Issues in Business Management and Economics
Vol.10 (2), pp. 9-21 August, 2022
Available online at https://www.journalissues.org/IBME/
https://doi.org/10.15739/IBME.22.002
ISSN:2350-157X(Online) ISSN:2814-3795(Print)

Original Research Article

Public health spending, macroeconomic uncertainty and health outcome: New evidence from Nigeria

Received 12 May, 2022 Revised 18 July, 2022 Accepted 28 July, 2022 Published 6 August, 2022

Ahmed Adefemi Adesete*[1], Risikat Oladoyin S. Dauda[1], and Uche I. Okirie[2]

[1]University of Lagos, Akoka, Nigeria,
[2]University of East Anglia, Norwich Research Park

*Corresponding Author
Email: adeseteahmed@gmail.com

This study aims to examine the effect of public health spending and macroeconomic uncertainty on health outcome in Nigeria. The autoregressive distributed lag (ARDL) model was the method used to analyze the objectives of the study, as there were mixture of both level (I(0)) and first difference (I(1)) series. Conditional variance from the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model was used to proxy macroeconomic uncertainty, using inflation rate as the main macroeconomic variable. Annual time series data on public health expenditure and health outcome indicators used for this study ranges between 1981 to 2020. Monthly time series which ranges between the period of January 1981 and December 2020 for inflation was used to derive macroeconomic uncertainty using the GARCH model. The estimation result shows, that public health expenditure and macroeconomic uncertainty does not have a significant impact on health outcome in the short run and long run. Finally, public income was identified as the most important determinant of health outcome in Nigeria both in the long and short run and is positively related to the health outcome. Results obtained shows that as public income increases, life expectancy rate is expected to improve and infant mortality rate will reduce. The study recommends that the Nigerian governments should efficiently allocate public health expenditure and implement welfare enhancing policies in order to improve the income level and well-being of households.

Keywords: Expenditure, health outcome, infant mortality rate, life expectancy rate, macro-economy, public health, uncertainty

JEL Classification Codes: C51, H51, I10, I12, I15, I18

INTRODUCTION

Health is one of the component of human capital which forms part of the critical determinant of the economic growth and development of a nation based on empirical literatures. World Health Organization's (WHO) constitution defines health as "a state of complete physical, mental and social well being and not merely the absence of disease or infirmity" (WHO, 2019). The united nations(UN) also emphasized the importance of health as one of the catalyst of growth in its sustainable development goal(SDG) 3. SDG 3 was aimed mainly to ensure healthy lives and promote well-being for all at all ages. However, health plays a major role in the economic growth and development of a country (Boachie, 2017; Ifunanyachukwu et al., 2019). Good health enhances the "capability to work" of an individual, thus increasing the utility derived from working by the individual and also utility it yields to the nation as a whole resulting in increase in the market value of the individual and also increase in national output (Grossman, 1972). Improving a nations health condition is identified by empirical literatures and policy-makers, as one of the important means of boosting the human capital of a nation to achieve sustainable development and improve welfare of the populate of that nation (Grossman, 1972; Sen, 2006; Olayiwola et al., 2021).

The role of public health spending thus cannot be overemphasized at improving the contribution of health sector to economic growth of Nigeria. The way a country finances its health care system is a critical determinant for reaching universal health coverage (Olatubi et al., 2018). It is vital for every nation to invest in health as it helps to promote better life, boost labour productivity, ensure economic security and add value to human life. Furthermore, in order to ensure optimal allocation of scarce resources to the health sectors, macroeconomic implications of the economy cannot be neglected. These macroeconomic implications include the feedback effect on health outcome. Improving the health status of the health sector of a nation involves investing in health which requires the mobilization of both financial and non-financial resources (Boachie et al., 2018). This however further stresses the role of macroeconomic implications of these allocations for better health outcome in Nigeria.

This paper is structured into five sections, with introduction as section one. Section two contains the literature review, while section three encompasses the methodology. Section four presents the analysis of empirical results. Section five discusses the conclusion and policy recommendations as well as limitations and further directions. The annual time series data on public health expenditure and health outcome indicators used for this study ranges between 1981 to 2020. Month time series which ranges between the period of January 1981 and December 2020 for inflation was used to derive macroeconomic uncertainty using the GARCH model.

The need for the effect and significance of public health expenditure on health outcome has received tremendous attention from researchers all over the world. With the emergence of COVID-19, there has been reignited interest of policy-makers and researchers as to if increasing public health expenditure would help improve health outcome in particularly developing economies like Nigeria. This results in a puzzle on if increasing public health expenditure would help improve outcome and invariably mitigate the impact of the recent spread of the COVID-19. Finding a solution to this question could help the Nigerian government find the best possible way to significantly reduce the impact of the COVID-19 pandemic and other health related infections. The question to be answered would be, will public health expenditure be sufficient to improve health outcome in Nigeria? If the answer is yes, then increasing public health expenditure should help douse the recent COVID-19 pandemic and improve the country's health outcome. Some studies suggest (Onofrei et al., 2021), Adewunmi et al. (2019) and (Edward et al., 2019) that, public health spending has a positive effect on health outcome, some argued negative impact of public health spending on health outcome and some finally argued public health spending is not a significant factor of health outcome. On the other hand, if the answer on the significance of public health expenditure on health outcome is no, another question would have to be answered that, what are the other economic or social factors that would help improve health outcome in Nigeria? This necessitates the need to examine other macroeconomic factors that affects health outcome like macroeconomic uncertainty, income and urbanization. Allocations to the health sector and performance of the health sector generally is affected by the instability in the macroeconomic environment and policies which then directly affects health outcome (Ajayi, 2012 and Banks et al., 2020). This justifies the inclusion of macroeconomic uncertainty in this paper and very few studies (Raji, 2020 and Ajayi, 2012) have examined the effect of macroeconomic uncertainty on health outcome in Nigeria. This study will however examine the effect of public health spending and macroeconomic uncertainty on health outcome indicators in Nigeria.

