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Bivariate Granger Causality Analysis between Education and Health Indicators in Nigeria: Implications for Achieving Sustainable Development Goals

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Abstract:
There existed lack of empirical evidence in Nigeria on the Granger causality between health and education in particular. This study therefore provided econometric estimation of the Granger causality relationship between the variables. The questions of the study are: Does Granger causality existed between health and education variables in Nigeria? If it does exist, what is the direction of the Granger-causality? This relationship is examined using the variables of; secondary school enrolment, literacy rate, primary school enrolment for education, while, maternal mortality, life expectancy and disease burden were used for health. These variables were chosen because of the availability of data among other variables for measuring health and education. Results showed that bidirectional relationship existed between burden of disease and mortality rate and between primary school enrolment and literacy rate. Other variables for example, out-of-pocket expenditure to burden of disease, mortality rate and literacy rate showed unidirectional relationship. While some others, primary school enrolment and out-of-pocket expenditure showed no causality. From the study, it was concluded that health and education indicators are interwoven, quality education leads to good health and good health leads to quality education. The results have important implications for attaining the targets envisioned by the UN2030 Sustainable Agenda and Africa 2063 Development Aspirations. The data implications are also discussed.

Keywords: *Bivariate Granger causality, education, health, human capital development, Nigeria*

1. Introduction

Human capital development is a complex process involving multiple interactions among different components. Health and education provide such basic interactions among other human capital development components. Health is central to well-being, and education is essential for a satisfying and rewarding life (Bloom, 2005; Todaro& Smith, 2011). As Bloom and Canning (2000; 2003) have observed, healthier individuals affect the economy in four ways; for example, they might be more productive at work and so earn higher incomes. Health is closely linked to economic growth and sustainable development. According to World Health Organization (WHO), increasing life expectancy at birth by 10% will increase the economic growth rate by 0.35% a year. Similarly, ill health is a heavy financial burden. As reported by the Commission on Macroeconomics and Health (2001), 50% of the growth differential between the rich and poor economies is due to ill-health and life expectancy. The African Population and Health Research Centre (APHRC, 2017) outlined the most common cause of maternal death in Nigeria to include heavy bleeding following delivery (hemorrhage) which account for 23% of all maternal death, followed by infections following childbirth(sepsis) at 17%. The Report of the Centre also included abortions performed in Nigeria. The abortions performed in Nigeria are clandestine and unsafe, terminated by either person lacking the necessary skills or in an environment lacking the minimum medical standard or both. The abortion rate in Nigeria, at 33 per 1000 women aged 15 and 49 years, is higher than sub-Saharan Africa's average of 31 per 1000 women.

It is natural to believe that a productive development strategy would be to raise the schooling level of the population. For an economy, education can increase the human capital in the labour force, which increases labour productivity and thus leads to a higher level of equilibrium in output. In Nigeria, education is majorly affected by poor funding. Precisely, the Federal Government spending on education is below 10 percent of its overall budget. Budgetary allocation to the Federal Ministry of Education, relative to its total budget size, has fallen from a 2015 high of 12.46% to a

low of 7.04% in 2018(BUdgit, 2018) The UN Sustainable Development Goals was agreed upon on September 2015 by 189 countries to achieve sustainable development in its three dimensions-economic, social and environmental in a balanced and integrated manner. The commitment is summarized in the 17 targets as follows: to eradicate poverty; end hunger; ensure healthy lives and promote well-being of all women and girls; inclusive and equitable education, gender equality; sustainable water and management for all; affordable energy; inclusive and sustainable economic growth; resilient infrastructure; reduce inequality; inclusive settlement; sustainable consumption, climate change combat, sustainable oceans, seas and marine resources, sustainable terrestrial ecosystem; peaceful society and develop a global partnership for development.

The causal relationship between health and education has continued to attract much attention of many researchers. The aim of the paper therefore is to determine the causality between both variables in Nigeria. This helps to draw relevant policy conclusions. For that purpose, a Granger causality econometric model was specified, using maternal mortality rate, life expectancy and disease burden as variables for health and primary, secondary and literacy rate as variables for education for the period, 1990-2016 for which consistent and more comprehensive data is available. On the basis of the empirical estimates, conclusions are drawn on the relative relevance of health and education policies. This takes us to the next sub-section.

1.1. Research Problem

Greater health capital may raise the return on investment in education as healthier individuals are more able to productively use education at any point in life among others. Again, greater education capital may raise the return to investment in health as schools teach basic personal hygiene and sanitation. Many health programmes rely on skills learned in school including literacy and others. These theoretical expositions may not be the case with Nigeria. Buttressing this assumption, since independence in Nigeria in 1960 to date, the Nigerian health sector is characterized by challenges and difficulties hindering efficient healthcare delivery which in turn hinders qualitative education. The healthcare performance major indicators are poor. For example, the maternal mortality ratio for Nigeria remains quite high at about 814 per 100000 live births according to World Health Statistics Report (2018). This no doubt affects negatively children school enrolment ratio. While there is evidence that use of skilled maternity care is growing, unattended home deliveries are widespread, consistently averaging 60% of all deliveries in Nigeria since the 1990s. Barriers to seeking optimal maternity care include cost of services, distance to health facilities, and long waiting times for those seeking care at public health facilities (APHRC, 2017)

