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Under-Five Mortality Rate and Health Human Capital in Sub-Saharan Africa: Evidence from Panel Vector Autoregressive Analysis

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Abstract

Malnourished children, particularly those with severe acute malnutrition have a higher risk of death from common illness such as diarrhea, pneumonia and malaria. Nutrition –related factors contribute to about 45% of death in children under-5 years of age. The paper examined the relationship between under-five mortality rate and health human capital in sub-Saharan African (SSA) countries between the periods of 1995 to 2022 using the dynamic panel vector autoregressive (PVAR) technique, anchored on the theoretical framework of Grossman health production function. The variables of the model are: under-five mortality rate, the dependent variable; per capita income, food security, electricity consumption, carbon emission, government health expenditure (% of GDP), government education expenditure (% of GDP) and poverty headcount ratio as independent variables. The data for the variables were sourced from World Bank Development Indicator (WDI, 2023) and African Development Bank Database (2020). The finding showed that per capita income was positively related to under-five mortality rate while electricity consumption was negatively but significantly related to under-five mortality rate. The study therefore recommended among others the need for policymakers to initiate expansionary fiscal policy and restrictive monetary policy to promote and sustain per capita income through the channel of investment in the focused SSA countries so as to promote employment generation and for reducing /eliminating under-five mortality rate.

Background to the Study

If Africa is to meet up with the Sustainable Development Goals, (SDGs) it must reverse the previous patterns of rapid population growth, stagnating primary enrollments, declining health, poor nutrition, and growing income insecurity, all affecting children and women disproportionately as a result of deteriorating family structures. Reversing the pattern means understanding its cause especially under-five mortality rate and the importance of health human capital. Health is a key component of an individual's welfare and standard of living. Economic development is no longer confined to a process of persistent increase in per capita income. Other dimensions are now considered central aspects of this process; the most notable of them are improvements in health and education. Undoubtedly, the health of children and young people are among the most important health issues. In this regard, infant mortality (IMRs) rates and the under-five (U5MR) are the most widely used as credible measures of child health (Isa & Quattara, 2012; Alves & Belluzzo, 2004). Infant mortality rates have been explained variously to mean the probability of dying before age one while under-five mortality has also been defined as the probability of dying between birth and age five years expressed per 1000 live births which have been a common indicator for children's wellbeing. Both the infant mortality and under-five mortality rates are various called health status and they are most widely used in the literature (Anyanwu & Erhijakpor, 2007). However, our focus in the study is on under-five mortality rate (U5MR)

There exist a continuously growth healthcare gap between the SSA and the rest of the world. SSA account for 11% of the world's population and bears 24% of the global disease burden. The rural inhabitants succumb to and are victims of poor health care facilities, personnel and access to medication. Despite the financial influx of capital from the donor agencies, only few countries in sub-Saharan African (SSA) are able to provide the minimum health care as defined by the World Health Organization (WHO) to be within the range of $ 34-$40 person (WHO, 2020). Comparatively, the average annual growth rate of human development index (HDI) for sub-Saharan Africa is about 4.01% compared to East Asia and Pacific and Latin American regions with over 20%. Again, progress in reducing child mortality since 1990 to date has been particularly slow in SSA, where rates of infant and child mortality are increasing on daily basis. Indeed, the gap between the development goals and target reality is greatest in sub-Saharan Africa where under-five mortality was 185 in 1990, 163 in 2005 and about 214 in 2020. In 2019, the region had an average under-five mortality rate of 76 deaths per 1000 live births. These dramatic decline in infant and under-five mortality rates have been traced to several socio-economic factors. The most commonly sighted in the literature are per capita income growth; expenditure on health and education. Others include the poverty head-count ratio, while less attention has been paid to food security and environmental factors (WHO, 2020).

