



# Public Health Expenditure and Under-five Mortality in Nigeria: An Overview for Policy Intervention

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## Abstract

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**AIM:** This study looked at the contribution of the health expenditure by the government on under-five mortality in Nigeria.

**METHODS:** The autoregressive distribution lag technique was employed in this study in examining the long-run effect of public health expenditure on under-five mortality in Nigeria. Data were sourced from the World Development Indicators for the period 1985–2017.

**RESULTS:** Results from the study showed that though public health expenditure is statistically significant, it showed a positive relationship with the under-five mortality.

**CONCLUSION:** The implication of this result is that 1 unit increase in public health expenditure would improve increase under-five mortality rate by 1.56 units. However, in the Nigerian context, this can be better explained by the lack of proper health-fund coordination and other factors such as maternal education. Therefore, the study concluded by recommending that proper health-fund coordination should be put in place to ensure that budget allocated to the health sector is being spent properly.

## Introduction

Health expenditure covers a wide spectrum of health-care services as family sanitation, preventive and curative health service, emergency aid, and nutrition activities are an indication of the health status of any population. Health spending is an indicator of the final usage of goods and services that are health-based and also a capital investment in health infrastructure [1]. Furthermore, in another context, health can be seen as a way of measuring quality of life and it also should be noted that the value of health outcome is closely related to the health expenditure and financing in a country [2], [3], [4], [5].

Good health is imperative due to its ability to enhance labor productivity, growth of the country, and well-being of the people. Studies have shown positive impacts of health, economic, and individual growth. Studies such as Bakare and Olubokun [6] illustrated that health spending has a positive influence on health status, labor productivity and efficiency, and growth in the country. The health expenditure is beneficial to the growth of a country

and also a pre-requisite for efficiency, effectiveness, and productivity of the labor force (Fasoranti, 2015) [7]. The health service plays an important aspect in ensuring the enhancement of human capital development, high life expectancy (LEA), increased labor supplies, and the improvement in the performance of macroeconomic variables [6].

According to Novigno *et al.* [8], health expenditure in low-income countries is relatively low compared to heavy-income countries; this could be as a result of internal and external loans, inadequate tax revenues and foreign grants. Health expenditure in low-income countries is averaged between US\$13 and US\$21 as compared to health spending of high-income expenditure that exceeds the US \$2,000 in 2001 [9]. Meroyi (2018) [10] argues that while developed countries have succeeded in providing funding that would decrease the occurrence of diseases through funding and implementation of proper health policies, however, countries in West Africa are faced with challenges particularly ones surrounding health-care infrastructures, issues such as high infant/child mortality rate, poor health-care facilities, poverty, and insufficient budgetary allocation are contributing to the underdevelopment

of the West African regions (Nwakanma and Nnamdi, 2013) [11]. Nonetheless, fewer studies in West Africa have been able to study the effect of public spending on infant and child mortality.

Balk *et al.* [12] attributed the impact of the increasing infant mortality rates in West African countries to demographic factors, nutrition, illness injury, maternal factors, parental education, health-care delivery services, health-care amenities, and environmental conditions. West Africa countries are faced with challenges particularly ones surrounding health-care infrastructures, issues such as high infant mortality rate, poor health-care facilities, poverty, and insufficient budgetary allocation are contributing to the underdevelopment of the West African regions (Nwakanma and Nnamdi, 2013; Meroyi, 2018) [10], [11]. Root [13] using the population density to ascertain the environmental determinant of child mortality in West Africa. Furthermore, the author utilized information from the Demographic Health Survey, compared patterns from West, East, and South Africa regions which were analyzed based on population density and vector habitat data. Recent studies have been able to employ advanced techniques in the study of the contribution of government health expenditure (GHE) on infant and under-five mortalities. This includes Oyedele and Adebayo [14] study of health expenditure and health outcome among Economic Community of West African States and established dissimilarity in the health expenditure across countries and convergence within countries at a steady rate.

Notwithstanding, some countries in West Africa have made remarkable progress in lowering the rate of under-five mortality rate. In Niger, the improve health care in resolving diseases such as pneumonia and diarrhea has led to 22% decline in the under-five mortality rate [15]. Furthermore, the delivery of insecticide-treated mosquito net (ITN) has led to 25% reduction in mortality cases and 19% reduction arising from the effective implementation of nutrition intervention programs. In Liberia at the completion of 2010, the prevalence of malaria and malnutrition of under-five children was cut down by 2.2% as a result of the provision of ITN and basic care package (Bulger *et al.*) [16]. Furthermore, in Ghana, there have been a sharp decrease in infant and under-five mortalities through the intervention of programs such as the Community-based Health Planning and Services, Ghana Essential Health Intervention Project, and the assistance of community health-care personnel who are skilled to treat diseases such as diarrhea, acute respiratory disease, and malaria [15].