Literature review

There are several literatures that have explored the relationship between public health spending and health outcome such as life expectancy rate, under-5 mortality rate, birth rate and death rate. Furthermore, these literature has produced conflicting results over time with no general consensus. Some studies are based on time series analysis (Azuh et al., 2020; Besuthu et al., 2019; Osakede, 2021) while some studies are based on cross-country data analysis (Edward et al., 2019; Ibukun, 2021; Nketiah-Amponsah, 2019; Onofrei et al., 2021). However, most of these studies reveals (Edward et al., 2019; Azuh et al., 2020; Onofrei et al., 2021); direct relationship between public health spending and health outcome while very few (Ibukun, 2021) reveals negative relationship between public health spending and health outcome adopting various health outcome indicators and different estimation techniques.

Ibukun (2021) investigated the role of governance on the nexus between health expenditure on three health outcomes in West Africa. This study adopted the two-least squares estimation approach using a panel of fifteen West African countries including Nigeria, Chad and Guinea-Bissau within the period of 2000-2018. Three health outcomes indicators (infant mortality, under-five mortality and life expectancy) and six measures (Government Effectiveness, Rule of Law, Voice & Accountability, Regulatory Quality, Political Stability and Lack of Violence, and Control of Corruption) of the quality of governance were used. The study found that health expenditure has a negative impact on infant mortality and under-five mortality but has a positive impact on life expectancy.

However, the quality of governance played an important role in the relationship between these health outcome indicators and public health expenditure. This is because the study examined that West African countries with higher quality of governance benefit better from their public health spending. Edward et al., 2019 also investigated the impact of health expenditure on health outcome in sub-Saharan Africa (SSA). The result of the study showed that increases in health expenditures have the tendency to improve health outcomes (life expectancy, under-five mortality and maternal mortality) in SSA. This is also in line with the findings of Nketiah-Amponsah (2019), which discovered that public health expenditure has a positive and significant impact of three health outcome indicators (maternal mortality, life expectancy rate and infant mortality rate) in SSA.

Similarly, Onofrei et al. (2021) also found that public health expenditure could be used to improve life expectancy and reduce infant mortality among EU developing countries in their study "Government Health Expenditure and Public Health Outcomes: A Comparative Study among EU Developing Countries". This study noted that the effectiveness of the health sector is dependent on the governance status of the EU developing countries. As a result, it recommended that policy-makers should provide a policy mix of both political and financial support to improve health outcome. Azuh et al. (2020) also discovered that there was a positive significant relationship between public health expenditure and under-five mortality in Nigeria using the ARDL estimation technique.

Meanwhile, some studies concluded that public health expenditure does not have a significant impact on health outcome. Osakede (2021) analysed the relationship between public health expenditure and health outcome in Nigeria using a time series data that ranges within 1980 to 2017 whilst taking account of the role of governance. The study found that public health spending does not have a significant effect on health outcome except when interacted with the quality of governance. Hence the interaction of public health spending and governance indicators (government effectiveness and control of corruption) resulted in the decline in maternal mortality rate. Besuthu et al. (2019) also investigated the relationship between public health expenditure and health outcome in South Africa using fixed and random effects model. The results of the study suggest that public heath expenditure does not have a significant impact on under-five mortality at 5% level of significance but it has a positive significant impact on life expectancy.

METHODOLOGY

Theoretical Framework: Dissecting the Grossman Model

Grossman posits from his basic equation that, health outcome that is utility derived from the production and consumption of health is mainly affected by healthcare expenditure and other commodities consumed by individual.

$$U = u\left(t^s\left(H_t\right), X\right) \quad (1)$$

$$t = 1,2,3,\ldots\ldots, T$$

$$I\left(M_0, t^1\right) = H_1 - H_0\left(1-\Delta\right) \quad (2)$$

$$w_0\left[1 - t_s\left(H_0\right) - t^1\right] + w_1\left[1 - t_s\left(H_1\right)\right] = \rho M + cX_0 + cX_1 \quad (3)$$

U : Utility
H : Stock of Health
t^s : Sick time
t^1 : Time spent on preventive effort
X : Home goods
I : Investment
Δ : Rate of depreciation
ρ : Unit price of medical goods
M : Medical services

Equation 1 defines the basic utility function of a consumer of healthcare services and other commodities as assumed by Grossman model (1972), it defines an individual satisfaction can either come from the consumption of healthcare services when an individual is ill or from the consumption of other commodities other than healthcare services.

Equation 2 indicates that investment made on preventive effort towards improving health care services is determined by initial medical service received and the time spent on the preventive effort. Thus, the total health-stock from this investment is the health-stock derived after being subjected to depreciation in health condition. This alternatively means that, over an entire life of an individual, there is tendency for reduction in the quality of health as such individual ages, thus it becomes necessary to have healthcare investment on preventive effort so as to maintain the quality of health over these years.

Equation 3 defines the total wealth of an individual over his life time. This equation indicates that the total income spent on preventive effort and on sick time which represents the wealth of an individual is approximately equal to the sum of the total amount of investment on medical services and investment on other commodities.

Discounting the present value of income that accrues to health service received during sick time and the present value future investment on other commodities in Equation 3 `so as to be able to estimate the future values individual investment on healthcare services.

As specified in Schmidt (2016),

Present Value = Future Value/$(1 + r)^t$, Let $(1 + r)^t = R$,

Present value = Future value /R, Applying this to discount equation 3,

Discount present value (3) by adding another constant and discount factor (R):

$$A_0 + w_0\left[1 - t^s\left(H_0\right) - t^1\right] + \frac{w_1\left[1 - t^s\left(H_1\right)\right]}{R} = \rho M + cX_0 + \frac{cX_1}{R} \quad (4)$$

Equation 4 represents the discounted value of Equation 4 after dividing future value of income that accrues to health service received during sick time and the future value of investment on other commodities in Equation 3 by a discount factor R to derive the present values.