In 2021, 1 in 14 children in sub-Saharan Africa died before reaching their fifth birthday -15 times higher than the risk of children born in high income countries and 20 years behind the world (UNICEF, 2022). Sub-Saharan Africa and Southern Asia account for more than 80% of the 5 million under-five deaths in 2022 while they only account for 53% of the global live births. Half of all under-five death in 2022 occurred in 5 countries of Nigeria, India, Pakistan, Congo and Ethiopia. Nigeria and India account almost a third of all death (WHO, 2023)

The countries of Benin, Cote d'Ivoire, Ghana, Mali and Nigeria were the selected countries for the study based on geographical, economic and health system factors. These countries have fairly developed health systems, and they are Economic Community of West African States (ECOWAS)countries of the SSA countries. The countries were also chosen based majorly on the availability of data. Studying on them bearing in mind the seemingly characteristics would help African policy makers on improving child health and health care status in the countries.

The objectives of this paper are as follows:

1. Examine the effect of per capita income, food security, electricity consumption and government health expenditure on under-five mortality rate and health human capital in SSA.
2. Analyze the impulse response of per capita income, food security, electricity consumption and government health that traces the responsiveness of under-five mortality rate and health human capital in SSA.
3. Evaluate the shock effects of per capita income, food security, electricity consumption and government health expenditure on under-five mortality rate and health human capital in SSA.

This paper is limited to the drivers of under-five mortality rate in the selected sub-Saharan African countries (SSAs) between the periods of 1995 to 2022. It is limited to these selected SSA countries (Benin, Ghana, Cote d'Ivoire, Mali and Nigeria) following the challenges of cross-country studies- data collection, Ghana, Cote d'Ivoire, Mali and Nigeria). This paper is organized into five sections- Section one presents the introduction; section two presents the empirical literature review while section three present the methodology. Section four is on the results and analysis. Section five is on summary of the conclusion and policy recommendations.

Empirical Literature Review

This section reviews extant empirical literature on the key drivers of under-five mortality rate. Novignon and Lawanson (2017), examined health expenditure and child health outcomes in SSA between 1995 and 2011 using the panel data approach. Some of the variables used are total health expenditure, public health and private health expenditure. The results show a positive and significant relationship between health expenditure and child health outcomes with elasticities of -0.11 for infant mortality, -0.15 (under-five mortality and 0.08 (neonatal mortality). The current study included more predictor variables-GDP per capita, food security, C_{O2} emission and electricity consumption over and above Novignon and Lawanson (2017), that concentrated only the expenditure predictors. The study didn't capture other variable, a major shortcoming of the study.

David (2018), examined the infant mortality and public health expenditure in Nigeria from 1980-2016 using the Ordinary Least Square and the ARDL approach. The results show that government health expenditure, private health expenditure, immunization and external health resources significantly influence mortality negatively both in the short-run and long-run. The study used the ARDL and causality for test for Nigeria while the current study used the panel VAR for sub-Saharan Africa, thereby enlarge the scope of the empirical literature.

Yeshalem and Abiot (2019), examined food security as not the only solution to prevent under-nutrition among 6-59 months old children in Western Ambara region, Ethiopia using a community-based cross sectional and interviewer-administered questionnaire on 6-59 months old children from June 01-30/2017. A multi-stage sampling strategy was used to select study participants. The results reveal that lack of getting antenatal care was 2.0, 95% while taking food less than four times per day was 2.00, 95%. The paper concluded that health professionals and health extension workers should give nutrition counseling about the frequency and diversity of meal, environmental and personal hygiene by giving emphasis to mother who have no formal education. While the former study considers other factor-underweight, wasting and overweight/obesity as contributing factors to infant mortality, the present study concentrated only on food insecurity as factors to increased mortality in sub-Saharan Africa.

Shohande (2020), examined the effects of energy use on infant mortality rates in Africa from the period 1999 and 2014 using a panel of 23 African countries. Some of the variables used include inflation rate, urbanization rate, government spending on education, improved water sources, aggregate institutional index and GDP per capita. The study showed that energy predictors have a negative and significant impact on infant mortality. While this study used the proceed Ordinary Least Square (OLS) and the Generalized Method of Moment approaches, the current study used the panel VAR approach. The difference between the previous study and current study lies on the use of random and fixed effects panel estimation. The current focused on panel VAR.