Generally, West African countries experience higher mortality rates than countries in North and Southern Africa. The low GHE among West and Central Africa countries could have led to very high mortality and morbidity rate amounting to 65% of the mortality burden for the 3.1 million deaths in which Nigeria accounts for the highest under-five mortality rate

with 46% while, some countries such as Mali, Niger, Cote d'ivoire, and Burkina Faso sharing 19% of the figure [17]. Contrarily to other West African countries, Ghana has shown considerable improvement in health outcomes as Adua *et al.* [15] findings showed that Ghana's health expenditure had grown from 4.5% in 2009 to 5.2% in 2012. Based on the author's findings, an improvement on the health outcome cannot be as a result of an increased government health spending.

Nevertheless, researchers have been able to give reasons to some of the shortcomings present in the health-care sector in Nigeria. For instance, Ogunsanya *et al.* (2018) [18] blamed Nigeria poor health performance to the fluctuating government revenue gotten from oil price. For instance, considering the country's budgetary allocation for health, the Federal Ministry of Health appropriation bill is 340.456 billion naira out of the total budget of 8.612 trillion naira in 2018 representing 3.95% of the total budget. Nonetheless, this is a reduction from the 4.23 and 4.16% in 2016 and 2017, respectively (Premium Nigeria, 2017) [19].

The 2018 health expenditure apportions 269.34 billion naira for recurrent expenditure and 71.11 billion naira for capital expenditure which is a far cry from the Abuja declaration that 15% of the yearly budget would be allocated to improving the health sector of their country. However, the performance of Nigeria in the reduction of under-five mortality has adversely affected the average performance of the Sub-Saharan region. Nigeria's under-five mortality rate is relatively higher than its contribution to under-five mortality reduction (Morakinyo and Fagbamigbe, 2017) [20]. Based on this background, this study presents a brief insight on Nigeria's government spending on health care and under-five mortality.

## Empirical Literature

Differences factors constitute of the amount of money and resources spent on health in various countries. In developing countries, including Nigeria, per capita, spending on health is very low, leading to poor access to quality health care, high morbidity, and mortality in addition to low productivity and economic growth. According to the United Nations (UN) World Development Report [21], improved health contributes to economic growth, improved health conditions, reduction on production losses, increases the enrolment of children in school, and better use of natural resources. Yorulmaz and Tahsin [22] found that infant mortality rate and proportion of the population age 65 and above both have statistically significant effects on per capita health-care expenditure.

Good health is a function of better health spending leading to human development, economic

growth, and development of any nation. Gottret and Schieber (2006) [23] stated a clear upward trend between countries' income levels and the levels of public and total health expenditure as a share of GDP. Huber *et al.* [24] observed that the length of democratic experience might be an important predictor of expenditure on education, health, and social security and welfare. Gupta *et al.* [25] included infant mortality rate in their study and emphasized that health expenditure decreased the death of infant who is under-five. The work of Filmer and Pritchett [26] found that doubling public spending from 3% to 6% of GDP would improve child mortality by only nine to 13%. Gupta *et al.* [27] undertook a cross country analysis of 56 countries and concluded that increasing public expenditure on health has the ability to reduce the mortality rates of infants and children in a population.

Similarly, the results of Feyisetan [28] and Bakare and Olubokun [6] revealed that LEA rate is negatively correlated with health-care expenditure both in the short- and long-run and income elasticity of health-care expenditure was below unity both in the short-run and long-run, respectively. Furthermore, Ude and Ekesiobi [29] showed that per capita health spending and per capita education expenditure have a significant effect on the under-five mortality rate in Nigeria, meaning that child mortality could significantly reduce with increased health spending in Nigeria. Micheal and Ramu [30] study concluded that public health expenditure and literacy/education improve health status by reducing infant mortality. A survey in sub-Saharan Africa shows that health-care expenditure significantly influences health status through improving LEA at birth, reducing death, and infant mortality rates (Jacob and Furgerson, 2012) [31]. Infant and under-five mortality are known to be the most important indicators for early childhood development and health status of the population for given countries [32]. Most studies found a clear relationship health expenditure and infant and under-five mortality rate [8], [30], [33], [34], [35], [36]. Edeme *et al.* [37] found that public health expenditure and health outcomes have a long-run equilibrium relationship. Furthermore, the results showed that an increase in public health expenditure improves LEA and reduces infant mortality rates. Boz and Kurtulus [38] observed that increase in health expenditures and income levels has a positive effect on the under-five mortality rate; also, the income distribution deterioration has a negative impact on the under-five mortality.

