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Nexus Among Public Health Expenditure, Environmental Pollution, Governance and Health Status: Empirical Perspective from Nigeria

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Abstract: The study, empirically examines the nexus among public health expenditure (PHE), environmental pollution, governance (QoG) and health status in Nigeria using annual time series data spanning from 1981-2020. Autoregressive distributed lag (ARDL) approach and two stage least square (2SLS) techniques were utilized. Data on PHE, environmental pollution captured by CO2 emission and governance (QoG) measured by corruption perception index (CPI) were regressed on infant mortality rate (IMR) and under five mortality rates (U5MR) as measures for health status. Generally, there is evidence of long-run association between the various variables in the respective model specification. The results reveal (i) a negative and significant effect of PHE on both health status, implying that a 1% increase in PHE reduces IMR and U5MR by 0.03%; (ii) a significant and negative effect of CO2 emissions on health status, which imply that a 1% increase in CO2 emissions will reduce U5MR and IMR respectively by approximately 0.05%. (iii) QoG measured by CPI has a negative though statistically insignificant effect on health status, showing that a percent increase in CPI approximately decreases IMR and U5MR by 0.03%, (iv) a negative and significant effect of GDP per capita on health status which imply that economic growth is associated with an improvement in the health status of the population. Here a percent increase in per capita income reduces IMR and U5MR by 0.43 and 0.49 percentage point respectively. The study recommends that there is need for policymakers in developing countries like Nigeria to aggressively deploy fiscal policy to boost allocations on public health expenditure and ensure progress across all four pillars of sustainable development through good governance devoid of corruption in term of misallocation of public resources, poor management and better institutions as these are essential for both individual and societal well-being..

Keywords: 2SLS · Public Health Expenditure · CO2 emission per capita · Quality of Governance · Health Status.

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Introduction:

Health is a resource with innate value, because it is essential for inclusive economic and social development. It serves as an essential stimulus for development and growth of a sustainable economy and it relates to the four pillars of sustainable development which include economic, social inclusion, environmental sustainability and effective governance. Advancement in each of these areas is necessary for both individual and societal well-being (Sustainable Development Solutions Network, 2014). These four pillars are known to affect the health status of the population. The development of a healthy population is what drives a nation's economy and people are a country's most valuable resource for sustainable development as COVID-19 pandemic outbreak has demonstrated.

However, the improvement of population health status and the promotion of a secure and healthy environment are now top governmental priorities and a significant concern on a global scale. This is because of the demands of Sustainable Development Goal 3 (SDGs 3), which aptly states that by 2030, everyone, regardless of age, live healthy lifestyles and promote wellbeing inclusive of reduction in maternity ratio to less than 70 per 100,000 live births, end preventable deaths of new-borns and under 5 mortalities to at least as low as 25 per 1,000 live births, reduction in number of death and illnesses from environmental pollution among others (United Nations, 2015).

Consequently, the quality of a country's human capital is determined by the degree of government health expenditure as demonstrated by Anyanwu and Erhijakpor (2007). However, Makuta and O'Hare (2015) argued that increased public health spending is a necessary but insufficient condition to ensure better health outcomes, however, they did not address the problem precisely. To achieve the desired improvement on the health status of the population, efficient resource management is required. Environmental pollution has grown to be a significant problem on a global scale since it worsens climate change and has a negative impact on people's health due to an increase in morbidity and mortality rates (Omri et al, 2022). In addition, governance also has a significant effect on the health of the people and is seen as a crucial and indispensable steering tool for sustainable development (Van Zeijl-Rozema, et al, 2008). Poor governance, such as corruption, hinders the provision of healthcare services, which negatively affects the citizens' state of health. Corruption has been dubbed an "African problem" (Cockroft, 2012 cited in Mhango & Chirwa, 2018).

The study was undertaken with the broad objective of examining the nexus among public health expenditure, environmental pollution, governance and health status in Nigeria. Specific objectives are to: (1) examine the effect of public health expenditure, CO2 emission and quality of governance on health status of the population in Nigeria. (2) Determine the long-run association among public health expenditure, CO2 emission and quality of governance and health status of the population in Nigeria.