Azuh, Osabohien, Orbih and Godwin (2020), examined government health expenditure and under-five mortality in Nigeria between the period 1985 and 2017 using the autoregressive distributed lag approach. The variables used are under-five mortality rate, Birth crude rate C_{O2} emission, electricity consumption, public health expenditure. The results show that though public health expenditure is statistically significant, it showed a positive relationship with the under-five mortality. While the previous studies focused only on public health expenditure as a determinant of under-five mortality rate, our study is incorporate more determinants GDP per capita, food production index (food security) and government education expenditure. Again, while the previous study used ARDL-a dynamic analytic approach for Nigeria, the current study used panel VAR, a dynamic approach for SSA.

Bickton *et al.*, (2020), examined household air pollution and under-five mortality in Sub-Saharan Africa: an analysis of 14 demographic and health survey using the pooled

Demographic and Health Survey (DHS) data from 14 SSA countries collected between 2015 and 2018. The result revealed that children from households who cooked inside the home and higher risk of under-five mortality compared to households that cooked in separate building. While both studies focused on SSA, the former considered 14 SSA countries. The current study used on 5 countries. Again, while the former used demographic data, the current study used the panel VAR approach.

Summing up,, from the reviewed empirical results, three conclusions could be deduced: i) Those studies with positive results between under-five mortality rate and determinants(Anyanwu & Erhijakpor (2007); Yaqub *et al.,* (2015): Igbinedion (2018), Adewumi *et al.,* (2018); Novignon & Lawanson (2017); Azuh *et al*., (2020); and Nketiah-Amposah (2019); ii) Those studies with negative outcome (Baird *et al.,* 2011, Shohande, 2020; Kiross *et al.,* 2021 and Theint, 2020),iii) Inconclusive results O'Hare *et al* (2013); Gabriels and Schettino, 2007 and Akhigbodemhe & Apopo (2018). Therefore, this paper is justified on its empirical and policy dimensions. Empirically and methodologically, from the methodological review, the papers that employed panel estimation are (Baird *et al* 2011; Yourself *et al;* 2016; Anyanwu & Erhijiakpor; (2007; Theint, 2020; Nketiah-Amponsah, 2019). These papers attempted determining the fixed and random effects; however, some other studies employed VAR approach (Ashley *et al,* 2009; Yesham & Abiot, 2019, Ajar *et al,* 2010; Adriano & Mollen, 2019). However, there's no identification of Panel VAR in the papers. The choice of Panel VAR approach has been justified. It allows us to explore the endogenous interactions, between U5MR and the determinants as selected in the study. Again, the impulse response functions (IRFs) and variance decomposition (VDCs) helps us to evaluate the dynamic links between U5MR and its drives: food production index, electricity consumption, carbon emission, government health expenditure, government education expenditure and real GDP per capital.

Methodology

The section presents the research design of this paper, which is basically quantitative (econometrics) in nature. It highlights the structure and plan of the analytical approach. C

Theoretical Framework

In spite of the theoretical significance of the endogenous growth models, doubt have been raised on their empirical significance by Mankiw, Romer and Weil (MRW) (1992), Jones (1995) and Parante (2001). The main contribution of the endogenous growth models is twofold: They identify factor that affect the rate of technical progress, which is exogenous in the mechanical growth model, and how that these factors have permanent growth effects. MRW extended the mechanical growth model by adding variables as shift variable in the production function. The implications of this extension are that the neoclassical model is satisfactory for growth accounting and developing policy. The extended growth model is explained as follows:

$$Y(t)= K(t)^{\alpha} H(t)^{\beta} (A(t) L(t))^{1-\alpha-\beta} \quad (1)$$

Where H is the stock of human capital and other variables remain constant. This is premised under the assumption that the same production function applies to human capital. Re-introducing and re-specifying equation 3.1, the MRW model contraption, human capital, can be introduced into the growth eqaution as follows:

$$Y = f(K_{t-1}, H_t, L_t, E_t) \quad (2)$$

Where Y is the aggregate real output, which is an indicator for economic growth, K= human capital, L= labour force, E= under-five mortality rate. However, since the concern of the study is on the drivers of under-five mortality rate and not on economic growth, the underlying model suffices as the adapted model of the study.