On the other hand, despite huge government investment in education and the persistent rise in school fees, education in Nigeria still suffer so many setbacks. UNESCO (United Nations Educational, Scientific and Cultural Organization) recommended that government should commit 15% and 20% of the nation's budget to education if we hope to reverse the declining trend in education in Nigeria. Unfortunately, educational sector allocations over the years, as a percentage of the budget arefalling (Budgit, 2018).To address the challenges of health and education in Nigeria and to ensure its combined contributive role to economic development, the policymakers have employed many programmes and policies including: Maternal and Child Health Programme (MNCH); National Immunization Coverage Scheme (NICS); National Health Insurance Scheme (NHIS); National Health Policy; Universal Basic Education (UBE). Health Sector Reform and 6-3-3-4 system of education among others have not yielded the desired result thereby limiting their contributions to economic development in Nigeria. Research wise, the few empirical studies in Nigeria on human capital development (health and education) in particular to the best of our knowledge did notexamine the causality between health and education variables, as statistical correlation cannot be used as an indication of a causal relationship. We know little about the direction of causality, that is whether health drives education or vice versa. It may be more interesting to examine such a causal relationship exists and if so, which variable drives the other. Unfortunately, this important issue(s) has been ignored by previous studies(see Ogunleye et al; 2017; Eigbiremolen & Anaduka, 2014); Oyewole&Adegoke, 2018; Okumoko et al; 2018); Ademike&Sheriffdeen, 2017); Iyobonyi &Muftau, 2014); Oboh et al (2010); Isola & Alani, 2006); Adeyemi& Ogun Sola, 2016); Ogujiuba, (2013); Ekperiware et al; 2017); Eseyin et al, 2014); Shobande et al; 2014); Ojokuku&Sajuyigbe, 2015); and Amodu et al; (2017). The study by Adenike and Sheriffdeen (2017) examined the interactive effect of health and education on economic growth in Nigeria thereby limiting the knowledge. The present study examines the causality between health and education in Nigeria using the Granger causality approach. The questions of the study as follows:

- Does reverse causality exist between health and education variables in Nigeria as posited in the development literature.
- What is the policy implication of the causality between the variable Nigerian relationship between health and education?

The next section is on the justification and the relevance of the paper.

1.2. Justification/Scientific Contribution and Relevance of the Study

The study extends and contributes to the development literature on health and education relationship in Nigeria in four ways. First, it shows why understanding the relationship between health and education matters and hence why policymakers in Nigeria need to pay more attention to health and education. Second, unlike previous studies and most significantly, Adenike and Sherriffeen (2017), the current study focuses majority on determining the Granger causality between health and education and proxy variables. Third, the study shows interesting stylized facts on health and

education selected variables in Nigeria. Four, the study offers policy suggestions in the light of the empirical evidence that would help to effectively tackle the challenges of health and education in Nigeria.

The relevance of the study is linked to the fact that the global development agenda (SDGs and MDGs) beamed development searchlight on affordable healthcare delivery and quality education as targets for development in the 21st century. Understanding the health benefits of education is thus integral to reducing health disparities and improving the well-being of the Nigerian populace. The next section is on some stylized facts about health and education in Nigeria.

2. Trends and Profile of Health and Education Indicators in Nigeria

This section x-rays the human development indicators of Nigeria in terms of health and education. Basically, it aims at examining the trend of the variables and possibly make comparisons where necessary between Nigeria, sub-Saharan Africa (SSA) and rest of the world. Using the most current year as a case study, Nigeria's human development index (HDI) value for 2017 is 0.532, which put the country in the low development profile at 157 out of 189 countries sampled. Between 2005 and 2017, Nigeria's HDI value increased from 0.465 to 0.532, an increase of 14.4 percent (UNDP, 2018). Between 1990 and 2017, Nigeria's life expectancy at birth increased by 8.0 years, while, mean years of schooling increased by I year and expected years of schooling increased by 3.3 years. Similarly, Nigeria's GNI per capita (standard of living) increased by about 87.4 percent between 1990 and 2017.

	Life Expectancy @ Birth	Expected Years of Schooling	Mean Years of Schooling	GNI per capita (2011) PPP$	HDI Value
1990	45.9	6.7	-	2,792	-
1995	45.9	7.2	-	2,569	-
2000	46.3	8.0		2,451	-
2005	48.2	9.0	5.2	3,669	0.465
2010	50.8	8.4	5.2	4,862	0.484
2015	53.0	10.0	6.0	5,527	0.527
2016	53.4	10.0	6.2	5,326	0.530
2017	53.9	10.0	6.2	5,231	0.532

Table 1: Nigeria's HDI Trends (1990-2017)
Source: UNDP Briefing note on Nigeria, 2018 Statistical Update

Comparatively, Nigeria's 2017 HDI of 0.532 is above the average of 0.504 for countries in the low human development group but below the average of 0.537 for countries in Sub-Saharan African (SSA). Within the SSA countries, Congo and Ethiopia are close to Nigeria in 2017 HDI ranking and population size, which have HDIs ranked 176 and 173 respectively.

	HDI Value	HDI Rank	Life Expectancy at Birth	Expected Year of Schooling	Mean Year of Schooling	GNI and Capita (DPPU$)
Nigeria	0.532	157	53.9	10.0	6.2	5,231
Congo Democratic Republic	0.457	176	60.0	9.8	6.8	0,796
Ethiopia	0.463	173	65.9	8.5	2.7	1,719
Sub-Saharan Africa	0.537	-	60.7	10.1	5.6	3,399
Low HDI	0.504	-	60.8	9.4	4.7	2,521

Table 2: Nigeria HDI Relative to Selected Countries and Group (1990-2017)
Source: UNDP Briefing note on Nigeria, 2018 Statistical Update

The HDI is an average measure of basic human development achievements in an economy. The HDI likewise other averages masks inequality in the distribution of human development across the population. The 2010 human development report (HDR) introduced the inequality-adjusted HDI (IHDI), which takes into account inequality in all three dimensions of the HDI by discounting each dimension's average via its level of inequality. Following the Report and adjusting for inequality, Nigeria's HDI falls to 0.347, a loss of 34.7 percent due to inequality in the distribution of the HDI dimension indices while Congo Democratic Republic and Ethiopia showed lost due to inequality of 30.3 percent and 28.4 percent respectively. The average loss due to inequality for low HDI is 31.1 percent and for Sub-Saharan Africa it is 30.8 percent. Table 2.3 present the IHDI for Nigeria in 2017.