The key contribution of this Study: this is the first study to the best of our knowledge that examines the nexus among public health expenditure, environmental pollution, governance and health status in the literature, especially in Nigeria. Previous studies in Nigeria that considered related study did not incorporate the effect of governance in their model framework. Most of these

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studies only focused on examining the relationship between public health expenditure, environmental pollution and Health outcomes or any two of the variables while systematic analysis of all four of these variables (public health expenditure, environmental pollution, governance and health status) are still rare in the literature. This is novel aspect of this study.

The sequence of the study is structured as follows. Following the introduction, session 2 is the theoretical framework and empirical literature. Section three presents the research method while section four presents the empirical findings, results and discussions. Lastly, section 5 presents the conclusions and recommendations.

2. Review of Related Literature

2.1.Public Health Expenditure, Economic Growth and Health Status.

The correlation between public health expenditure, economic growth and health status/outcomes have been the subject of a plethora of empirical research over the years. Studies such as Nwakanma and Ibe (2014), Boachie & Ramu (2016) and Edeme, et al (2017) examined the link between public health expenditure (PHE) and health outcomes both in Nigeria and Ghana employing different technigues in their analysis. They concluded that public healthcare expenditure is associated with improvement in health status. Boachie, Ramu & Polajeva (2018) re-examined the link between government health expenditure and health outcomes in Ghana within the period of 1980-2014 using life expectancy, infant and under five mortality rates as measures for health outcomes. The study employed both OLS and 2SLS estimator, the results revealed that aside from income, PHE contributed to the improvements in health outcomes in Ghana. Edeme & Olisakwe, (2019) linked public health expenditure, economic growth and health outcomes in Nigeria from 1981-2017 and adopted the pairwise granger causality among them. The finding suggests increase in public health expenditure decreased infant mortality rate (IMR) while IMR is negatively correlated with economic growth. Also, the direction of causality among public health expenditure, IMR and growth is unidirectional, from public health expenditure to growth.

2.2. Relationship between Public Health Expenditure, Governance and Health Status

Empirical studies on public health expenditure, governance and health status are reviewed as follows. Such studies such as Makuta & O'Hare (2015) used two staged least square (2SLS) on panel data from 43 countries in SSA between 1996-2011 to estimate the effect of public health spending (PSH) and quality of governance (QoG) on under five mortality (U5M) and LE controlling for GDP per capita and other socio-economic factors. The result showed that improving QoG would improve health outcomes in SSA, while the same increase in PSH is twice as effective in reducing U5M and increasing LE in countries with QoG when compared with countries with poor QoG.

Yaqub, Ojapinwa & Yussuff (2016) used OLS and 2SLS to determine how effectiveness of public health expenditure (PHE) is affected by governance in Nigeria between 1980-2008. PHE, governance captured by corruption perception index were regressed on IMR, U5M and life expectancy. The result obtained showed that PHE has negative effect on infant and under five mortalities when the governance indicators are included. This implies that increasing PHE is less likely to lead to improvement in health status unless corruption issue is addressed.

Ahmad & Hasan (2016) analysed the impact of public health expenditure and governance on health outcomes in Malaysia between 1984 and 2009. The result based on Autoregressive Distributed Lag (ARDL) showed that a stable long-run relationship exists between health outcomes (IMR, U5MR and life expectancy) and their determinants (PHE and governance): income level, public health expenditure, corruption and government stability. The results also revealed that public health expenditure and corruption affect long and short run health outcomes in Malaysia.

Mhango and Chirwa (2019) examined the link between public health expenditure, governance measured by corruption perception index and health outcome (infant mortality) in Malawi between 1990-2017. The results shows that public health spending worsens health outcomes when there is poor governance. Similarly, Osakede (2020) taking into account the role of governance by assessing how the quality of governance directly affects health status using time series data in Nigeria from 1980-2017 and indirectly as a mediator for the effectiveness of public health spending. Using 2SLS the results show that PHE had no significant effect on health outcome except when interacted with governance quality which conform with the study of Yaqub et al (2016) and Mhango & Chirwa (2019) above.

2.3. Relationship between Public Health Expenditure, Environmental Pollution, Governance and Health Status.

A relatively large numbers of scholars have examined the relationship between public health expenditure, environmental pollution and health outcome. However, no none literature to the best of our knowledge has examined the relationship among public health expenditure, environmental pollution, governance and health status, especially in the context of Nigeria. Here, we reviewed literatures on the three variables - public health expenditure, environmental pollution and health outcome. For instance, studies from Sirag et al (2017) who examined the association between health financing, CO2 emission and health outcomes using FMOLS and DOLS methods. The results indicate a negative effect of CO2 emissions on health outcomes. The study also

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highlighted the significance of some socioeconomic variables, education, and health, in enhancing health outcomes.