Maximizing the total utility function which comprises of total utility at present period and future period subjected to Equations 2 and 4 to form a Lagrangian function.

$$L = u\left[t^s(H_0), X_0\right] + \beta u\left[t^s(H^1), X_1\right] + \mu\left[H_1 - H_0(1-\Delta) - I(M_0, t^1)\right] + \lambda\left[A_0 + w_0\left(1 - t^s(H_0) - t^1\right) + \frac{w_1\left(1 - t^s(H_1)\right)}{R} - \rho M - cX_0 - \frac{cX_1}{R}\right] \quad (5)$$

Differentiating **equation 5** with respect to future health stock (H_1), time spent on preventive effort (t^s), medical service at present period (M_0), other commodities at present period (X_0), total medical service (M) and other commodities at future period (X_1).

$$\frac{dL}{dH_1} = \beta\frac{dU}{dt^s}\cdot\frac{dt^s}{dH_1} - \mu - \frac{\lambda}{R}[w_1]\frac{dt^s}{dH_1} \quad (6)$$

$$\frac{dL}{dt^1} = \mu\frac{dI}{dt^1} - [w_0]\lambda \quad (7)$$

$$\frac{dL}{dM_0} = \mu\frac{dI}{dM_0} - [P]\lambda \quad (8)$$

$$\frac{dL}{dX_0} = \frac{dU}{dX_0} - [c]\lambda \quad (9)$$

$$\frac{dL}{dX_1} = \beta\frac{dU}{dX_1} - \frac{[c]\lambda}{R} \quad (10)$$

$$\frac{dL}{dM} = \mu\frac{dI}{dM} - [P]\lambda \quad (11)$$

Take the first order condition for equations 6 to 11 which is one of the condition for optimization by equating each of this equation to zero.

Take the first order conditions of (6), (7), (9), (10) and (11) such that:

$$\frac{dL}{dH_1} = 0, \frac{dL}{dt^1} = 0, \frac{dL}{dM} = 0, \frac{dL}{dX_0} = 0, \frac{dL}{dX_1} = 0$$

$$\beta\frac{dU}{dt^s}\cdot\frac{dt^s}{dH_1} - \mu - \frac{\lambda}{R}[w_1]\frac{dt^s}{dH_1} = 0 \quad (12)$$

$$\mu\frac{dI}{dt^1} - [w_0]\lambda = 0 \quad (13)$$

$$\mu\frac{dI}{dM} - [p]\lambda = 0 \quad (14)$$

$$\frac{dU}{dX_0} - [c]\lambda = 0 \quad (15)$$

$$\beta\frac{dU}{dX_1} - \frac{[c]\lambda}{R} = 0 \quad (16)$$

Simplifying equations 12 to 16 and making μ the subject of the formula in equation 12, dI/dt^1 the subject of the formula in equation 13, dI/dM the subject of the formula in equation 14, dU/dX_0 the subject of the formula in equation 15, dU/dX_1 the subject of the formula in equation 16.

$$\beta\frac{dU}{dt^s}\cdot\frac{dt^s}{dH_1} - \frac{\lambda}{R}[w_1]\frac{dt^s}{dH_1} = \mu \quad (17)$$

$$\frac{dI}{dt^1} = \frac{[w_0]\lambda}{\mu} \quad (18)$$

$$\frac{dI}{dM} = \frac{[P]\lambda}{\mu} \quad (19)$$

$$\frac{dU}{dX_0} = [c]\lambda \quad (20)$$

$$\frac{dU}{dX_1} = \frac{[c]\lambda}{\beta R} \quad (21)$$

Equation 18 represents the marginal effect of time on preventive effort on investment, **equation 19** represents the marginal effect of medical services on investment, **equation 20** marginal utility of present value of other commodities consumed, **equation 21** represents the marginal utility of future value of other commodities consumed. Take the ratio of equations 18 to 19, equations 19 to 20 and equations 20 to 21 and simplifying to derive λ/R and substituting in equation 17 to derive the fundamental equation of the Grossman model (1972) which is equation 22 below:

$$\frac{-dt^s}{dH_1}[\beta]\left[\frac{-dU}{dt^s} + \left[\frac{dU}{dX_1}\right]\left[\frac{w_1}{c}\right]\right] = \left[\frac{dU/dX_0}{dI/dM}\right]\left[\frac{P}{c}\right] \quad (22)$$

Interpretation of equation (22)

LHS interpretation

(1) Effectiveness as a precondition for better health outcome/utility defined by dt^s/dH_1 which alternatively indicates that the less sick time of an individual, the higher the effectiveness of that individual which in turn lead to a better health outcome.

(2) Health generates two types of utility which are direct utility and indirect utility.

(3) Valuation of health as a consumption good generates direct utility. It would thus be noted from equation 22 that there is a negative relationship between consumption of home goods and marginal investment on medical services and a positive relationship between marginal utility of home goods and consumption of home goods.

(4) Valuation of health as an investment good generates indirect utility. However, there is a negative relationship between consumption of home goods and marginal investment on medical services and a positive relationship between marginal utility from consumption of health services and marginal investment on medical services.

RHS interpretation

(1) dU/dX_0 indicates subjective loss suffered for forgoing consumption in favour of health. This further implies that, if

healthcare services consumption is foregone for the consumption of other commodities and the utility captured by this effect is measured by dU/dX_0.
(2) This loss is mitigated to the extent that medical service purchased are highly effective(dI/dM is large)
(3) Productivity is deflated with price because investment in health brings few units of medical services if price of medical services is high.

$$\frac{dU}{dt^s}\cdot\frac{dt^s}{dH_1}[\beta]: \text{Valuation of health as a consumption good}$$

$$\left[\frac{\text{dU}}{\text{dX}_1}\right]\left[\frac{w_1}{c}\right]\frac{dt^s}{dH_1}.[\beta]: \text{Valuation of health as an investment good}$$

Model Specification

With the aid of the Grossman model that examined mainly the relationship between cost of health inputs and demand for health capital. Grossman emphasized that benefits of good health are greater for high wage workers so they demand higher optimal health stock, thus government expenditure on health should increase to reduce the cost of health inputs, thereby increasing optimal capital stock and finally increasing health outcome. Thus, uncertainty in the macroeconomic environment was also identified as a very important factor which influences the allocation of resources to the health sector. However, this justifies the inclusion of macroeconomic uncertainty (MUN) as one of the important variables in the model to be used for this study in order to determine the effect of macroeconomic uncertainty on health outcome in Nigeria. There was also a need to examine the effect of income and urbanization on health outcome which was also justified by Biadgilign et al. (2019) who did a similar study on nexus between good governance, public health expenditures, urbanization and child under-nutrition Ethiopia.