Nigeria is known for her high infant/mortality rate in the world which could be based on the health-care system's poor state in the country [17]. Meroyi (2018) [10] argues that despite the availability and accessibility of intensive care technology for infants, the infant mortality rate in the country remains very high. In spite of the global reduction in infant-mortality rates, Nigeria has been unable to make reasonable improvements statistically, as further statistics have revealed that up to 20% of child deaths in Sub-Saharan Africa still takes place in Nigeria. Edeme *et*

*al.* [4] maintain that a rise in government spending bridge the income inequality of the populace and also enable their access to financing quality health care. Researchers believe that increased public expenditure, financed health care, maternal education, increased per capita income reduces the rate of infant mortality [4]

In an empirical study, David [39] used the autoregressive distribution lag (ARDL) to establish a positive relationship between infant mortality and long-run government health spending, also the Granger causality technique and cointegration were to ascertain the correlation between infant-mortality and public health spending in Nigeria from 1980 to 2016. Similarly, Edeme *et al.* [37] in their work observe that there exists a long-run equilibrium between government health spending and health outcomes. Arun and Kumar (2016)'s [40] findings elicited that the rate of infant mortality and total population % more than 65 years have an inverse correlation with that of per capita public health expenditure. However, a recent study by Adewumi *et al.* [41]. revealed that there exists a significant association between infant mortality, neonatal mortality, and child mortality rates and public health spending in Nigeria.

However, the contribution of GHE is marginally low to be reflected in the effective action of the country's health-care system as a result of various factors examined by researchers. Yaqub *et al.* [42] confirmed that a rise in public health spending is less likely to improve the health status of the country if the issue of corruption is not properly addressed. Furthermore, Amaghionyeodiwe [43] studied the effect of GHE on the income inequality gap using the ordinary least squares (OLS) method of estimation. The study revealed that public health spending has no improvement in health infrastructure while it bridges the income gap between the rich and the poor. Furthermore, health expenditure would have a lesser impact on human development if certain factors are not taken into full consideration. These factors include corruption eradication, economic reform, transformational leadership, democratic principles, and social and political inclusiveness [44]. In a bid to tackle the issue, the authors recommended that the implementation of important health policies should improve national efficiency productivity [43], [45].

Boachie and Ramu [30] examined the effect Public expenditure on health status in Ghana employing the standard OLS and Newey-White method for the period of 1990–2002 after controlling from female participation, real capital per income, and literacy level and revealed that issue of infant-mortality rising because of public expenditure.

Furthermore, Boachie and Ramu [30] studied the nexus between public health spending and health outcomes in Ghana using the OLS and two-stage least square (2SLS) square estimators for the analyses showed the effect of public health expenditure in decreasing infant percentage of under-five mortalities. Furthermore, Odhiambo (2009) [46] examined 41 SSA countries for a period of 2000–2009 using the dynamic panel and

estimation method to explain the impact of public health expenditure in decreasing the rate of infant and under-five mortality. In Asian countries, Shetty and Shetty [47] study established an inverse connection between public health expenditure and infant mortality employing data from 34 Asian countries. Contrarily, Barenberg *et al.* [48] used the panel data to study the impact of GHE on the infant mortality rate of Indian state between 1983–1884 and 2011–2012. The study revealed that factors such as income per capita, urbanization, and rate of female literacy reduce the infant mortality rate.

Amoo *et al.* (2014) [49] contended that despite the global decreased rate of infant mortality in Nigeria, the country has not been able to make reasonable improvements statistically. In this regard, several researchers have been driven to understand the relationship between health outcomes and health expenditure [4], [5], [6], [42], [50], [51].

Moreover, with the aim of linking public health expenditure directly or indirectly to infant mortality and under-five mortalities in Nigeria, Similarly, Yaqub *et al.* [42] employed the OLS and 2SLS to study the impact of GHE on infant and under-five mortalities. The result shows that public health spending has an inverse relationship with the child and under-five mortality when corruption is involved. In the same vein, David [39] used the ARDL bounds testing approach and granger casualty to an empirical study of the connection between GHE and infant and under-five mortalities. The result established the negative impact of GHE, external health resources, and immunization on infant mortality both in the short and long run.

## Methodology

Based on the findings of the previous studies, this study builds its model. The rationale or the motivation for the study is hinged on the argument that government expenditure on health has the potential of reducing the rate of death associated with children under-5 years of age. This is through based on literature that government spending on health in terms of employing more qualified doctors and other health professionals, building of more health centers and hospitals, among other things that could aid effective health outcomes are of no doubt to reducing mortality relating to under-five.

### Model specification

As pointed earlier, the insight of the model is drawn from the previous studies who used ARDL cointegration approaches such as Osabohien *et al.* [52] and others who have worked on government expenditure such as the empirical study of Edeme *et al.* [4], Matthew *et al.* [3] among other studies carried out in this area.