Nwani, et al, (2018) employed ARDL model and concluded that public health expenditure has a positive and significant impact on Health outcome (HO) in Nigeria while environmental pollution proxied by per capita CO2 emission has a negative and significant effect on health outcomes while economic growth has a positive impact but insignificant in enhancing life expectancy proxy for health outcomes. Similarly, Matthew et al (2018) study confirms Nwani, et al (2018) works and concluded in their study on the long-run effect of greenhouse gas (GHG) emission on health outcomes in Nigeria between 1985-2016 and found from ARDL model that a 1% increase in greenhouse gas (GHG) has a negative impact on health status implying reduction in life expectancy by 0.0422% invariably, raising mortality rate to 146.6%. Afolayan & Aderemi (2019) used dynamic Ordinary least square (DOLS) and granger causality for the period 1980-2016 shows that environmental degradation caused by CO2 has a negative and insignificant effect on health outcomes in Nigeria whereas electric power consumption and fossil fuel combustion significantly increased rate of mortality in the country. Rahman & Alam (2021) examine the nexus between health status, health expenditures (both public and private), energy consumption and environmental pollution in the SAARC-BIMSTEC region from 2002-2017 using panel ARDL model, heterogeneous panel causality test, the cross-sectional dependence test, the cointegration test and Pesaran cross sectional dependent (CADF) unit root test. The results authorized a co-integration among the variables used. Public and private health expenditure, energy consumption and economic growth (PERGDP) have positive and statistically significant effect. Also, in the long-run CO2 has a significant negative effect on the health status of these region.

Osabohien et al, (2021) applied ARDL techniques to examine how energy consumption as proxy by (CO2) emission impact on life expectancy in Nigeria. The results concludes that inter alia, CO2 on average could reduce life expectancy by 0.35% indicating a significant and negative effect on life expectancy. Li, et al (2022) used the Fourier bootstrap ARDL model to study the cointegration relationship and short-term causality between health expenditures, CO2 emission, and economic growth in the BRICS countries. The results show that, in the long-run, Brazil and China have cointegration relationships between CO2 emission as the dependent variable and health expenditure and economic growth as the independent variables. In the short-run, there is a negative causal relationship between India's CO2 emissions and health expenditure; other countries only show a one-way relationship between CO2 emission, health expenditure, or economic growth.

Using data for Saudi Arabia over the period 2000– 2018, Omri et al, (2022) investigated the ability of R&D (expenditures and environmentally related R&D) to reduce the incidence of emissions on population health outcomes, particularly infant mortality and life expectancy. The study revealed among the results using Units root, Johansen cointegration and dynamic ordinary least square (DOLS) techniques that there is a negative impacts of CO2 emissions on health outcomes in all the estimated model. The study concludes among other results that health and R&D expenditures can improve health outcomes proxy by infant mortality and life expectancy through reducing CO2 emission.

Following the literature reviewed so far previous studies in Nigeria that considered related study did not incorporate the effect of governance in their model framework. Most of these studies only focused on examining the relationship between public health expenditure, environmental pollution and Health outcomes or any two of the variables while systematic analysis of all four of these variables (public health expenditure, environmental pollution, governance and health status) are still rare in the literature. This is novel aspect of this study.

3. Model Specification

The theoretical framework for this study is anchored on health production function developed by Grossman, (1972) model of demand for health that treat social, economic and environmental factors as inputs of health production. It highlighted a production functional relationship between input and output, structured as follows:

HS = F (X)………………………. (1)

Where HS is the health status of the population and X is the vector of individual health inputs. However, Grossman's model only examines the micro-level model, whereas the goal of the study is to examine the production function at the macro-level in order to integrate upstream factors, such as socioeconomic, environmental and institutional factors, that affect health (Makuta and O'Hare, 2015 and Omri et al, 2022). Hence, the study modifies the original Grossman's micro-level to macro-level model without sacrificing the theoretical framework.