	IHDI Value	Overall loss (%)	Human inequality coefficient (%)	Inequality in life expectancy @ birth (%)	Inequality in education (%)	Inequality in income (%)
Nigeria	0.347	34.7	34.6	37.4	38.1	28.2
Congo Democratic Republic	0.319	30.3	30.2	36.1	26.3	28.3
Ethiopia	0.331	28.4	27.3	24.9	43.5	13.4
Sub-Saharan Africa	0.372	30.8	30.7	30.8	33.7	27.7
Low HDI	0.347	31.1	30.9	31.2	37.0	24.6

Table 3: Nigeria's IHDI Relative to Selected Countries (1990-2018)
Source: UNDP Briefing note on Nigeria, 2018 Statistical Update

Further in the analysis of HDI, in 2014, a new measure, the GDI (Gender Development Index) based on the sex-disaggregated human development index, defined as a ratio of the female to the male HDI was introduced. The GDI measures gender inequalities in achievement in three basic dimensions of human development health (measured by female and male life expectancy at birth), education (measured by female and male expected years of schooling for children and mean years for adults aged 25 years and older; and command over economic resources (measured by female and male estimated GNI per capita).

The UNDP statistical update for Nigeria showed that out of the 164 countries whose GDI was calculated in 2017, female HDI value for Nigeria was 0,494 and 0,569 for male. When compared with Congo Democratic, the female has HDI value of 0,420 and the male has 0,493 while the rest of SSA has 0,506 and 0,567 respectively.

	Life Expectancy at Birth		Expected Years of Schooling		Mean Years of Schooling		GNI Per Capita		HDI Values		F.M Ratio
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	GDI Value
Nigeria	54.7	53.1	9.2	10.8	5.0	7.3	4,433	6,008	0,494	0,569	0.868
Congo Democratic	61.5	58.5	8.7	10.6	5.3	8.4	703	889	0,420	0,493	0.852
Ethiopia	67.8	64.0	8.2	9.1	1.6	3.8	1,304	2,136	0,424	0,501	0.846
Sub-Saharan Africa	62.4	59.0	9.5	10.6	4.7	6.5	2,763	4,034	0,506	0,567	0.893
Low HDI	62.3	59.2	8.7	10.1	3.8	5.7	1,915	3,126	0,465	0,540	0.862

Table 4: Nigeria'sGDI Relative to Selected Countries (1990-2018)
Sources: UNDP Briefing Note for Countries on the 2018 Statistical Update

Year	Recurrent Expenditure	Capital Expenditure	Overhead costs	UBE Budget	Education Budget	Total Budget	Education Budget as % of Total
2012	317.89	55.06	27.19	63.12	563	4,697	9.86%
2013	337.53	71.94	23.29	76.28	509	4,987	10.21%
2014	421.03	51.28	22.97	70.47	566	4.695	12.03%
2015	441.34	23.52	18.32	68.38	552	4,425	12.46%
216	426.85	35.43	17.99	71.1	557	6,080	9.17%
2017	375.11	50.43	22.89	95.18	544	7,441	7.31%
2018*	544.27	61.73	27.68	113.73	606	8,610	7.04%

Table 5: Summary of Education Sector Allocation, 2012-2018
*Source: Budget office, BudgiT Research (2005) *Proposed budget*

Budgetary allocation to the Federal Ministry of Education, relative to its budget size has fallen from a 2015 high of 12.46% to a low of 7.04% in 2018. Meanwhile, UNESCO Declaration recommends that government should commit 15% to 20% of the nation's budget to education if we hope to reverse the trend of decline in education expenditure in Nigeria.

3. Empirical Literature Review

This section reviewed the relevant literature to the study. The aim is to show the trend of studies on health and education [human capital in general] with the intention of identifying the knowledge gap and bridging the knowledge gap thereby extending the frontiers of knowledge. Appleton and Teal (1998) examined human capital, economic growth and

welfare in Africa. The study concluded that there are long term effects of educating one generation on the welfare of their future children. The long-term intergenerational effects of health and education are an important reason for promoting social sector investments despite tight current fiscal constraints. The paper also concluded that once a generation of children is exposed to life without adequate healthcare, nutrition or schooling, there is little that can be done during their adulthood to reverse the damage.

Sacredoti, Sonia and Jon (1998) studied the impact of human capital on economic growth in West Africa with yearly observations for the period 1970-1976, using the Seemingly Unrelated Regression (SUR) methodology. The variables used include: human capital stock, inflation, labour force, primary school enrolment, gross domestic investment among others. The findings revealed that private capital was found to be important to growth, but human capital appears to be insignificant. The paper also identified the terms of trade, trade openness, the government deficit, and share of government investment in total investment as key policy variables affecting growth.

Ishola and Alani (2006) examined the contributions of different measures of human capital development to economic growth in Nigeria. The data set for the study consisted of annual time series data for 1980 to 2005.The variables used for the study are growth rate of GDP, adult literacy rate, life expectancy, growth rate of labour, growth rate of capital and the structural adjustment programme while employing Ordinary Least Square (OLS) for the analysis. The result revealed that both education and health components of human capital development are crucial to economic growth in Nigeria.

Odonkor, Kwaku, Eric and Mohammad (2011) examined human capital development and economic growth in Ghana between the period 1970-2010 and using the OLS. Some of the variables used include education expenditure, life expectancy rate, labour force and public health expenditure. The result showed that the education expenditure, life expectancy rate, labour force and public health expenditure were positively related to economic growth in Ghana while public health expenditure proved non-significant with economic growth in Ghana.

Ogujiuba (2013) examined the impact of human capital formation on economic growth in Nigeria. The model was estimated using annual data from 1970-2010. The variable used are real gross domestic product growth rate, capital expenditure on education, recurrent expenditure on education, real gross capital formation, primary education enrolment, post-primary education enrolment and tertiary education enrolment. Finding showed that investment in human capital in the form of education and capacity at the primary and secondary levels impacted significantly on economic growth, while capital expenditure on education were insignificant to the growth process.

Pelinescu (2014) studied the relationship between human capital and economic growth in the EU countries from 1990-2012 and using the panel data approach. The variables used include GDP per capita, human capital expenditure on education, and qualification of employee, proxy for secondary education. The unexpected is the negative relationship between expenditure in GDP and GDP per capita, a possible explanation being the heterogeneity of countries considered.