Health Outcome(HO) = f(Macroeconomic Uncertainty(MUN), Public expenditure on health(PHE), gross domestic product per capita (INCOME/GDPPC), Urbanization(UBN)).

Health outcome : proxy with infant mortality rate (IMR), and life expectancy rate (LER).

Analytical Technique

The first step in any time series modelling is examining the statistical properties of the variables to be used (Adhikari and Agrawal, 2013). However, the unit root and co-integration property would be examined. Unit root test examines the stationarity of the series while co-integration test is a group test statistic that checks for the long-run relationship among variables employed in this study. If variables are found to be non-stationary at level(I(0)), the variables are differenced such that it would be stationary at first difference(I(1)). If all variables are established to be stationary at first difference only, then there is an error correction model (ECM). If there are a mixture of I(0) and I(1) variables, then this invalidates the assumption of the conventional Johansen co-integration test. Hence, the ARDL bound test would be used to test for co-integration and if all variables are stationary at I(1) or I(0).

If it is ascertained that all variables are integrated at I(1), then ARDL or unrestricted error correction model can be estimated. But if the variables are all integrated of I(0) then a normal long run equation will be estimated or vector autoregressive (VAR) model can be used.

Sources and Measurement of Data

Table 1 indicates the explanation of the type, source, description and appriori expectation of the variables used in this paper.
Data duration: The annual time series for LER, IMR, UBN, PHE and INCOME were for 40 years ranging between 1981 to 2020. Monthly time series was used for inflation rate and this was between January 1981 to December 2020. This monthly series was used to derive macroeconomic uncertainty - conditional variance from the inflation GARCH equation. The monthly series of inflation was sourced from the central bank of Nigeria (CBN) database.

ANALYSIS AND INTERPRETATION OF RESULTS

Pre-Estimation Analysis

Descriptive Analysis

Table 2 shows the descriptive statistics for infant mortality rate per 1000 live births (IMR), urbanization proxy with urban population density (in people per square km), public health expenditure (in billion Naira), life expectancy at birth (in years) and GDP per capita (in Naira) which is a proxy to household income. The table also includes macroeconomic uncertainty (MUN), which was proxy with conditional variance from an estimated inflation rate GARCH equation (see the appendix for the equation). The GARCH equation was estimated using the monthly series for inflation rate which ranges between January 1981 to December 2020.

From Table 2, all the series are positively skewed except infant mortality rate. Theoretically, this implies that the mean and median of UBN, PHE, LER, INCOME and MUN will be less than its mode. It also indicate that most of their values are clustered around the left side of their distribution. The kurtosis values shows that the series for infant mortality rate (IMR), urbanization (UBN), life expectancy rate (LER) and INCOME are all platykurtic because the kurtosis statistic is less than 3 while other series (public health expenditure (PHE) and macroeconomic uncertainty (MUN)) are leptokurtic. According to the jarque-bera statistic, all the series used for this study except public health expenditure and macroeconomic uncertainty were normally distributed. This is because the probability value of the jarque-bera statistic of the normally distributed series were greater

Table 1. Description and Sources of Data

S/N	TYPE	LABEL	DESCRIPTION	APPRIORI EXPECTATION	SOURCE
1	Endogenous	LER	LER represents life expectancy rate in years.		WDI
2	Endogenous	IMR	IMR is the infant mortality rate for Nigeria per 1000 live births.		WDI
4	Exogenous	MUN	MUN represents macroeconomic uncertainty which was proxied with conditional variance from a GARCH equation. Inflation rate was used to estimate the GARCH equation.	**Negative**	WDI/CBN database
5	Exogenous	PHE	PHE represents public health expenditure proxied with government expenditure in the health sector.	**Positive**	CBN Statistical bulletin
7	Exogenous	INCOME/GDPPC	GDPPC represents real GDP per capita in Naira which was used as a proxy to INCOME.	**Positive**	WDI
8	Exogenous	UBN	Urbanization proxy with urban population density in people per square km	**Negative**	WDI

WDI: World Development Indicator
CBN: Central Bank of Nigeria

Table 2. Descriptive statistics of dependent and independent variables

	IMR	UBN	PHE	LER	GDPPC	MUN
Mean	103.941	2952.983	80.986	48.446	268654.00	2.312
Median	108.650	2539.233	20.580	46.389	239635.20	0.394
Maximum	124.600	6228.457	388.370	55.020	385349.00	19.343
Minimum	72.700	994.585	0.040	45.637	199039.10	0.009
Std. Dev.	19.216	1542.160	112.061	3.171	67204.62	4.233
Skewness	-0.278	0.600	1.330	0.836	0.510	2.512
Kurtosis	1.405	2.174	3.613	2.142	1.618	9.056
Jarque-Bera	4.756	3.537	12.423	5.883	4.912	103.187
Probability	0.093	0.171	0.002	0.053	0.086	0.000

Source: Author's computation (2022)

Table 3. Augmented Dickey Fuller test

Variables	Level	First Difference	Order of Difference
LOG(IMR)	0.523	0.031	I(1)
LOG(UBN)	0.060	0.002	I(1)
LOG(PHE)	0.995	0.000	I(1)
LOG(LER)	0.005	0.239	I(0)
LOG(GHG)	0.740	0.003	I(1)
LOG(INCOME)	0.712	0.046	I(1)
LOG(MUN)	0.937	0.000	I(1)

Source: Author's computation (2022)

than 5%.