The model used for this study was adopted with modification from Makuta & O' Hare (2015) and Omri, et al (2022), who designed (X) into socioeconomic and environmental factors used in the production function. In line with this model, the present study has also adopted a model which expresses a functional relationship among public health spending, environmental pollution, with the inclusion of an institutional factor-governance to determine the health status of the population. The model has been presented in a functional form of the second regression as follows:

HS = f (PHEX, CO2, QoG, GDPPC) ………………………………. (2)

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In its scalar form, the above functional form of the regression equation was transformed into an econometric form of the model as thus:

$HS = \beta o + \beta 1\ PHEX + \beta 2CO2 + \beta 3QoG + \beta 4\ GDPPC + \mu i$……………………(3)

The variables in equation 3 were transformed into natural logarithm form equation following the multivariate regression of the determinants of the health status as thus:

$Ln\ (HSt) = \beta o + \beta 1\ ln\ (PHEXt) + \beta 2\ ln\ (CO2t) + \beta 3\ ln\ (QoGt) + \beta 4\ ln\ (GDPPCt) + \mu t$ …. … (4)

Therefore, HS defined by IMR and U5MR are decomposed into two models as:

$IMR = \beta o + \beta 1\ lnPHEXt + \beta 2\ lnCO2t + \beta 3\ lnQoGt + \beta 4\ lnGDPPCt + \mu t$ …………. (5)

$U5MR = \beta o + \beta 1\ lnPHEXt + \beta 2\ lnCO2t + \beta 3\ lnQoGt + \beta 4\ lnGDPPCt + \mu t$ ………… (6)

Where βo is the intercept; β1, β2, β3, and β4 are coefficients, the parameters of the explanatory variables while µt is the error term, t is the time period and ln denote natural logarithm. HS - Infant mortality (IMR) and under five mortality rates (U5MR): IMR is the number of deaths per 1,000 live births of children under one year of age while under-five mortality rate (U5MR) refers to the probability of a child dying between birth and exactly 5 years of age, expressed per 1,000 live births. **PHEX (Public Health Expenditure**): the study used Domestic general government health expenditure per capita (current US$) from the world development indicators (WDI) 2021 as proxy for PHEX. **CO2 (Carbon dioxide (CO2) emission per capita**: CO2 is a proxy variable for environmental pollution. **QoG (Quality of Governance):** We use corruption perception index (CPI) as a measure of governance**.GDPPC (Gross Domestic Product per capita):** GDPPC is a proxy variable for economic growth. Gross Domestic Product Per Capita (constant 2015 US dollars)

The error correction model (ECM) estimate measures the speed of adjustment back to long-run equilibrium relationship when the system is exposed to a shock. Therefore, the short-run error correction mechanism is specified as follows:

$\Delta lnHSt = \alpha + \sum\beta 1\Delta lnPHEXt\text{-}i + \sum\lambda k\Delta lnCO2t\text{-}k + \sum\delta j\ \Delta lnQoGt\text{-}j + \sum\varphi k\Delta lnGDPPCt\text{-}k + \propto 1\ lnPHEXt\text{-}1 + \propto 2\ lnCO2t\text{-}1 + \propto 3\ lnQoGt\text{-}1 + \propto 4\ lnGDPPCt\text{-}1 + \Psi ECM\ (\text{-}1) + \mu t$

Where ECMt-1 is the error correction term which results from the long-run equilibrium relationship and the sign is negative; Ψ is the parameter showing the speed of adjustment to the equilibrium level.

3.2. The Data and Estimation Techniques

This study used annual time series data for Nigeria spanning over the period of 1981-2020. The data were collected from the World Development Indicator (WDI) (2021, National Bureau of Statistics (NBS), Central Bank of Nigeria (CBN) statistical Bulletin various issues. Auto regressive Distributed Lag (ARDL) technique was used for estimating the long-run and short-run relationship. The instrumental variable techniques using two stage least square (2SLS) was employed to address the endogeneity issues by introducing the problematic variables as instrumental variables to estimate the two models of health status.

4.Results and Discussions

4.The Preliminary Diagnostics Analysis Result

Table 1: The Unit Root Test: Augmented Dickey Fuller (ADF) and Phillip-Perron (PP)

The starting point of the analysis is to evaluate the stationarity and cointegration properties of the data. However, Gujarati (2013) explained that the various methods often used to test for stationarity are Augmented Dickey Fuller, the Phillip Perron (PP) test and the graphical methods (the correlogram) among others. In order to determine the stability of unit root test results, ADF and PP were employed for this study and the unit root, test to ensure the reliability of our empirical test (Li, et al, 2021).