Matthew *et al.* [3] in their empirical work argued that the ability of the government to control the effect of the emissions of greenhouse gasses contributes a lot to the low health outcome or low LEA in Nigeria. Based on this argument, this study seeks to further validate how government expenditure will help in mitigating this effect on under-five mortality. Therefore, based on the above argument, the baseline for the model is specified in equation (1)

$$UMR_t = f(BRC_t, CLW_t, CNI_t, CO_{2t}, EP_t, LEA_t, GHE_t) \quad (1)$$

Equation (1) above represents the implicit form of the study model, the explicit form of the model is depicted in equation (2). The explicit form of the model, as specified in equation (2), is built in the double log form.

$$UMR_t = A BRC_t^{\beta_1} CLW_t^{\beta_2} CNI_t^{\beta_3} CO_{2t}^{\beta_4} EP_t^{\beta_5} LEA_t^{\beta_6} GHE_t^{\beta_7} \cdot \mu_t \quad (2)$$

Since equation (2) is a non-linear model, which will not be possible to estimate using the ARDL, we, therefore, linearize it for us to be able to estimate it, as shown in equation (3).

$$UMR_t = \beta_0 + \beta_1 BRC_t + \beta_2 CLW_t + \beta_3 CNI_t + \beta_4 CO_{2t} + \beta_5 EP_t + \beta_6 LEA_t + \beta_7 GHE_t + \mu_t \quad (3)$$

According to Ejemeyowwi *et al.* [53], the variables are logged to have them in the same measurement unit and to verify that the measures are also Best Linear and Unbiased–BLUE. Furthermore, aside from integrating them to the same base (unit of measurement), another major rationale for logging the variables is to ensure the best outcome and reduce the incidence of heteroscedasticity (ensuring that the classical assumption of the OLS is not violated) in the model [54], [55], [56].

Where:  $UMR_t$ : mortality-rate, under-five (per 1000 live births) at time  $t$ .  $BRC_t$ : Birthrate, crude (per one thousand people) at time  $t$ .  $CLW_t$ : Children (0–14) living with HIV at time  $t$ .  $CNI_t$ : Children (ages 0–14) newly infected with HIV at time  $t$ .  $CO_{2t}$ :  $CO_2$  emissions at time  $t$ .  $EP_t$ : Electric power consumption (kWh per capita) at time  $t$ .  $LEA_t$ :  $LEA$ , total (years) at time  $t$ .  $GHE_t$ : Health expenditure, public (% of public expenditure) at time  $t$ .

$\mu_t$ : Error term

Furthermore, the predictors expected signs of coefficient  $\beta_0 > 0$ ,  $\beta_1 > 0$ ,  $\beta_2 > 0$ ,  $\beta_3 > 0$ ,  $\beta_4 > 0$ ,  $\beta_5 < 0$ ,  $\beta_6 < 0$  and  $\beta_7 < 0$ .

In equation (3) the ARDL model is outlined below:

$$\begin{aligned} \Delta UMR_t = & \delta_0 + \sum_{i=1}^p \delta_1 UMR_{t-1} + \sum_{i=0}^p \delta_2 \Delta BRC_{t-1} \\ & + \sum_{i=0}^p \delta_3 \Delta CLW_{t-1} + \sum_{i=0}^p \delta_4 \Delta CNI_{t-1} \\ & + \sum_{i=0}^p \delta_5 \Delta CO_{2t-1} + \sum_{i=0}^p \delta_6 \Delta EP_{t-1} + \\ & \sum_{i=0}^p \delta_7 \Delta LEA_{t-1} + \sum_{i=0}^p \delta_8 \Delta GHE_{t-1} \\ & + \beta_1 UMR_{t-1} + \beta_2 BRC_{t-1} + \beta_3 CLW_{t-1} + \beta_4 CNI_{t-1} \\ & + \beta_5 CO_{2t-1} + \beta_6 EP_{t-1} + \beta_7 LEA_{t-1} + \beta_8 GHE_{t-1} + \mu_t \end{aligned} \quad (4)$$

Using cointegration, the long-run relationship is measured employing the conditional ARDL model as outlined below:

$$UMR = \delta_0 + \beta_1 UMR_{t-1} + \beta_2 BRC_{t-1} + \beta_3 CLW_{t-1} + \beta_4 CNI_{t-1} + \beta_5 CO_{2t-1} + \beta_6 EP_{t-1} + \beta_7 LEA_{t-1} + \beta_8 GHE_{t-1} + \mu_t \quad (5)$$