Empirical Model Specification

Based on the models of Anyanwu and Erhijiakpor (2007) and Novignon and Lawanson (2017) and adjusting the extended growth model of Barro (1962) and health production function of Grossman (1972), the model of the study can be specified as thus:

$$U5MR_{i,t} = \beta_O + \beta_1 PCI_{i,t} + \beta_2 FSEC_{i,t} + \beta_3 ELCON_{i,t} + \beta_4 C02\,EM_{i,t} + \beta_5 GOVtHEXi_{,t} + \beta_6 G_O VEXP_{i,t} + \beta 7\ POVR + II \quad (2)$$

Where: U5MR = Under five mortality rate, PC1 = Per capital Income; FSEC =Food security, proxy food production index; ELCON =Electricity Consumption; C02EM Carbon emission; GovtHEX = Government health expenditure; GovtEX=Government education expenditure; POVR=Poverty head count ratio; U =stochastic error term, subscript i represents country and t denotes time measured in years. It is worthy of note that both headcount ratio and per capita income enters the model with different intuitions. While per capita income measures the amount of money earned per person in the focused countries, poverty headcount ratio is the percentage of the selected sub-Saharan African countries living below the poverty line. Moreover, other variables not identified in the model but subsisting in the literature could be as a result of unavailability of data or choice of analytical technique. Equation 2 of the study is under the assumption:

$$Yt = \alpha + \beta_1 Yt\text{-}1 + \beta_2 Yt\text{-}2 + \ldots \beta p Y_{t-P} + e_t \quad (3)$$

Where α is the intercept, a constant and $\beta_1 \ldots \beta_2$ to β_p are the coefficient of the lag of Y till order p. It contains up to one lag of each of the predictor. While the simple regression model in equ. (3.2) might provide some insights into the determinants of U5MR, it is plaqued by endogeniety arising from the correlation between unobservable characteristics of the population, e.g. cultural factors and attributes in a particular country, and some of the independent variables such as education and income per capital, additionally, the health production function might be better represented as a dynamic model since U5MR is dependent on the stock of health in reviewing periods (Grossman 1972).

Definition of Variables/Justification for the Model

The dependent variable is under-five mortality rate (U5MR) and its one of the health outcomes of the health sector. The U5MR measures the probability of dying between birth and age five years expressed per 1000 live births. Both the U5MR and the infant mortality have been a common indicative for children's wellbeing. Both have been used in the empirical literature (Olarinde & Bello, 2014; Issa & Quattera, 2012; Anyanwu & Erhijakpor, 2007).

Per capital Income (PCI): This is an explanatory variable in the UM5R model. The per-capita income, a proxy for socio-economic status (standard of living), has been shown to be a crucial determinant of health human capital outcomes (Baldaui *et al.,* 2014; Robert, 2003). Thus, Gupta *et al.,* (1999) had stated that the population's health status (U5MR or IMR) improves as per capital income rise, suggesting that increasing income would be associated with lower under-five and infant mortality rates. In addition, higher income leads to improved public health infrastructure such as water and sanitation, better nutrition, better housing and the ability to pay for health care (Pitched & Summers, 1996, cutter *et al.*, 2006). According to basic economic theory, if everything else is held constant, and if health care is a normal good, an increase in per capital income will lead to increase in the demand for health care. Therefore, increase in per capital income in expected to lower under-five and infant mortality ratio, $\beta_1 > 0$.

Food Production Index (FPI): This enters into the model as explanatory variable. The food production index measures food availability. FPI is grouped under the socio-economic variables driving U5MR and IMR in sub-Saharan in Africa. Food security is an important element in the multi-factorial systems analysis of health and well-being. A good and balanced diet is one of the most important contributing factors to achieve and maintain a good state of health (Chena & Peter 2020). We therefore expect a positive relationship between food security and reduction in U5MR, as such $\beta_2 > 0$.

Electricity Consumption (ELCON): The third explanatory variable in the model is ELCON. Electricity consumption and energy consumption have several direct and indirect impacts on health status. Household energy efficiency interventions have been shown to result in a diverse range of positive health impacts (Thomas *et al;* 2009; 2013), including children's respiratory health, weight and susceptibility to illness and the mental health of adults (Liddell & Morris, 2010), better self-reported health, and reduced respiratory symptoms and school absence due to asthma (PHIS, 2006). Electricity availability is important for health care provision and efficient services. Doctors and nurses are more motivated to access clinics and care centers where energy provision (electricity) is available. Hence, the current study postulates a positive relationship between under-five mortality and electricity consumption, as such $\beta_3 > 0$.