Table 1. Unit roots rest

	ADF		PP		Remark
	Level	First Diff.	Level	First Diff.	
IMR	1.3704	-3.5449**	1.25736	-3.1359**	I(1)
U5MR	0.9056	-3.4405**	1.25578	-3.1483**	I(1)
PHEX	-1.1813	-9.8993***	0.06139	-24.075***	I(1)
CO2	-2.0648	-6.3308***	-2.0899	-6.3308***	I(1)
GDPPC	-1.2924	-3.7968***	-0.4904	-3.7968***	I(1)
QOG	-1.6659	-8.6754***	-1.3515	-20.6586***	I(1)

Note: ***, **, and * denote 1%, 5% and 10% significance level respectively. All variables are in natural logarithm.

For this purpose, Table 1 presents the stationarity test for all variables using the standard unit roots tests of Augmented Dickey-Fuller (ADF) (1981) and Phillips and Perron (PP) tests (1988). Accordingly, the unit root tests suggest that all variables contain a unit root at levels but become stationary after first differences. In other words, all the variables are integrated at order one, I(1). Since no variable is integrated beyond order one, then the next pre-diagnostic test would be the evaluation of the possible cointegration, that is long-run relationship between the variables according to the model specification provided above.

The ARDL Bound Test to Co-integration Results

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Table 2. ARDL Bounds Test

Model 1: U5MR				Model 2: IMR		
K = 4	I(0)	I(1)		K = 4	I(0)	I(1)
10%	2.66	3.838		10%	2.66	3.838
5%	3.202	4.544		5%	3.202	4.544
1%	4.428	6.25		1%	4.428	6.25
F-statistic	4.4005			F-statistic	8.8437	
Optimal Model	ARDL(4,4,4,2,0)			Model	ARDL(2,0,0,1,0)	
Diagnostics						
Heteroskedasticity Test	0.8524	0.6307			1.5673	0.1835
Serial Correlation LM Test	0.4096	0.6711			1.9939	0.1251
Ramsey RESET Test	0.762	0.3956			2.2934	0.1407
Normality Test	1.1547	0.5613			1.1387	0.5658

Table 2 presents the ARDL bounds test for cointegration for each specification of the under-five and infant mortality rates with each having four explanatory variables. The optimal model specification for each variable based on the Akaike Information Criterion (AIC) for lag length specification are ARDL (4,4,4,2,0) and ARDL (2,0,0,1,0) for the under-five and infant mortality rates. The F-statistics for the bounds test is 4.4005 which is higher that the upper bound of 3.838 at the 10% significance level for the specification with under-five mortality rate. Also, the F-statistics for the infant mortality rate is 8.843 which is higher than the upper bound of 6.25 at the 1% significance level. Therefore, for both model specification, the test suggests that the null hypothesis of no cointegration is rejected respectively, and therefore there is evidence of long-run relationship between various variables in the respective model specification. Further, the optimal model selection is robust to the presence of heteroscedasticity, serial correlation, functional form and normality. For each of these diagnostics, their respective null hypothesis suggesting their presence in the model specification are rejected.

4.2. Two Stage Least Squares (2SLS) Results

Before, presenting the ARDL long- and short-run estimates, we first turn to the two stage least squares analysis which is robust to endogeneity and measurement errors in the variables.

Table 3. 2SLS Regression of Health Outcomes

	U5MR				**IMR**		
Variable	Coefficient	Std. Error	Prob.		Coefficient	Std. Error	Prob.
Constant	**8.9440**[a]	0.4549	0.0000		**7.9644**[a]	0.4032	0.0000
PHEX	**-0.0289**[a]	0.0059	0.0000		**-0.0263**[a]	0.0052	0.0000
CO2	**-0.0529**[b]	0.0233	0.0299		**-0.0480**[b]	0.0207	0.0265
GDPPC	**-0.4946**[a]	0.0623	0.0000		**-0.4318**[a]	0.0552	0.0000
QOG	-0.0279	0.0247	0.2666		-0.0253	0.0219	0.2556
R-squared		0.9738				0.9739	
Adjusted R-squared		0.9707				0.9708	
Durbin-Watson stat		1.7612				1.7761	
Prob(F-statistic)		0.0000				0.0000	
J-statistic		0.0000				0.0000	
Instrument rank		5				5	

Note: a, b, and c denote 1%, 5% and 10% significance level respectively. All variables are in natural logarithmic transformation.