The short-run dynamic relationship is measured employing the ECM stated as follow:

$$\begin{aligned} \Delta UMR = & \delta_0 + \sum_{i=1}^p \delta_1 UMR_{t-i} + \sum_{i=0}^p \delta_2 \Delta BRC_{t-i} + \\ & \sum_{i=0}^p \delta_3 \Delta CLW_{t-i} + \sum_{i=0}^p \delta_4 \Delta CNI_{t-i} + \sum_{i=0}^p \delta_5 \Delta CO_2 \\ & + \sum_{i=0}^p \delta_6 \Delta EP_{t-i} + \sum_{i=0}^p \delta_7 \Delta LEA_{t-i} + \sum_{i=0}^p \delta_8 \Delta GHE_{t-i} \\ & + \alpha ecmt_{t-1} + \mu_t \end{aligned} \quad (6)$$

$\delta$  represents the intercept;  $\mu_t$  implies white noise, also, it elucidates producers that are not clearly represented in the model;  $\delta_1$ - $\delta_5$  denotes the short-run elasticities (i.e., coefficients of the 1<sup>st</sup>-differenced predictors);  $\beta_1$ - $\beta_5$  denotes the long-run elasticities which is the coefficients of the predictors;  $ecmt-1$  denotes error correction term lagged for one period;  $\alpha$  denotes the speed of adjustment from short run to long-run equilibrium in case of shock;  $\Delta$  characterized first difference operator, and  $P$  specifies Lag length. The joint significance of the F test of the coefficients of the lagged levels of the variables was used to test the hypothesis of no cointegration amidst the variables against the presence of cointegration. The null hypothesis states the no cointegration between health expenditure and under-five mortality, which is provided as follows:

$$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8$$

The alternative hypothesis was established as:

$$H_1: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq \delta_7 \neq \delta_8$$

The F-test entails a non-standard distribution irrespective of the fact that the proxies are unified at order 0, which is [1(0)], or order 1, that is [1(1)]. The two sets of adjusted critical values show the lower and upper bounds used for inference (Pesaran *et al.* 2001). One set hypothesized that the proxies are unified at order 0, that is, [1(0)] and the other acquires all that is unified at order 1, that is, [1(1)]. The null hypothesis of the cointegration is rejected If the calculated F-statistics drops above the upper bound critical value. To sum up, if it falls between the lower and upper bound, then the outcome of the

hypothesis would be indecisive. The optimal lag length for the specified ARDL model was based on AIC.

### Data sources and measurement of variables

A time-series data were employed in this study 1985–2017 obtained from World Bank Development Indicators and various publications regarding health expenditures in Nigeria. The variables include the under-five mortality rate, birth rate (BRC), children living with HIV (CLW), children newly infected with HIV (CNI), CO<sub>2</sub> Emission, Electricity Power Consumption, Health Expenditure, and LEA (Table 1).

**Table 1: Data description**

Variables	Symbols	Source	Measurement
Dependent variable			
Under-five mortality rate	UMR	WDI	per 1,000 live births
Birth rate crude	BRC	WDI	per 1,000 people
Children living with HIV	CLW	WDI	Between ages 0 and 14
Children newly infected with HIV	CNI	WDI	Between ages 0 and 14
Carbon dioxide emission	CO <sub>2</sub>	WDI	Kiloton (KT)
Electricity power consumption	EP	WDI	kWh per capita
Life expectancy at birth	LEA	WDI	Total years
Government health expenditure	GHE	WDI	(% of government expenditure)

Source: Authors. WDI: World development indicators.

## Results and Discussion

The model in this study was subject to econometrics and statistical analysis and the results were presented below:

### Descriptive statistics

The proxies' features employed in this research work is been examined through a descriptive analysis which gives a basic summary of the variables and their measures (Table 2).

### Estimates from the unit root test

Granger *et al.* (1974) and Granger (1986) [57], [58] have suggested that peradventure time-series predictors are non-stationary, all statistical results of regression will differ from traditional coefficient theory and would, therefore, be misleading. Whether or not the proxies used had a unit root in the analysis was included in the ADF test (Table 3).

**Table 2: Description of the variables used in this analysis**

	UMR	BRC	CLW	CNI	CO <sub>2</sub>	EP	LEA	GHE
Mean	157.7684	42.18705	157157.9	38052.63	82872.08	113.6563	48.6120	6.6784
Median	157.3000	42.5350	170000.0	39000.00	95055.97	120.6351	48.2460	6.4800
Maximum	204.3000	43.3630	210000.0	43000.00	106068.0	156.7972	52.5490	9.1900
Minimum	111.6000	39.8380	63000.00	27000.00	37869.11	74.4906	45.8770	3.7300
SD.	30.4409	1.1050	49813.28	4527.370	24019.45	28.3719	2.3405	1.5133
Skewness	0.0231	-0.7560	-0.5563	-0.9652	-1.092457	-0.1395	0.2978	-0.1783
Kurtosis	1.6817	2.3403	1.9414	3.1485	2.557581	1.5931	1.6226	2.3035
Jarque-Bera	1.3773	2.1544	1.8672	2.9676	3.934251	1.6286	1.7828	0.4846
Probability	0.5022	0.3405	0.3931	0.2267	0.139858	0.4429	0.4100	0.7847
Sum	2997.600	801.5540	2986000	723000.0	1574569.	2159.469	923.6280	126.8900
Sum Sq. Dev.	1667974	21.9793	4.4710	3.6908	1.0410	14489.45	98.6057	41.2258

Source: Authors using E-views 9.