Unit Root Test

Tables 3 shows the augmented dickey fuller (ADF) test for the series used in this study. According to the test, the series for IMR, UBN, PHE, GHG, INCOME and MUN were stationary at first difference only because the probability value at I(1) were less than the chosen level of significance (5%). Only life expectancy rate (LER) was stationary at level only. Since there are a mixture of I(0) and I(1)

Table 4. ARDL bound test for IMR equation

Null Hypothesis: No long-run relationships exist		
Test Statistic	Value	K
F- statistic	4.849	4
Critical Value Bounds		
10%	3.03	4.06
5%	3.47	4.57
2.5%	3.89	5.07
1%	4.4	5.72

Source: Author's computation (2022)

Table 5. ARDL bound test for LER equation

Null Hypothesis: No long-run relationships exist		
Test Statistic	Value	K
F- statistic	25.805	4
Critical Value Bounds		
Significance	I0	I1
10%	3.03	4.06
5%	3.47	4.57
2.5%	3.89	5.07
1%	4.4	5.72

Table 6. VAR lag selection criteria for IMR equation

Lag	LogL	LR	FPE	AIC	SC	HQ
0	40.599	NA	5.58e-09	-1.977	-1.710	-1.885
1	374.233	533.815	2.37e-16	-18.985	-17.118	-18.340
2	439.988	82.664	5.24e-17	-20.685	-17.219	-19.489
3	518.203	71.510*	8.22e-18*	-23.097*	-18.031*	-21.439*

Source: Author's computation (2022)

Table 7. VAR lag selection for LER equation

Lag	LogL	LR	FPE	AIC	SC	HQ
0	55.565	NA	2.37-09	-2.832	-2.566	-2.740
1	421.518	585.525	1.59e-17	-21.687	-19.820	-21.042
2	504.975	104.917	1.28e-18	-24.399	-20.932	-23.202
3	631.450	115.635*	1.27e-20*	-29.569*	-24.503*	-27.820*

Source: Author's computation (2022)

variables, this violates the assumption of the Johansen co-integration test. Hence, the bound test is the most appropriate to test for co-integration in this instance.

Bound Test

Table 4 shows the bound test result for infant mortality rate (IMR) with relation to other variables (UBN, PHE, MUN, INCOME).

Table 5 indicates the bound test result for life expectancy rate (LER) and other variables (UBN, PHE, MUN, INCOME).

The bound test results from Tables 4 and 5 implies that all variables are stationary at I(1) and that there is the presence of co-integration (that is long run relationship) among all the variables used in this study. This is because the F-statistic value for IMR and LER were greater than the I(1) critical bound value at 5%. With the result of this bound test, it is appropriate to the unrestricted error correction model or the autoregressive distributed lag model as estimation techniques. Before the estimation of the ARDL model, the optimal lag of the model would be established using the VAR lag selection criteria.

Lag Selection

Tables 6 and 7 shows the VAR optimal lag selection criteria

Table 8. IMR ARDL equation (2,0,2,2,0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
SHORT-RUN EQUATION				
DLOG(IMR(-1))	0.763	0.106	7.178	0.000*
DLOG(MUN)	-0.000	0.000	-0.756	0.456
DLOG(PHE)	0.001	0.001	0.772	0.447
DLOG(PHE(-1))	-0.002	0.001	-1.822	0.080**
DLOG(UBN)	0.301	0.249	1.207	0.238
DLOG(UBN(-1))	-0.576	0.255	-2.259	0.033*
DLOG(INCOME)	-0.033	0.017	-1.895	0.069**
D(@TREND)	-0.0154	0.004	-3.693	0.001*
ECT(-1)	-0.1529	0.040	-3.853	0.001*
LONG-RUN EQUATION				
LOG(MUN)	-0.002	0.003	-0.730	0.472
LOG(PHE)	0.014	0.010	1.450	0.159
LOG(UBN)	1.816	0.328	5.532	0.000*
LOG(INCOME)	-0.213	0.072	-2.940	0.007*
C	-4.881	2.340	-2.086	0.047*
@TREND	-0.101	0.015	-6.830	0.000*

Source: Author's computation (2022)

result for the ARDL equation of infant mortality rate (IMR) and life expectancy rate (LER) respectively.

According to the result from Tables 6 and 7, the final prediction error (FPE), Akaike Information Criterion, Schwartz Information Criterion and Hanann Quinn Criterion indicates that three (3) is the maximum lag for the variables in IMR and LER ARDL equation. This means that the lag for the variables in the IMR and LER equations must not exceed three.

RESULTS AND INTERPRETATION

Table 8 is the infant mortality rate (IMR) ARDL model result with the lags IMR (2), MUN (0), PHE (2), UBN (2), INCOME (0). The model contains both the short-run and long-run equation estimation result. Trend was included in the equation because it was an important and highly significant variable. Additionally most of the variables included in the equation also showed an evidence of trend.

IMR Short run equation discussion

From the short run equation in Table 8, there was a positive insignificant relationship between public health expenditure at current period (PHE) and infant mortality rate (IMR). However, public health expenditure in the previous one year (PHE (-1)) has a negative significant effect on infant mortality rate (IMR) in the short run. Although the probability value of PHE(-1) is greater than 5%, but it is less than 10%. This means that it could be said that PHE (-1) is significant at 10% significance level. The significance of PHE(-1) could be because of the lag effect of government spending, indicating that it may take at least one year for health care spending to have a significant effect on health outcome in Nigeria. Summarily, it means that if government increases its healthcare spending at present period, this would not have a significant impact on infant mortality rate until the next period. It could be concluded that a 1% increase in public health expenditure in the last one year would reduce infant mortality rate significantly by 0.002%. On the other hand, macroeconomic uncertainty (MUN) does not have a significant impact on infant mortality rate (IMR) in the short run even though there is a negative relationship between these two variables.

Other variables like urbanization in the previous one year (UBN(-1)), household income (INCOME), TREND included in the short run equation were all statistically significant and have a negative effect on infant mortality rate while urbanization at present period (UBN) have a positive insignificant impact on IMR. This implies that an increase in urban population last year (UBN(-1)) would result in a decrease in infant mortality rate in the current year (IMR) but UBN does not have a significant impact on IMR. This could be largely attributed to the concentration of medical personnels and facilities in the urban area, and this is largely attributable to the better health care services available and low infant mortality rate in the urban areas. The higher the level of urbanization, the higher the number of medical persons concentrated in the urban area.

In addition, the income of households (INCOME) also have a negative significant effect on infant mortality rate in the short run at 10% significance level. If income increases by 1%, infant mortality rate would decrease by 0.033%. This conforms with the expected theoretical relationship between income and IMR. It also explains the reason why higher income household or country have lower infant mortality rate and vice versa. Hence, the shows the importance of enhancing the income of households on their health and metal well-being.

