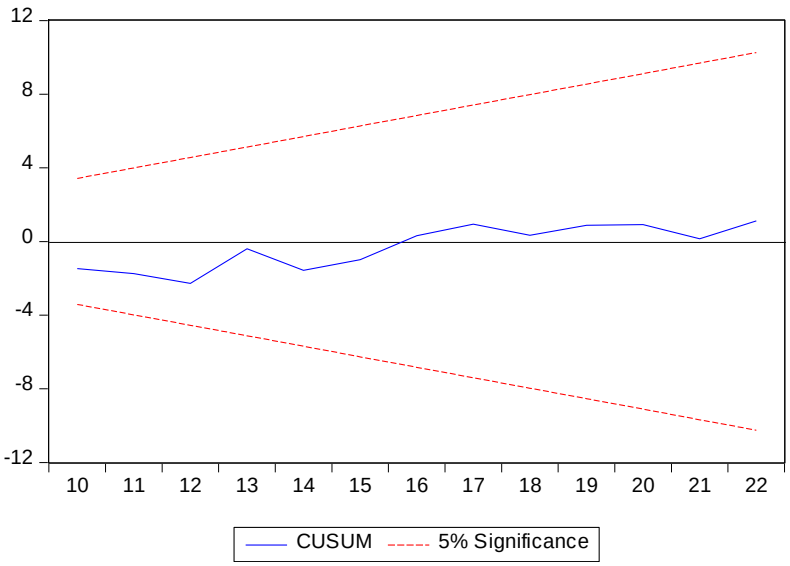

Figure 2. Plot of CUSUM

5.0 Conclusion and Policy Implications

This study employed the ARDL, fully-modified OLS (FMOLS) and dynamic ordinary least squares (DOLS) estimation techniques to analyze the long run impact of Public health expenditure on life expectancy in Nigeria from 1990 to 2022. The results shows that Public health spending has a significant positive effect on health outcome in Nigeria. Similarly it was found that per capita income growth rate had significant positive effect on life expectancy while carbon dioxide emissions ($CO_{2)}$ reduce life expectancy in Nigeria.

The policy implication of these findings is that continuous increase of the public health expenditure can improve life expectancy as well as improve environmental quality. Hence, the study recommends enhanced government expenditure to increase life expectancy of the citizens. Further, considering the critical implications of carbon dioxide emissions ($CO_{2)}$ on the health, there ais need for all relevant law enforcement agencies to implement effective controls aimed at minimizing the impact of the emissions and its attendant health effects. In addition, effective measures such as Public awareness, Conditional Cash Transfer (CCT) and Adolescent Girls Initiative for Learning and Empowerment (AGILE) programs should be improved to break the socioeconomic barriers to girl-child education in Nigeria.

In consideration of the fact that this study is focused on time series analysis or a specific country (Nigeria), its results and inferences could not be generalized. In addition, the study did not consider the nonlinearities of the long run impact of public health expenditure on life expectancy. Hence, future empirical studies could be worthwhile to address these limitations and improve on our findings.

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