**Table 3: ADF unit root test**

Variables	ADF level	ADF 1 <sup>st</sup> diff	Mackinnon critical value			Order of integration
			1%	5%	10%	
IMR	-0.9387	-7.3198	-3.752946	-2.998064	-2.638752	I (1)
BRC	1.8642	-3.6548	-4.416345	-3.622033	-3.248592	I (1)
CLW	-1.9528	-3.9329	-4.498307	-3.658446	-3.268973	I (1)
CNI	-3.9187	-1.9364	-3.808546	-3.020686	-2.650413	I (0)
CO <sub>2</sub>	-2.5588	-5.2421	-3.689194	-2.971853	-2.625121	I (1)
EP	-0.9115	-6.7122	-3.689194	-2.971853	-2.625121	I (1)
LEA	-4.8368	-1.4965	-4.309824	-3.574244	-3.221728	I (0)
GHE	-2.0726	-4.8770	-3.886751	-3.052169	-2.666593	I (1)

Source: Authors using E-views 9.

ADF unit root testing of the proxies specifies that all the proxies that include under-five mortality rate (UIMR), BRC, CLW, carbon dioxide emission (CO<sub>2</sub>), electricity production (EP), and GHE attained their stationarity at first difference which indicates they were unified of order one. Therefore, since all variables did not attain stationarity at the same order of integration, this study made use of the ARDL Bounce test to estimate the model.

**ARDL bounds test for cointegration**

This test is performed to assess the long-run equilibrium between health expenditure and under-five mortality in Nigeria.

The finding in Table 4 shows that F-statistics goes beyond the critical value of the upper limit at a significant level of 5%, indicating that there is a long-run relationship between spending on public health and under-five mortality in Nigeria. Figure 1 presents the ARDL model selection employing the AIC.

**Table 4: ARDL bounds test result**

Test-statistics	Value	K
F-statistics	6.465772	7
Critical value bounds (%)		
Significance	I (0)	I (1)
10	2.03	3.13
5	2.32	3.5
2.5	2.6	3.84
1	2.96	4.26

Source: Authors. ARDL: Autoregressive distribution lag

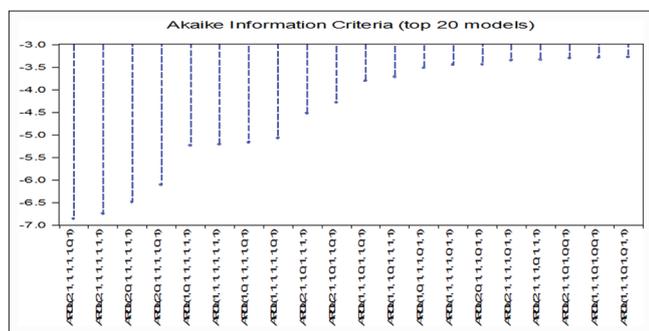


Figure 1: Autoregressive distribution lag model selection criterion

Based on the optimal model [ARDL (2, 1, 1, 1, 1, 1, 0, 1)], the normalized cointegrating equation for the ARDL regression can be specified as:

$$\begin{aligned}
 \text{Cointeq} = & \text{UFMR} - (-4.6211 * \text{BRC} + 0.0007 * \\
 & \text{CLW} - 0.0008 * \text{CNI} - 0.0002 * \\
 & \text{CO}_2 - 0.0004 * \text{EP} - 25.2994 * \\
 & \text{LEA} + 1.1560 * \text{GHE} + 1577.8746
 \end{aligned}$$

**Table 5: Long-run relationship estimation**

Variables	Coefficient	Standard error	T-stat.	p-value
BRC	-4.621063	1.515250	-3.049703	0.0928
CLW	0.000653	0.000080	8.195696	0.0146
CNI	-0.000785	0.000146	-5.361402	0.0331
CO <sub>2</sub>	-0.000151	0.000014	-10.825701	0.0084
EP	-0.000448	0.005528	-0.081008	0.9428
LEA	-25.299415	1.784368	-14.178359	0.0049
GHE	1.156001	0.129409	8.932944	0.0123
C	1577.874	133.597482	11.810661	0.0071

Source: Authors using E-views 9.