Lastly, the major coefficient that distinguishes the short run equation from the long run equation is the error

Table 9. LER ARDL Equation (2,0,0,2,1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
SHORT-RUN EQUATION				
DLOG(LER(-1))	0.726	0.044	16.33	0.000*
DLOG(MUN)	0.000	0.000	1.362	0.184
DLOG(PHE)	-0.000	0.000	-1.263	0.217
DLOG(UBN)	0.038	0.027	1.402	0.172
DLOG(UBN(-1))	0.066	0.024	2.770	0.010*
DLOG(INCOME)	0.001	0.002	0.374	0.711
D(@TREND)	0.001	0.000	3.996	0.000*
ECT(-1)	-0.056	0.007	-8.588	0.000*
LONG-RUN EQUATION				
LOG(MUN)	0.001	0.001	1.346	0.190
LOG(PHE)	-0.002	0.002	-1.349	0.189
LOG(UBN)	-0.386	0.112	-3.445	0.002*
LOG(INCOME)	0.081	0.022	3.656	0.001*
C	5.354	0.639	8.380	0.000*
@TREND	0.024	0.005	4.909	0.000*

Source: Author's computation (2022)

correction term (ECT). The coefficient of the ECT conforms with the three basic assumptions:

(1) The absolute value of the ECT coefficient (|-0.153|) is less than one.

(2) It is negative and less than one (-0.153)

(3) It is significant because its probability value is less than 5% (0.001 < 5%)

The ECT is the speed of adjustment from short run disequilibrium to long run equilibrium. From the short run equation of the infant mortality rate (IMR) model, the speed of adjustment is 15.29%. At this rate, this implies that it would take approximately 78 months to reach long run equilibrium in the case of any adjustment to any of the independent variables.

IMR Long run equation discussion

In the long run, public health expenditure have a positive insignificant effect on infant mortality rate (IMR) while macroeconomic uncertainty have a negative insignificant impact on IMR. This is in line with the findings of Osakede (2021), which concluded that public health expenditure does not have a significant impact on health outcome in SSA except when it is augmented with governance. On the other hand, urbanization have a positive and significant effect on IMR, because its probability value is less than 5%. This means that if there is an increase in the number of people in urban area, infant mortality rate is expected to increase. Additionally, income is have a negative significant impact on infant mortality rate in the long run, which confirms with appriori expectation, This means that infant mortality rate is expected to be low in higher income household while it would be higher in low income household. Hence, this explains the reason for high infant mortality rate in developing economies and vice versa.

Table 9 shows the ARDL model for life expectancy rate (LER). It highlights both the short run and long run equations. All the variables in the short run equation are differenced.

LER Short run discussion

In the short run, there is a positive insignificant relationship between macroeconomic uncertainty and life expectancy rate but public health expenditure have a negative insignificant impact on LER. However, there is a positive significant relationship between life expectancy rate in past one year (LER(-1)), income and life expectancy rate (LER).

Examining and checking the error correction term in the short run equation to confirm if the conventional three conditions of error correction term exists:

(1) The error correction term (-0.056) in the short run equation in Table 9 is statistically significant.

(2) The error correction term (-0.056) is negative.

(3) The absolute value of the error correction term (|-0.056| = -0.056) is less than one.

Ascertaining that the error correction term (ECT) meets the three condition, the coefficient of the error correction term indicates that about 5.60% of disequilibrium was corrected within one year. That is, the rate or speed of adjustment from short-run disequilibrium to long run equilibrium is 5.60%.

LER Long run equation discussion

According to the long run equation in Table 9, public health expenditure has a negative insignificant impact on life expectancy rate (LER) while macroeconomic uncertainty have a positive insignificant impact on LER. This is consistent with the result of (Besuthu et al., 2019) which found that public health expenditure does not have a significant impact on life expectancy rate according to the study's pooled OLS output.

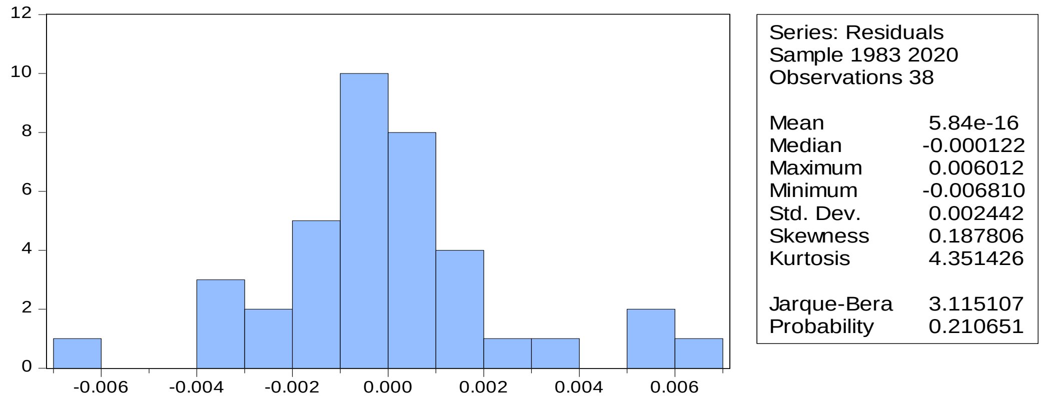

Figure 1: Normal distribution test for IMR equation

Table 10. Serial correlation test for IMR equation

Breusch-Godfrey Serial Correlation LM Test			
F-statistic	1.778	Prob. F(3.23)	0.179
Obs *R-squared	7.153	Prob. Chi-Square(3)	0.067

Table 11. Heterosedasticity test for IMR equation

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	1.402	Prob. F(11.26)	0.230
Obs *R-squared	14.150	Prob. Chi-Square(11)	0.225
Scaled explained SS	11.101	Prob. Chi-Square(11)	0.435