Boachie (2015) examined the effect of health on economic growth in Ghana between from the period 1982 to 2012. The author employed the autoregressive distributed lag-approach (ARDL) on the variables of life expectancy, real GDP per capita, education, international trade, foreign direct investment (FDI), inflation and physical capital. The findings revealed that economic growth is significantly driven by health, both in the short and long-run. However, the favourable growth effect of health in the short-run is found to be lower. The implication is that improvement in health status of the population raises output in the economy.

Shuaibu and Popoola (2016) examined the determinants of human capital development (HCD) in 22 African countries. The study used the World Bank Development Indicators Online data source, covering the period 2000-2013. The findings showed that all the variables significantly influence HCD in the long-run, whereas the contemporaneous models suggested that only institutions matter. Some of the variables used include public expenditure on education, public expenditure on health, infrastructure and human capital development.

Islam, Ahmad, Kusuma and Belinda (2016) examined education and human capital effect on Malaysia's economic growth between the period 2000-2010 using the regression (questionnaire) and correlation approaches. The variables used are economic growth, education and human capital. The findings revealed that there is a positive relationship between education and economic growth in Malaysia and there exists a positive relationship between human capital and economic growth in Malaysia.

Ogunleye, Owolabi, Sanyaolu and Lawal (2017) examined human capital development and economic growth in Nigerian from the period 1981 to 2015. The method employed for the study is the OLS. The variables used are gross domestic product, life expectancy, and total government expenditure on education, total government expenditure on health, primary school enrolment, secondary school enrolment and tertiary school enrolment. The result showed that human capital development has significant impact on economic growth as proxy by the gross domestic product. However, life expectancy and primary school enrolment exhibited a negative and statistically insignificant impact on economic growth in Nigeria within the reviewing period.

Adenike and Sheriffdeen (2017) studied the interactive effect of health and education on economic growth. The variables used in the study include: education and health government expenditures, physical capital and capital formation. The data were analyzed using Fully Modified Ordinary Least Squares (FMOLS) technique. The results of the study showed that there was positive and significant relationship between the interactive effect of human capital components and growth in Nigeria.

Pooja (2019) explored the contributions of human capital in economic growth, a comparative study of India and China, from the period 1970-2016, using the Principal Component Analysis (PCA) and the Engle Granger Causality Tests. The study observed unidirectional causality between public health expenditure (PHE) and economic growth. It further

showed that GDP granger causes PHE in both India and China. It also showed that both health and education indexes have positive impact on growth in India however the results of regression depict that both health and education negatively affect the growth rate in China.

Muhammed, Abiodun and Manzoor (2018) examined the relationship between human capital, social capabilities and economic growth from the period 1996 to 2011 on 132 countries over 15 years and applying the Fixed Effects (FE) models, Random Effects (RE) models and Generalized Method of Moments (GMM). The empirical results revealed that human capital plays a positive role in per capita GDP growth only in the presence of better economic opportunities and high-quality legal institutions.

In conclusion, evidence from the empirical literature reviewed showed that education and health are crucial for the economic growth process. However, virtually all the studies reviewed examined the individual effects of education and health elements of human capital while few studies examined the interactive effect of health and education on economic growth. While the previous reviewed studies contributed to the literature on human capital development (health and education), the issues of causality between health and education was missing, thereby creating a lacuna in the human capital development literature. This study intends to fill this vacuum and thereby extend the body of knowledge.

3.1. Theoretical Framework and Model Building

The framework of the study is anchored on the theory of joint investment in skill capital, health capital and longevity propounded by Galama and Kippersluis (2015) on the assumption that the human-capital theory and health-capital theory has fallen short of providing a comprehensive framework to study the interactions between education, health and longevity (Grossman, 2008). The joint investment theory is an integrated (unified) theory of the human-capital and health-capital theories. The theory makes two main contributions to the literature. The first contribution is of important nature: by explicitly modeling joint investment in both skill and in health, the model defines and highlights the similarities and difference in the nature of skill and health. Like skill, health is investment goods that increase individuals' productivity (Grossman, 1972a). The theory of joint investment made further clarifications. First, skill capital determines the wage rate, while health capital determines the time spent working, both within a day by decreasing sick time, but also over the life cycle by affecting retirement and life expectancy. Second, individuals start life with a healthy body, but the terminal health state is universally low. Skill grows while health declines. Third, skill is valued very early in life while health is valued mostly later in life. Hence, investments in skill are high when young, while investment in health is high when old.

The second contribution of the theory of joint investment in skill, health and longevity provides new insights, new predictions and stylized facts that the individual theories of skill and health capitals on their own cannot. The novelty stems from: first, the theory predicts that health affects both educational attainment and skill formation such that (i) health and skill are strongly complementary in generating earnings, so that an increase in health proportionally raises the return to investment in skill (ii) healthy individuals are more efficient producers of skill, and (iii) healthy individuals live longer, increasing the return to skill investment by increasing the period over which its benefits can be reaped. Second, the theory predicts a central role for longevity in explaining observed associations between wealth, skill and health. The reason behind this is that the horizon (longevity) is important in determining the return to investment in skill and in health.

Individuals invest in health (and longevity) through expenditures on (example, medical care) and time investment (e.g. exercise), they invest in skill capital through outlays and time investments in skill (e.g. schooling and on-the-job training). Following Galama and Kipperslius (2015), an individual maximizes the lifetime utility function, such that:

$$\text{ч} = X_c, L, I_E, \max_{I_H}, S,R,T \{\int_0^S \text{ч}[\cdot]e - \beta^t dt + \int_S^R \text{ч}[\cdot]e - \beta^t dt + \int_R^T + \text{ч}[\cdot]e - \beta^t dt\} 1$$

where time t = 0, corresponds to the mandatory schooling age, S denotes years of post-mandatory school, R denotes the retirement age, T denotes total lifetime, β is a subjective discount factor and individuals derive utility ч[X_c (t), L(t), H(t) from consumption goods and services X_c (t), leisure time L(t), and health H(t).