Table 3 presents the two stage least square regression (2SLS) results for the respective specification of the health status, namely the infant mortality rates (IMR) and under-5 mortality (U5MR). The interpretation that follows is for both health status measures. First, the impact of public health expenditure has a negative and significant effect on both measures of health status (IMR and U5MR) which is in line with Yaqub, et al (2012). For instance, a one percent increase in public health expenditure reduces under-five and infant mortality by approximately 0.03 percentage points. This mean that increased funding of the health sector by government has the tendency of improving the health status of the population. With reference to the chosen measures of health status, the implication is that effective and efficient health sector funding has the effect of reducing child mortality in the country. The negative effect of public health expenditure is in tandem with the a priori expectation.

Considering the effect of environmental pollution as proxied using the carbon dioxide (CO2) emissions. The result show that carbon emissions have a significant though negative effect on health status. By implication, this means that a one percent increase in carbon emissions will reduce under-five and infant mortality rates respectively by approximately 0.05 percentage points. It is worthy of note that the negative effect of carbon emissions is contrary to the expected a priori

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positive effect. This is because high concentration and significant exposure to atmospheric pollution which is hazardous to health is often associated with health-related ailments which can result in blindness and even death in the worst-case scenario. Thus, while carbon emissions may be a significant determinant of health status and a vital part of the environment, its health-improving effect especially in the case of Nigeria may be because of the less concentration of carbon emissions in the country so that its effect is highly negligible.

Turning to the effect of the economic growth as proxied by the GDP per capita, the result shows a negative and significant effect which imply that economic progress is associated with an improvement in the health status of the population. Here, a one percent increase in per capita income reduces under-five and infant mortality by 0.49 and 0.43 percentage points respectively. This effect conforms with the a priori expectation because progress in a country's economic development is often associated with improved health conditions such as funding, construction of health facilities, free and/or subsidized health service delivery, or more general, access to health facilities and service delivery, provision of human resource for health among others.

Lastly, the quality of governance (QoG) as measured by the corruption perceptions index equally has a negative though statistically insignificant effect on the health status measures. For instance, a percent increase in the control of corruption has approximately a 0.03 percentage decrease in under-five and infant mortality rates. This means that good governance devoid of corruption in term of misallocation of fund, poor management and better domestic institutions can enhanced the health status and conditions of a country's citizens. Better institutional quality and good governance with transparency, efficiency and accountability would facilitate easy access and equitable provision of healthcare services and delivery. However, its non-significance in the case of Nigeria, suggest that her domestic institutions are weak in ensuring better health conditions. This is so, because Nigeria is riddled with corruption which tends to limit access to healthcare services as well as leading to poor provision and funding of the healthcare sector.

4.3. ARDL LONG AND SHORT-RUN RESULTS

Table 4 presents the ARDL long-run results for both model specifications with the under-five and infant mortality rates respectively. The impact of public health expenditure is relatively mixed depending on the measure of health status. Whereas public health expenditure has a negative and significant effect on under-five mortality rate, the reverse is the case for infant mortality rate with a positive though non-significant effect. This means that public health expenditure has the potential of reducing under-five mortality rather than infant mortality rate. In this context, a percent increase in public health expenditure leads a to 0.22 percentage point reduction in under-five mortality. The non-significance of the public health expenditure on infant mortality rate may be as a result of other health-related complications following poor nutrition, non-adherence to ante-natal processes etc.

Table 4: ARDL Long-run results for health status measures

	U5MR				IMR		
Variable	Coefficient	Std. Error	Prob.		Coefficient	Std. Error	Prob.
PHEX	**-0.2198**[b]	0.0898	0.0255		0.0396	0.0417	0.3493
CO2	**-0.3485**[b]	0.1254	0.0128		**-0.1806**[c]	0.0962	0.0703
GDPPC	1.2917	0.8226	0.1348		**-1.0383**[b]	0.4377	0.0243
QOG	-0.0473	0.0577	0.4241		0.0054	0.0518	0.917
Model 1: ECM = U5MR – (-0.219*PHEX -0.348*CO2 + 1.291*GDPPC - 0.047*QOG)							
Model 2: ECM = IMR - (0.039*PHEX -0.181*CO2 -1.038*GDPPC + 0.005*QOG)							
Note: a, b, and c denote 1%, 5% and 10% significance level respectively. All variables are in natural logarithmic transformation.							