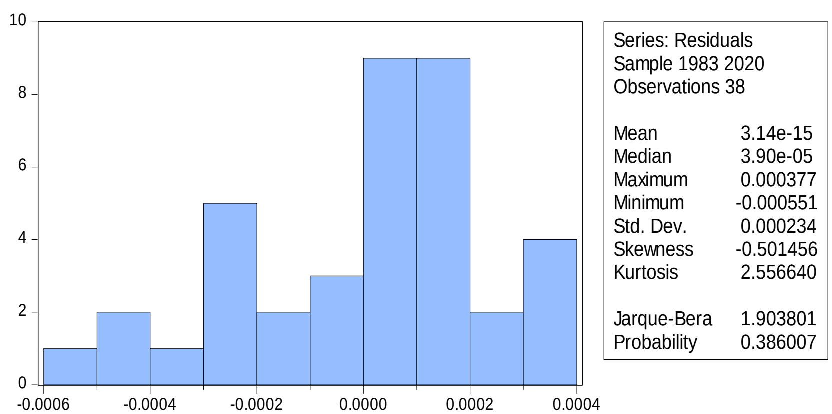

Figure 2: Normal distribution test for LER equation

Urbanization (UBN) and income (INCOME) were all statistically significant factors that influences life expectancy rate (LER) in the long run. While urbanization is negatively related to LER, there is a positive significant relationship between income and LER in the long run.

Post-Estimation Analysis

IMR equation

From the normal distribution test of the infant mortality rate ARDL model in Figure 1, the residuals of the model are normally distributed because the probability value of the Jarque Bera statistic is greater than 5%. Additionally, in Tables 10 and 11, there is no evidence of serial correlation and heteroscedasticity in the IMR model because the probability values of these tests are higher than 5%.

LER equation

According to Figure 2, the residuals of the LER equation are normally distributed because the probability value is more

Table 12. Serial correlation test for LER equation

Breusch-Godfrey Serial Correlation LM Test			
F-statistic	11.61589	Prob. F(324)	0.0001
Obs *R-squared	22.50236	Prob. Chi-Square(3)	0.0001

Table 13. Heteroscedasticity test for LER equation

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	1.124	Prob. F(10, 27)	0.381
Obs *R-squared	11.168	Prob. Chi-Square(10)	0.345
Scaled explained SS	4.388	Prob. Chi-Square(10)	0.928

than 5%. Also, in Table 12, there is no evidence of heteroscedasticity, as the probability value of the test statistic is greater than 5%. Meanwhile, in Table 13, there is evidence of second degree serial correlation. Due to this, the coefficient of the LER equation were adjusted for serial correlation using the HAC (Newey-West) coefficient covariance matrix adjustment.

CONCLUSION AND POLICY RECOMMENDATIONS

This study basically examined the effect of public health expenditure (PHE) and macroeconomic uncertainty (MUN) on health outcome in Nigeria. This study uses the autoregressive distributed lag (ARDL) model to capture the objective of this study. It is important to note that, there is long run relationship between health outcome indicators (infant mortality rate and life expectancy) and the explanatory variables (INCOME, public heath expenditure (PHE), macroeconomic uncertainty (MUN) and urbanization (UBN)) employed in this study. Meanwhile, pubic heath expenditure is not significantly related to heath outcome due to the mismanagement of fund, inequality in the distribution of public health expenditure, capital flight of high skilled workers and corruption in the health sector in Nigeria. This was justified by Yaqub et al. (2012) that concluded that public health expenditure would only improve health outcome in Nigeria if it being augmented with effective governance and institutions. Also, macroeconomic uncertainty does not have a significant impact on health outcome (life expectancy rate and infant mortality rate) both in the short and long run. Income is the most significant factor, as it has a positive significant impact on health outcome. According to the empirical result, if income increases, life expectancy rate is expected to improve and infant mortality rate is expected to decrease.

Policy recommendations

This study from its empirical findings thus recommends the following:

1) From the empirical findings of this study, income is the most significant factor and also negatively related to infant mortality rate (IMR) and life expectancy rate (LER). Government should ensure that its policies are welfare enhancing policies and also policies that would reduce income inequality between the poor and the rich households. This would would help improve the health status of households thus finally resulting in the improvement in health outcome of Nigeria generally.

2) Public health expenditure was not a significant factor influencing infant mortality rate and life expectancy rate. This could be due to mismanagement of funds. Government can however moderate its budgetary allocation to the health sector while ensuring checks and monitoring mechanism are put in place to prevent the mismanagement of this public health spending.

3) Urbanization has a negative significant effect on life expectancy rate (LER). As a result, more healthcare and infrastructural facilities should be developed in rural areas to reduce the rate of rural-urban migration. This would help put urban population in check and this would positively impact Nigeria's health outcome.

4) Economic stabilization policies should be promoted to minimize macroeconomic uncertainty so as to ensure optimal allocation of resources to the health sector in Nigeria. This would in turn lead to optimal performance of the health sector thus improving health outcome in Nigeria.

Limitations and future directions

There was data limitations on getting Nigeria's data for out-of-pocket and private health expenditure. Future research can consider the impact of the interaction of public health expenditure, macroeconomic uncertainty and quality of governance. This is due to the impact of political factors on allocation of health expenditure and other public resources in the health sector. Additionally, future research could also look to use neutrosophic statistics, that deals with uncertain data for macroeconomic uncertainty (Smarandache, 2014); (Muhammed et al., 2018).

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of the paper.

REFERENCES

Adewumi SB, Acca YA, Afolayan O (2018). Government health expenditure and health outcomes in Nigeria: The challenge to underdeveloped economy. Int J Res Innov Soc Sci. 2(12):463-471.

Adhikari R, Agrawal R (2013). An Introductory Study on Time series Modeling and Forecasting. 10.13140/2.1.2771.8084.

Ajayi, S.I. (2012), Effects of Macroeconomic Policies on Health. African Development Review, 24: 270-278. https://doi.org/10.1111/1467-8268.12000

Azuh DE, Osabohien R, Orbih M, Godwin A. (2020). "Public Health Expenditure and Under-five Mortality in Nigeria: An Overview for Policy Intervention" Open Access Macedonian Journal of Medical Science; 8(E):353-362.

Banks J, Karjalainen H, Propper C (2020). Recessions and health: The long-term health consequences of responses to the Coronavirus. Fiscal Studies, 41(2):337-344.