3.2. Model Specification

In line with our basic objective for the study and following the exposition of Galama and Kipperslius (2013) we specified a Granger causality test of the relationship between health and education in Nigeria. Granger causality test is a statistical hypothesis test to determine whether one-time series is useful in forecasting another, following Granger (1969). The test involves estimation of the following vector autoregression (VAR).

$$X_t = \Sigma\alpha_i Y_{t-I} + \Sigma\beta_j X_{t-J} + \mu_{1t} \quad 2$$

$$Y_t = \Sigma\lambda_i Y_{t-I} + \Sigma^{\delta}_j X_{t-J} + \mu_{2t} \quad 3$$

Where, ч_{1t} and ч_{2t} are serially uncorrelated. The first equation represents that the variable X is decided by lagged variable Y and X, μt is the residual. Granger causality implies that the lagged Y influences X significantly and the lagged X influences Y. This can be tested if estimated lagged coefficient $\Sigma\alpha_i$ and $\Sigma\lambda_i$ are different from zero with F-statistic. If the joint test rejects the two null hypotheses that $\Sigma\alpha_i$ and $\Sigma\lambda_i$ both are not different from zero, then the causality relationships between X and Y are confirmed.

On the justification of the Granger-causality testing, Hoover (2006) stated that Granger-causality is the most influential approach to causality analysis in economics. Despite criticism following the difference between Granger causality and the causal effect (Liu &Bahadori, 2012), Granger-causality is now being applied not only to econometrics, but also to neuroscience, epidemiology, and financially analysis among others. The Granger-causality test can get three different results: In the first instance, the null is rejected in one test, i.e., the existence of unidirectional causal relationship

between two time series (Health and Education). In the second instance, bi-directional Granger-causality may exist, which means: (i) there is an instant Granger-causality between the time series (ii) X and Y are determined by a third variable (Sims, 1977). The third instance, i.e. no rejection of the null hypothesis in both tests, usually as a sign of no Granger causality. To defend the criticism of using the Granger-causal test, Granger (1988:2000) wrote as follows: "Possible causation is not considered for any arbitrary selected group of variables but only of variables for which the researcher has some prior belief that causation is, in some sense likely"

The health variables for our study are; burden-of-disease, out-of-pocket expenditure (OOP) and infant mortality rate. The education variables are; primary school enrollment, secondary school enrollment and literacy rate. The choice of these variables among the other human capital (health and education) variables is that they have been used mostly in previous studies as reviewed in the literature. The variables, measurement and sources of data are presented in Table 1(see appendix 1). The data for selected variables are obtained for the time period 1970-2018 and were sourced from the World Bank Development Indicator (2018) online

Procedurally, the first step to Granger causality test is the determination of the optimal lag length using the relevant information criteria. Meanwhile, the choice of information criteria to be used is entirely the researchers' because no information criterion is superior to the other (Wang, 2019). However, while the Akaike Information criteria (AIC) is suitable for very large sample size. Given that the sample size of 27 is relatively small; our optimal lag length is based on the selection by the Schwarz Information Criterion (SIC) which is 3. Note also that the Granger causality is sensitive to lag and as such, relying on a single lag length may lead to spurious conclusion. The presence or absence of Granger-causality can be substantiated by the judicious choice of lag-length (Daniel & Dallas, 1984). In other to overcome the challenges, we consider testing from phase 1 to 3.

4. Empirical Results and Discussions

4.1. Pre-Estimation Test

4.1.1. Descriptive Statistics

Table 2 describes the variables used in the study, and reports descriptive statistics for each one. It showed the characteristics of the variables of estimate.

	SSE	PSE	LTR	MTR	OPE	BUD
Mean	0.880169	0.865561	0.752706	100.8870	55.88686	0.374444
Median	0.849580	0.843900	0.772353	102.9000	65.83498	0.350000
Maximum	1.115590	0.967420	0.824964	125.9000	77.75203	0.570000
Minimum	0.770550	0.789210	0.050000	67.05000	0.050000	0.220000
Std. Dev.	0.092820	0.053333	0.141371	20.42192	27.47753	0.112672
Skewness	1.114196	0.532975	4.796226	-0.216194	-1.522905	0.427324
Kurtosis	3.397948	1.934070	24.38930	1.599120	3.482018	1.844651
Tarque-Bera	5.764603	2.556512	618.2068	2.418102	10.697972	2.323392
Probability	0.056006	0.278523	0.000000	0.298480	0.004753	0.312955
Sum	23.76456	23.37014	20.32307	2723.950	1508.945	10.11000
Sum Sq. Dev.	0.224002	0.073955	0.519629	10843.43	19630.38	0.330067
Observation	27	27	27	27	27	27

Table 6: Descriptive Statistics of the Model Variables
Source: Authors' Computation Using E-VIEW 10.0

From the table, the mean value of SSE is 0.88, PSE is 0.86, LTR is 0.75, MTR is 100, OPE is 56 and BOD is 0.37, meaning that on average the variables grew by 88%, 86%, 75%, 100%, 56% and 37%. The standard deviation showed that out-of-pocket health expenditure (OPE) was 27.48% and the most volatile variable in the time series followed by maternal mortality rate (MTR) with 20.42%, while primary school enrolment (PSE) was the least volatile variable. The skewness statistics showed that literacy rate, maternal mortality rate and out-of-pocket health expenditure were negatively skewed and the remaining variables were positively skewed. Again, kurtosis statistics showed primary school enrolment, maternal mortality rate and burden-of-disease were platykurtic, suggesting that their distributions were flat relative to normal distribution, while secondary school enrolment, literacy rate and out-of-pocket health expenditure were lepokurtic, suggesting that the distribution is peaked relative to normal distribution. Finally, the Jargue-Bera statistic rejected the null hypothesis of normal distribution for literacy rate and out-of-pocket health expenditure at 5 percent critical values while the null hypothesis of normal distribution for the other variables (SSE, PSE, MTR, BOD) were accepted at the same critical value. The significant values of the descriptive statistics were further confirmed by the time series properties examination as presented in the succeeding section.