Carbon Emission (C02EM): CO2EM is a driver of UM5R. The adverse effects of gas/carbon emissions on human capital are quite all encompassing (NPL, 2006). Specifically, the pollutants have known adverse effect on human health especially children, who are the most susceptible age group due to their peculiarities. Ozone, sulphur dioxide, nitrogen dioxides and gaseous substances can cause an increase in respiratory tract illness, asthma attacks and a reduction in the findings of the lungs. In some communities, breathing and circulate hospitalization, cardiac death and even cancer of the lungs are attributed to unpleasant repercussions of air pollution (Oguntoke & Adeyemi, 2017). We, therefore, hypothesize a negative relationship between carbon emission represented by $C0_2$ and U5MR, and such $\beta_4 < 0$.

Government Health Expenditure (GOVTHEX)

In accordance with the literature reviewed, health expenditure as an indicator of the volume of resources flowing into the health sector is expected to have a positive effect on under-five rates, thus an increased in health expenditure implies a broader access to health care and services which helps to decrease under-five mortality rates. Given the redistributive influence of public intervention, a positive correlation between government health expenditure and health outcome is expected (Anyanwu & Erhiajakor, 2007, Ehikioya & Mohammed, 2013). Therefore, a positive relationship is expected between GOVTHEX and UM5R, $\beta_5 > 0$.

Government Education Expenditure (GOVTEXP) (Percentage of GDP)

The choice of government expenditure as a percentage of GDP is more robust that any other educational indicator. It involves both recurrent and capital expenditure which is very much important in explaining educational outcomes like school attainment and mean –year –of schooling among others. As the government education expenditure increases in the health sector, especially in teaching hospital, and other specialist hospitals, U5MR decreases. It has been argued that as the literacy rate increases especially the female literacy rate, the health status of U5MR decreases (Baldacci *et al,* 2004; World Bank, 1993; Schulz, 1993). Indeed, in developing countries, women play a more important role in family health, as female education is positively associated with child health and negatively associated with fertility rates. Also, educated mothers are more likely to be aware of nutrition and their children's health (Gubhaju, 1986; Zakir & Wunnava, 1993; Curie & Moretti, 2003). Hence, we hypothesized a positive and direct relationship between government health expenditure and under-five mortality rates, $\beta_6 > 0$.

Head Court Ratio (PCR)

Poverty and low-income status are associated with various adverse health outcomes, including shorter life expectancy, higher infant mortality and higher under-five mortality rates. Poverty is a complex and insidious determinant of health status caused by systemic factors that can persist for generations in a family. Poverty can make households to be susceptible to greater personal and environmental risk less well nourished and less able to access health care facilities. The poor household is therefore more at risk of poor healthcare vis-a-viz low health outcomes, under-five mortality inclusive (Ubi & Ndem, 2019). Therefore, we expect a negative relationship between poverty head court ratio, measure in $1.90 a day (2011 purchasing power parity, % of population) and under-five mortality rates).