Birthrate (BRC) has a negative relationship with the under-five mortality showing a one-unit rise in birthdate would bring a 4.62 unit decrease in the under-five mortality rate. CLW has a direct relationship with the under-five mortality as a one-unit rise in BRC would bring a 0.0007 unit increase in the under-five mortality rate. Children within the ages of (0–14) years newly infected with HIV (CNI) had a negative relationship with the under-five mortality rate as one unit rise in BRC would bring a 0.0008 unit decrease in under-five mortality rate.

CO<sub>2</sub> had an inverse relationship with the under-five mortality as contrary to “a priori” expectation that is a one-unit increase in CO<sub>2</sub> would result in a 0.000151 unit decrease in UIMR. A one-unit increase in EP would result in a reduction in under-five mortality by 0.000448 unit. LEA had an inverse relationship with the under-five mortality which is in line with theoretical expectations. In essence, a one-unit increase in LEA would bring about a 25.299 unit decrease in under-five mortality. GHE on health had a positive relationship with the under-five mortality which is contrary to a priori expectations. A one-unit increase in government expenditure on health would result in a 1.156 unit increase in under-five mortality rates (Table 5).

The result in Table 6 presents the coefficient of the ECM (-1) is 0.112083, although it is positive, it satisfies the condition of lying between 0 and 1. This shows that when there is disequilibrium, the speed at which the economy will return to equilibrium, in the long run, is 11%. In the short run, BRC and GHE have an inverse relationship with the under-five mortality which implies a one-unit rise in BRC and GHE would lead a 1.85 and 0.05 unit decrease in under-mortality rate, respectively.

**Table 6: Short-run relationship estimation**

Variables	Coefficient	Standard error	T-stat.	p-value
D (UFM (-1))	-0.183291	0.054303	-3.375328	0.0777
D(BRC)	-1.851322	1.330913	-1.391017	0.2988
D(CLW)	-0.000049	0.000004	-12.039189	0.0068
D(CNI)	0.000012	0.000007	1.704681	0.2304
D (CO <sub>2</sub> )	0.000003	0.000001	5.025213	0.0374
D(EP)	0.004137	0.000513	8.056675	0.0151
D(LEA)	2.835631	0.225520	12.573771	0.0063
D(GHE)	-0.051993	0.003651	-14.241047	0.0049
ECM (-1)	0.112083	0.014418	7.773938	0.0161

Source: Authors.

### Diagnostic test and stability test

The ARDL model is confirmed with the use of certain diagnostic and stability checks. This is to ensure that the model is unbiased and robust to make the correct statistical inferences. The diagnostic test applied in this study includes heteroskedasticity test, Ramsey RESET, and Jarque-Bera test are presented in Table 7.

**Table 7: Result from the diagnostic**

Heteroskedasticity test: Breusch-Pagan-Godfrey			
f-statistics	1.338495	Probability F(15,2)	0.5094
Observation *R-squared	16.36938	Probability Chi-square (15)	0.3579
Scaled explained SS	0.075578	Probability Chi-square (15)	1.0000
Jarque-Bera test			
Jarque-Bera	1.246348	Probability	0.536240
Ramsey reset test			
	Value	Df	p-value
f-statistics	0.035153	(1.1)	0.8820

Source: Researcher's compilation.

The Breusch-Pagan-Godfrey test was verified with ARDL residual heteroskedasticity. Results from Table 7 indicate that the R-squared has a probability value that is more than 5% which specifies that we do not reject the null hypothesis which states that no heteroskedasticity present in the model. To determine if the ARDL residuals were normally distributed, the Jarque-Bera test statistic was carried out. The probability value of the Jarque-Bera test is higher than 5% which shows that the ARDL residuals are normally distributed in the findings. While Ramsey RESET test statistic was measured employing the ARDL functional misspecification, the results indicate that the probability level is  $>0.05$  (5%); so, we confirm that the null hypothesis was accepted, implying the functional form of the ARDL model.

### Stability test

This study adopted the use of the cumulative sum test and the cumulative sum of squares residual test (CUSUM) to estimate the stability model. Figure 2 indicates that the CUSUM and CUSUM of SQUARES residual tests of the ARDL model. Figure 2 confirms that all the plots in CUSUM and CUSUM of squares residual test rest within the significance level of 0.05. This further implies that the estimated parameters of the equation in the ARDL model are constant and stable to confirm and validate the outcome from the long-run and short-run relationship of the ARDL cointegration bound test, furthermore, robust and stable ARDL model meets the unbiased statistical inferences.