Source: Authors computation

For the impact of carbon emission, there is a negative and significant effect on both under-five and infant mortality rates which is similar with the 2SLS results. A percent increase in carbon emissions reduces under-five and infant mortality rates respectively by 0.35 and 0.18 percentage points. Here, the effect is stronger for under-five mortality than infant mortality. The effect of economic growth based on the GDP per capita income is positive though non-significant for under-five mortality whereas it has a negative and significant effect on infant mortality rate. So economic progress accompanied by better healthcare provision and service delivery reduces infant mortality which in turn limits the under-five mortality hence the non-significant effect. Lastly, domestic institutional quality is mixed, negative and positive respectively for under-five and infant mortality rates. However, as with the 2SLS results, the effect is non-significant.

Table 5. ARDL Short-Run Results

Panel A.	D(U5MR)				Panel B.	D(IMR)		
Variable	Coeff.	Std. Error	Prob.		Variable	Coeff.	Std. Error	Prob.
Constant	**-0.0500**[a]	0.0093	0.0001		Constant	**-0.2477**[a]	0.0349	0.0000
D(U5MR(-1))	**1.3234**[a]	0.1612	0.0000		D(IMR(-1))	**0.8426**[a]	0.0329	0.0000
D(U5MR(-2))	-0.3021	0.2681	0.2755		D(GDPPC)	0.0057	0.0066	0.3880
D(U5MR(-3))	**-0.2560**[c]	0.1334	0.0720		ECM(-1)	**-0.0201**[a]	0.0028	0.0000

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D(PHEX)	-0.0002	0.0002	0.2771					
D(PHEX(-1))	**0.0019[a]**	0.0003	0.0000					
D(PHEX(-2))	**0.0011[a]**	0.0003	0.0015					
D(PHEX(-3))	**0.0007[a]**	0.0002	0.0031					
D(CO2)	0.0009	0.0007	0.2309					
D(CO2(-1))	0.0017	0.0010	0.1182					
D(CO2(-2))	**0.0025[b]**	0.0009	0.0137					
D(CO2(-3))	**0.0016[c]**	0.0008	0.0630					
D(GDPPC)	0.0041	0.0044	0.3704					
D(GDPPC(-1))	**0.0087[b]**	0.0041	0.0495					
ECM(-1)	**-0.0110[a]**	0.0021	0.0001					
R-squared		0.9983				0.9798		
Adjusted R-squared		0.9972				0.9780		
F-statistic		877.9569				550.893		
Prob(F-statistic)		0.0000				0.0000		

Note: a, b, and c denote 1%, 5% and 10% significance level respectively. All variables are in natural logarithmic transformation. D denotes first difference; ECM is the Error Correction.

Source: Authors computation

Next, we turn to the short-run estimates of the ARDL model which is presented in Table 5 above and based on the optimal lag length as determined by the Akaike Information Criterion (AIC). In Panel A for the under-five mortality rate, public health expenditure has a negative though non-significant impact at levels whereas its first to the third lag are positive and statistically significant. Such positive short-run effect may be associated with the time lag in the implementation of the budgetary allocation to the health sector as well as its effectiveness and efficiency in the utilization. It must be mentioned that for developing countries that an expansion in public health expenditure as provided in the budget may not correspond with the actual provision of healthcare and associated service delivery. Thus, the fact that past public health expenditure tends to increase under-five mortality rate would suggest under-provision of healthcare amidst any increase budgetary provisions.

Similarly, the effect of carbon emissions in the short-run are positive with significance at the second and third lags. At these lags, carbon emissions increase mortality rate in under-five children by marginal 0.003 and 0.002 percentage points. This is because of the effect of atmospheric pollution tend to be gradual through accumulation in the respiratory tract. Hence, in the short-run, atmospheric pollution through an expansion in carbon emissions is hazardous to health. Also, the effect of per capita income is positive at current and first lag but significant only in the latter case with an income elasticity of approximately 0.01 percentage points. This means that economic progress without significant improvement in income distribution may not improve accessibility to healthcare services and provisions. This positive effect of income is found also for infant mortality though with a non-significant impact.