Estimation Technique and Procedure

The paper employed multivariate time series methodology of panel vector autoregressive (PVAR) estimation technique because this is a cross-country study and because of its relatively simple computational procedure and fairly satisfactory results. The application of panel VAR technique in estimation of drivers/responses of under-five mortality rates to the various variable shocks will not lead to specification bias since most of the socio-economic variables in the model are strictly endogenous to the countries used in the study. The PVAR models can be applied in levels irrespective of whether the variables are I(0) or I(1) (Pesaran & Pesaran, 1997). The choice of panel VAR approach has been motivated by mainly three reasons. First, the panel VAR approach allows us to explore the endogenous interactions between U5MR and the determinants. That is, it allows us to highlight the lagged effects of the drivers of U5MR and to check whether the feedback from U5MR to the determinants is realized or not. Second, the impulse response function (IRFs) and variance decomposition (VDC) help us to evaluate the dynamic links between U5MR and the drivers. Once all the coefficients of the panel VAR are estimated, the impulse response function and the variance decomposition will be computed. An impulse response function describes the responses of an endogenous variable (U5MR) overtime to a stock in another variable (drivers) in the system. IRFs are constructed from the estimated VAR coefficients and their standard errors. Variance decomposition measures the contributions of each source of shock to the (forecast error variance of each endogenous variable, at a given forecast horizon. Third, it expresses the magnitude of the overall effect of a shock providing the proportion of the movement in one variable explained by the shock to another variable overtime. In order to compute the IRFs, we used the Cholesky decomposition. The assumption behind the Cholesky decomposition is that series listed earlier in the VAR order affect the other variable contemporaneously, while the series listed later in the VAR order impact those listed earlier only with lag. Procedurally, the analysis commences with the descriptive/summary statics including the correlation matrix. This was followed by the Johansen Fisher panel co-integration test, the lag length selection criteria using the appropriate criteria and the impulse response function and the variance decomposition analysis. In the summary statistics, for example, attention was paid to the measures of central tendency (mean & median) and measures of dispersion (range, skewness & kurtosis) which all measures the data characteristics of the variables. The standard deviation is a preliminary measure of the degree of volatility and thus, the higher the standard deviation, the higher the degree of volatility.

Data Source

Table 1 presents the variables, the type in the UM5R model, the proxy, measurement and sources.

Table 1: Summary of Data in the Model & Description

Variables	Type	Proxy	Unit of Measurement	Sources (s)
Under-five mortality rates	Dependent Variable	Health outcome	Per 1000 births	AfDB (2020)
Per capita income	Independent	Income	(Annual %)	AfDB (2020) WDI (2021)
Food production index	Independent	Food Security	1999-2001 = 1000	AfDB (2020) WDI (2021)
Electricity consumption	Independent	Electricity infrastructure	Kwh per capita	AfDB (2020)
Carbon emission	Independent	Environmental Hazard	Meteric. tons per capita	WDI (2020)
Govt. health expenditure	Independent	Government expenditure	% of GDP	AfDB (2020) WDI (2021)
Govt. education expenditure	Independent	Government expenditure	% of GDP	AfDB (2020) WDI (2021)
Poverty Head Count ratio	Independent	Socio-economic indicator/poverty	At $1.90 a day (2011 PPP) (% of population)	AfDB (2020) WDI (2021)

Source: Researchers' Compilation (2021)

Result Presentations, Analysis and Discussion of Findings

This section presents the results of the estimated data, the interpretation, the discussion and evaluation of the research hypotheses based on the standard evaluation criteria outlined in chapter three, and in line with the economy structure of the selected sub-Saharan countries.

Results Presentation and Analyses

Summary of Descriptive Statistics

Table 1 presents the summary of the descriptive statistics i.e., the measures of central tendency which explains the extent of distribution of values of a variable around the mean, and measures of dispersion-which measures the tendency of values of a variable to scatter away from the mean. The measures include the Skewers and Kurtosis.

Table 2: Descriptive Statics

Variables	U5MR	$C0_2$	ELECON	GDP	GDP CGR	GHEXP	POVIK	FSEC
Mean	5.6252104	28.625	116.4952	8.56	2.2666	4.24	0.5241	3.24
Media	16.4200325	24.365	23.56824	7.256	3.00000	3.76	1.010001	1.625
Maximum	42.062854	106.821	2615.321	15.203	105.178	124	1.01000	2.489
Minimum	-172.528106	7.8962	-8.45229	0.2514	-47.02081	0.3	0.00000	1.0200
Std. Dev.	52.625021	9.2435	354.6593	2.1439	10.2776	11.2	0.32521	1.020
Skewers	-3.042956	1.6398	4.28634	-3.14	1.862423	10.4	-1.1441	5.824
Kurtosis	14.682154	15.1259	36.2175	1.462	38.12464	47.3	2.51478	52.61
Targue-Bera	1035.562 10	1462	11063.24	0.32	11524. 86	64.2	52.9524	48,7
Probability	0.0000010	0.00	0.00000	1687	0.000000	70.5	0.000000	0.00
Seen	728.4692	5106	21205.61	1803	654.7281	438.3	146.0010	136^0
Seen Squ.	18725.6	18206	24825.00	70.14	1.4063	1865	34.1218	$0,25^7$
Observation	195	195	195	195	195	195	195	195