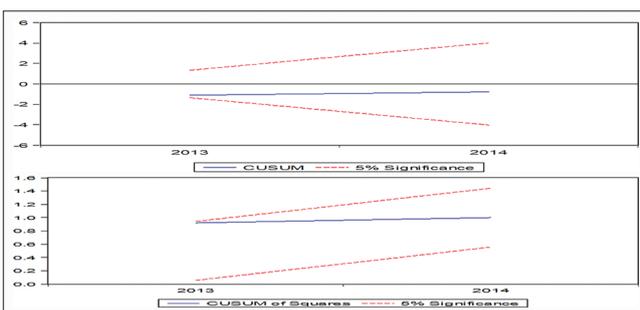


Figure 2: Test of model stability. Source: Authors

The findings showed that the average number of deaths among under five was 157.76/1000 live births, and there has also been a decline in the rate of under-five mortality; however, this decrease is at a slow pace. On the other hand, BRC had a mean value of 42.18, it also ranged between 39.8 and 43.3/1000 birth during this period. CLW from age 0 to 14 years had an average value of 157,157.9, a rapid increase of CLW was observed during this period from 63,000 to 210,000. CNI between the ages 0 and 14 years had a mean of 38,052, the value also ranged between 27000 and 43000 kt. There was an increase in CO<sub>2</sub> from 37869 to 106068. Electricity generated over that same period had an average value of 113.65 KWh per capita. Therefore, based on the findings, a new born in Nigeria is expected to live for about 49 years on the average. Depending on the time of birth, such a child has the capacity to live a minimum of 45 years and a maximum of 52 years. On the other hand, the government spent an average of 6.6% of its total budget on healthcare with a standard deviation of 1.5%. The minimum percent of government budget spent on health-care system in Nigeria is 3.7% and a maximum value of 9.1%.

According to the findings of the study, BRC has a negative relationship with the under-mortality rate in both the long- and short-run, which could mean that an increase in BRC would result to reduction of the under-five mortality rate. Furthermore, there exists an indirect relationship between BRC and under-five mortality rate as mediating factors such as better and more improved health-care facilities, proper education of mothers, proper ante-natal, qualified doctors, trained midwives, and nearness to health centers could come into play in reducing the rate of under-five mortality and increasing the BRC. Moreover, in the long run, children who are newly infected with the HIV virus would decrease the rate of under-five mortality if the disease is curtailed with the following steps such as ensuring quality health care, training medical personnel, and sensitizing of citizens.

Based on the findings, surprisingly, in the short run, there is a negative relationship between the CO<sub>2</sub> and under-five mortality as a possible explanation could be that the fact that CO<sub>2</sub> may not cause direct harm to the child or lead to child mortality in the short run. However, the impact on the long run could be very drastic and lead to an increase in the under-five mortality rate. This supports the findings of Osabohien *et al.* [59] that CO<sub>2</sub> has an adverse effect on health in the long run.

Furthermore, increased and constant access to the power supply in both rural and urban areas would result in the proper functioning of health-care facilities, better living conditions for the children. The improvement in power supply would have an indirect impact on the reduction of under-five mortality in the long run [60]. Based on the descriptive analysis in the study,

Nigeria's LEA had an average of 49 years, therefore increasing the LEA rate, the under-five mortality rate would be reduced if factors such as per capita income, better education, employment, and poverty reduction are taken under consideration. This supports the claims of Edeme *et al.* [37] that public health expenditure performs a mediating role in improving LEA and decreasing child mortality rate.

Expectedly, GHE has a negative relationship with the under-five mortality rate in the short run. This finding is in line with Adewunmi *et al.* [41] that public health expenditure has a significant impact on the reduction of the under-five mortality rate. However, this can only be reflected in the short run. Although, as opined by Yaqub *et al.* [42], Egharevba *et al.* [44], and Nwanosike *et al.* [45], this cannot be reflected in the long run as the contribution of government is slightly low to be reflected in the Nigerian health-care system.

## Conclusion

This paper analyzed the contribution of public health expenditure on the under-five mortality. The results show that BRC, CO<sub>2</sub>, LEA, and CNI have negative significant effects on the under-five mortality rate in the long run. In the short run, BRC, CLW, government expenditure has a negative significant impact on under-five mortality rate.

The findings of this study showed that it is necessary that the Federal Government of Nigeria introduced programs that will create awareness concerning the adverse effect of CO<sub>2</sub> on the individuals. Furthermore, an environmental sanitation plan that separates residential and industrial areas should be implemented as the emission of carbon dioxide has a long-run adverse effect on the health of individuals, most especially children. It is also imperative for governments in Nigeria to increase their shares of public health spending to better outcomes. As an increase, public expenditure should be reflected in the provision of quality health-care facilities to CLW.

The government should pay close attention to factors such as employment, increase per capita income, quality education, poverty reduction, and better living condition for individuals that have indirect impact on the reduction of under-five mortalities in Nigeria. Finally, an increased share in the GHE would be beneficial in the provision of health amenities to curb a high under-five mortality rate in the country.

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