4.1.2. Unit Root/Stationarity Test

To avoid the spurious regression results, the study tested the variables for unit root problem using the Augmented Dickey Fuller Test (ADF). The results are presented in Table 7

Variables	Level	First Difference	Order of Integration
Log(BOD)	-0.0020	-3.984559*	
Log(LTR)	-1.4720	-193.2811*	
Log(MTR)	-0.6433	-3.578181*	
Log(OPE)	-0.6695	-4.904803*	
Log(PSE)	-0.5261	-3.738656*	
Log(SSE)	-0.9486	-3.962506*	
Critical values			
1%	-3.831511	-3.5966	
5%	-3.029970	-2.9332	
10%	-2.655194	-2.6049	

Table 7: Unit Test Rest by ADF Method
Source: Authors' Computation Using E-VIEW 10.0
Note: * = 1%. The automatic maximum lag length for the unit root is based on the Schwarz Information Criteria (SIC)

Having established that the variables were stationary at first difference, we tested whether the variables have long-run co-movement using Johansen co integration test. The result of the cointegration test is presented in Table 8.

Rank	Trace statistic	0.05 critical value	Max-Eigen Statistic	0.05 critical value
R = 0	244.4090	95.75366	93.08471	40.07757
R≤ 1	151.3243	69.81889	61.86624	33.87687
R≤ 2	89.45804	47.85613	42.97832	27.58434
R≤ 3	46.47972	29.79707	28.75276	21.13162
R≤ 4	17.72696	15.49471	11.60705	14.26460
R≤ 5	6.119907	3.841466	6.119907	3.841466

Table 8: Johansen Co Integration Result (Long-Run Co-Movement)
Source: Authors' Computation Using E-View 10.0
Note: Trace Test Indicates 6 Cointegrating Equ(S) @ 0.05 Level Of Significance. Max-Eigen Value Test Indicates 5 Cointegrating @ 0.05 Level Of Significance

The result of the Johansen cointegration test presented in Table 2.4 shows that they variables using the trace and max-eigen statistics were integrated at the 5 percent significance level. This indicates that there is cointegration or long-run relationship between the variables of education and health. However, it has been observed that using differenced variables for regressions would imply the loss of valuable information about the long-run equilibrium relationship between health and education variables. Thus, the need to integrate short-run dynamics and long-run equilibrium (ECM) following the "Granger Representation Theorem", Maddala (1992; 597). The ECM results weren't presented as it supports the co integration evidence and bearing in mind that our concern is on causality.

The prerequisite of the Granger causality test is that the two variables (health& education) are stationary or cointegrated; otherwise the problem of spurious regression might occur.The Granger causality test result is presented in the appendix. The results show that there exists a unidirectional causality running from primary school enrollment to secondary school enrolment and this is maintained from phase/lag 1 to phase 3. This implies that any policy targeted on primary education is expected to affect secondary education from the first period to the third period. On the nexus between literacy rate and secondary school enrolment, we found evidence of unidirectional causality running from secondary school enrolment to literacy rate only at phase 1 only. This implies that any policy adjustment on secondary education is expected to affect literacy rate in Nigeria after the first period. While there was no evidence of causal relationship between secondary school enrolment and mortality rate in the first lag. We found evidence of bi-directional causality between both indicators in phase 2 and unidirectional causality running from morality rate to secondary school enrolment at phase 3. This generally suggests that policies can be taken on both variables to take effect after the second lag while in the third period; only secondary school enrolment is expected to respond to variations in mortality rate. There was no evidence of causality between secondary education and out- of- pocket health expenditure from lag 1 to lag 3. This does not mean that secondary education does not affect out-of-pocket expenditure. The results differing from the hypothesis may be due to following reasons i) small sample size of secondary education or out-of-pocket expenditure ii) the two variables might be 'rigid'. In other words, an increase or decrease of one variable does not necessarily cause a significant increase or decrease of the other (Wang, 2019). Thus, no policy effect is expected to manifest between the two variables.

At the first period lag, there was no causality between burden of diseases and secondary education, but after the second period, burden of diseases causes secondary education with no reserve causality, while secondary education unidirectional causes burden of diseases at the third period. Therefore, policy swap between the two variables can be effective at lag 2 and lag 3 with no reverse outcomes at each lag. Interestingly, we found that primary education influenced literacy rate for the whole of the periods with no reverse causality. This suggests that primary and secondary educations are the basis for high literacy rate in Nigeria. Primary education and mortality rate maintained a bidirectional causality between each other up till lag 2 before the causality became unidirectional running from morality rate to primary education at lag 3. Thus, each of the two variables can form the policy instrument to achieving the other within the first two phases. No evidence of causality exists between out- of- pocket health expenditure and primary education in the first

two phases, but at lag 3, we found that out- of- pocket health expenditure Granger causes primary education. This implies that any policy targeted to adjust out- of- pocket health expenditure is expected to affect primary education only after three periods.

Bidirectional causality was found between burden of diseases and primary education in the first period lag, while unidirectional causality running from primary education to burden of diseases was witnessed in the rest of lags 2 and 3. This suggests that policy adjustment in primary education is expected to influence burden of diseases in Nigeria. We also found evidence of a unidirectional causality running from mortality rate to literacy rate within the first two lags. This implies that policy adjustment should consider mortality rate, a driving force in the first two lags, while the reverse should be expected in the third lag. No causality was found between out- of- pocket health expenditure and literacy rate from lag 1 to lag 3. Thus, not much could be inferred in terms of policy implications. Bidirectional causality exists between burden of diseases and literacy rate only in the first lag, while no evidence of causality was further seen in the rest of the phases. We conclude that a reversed policy adjustment could achieve certain objective regarding to the two variables and this is expected to manifest after a period lag.

Moreover, a unidirectional causality running from out- of- pocket health expenditure to mortality rate was observed throughout the time lags (from lag 1 to lag 3). This implies that adjustment in out- of- pocket expenditure is expected to influence mortality rate in Nigeria up till third period lag. We also found evidence of bidirectional causality between burden of diseases and mortality rate in Nigeria. This implies that policy taken on either of the two variables would bring about reversed outcomes from the first to third period lag. Between burden of diseases and out- of- pocket health expenditure, we found that a unidirectional causality which runs from out- of- pocket health expenditure exists from lag 1 to lag 3. Thus, policy attempt should expect out- of- pocket health expenditure to drive burden of diseases in Nigeria.