Note: U5MR: Under-Five mortality rate; C02 Carbon, emission; ELECON: Electricity Consumption, GDPCUR: GDP per capital, GHEXP: Government health expenditure; GHEXP: Government education expenditure; POVHR: Poverty Headcount ratio significance level: 5%

Source: Computation by the Authors using EVIEW 11.0

Table 2 presents the descriptive statistics of the panel VAR model variables for under-5 mortality rate (per 1000 births), real GDP per capital growth (annual %), (food production index 1999-2001 = 100); electricity consumption (KWH per capital), $C0_2$ emission (metric tons per capital); government health expenditure (% of GDP); government education expenditure (% of GDP and poverty head count (at $1.90 a day, 2011 PPP) (% of population). From the presented evidence in Table 2, the mean for the variables ranges from 5.63 to 3.24, i.e., the mean/average values for under-five mortality to the independent variables. The range for the variables is the difference between the maximum and the minimum. For example, the range for under-five mortality is 26 while the range for food production index is 0.864. The skewness statistics showed that under-five mortality (U5MR), Government education expenditure (GEEXP) and poverty head count ratio (POVHC) are negatively skewed while C02EM, ELECON and real GDP per capita, government health expenditure and food production index are positively skewed. From the skewness results also, it can be concluded that there are no outliers in the distribution. The kurtosis statistics showed that the values of the data ranges from 1.462 to 47.3, suggesting that the variables/data are more peaked than the normal cure (Leptokurtic). Again, the Jarque-Bera statistic values of 1035.562 to 48.7 rejected the null hypothesis of normal distribution for the variables at the 5% (0.05) critical values.

Correlation Matrix

The correlation matrix is carried out in support of the descriptive statistic results. The correlation matrix plays an important role in multi- variance analysis of this type of study since it captures the degree of relationship between different components of a random vector (UM5R). The correlation matrix shows the correlation coefficient between the variables related to under-five mortality rate.

Table 3: Correlation Matrix

	U5MR	ELECON	FDL	GDPCUR	C02	GHEXP	GEXP	POVR
U5MR	1.00							
ELECON	0.82	1.00						
FSEC	0.74	-0.16	1.00					
GDPCUR	0.42	0.27	0.08	1.00				
C02	-0.66	0.3	0.1	0.84	1.00			
GHEXP	0.68	0.27	0.1	0.81	0.98	1.00		
GEEXP	0.76	-0.24	-0.11	-0.69	-0.89	-0.89	100	
POVHR	0.27	0.30	0.05	0.83	0.99	-0.29	0.43	1.00

Note: Variables previously defined.
Source: Researcher's Computation using EVIENV11

Each cell in the table shows the correlation between two specific variables. For example, the correlation between under-five mortality rate and electricity consumption is 0.82, which indicates that ELCON is strongly related to under-five mortality rate, while carbon emission is negatively related to under-five mortality. This indicates that under-five mortality is negatively related to environmental hazards as such, the higher the environmental hazard, the greater the occurrence of UM5R, all things being equal. None of these variables were found to be not basically related to under-five mortality. The correlation coefficients along the diagonal of Table 3 are all equal to 1 because each variable is perfectly correlated with itself.

Panel Unit Root and Co integration Results.
The results of the unit root test for each of the variables using the IM, Pesaran & Shin; Levin, Lin & Chu t* ADF-Fisher Chi-square and PP Fisher Chi-Square and PP Fisher Chi-square are presented in Table 4.