Besuthu H, Kin S, Dumisani H (2019). The Impact of Public Health Expenditure on Health Outcomes in South Africa. International J. Environmental Research and Public Health. 16. 1-13. 10.3390/ijerph16162993.

Biadgilign S, Ayenew HY, Shumetie A, Chitekwe S, Tolla A, Haile D, Gebreyesus SH, Deribew A, Gebre B (2019). Good governance, public health expenditures, urbanization and child undernutrition Nexus in Ethiopia: an ecological analysis. BMC health services research, 19(1), 40.

Boachie MK (2017). Health and Economic Growth in Ghana: An Empirical Investigation. Fudan J. Hum. Soc. Sci. 10:253–265.

Boachie MK, Ramu K Põlajeva T (2018). "Public Health Expenditures and Health Outcomes: New Evidence from Ghana". Economies 2018, 6, 58; doi:10.3390/economies6040058

Edward J, Wiggins A, Young M, Rayens M (2019). Significant Disparities Exist in Consumer Health Insurance Literacy: Implications for Health Care Reform. Health literacy research and practice. 3. e250-e258. 10.3928/24748307-20190923-01.

Grossman M (1972). On the concept of health capital and the demand for health. The Journal of Political Economy, 80(2): 223-255.

Ibukun CO (2021), "The role of governance in the health expenditure–health outcomes nexus: insights from West Africa", Int. J. Soc. Econ., 48(4):557-570.

Ifunanyachukwu N, Igboanugo and Dauda ROS (2019). "Education, Health Expenditure and the Quality of Life in Nigeria." Academic J. Econ. Studies, vol. 5 (4):94+. Gale Academic

Muhammad A, Nasrullah K, Mohammed A: (2018).Control Chart for Failure-Censored Reliability Tests under Uncertainty Environment. Symmetry 2 10, 690, DOI: 10.3390/sym10120690. http://fs.unm.edu/NS/ControlChartForFailure.pdf

Nketiah-Amponsah E (2019). "The Impact of Health Expenditures on Health Outcomes in Sub-Saharan Africa". Journal of Developing Societies. 35(1):134-152.

Olatubi MI, Oyediran OO, Adubi IO Ogidan OC (2018) "Health Care Expenditure in Nigeria and National Productivity: A Review," South Asian J. Social Stud. Econ. 1(1): 1-7.

Olayiwola SO, Bakare-Aremu TA Abiodun SO (2021). "Public Health Expenditure and Economic Growth in Nigeria: Testing of Wagner's Hypothesis". African J. Econ. Rev., 9(2):130-150.

Onofrei M, Vatamanu A.-F, Vintila G, Cigu E, (2021) "Government Health Expenditure and Public Health Outcomes: A Comparative Study among EU Developing Countries". Int. J. Environ. Res. Public Health, 18, 10725. https://doi.org/10.3390/ijerph182010725.

Osakede UA. (2021), "Public health spending and health outcome in Nigeria: the role of governance", International Journal of Development Issues, 20(1):95-112.

Raji R (2020). Infant and Under Five Mortality Rates in Nigeria: An Impact Analysis of Macroeconomic Conditions. Risk and Financial Management. 2. p1. 10.30560/rfm.v2n1p1.

Schmidt (2016). "A Journey Through Time: From The Present Value To The Future Value And Back Or: Retirement Planning: A Comprehensible Application Of The Time Value Of Money Concept". American Journal of Business Education, 9(3): 137-143.

Sen A (2006). Why Health Equity? In Public Health, Ethics and Equity. Edited by Anand Sudhir, Peter Fabienne and Sen Amartya. Oxford: Oxford University Press.

Smarandache F (2014). Introduction to Neutrosophic Statistics. 10.13140/2.1.2780.1289.

World Health Organization (2019). Health and Well-Being. Accessed via https://www.who.int/data/gho/data/major-themes/health-and-well-being on December 15, 2021.

Yaqub J, Ojapinwa T, Rukayat Y (2012). Public Health Expenditure and health outcome in Nigeria: the impact of governance. European Scientific Journal. 8.

APPENDIX

Inflation rate GARCH equation

Dependent Variable: INF
Method: ML ARCH - Generalized error distribution (GED) (BFGS / Marquardt steps)
Date: 12/05/21 Time: 12:55
Sample (adjusted): 1981M02 2020M12
Included observations: 479 after adjustments
Convergence achieved after 39 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.071517	0.017107	4.180528	0.0000
INF(-1)	0.999039	0.000957	1043.842	0.0000
Variance Equation				
C	0.002311	0.000879	2.627951	0.0086
RESID(-1)^2	0.687851	0.058234	11.81190	0.0000
GARCH(-1)	0.298657	0.026679	11.19456	0.0000
GED PARAMETER	5.363354	0.578651	9.268714	0.0000

R-squared	0.992149	Mean dependent var	18.98186
Adjusted R-squared	0.992133	S.D. dependent var	17.32813
S.E. of regression	1.536970	Akaike info criterion	1.471056
Sum squared resid	1126.806	Schwarz criterion	1.523311
Log likelihood	-346.3178	Hannan-Quinn criter.	1.491598
Durbin-Watson stat	0.024247		

ARCH effect test

Heteroskedasticity Test: ARCH

F-statistic	379.9011	Prob. F(1,476)	0.0000
Obs*R-squared	212.1655	Prob. Chi-Square(1)	0.0000

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 12/18/21 Time: 09:59
Sample (adjusted): 1981M03 2020M12
Included observations: 478 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.375117	0.049494	7.579082	0.0000
WGT_RESID^2(-1)	0.666500	0.034195	19.49105	0.0000

R-squared	0.443861	Mean dependent var	1.125502
Adjusted R-squared	0.442693	S.D. dependent var	0.910922
S.E. of regression	0.680031	Akaike info criterion	2.070818
Sum squared resid	220.1224	Schwarz criterion	2.088264
Log likelihood	-492.9256	Hannan-Quinn criter.	2.077677
F-statistic	379.9011	Durbin-Watson stat	1.544180
Prob(F-statistic)	0.000000		