In summary, it could be said that during the period under review, health indices and education indices are related, either unidirectly or reversely related. This answers the question(s) on the causality between health and education in Nigeria. For instance, without good health, education is badly affected and development is also affected and vice versa. This is in tandem with the literature.

5. Discussion of Empirical Findings

The result of the Johansen co-integration test indicates that there is evidence of long-term relationship between the health and education performance selected indicators in Nigeria. From the Granger-causality results, it was revealed that unidirectional, bidirectional and no causality relationship exist among the variables of interest, for example no evidence of causality existed between primary school enrolment, secondary school enrolment, literacy rate and out-of-pocket- expenditure on health in Nigeria within the reviewing period in all the lags. This follows high level of unemployment and low per capita income in Nigeria. The seemingly lack of relationship no doubt could be as a result of Wang (2019) expositions or better still, the high incidence of out-of-pocket (OPE) health payments as a major means of financing healthcare delivery in Nigeria. This has continued for many years in spite of a general consensus to move closer to the universal adult coverage (UHC). OPE health payment can make households face catastrophic expenses and become impoverished. Following this scenario, Aregboshola and Khan (2018) concluded that OPE health payments has led to a 0.8% rise in poverty headcount, resulting to about 1.3 million Nigerians being pushed below the poverty line. According to the authors, poverty headcount was 97.9% gross of health payments using the $1.25 a day poverty line. OPE health payments are capable of making households incur catastrophic health expenditure and this can exacerbate the level of poverty and thereby affecting the relationship with the identified variables.From the Granger results, unidirectional relationship was revealed between out-of-pocket health expenditure and burden-or-disease, between out-of-pocket health expenditure and mortality rate and between out-of-pocket health expenditure and literacy rate. The unidirectional relationship between out-of-pocket expenditure and burden of disease and between out-of-pocket expenditure and morality is not far-fetched. While health care needs are increasing, government expenditure on health in developing countries (Nigeria inclusive) is declining. As Sambo et al (2016), summed- up; out-of-pocket expenditure represents about 43% of all expenditure in Africa, Nigeria inclusive, compared to 37% from government and about 25% from donors. The authors posited further that the government expenditure is 14% while private expenditure is about 79.2% with a per capita income of about $260 in Nigeria. This shows that out-of-pocket expenditure is the main source of health care financing in Nigeria. The $5 per capita expenditure on health in Nigeria is far below the $14 recommended by World Bank for Africa(Lambo, 2003) and much lower than $34 per capita recommended by WHO Macro-economic Commission for Health for low income countries to provide basic health care services (WHO, 2001; Palmer, et al, 2004).Finally, bidirectional relationship exists between burden-of-disease and mortality rate, between primary school enrolment and mortality rate and between burden of disease and literacy rate. The Institute for Health Metrics and Evaluation (IHME, 2010) in its reports concluded that the three-risk factor for children under 5 and adults aged 15-49 years were childhood underweight and alcohol use, respectively. The bidirectional causality implies that both health and education can predict themselves in both directions. The policy implications of the results have also been discussed.

6. Concluding Remarks and Policy Recommendations

This study set out to determine the Granger causality between health and education variables in Nigeria from the period 1990-2018. The Granger-causality technique proposed by Granger (1969) is the adopted approach of analysis and the variables of the study are burden-of-disease, literacy rate, mortality rate, out- of-pocket health expenditure, primary

school enrolment and secondary school enrolment. The first step to the Granger causality test is the determination of optimal lag length using the relevant information criteria. Hence, we considered testing from lag 1 to 3.

Summarily, the results show first: that there is no evidence of causality or relationship between primary school enrolment, secondary school enrolment, literacy rate and out- of- pocket health expenditure within the three lags. Second, there exist unidirectional causality running from out- of-pocket health expenditure to burden of disease, between out-of-pocket health expenditure to mortality rate and mortality rate running to literacy rate without any reserve causality. Third, there existed bidirectional causality or reverse causality between burden-of-disease running to mortality rate, primary school enrollment to mortality rate and burden of disease to literacy rate. Therefore, we can conclude that during the period under review, health indicators of (burden of disease, mortality rate and out-of-pocket expenditure) and education indicators (literacy rate, primary school enrollment secondary school enrollment) are interrelated following the literature. This means that as components of human capital, health and education work hand- in- hand in promoting development in Nigeria. Furthermore, from the results, out-of-pocket expenditure was found to be showing no causality with most of the variables. This could be it catastrophic nature, which means that OPE affects the ability of households to purchase essential medical goods and services (education) (Aregbeshola & Khan, 2018). This affects health equity and health efficiency which in turn affect educational development. As a result, it is recommended that complimentary health and education policies be formulated and implemented by the policymakers to achieve the Sustainable Development Goals for health and education targets. Again, strengthening the already health and education policies in Nigeria becomes necessary.

7. Limitations of the Study

One significant limitation of the study is that not all indicators of health and education are included in the analysis due to data collection challenges. The World Development Indicator proved useful.It is hoped that future human capital development estimate will cover other variables.

8. Authors' Contribution

All the authors were involved in the design, conceptualization, estimating and interpretation of the data. The manuscript was reviewed for important intellectual content and approval for final draft were given by the authors.