Short-run Estimates: Turning to the short-run error-correction mechanism, the parameter for the lagged error correction (ecm) coefficient is negative with an estimate of -0.011 and 0.02 and statistical significance at 1% level for under-five and infant mortality rates respectively. This confirms the established cointegration relationship between the variables for each of the model specification. Moreover, the estimate measures the speed of adjustment back to long-run equilibrium relationship following a shock. Thus, the meaning of the coefficient estimate of -0.011 and 0.02 is that approximately 1% and 2% disequilibrium in health status as proxied respectively by the under-five and infant mortality rates of the previous year's shock adjust back to long-run equilibrium in the current year.

As already mentioned in Table 3, the ARDL model show no significant deviation from the standard OLS assumptions of normality of residuals, homoscedasticity, no serial correlation, and correct functional form specification. Furthermore, Figure 1 presents the structural stability tests based on the CUSUM and CUSUMSQ statistics which shows that the short-run model parameters lie within the critical bounds implying that all coefficients in the short-run error correction model are stable.

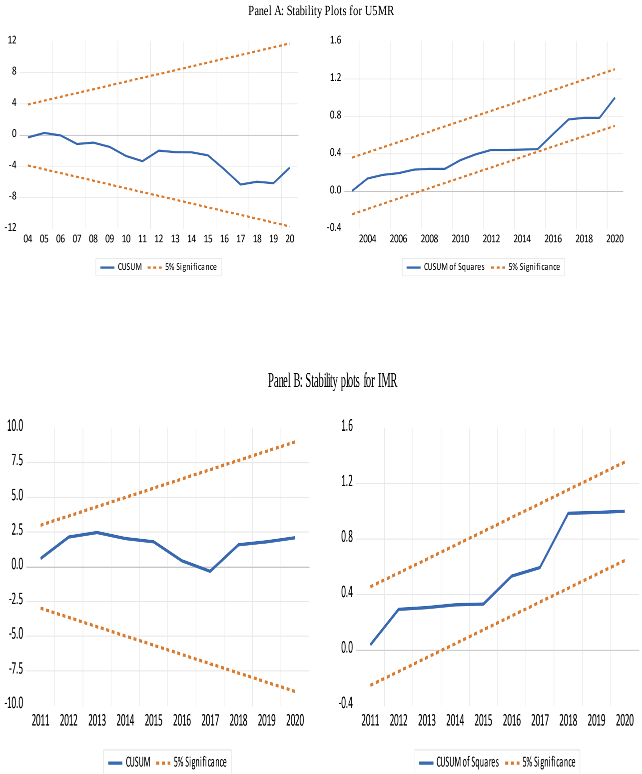

Figure 1: CUSUM and CUSUM Squares stability tests

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5.Conclusions and Recommendation

This study examines the nexus among public health expenditure, environmental pollution, governance and health status in Nigeria using annual time series data between 1981-2020. This study adds to the growing body of literature by introducing quality of governance to the model framework which to the best of our knowledge no none literature have studies in Nigeria. The ARDL model and 2SLS techniques were used to under study (public health expenditure, CO2 emission, quality of governance proxied CPI and health status measured by IMR and U5MR in Nigeria while GDPPC was the control variable. Empirically, the results show that there is evidence of long-run association between the various variables in the respective model specification. Generally, the results reveal (i) a negative and significant effect of PHE on both health status, implying that a 1% increase in PHE reduces IMR and U5MR by 0.03%. (ii) a significant and negative effect of CO2 emissions on health status, which imply that a 1% increase in CO2 emissions will reduce U5MR and IMR respectively by approximately 0.05%. (iii) QoG measured by CPI has a negative though statistically insignificant effect on health status, showing that a percent increase in CPI approximately decreases IMR and U5MR by 0.03%, (iv) a negative and significant effect of GDP per capita on health status.

The study recommends that effective and efficient health sector funding has the effect of reducing child mortality in the country. Also, there is need for policymakers in developing countries like Nigeria to aggressively deploy fiscal policy to boost allocations on public health expenditure and ensure progress across all four pillars of sustainable development through good governance devoid of corruption in term of misallocation of public resources, poor management and better institutions as these are essential for both individual and societal well-being.

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