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Appendix

Variable	Indicators	Symbol	Units	Data Source
Education Indicators	Primary school enrolment	(PSE)	%	World Bank Development Indicator (WDI, 2018), Nigerian Human Development Report, 2018.
	Secondary school enrolment	(SSE)	%	WDI
	Literacy rate	LTR	%	WDI 2018
Health Indicators	Burden-of-Disease	BOD	%	WDI 2018
	Maternal Mortality Rate	MTR	%	WDI 2018
	Out-of-Pocket health expenditure (%) of total expenditure on health	OPE	%	WDI 2018

Table 9: Description of Variables Used for Estimation of Health and Education Indicators
Source: Researchers' Construct (2019)

Granger Causality Tests
Date: 09/10/19 Time: 03:46
Sample: 1990 2018
Lags/Phase: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
PSE does not Granger Cause SSE	26	9.56230	0.0051
LTR does not Granger Cause SSE	26	0.03066	0.8625
SSE does not Granger Cause LTR		108.463	4.E-10
MTR does not Granger Cause SSE	26	2.66821	0.1160
SSE does not Granger Cause MTR		2.55833	0.1234
OPE does not Granger Cause SSE	26	0.12221	0.7298
SSE does not Granger Cause OPE		0.68253	0.4172
BOD does not Granger Cause SSE	26	2.67148	0.1158
SSE does not Granger Cause BOD		2.82236	0.1065
LTR does not Granger Cause PSE	26	1.78557	0.1945
PSE does not Granger Cause LTR		56.8798	1.E-07
MTR does not Granger Cause PSE	26	5.66150	0.0260
PSE does not Granger Cause MTR		6.08459	0.0215
OPE does not Granger Cause PSE	26	0.90277	0.3519
PSE does not Granger Cause OPE		0.47936	0.4956
BOD does not Granger Cause PSE	26	7.83664	0.0102
PSE does not Granger Cause BOD		5.06678	0.0342
MTR does not Granger Cause LTR	26	33.2286	7.E-06
LTR does not Granger Cause MTR		3.38537	0.0787
OPE does not Granger Cause LTR	26	2.31694	0.1416
LTR does not Granger Cause OPE		1.58546	0.2206
BOD does not Granger Cause LTR	26	16.0644	0.0006
LTR does not Granger Cause BOD		4.06217	0.0557
OPE does not Granger Cause MTR	26	36.9504	3.E-06
MTR does not Granger Cause OPE		0.20281	0.6567
BOD does not Granger Cause MTR	26	9.03046	0.0063
MTR does not Granger Cause BOD		28.0148	2.E-05
BOD does not Granger Cause OPE	26	0.46074	0.5041
OPE does not Granger Cause BOD		98.1853	9.E-10

Table 10: Granger Causality Test Result

Granger Causality Tests
Date: 09/10/19 Time: 03:47
Sample: 1990 - 2018
Lags/Phase: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
PSE does not Granger Cause SSE	25	4.84129	0.0193
SSE does not Granger Cause PSE		0.07524	0.9278
LTR does not Granger Cause SSE	25	2.51566	0.1060
SSE does not Granger Cause LTR		2.77571	0.0863
MTR does not Granger Cause SSE	25	6.06424	0.0087
SSE does not Granger Cause MTR		4.18317	0.0304
OPE does not Granger Cause SSE	25	0.04030	0.9606
SSE does not Granger Cause OPE		0.34566	0.7119
BOD does not Granger Cause SSE	25	3.26170	0.0594
SSE does not Granger Cause BOD		2.61367	0.0981
LTR does not Granger Cause PSE	25	0.05767	0.9441
PSE does not Granger Cause LTR		9.28225	0.0014
MTR does not Granger Cause PSE	25	6.87663	0.0053
PSE does not Granger Cause MTR		4.30996	0.0278

OPE does not Granger Cause PSE PSE does not Granger Cause OPE	25	1.41474 0.20610	0.2663 0.8155
BOD does not Granger Cause PSE PSE does not Granger Cause BOD	25	2.13594 5.56812	0.1443 0.0120
MTR does not Granger Cause LTR LTR does not Granger Cause MTR	25	6.26731 2.92550	0.0077 0.0768
OPE does not Granger Cause LTR LTR does not Granger Cause OPE	25	0.00470 1.40539	0.9953 0.2685
BOD does not Granger Cause LTR LTR does not Granger Cause BOD	25	1.48447 2.43670	0.2505 0.1130
OPE does not Granger Cause MTR MTR does not Granger Cause OPE	25	10.2907 0.28896	0.0008 0.7521
BOD does not Granger Cause MTR MTR does not Granger Cause BOD	25	7.82019 9.97344	0.0031 0.0010
BOD does not Granger Cause OPE OPE does not Granger Cause BOD	25	0.11469 10.2328	0.8922 0.0009

Table 11

Granger Causality Tests
Date: 09/10/19 Time: 03:47
Sample: 1990 - 2018
Lags/Phase: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
PSE does not Granger Cause SSE SSE does not Granger Cause PSE	24	3.40248 0.55186	0.0418 0.6538
LTR does not Granger Cause SSE SSE does not Granger Cause LTR	24	1.97812 1.72204	0.1555 0.2003
MTR does not Granger Cause SSE SSE does not Granger Cause MTR	24	4.23197 1.45328	0.0209 0.2625
OPE does not Granger Cause SSE SSE does not Granger Cause OPE	24	0.06873 0.17496	0.9758 0.9119
BOD does not Granger Cause SSE SSE does not Granger Cause BOD	24	2.20122 3.10258	0.1252 0.0544
LTR does not Granger Cause PSE PSE does not Granger Cause LTR	24	0.66253 3.76677	0.5864 0.0306
MTR does not Granger Cause PSE PSE does not Granger Cause MTR	24	3.50163 1.38943	0.0383 0.2801
OPE does not Granger Cause PSE PSE does not Granger Cause OPE	24	3.35273 1.45845	0.0436 0.2611
BOD does not Granger Cause PSE PSE does not Granger Cause BOD	24	2.13114 5.24029	0.1340 0.0096
MTR does not Granger Cause LTR LTR does not Granger Cause MTR	24	2.87798 3.30597	0.0665 0.0454
OPE does not Granger Cause LTR LTR does not Granger Cause OPE	24	0.09191 1.96108	0.9635 0.1582
BOD does not Granger Cause LTR LTR does not Granger Cause BOD	24	2.79803 0.90748	0.0715 0.4580
OPE does not Granger Cause MTR MTR does not Granger Cause OPE	24	4.25508 2.30589	0.0205 0.1133
BOD does not Granger Cause MTR MTR does not Granger Cause BOD	24	3.67209 7.44442	0.0332 0.0022
BOD does not Granger Cause OPE OPE does not Granger Cause BOD	24	0.05851 8.37156	0.9808 0.0012

Table 11
Source: Researchers' Computation using E-view 9.0