Table 4: Panel Unit Root Test Results
Test

Deterministic Specification: Individual Effects Statist ics			
		Prob.	Cross-Sections
Levin, Lin & Chu	-2.207 (U%MR)	0.0136	5
(Common unit root	-2.766 (POVHC)	0.0028	5
process	-1.0459 (GHEXP)	0.1478	5
	-5.822 (GEEXP)	0.0000	5
	-7.915 (GDPCUR)	0.0000	5
	-2.3705 (FPI)	0.0088	5
	-7.2027 (FP I)	0.0000	5
	-7.2149 (ELCON)	0.0000	5
	-7.2027 (C02EM)	0.0000	5

Determination: Specification: Individual effects and Individual linear trend (U5MR)			
IM, Persaran and Shin W-stat	-2.91202	0.0198	5
ADF-Fisher Chi-Square	25.2960	0.6048	5
PP-Fisher Chi-Square	36.4189	0.0001	
Determinative Specification: Individual effects and individual Linear Trend (POVR)			
IM, Persaran and Shin W-stat	-2.76600	0.00003	5
ADF-Fisher Chi-Square	29.5318	0.0010	5
PP-Fisher Chi-Square	51.3610	0.0000	5
Determinative Specification: Individual effects and individual Linear Trend (GHEXP)			
IM, Pesaran and Shin W -stat	-6.2361	0.0000	5
ADF-Fisher Chi-Square	54.9788	0.0000	5
PP-Fisher Chi-square	296.319	0.0000	5
Determinative Spe cification: Individual effe cts and individual Linear Trend (GHEXP)			
IM, Pesaran and Shun W-stat	-5.82243	0.0000	5
ADF-Fisher Chi-Square	66.0650	0.0000	5
PP-Fisher Chi-Square	296.319	0.0000	5
Determinative Specification: Individual effects and individual Linear Trend (GDPCGR)			
IM, Pesaran and Sh in W-stat	-7.91549	0.0000	5
ADF-Fisher Chi-Square	69.3621	0,0000	5
PP-Fisher Chi-Square	326.821	0.0000	5
Determinative Specification: Individual effects a nd individual Linear Trend (FSEC)			
IM, Pesaran and Shi n W-stat	-4.45276	0.0088	5
ADF-Fisher Chi-Square	38.7419	0.0000	5
PP-Fisher Chi-Square	100.913	0,0000	5
Determinative Specification: Individual effects and individual Linear Trend (ELCON)			
IM, Pesaran and Shin W -stat	-8.30270	0.0000	5
ADF-Fisher Chi-Square	74.8037	0.0000	5
PP-Fisher Chi-Square			5
Determinative Specification: Individual effects and individual Linear Trend (C0 2)			
IM, Pesaran and Shin W -stat	-6.31255	0.00000	5
ADF-Fisher Chi-Square	55.4813	0.0000	5
PP-Fisher Chi-Square	43.8636	0.0000	5

Source: Author Computation using EVIEW 11.0

Using data with some time dimension properties in econometric estimation requires some additional care due to the possibility of non-stationary. Although mostly connected to time series, panel data set may also be non-stationary thus jeopardizing panel estimation results. As presented in Table 4, there are a number of panel unit root and co integration test available for panel estimation. Considering the low power and size properties of unit root tests, we apply a battery of tests, most having non-stationary null hypothesis and one stationarity null hypothesis. The table presents the results of four different panel unit root test (Levin, Lin & Chu; IM, Pesaran and Shin; ADF-Fisher Chi-Square, PP-Fisher Chi-Square) with different deterministic specification, except the Levin, Lin and Chu and IM Pesaran and Shin tests, all others do not regret the unit root null hypothesis. Based on the mixed results presented in Table 4, we carefully concluded that panel non-stationarity is likely; therefore, we treat the variables as integrated as order one, i.e, I (1). Long-run relationship between non-stationary variables can only exist if they variables are co integrated. Table 5 present Kao while Table 6 presents Johansen Fisher panel co integration test results between U5MR and the interested variables.

Table 5: Kao Panel Co integration Test Results

Test	t-Statistic	Prob.
	-1.755764	0.0396
Residual Variance	11.20856	
HAC Variance	25.21711	

Source: Author's Computation using EVIEW 11.0

The Kao panel co integration test shows the rejection of no co integration as the residual and HAC variances are greater than the t-statistic value. This result is supported by the Johansen Fisher Panel co integration test results.

Table 6: Johansen Fisher Panel Co integration Test Results

Unrestricted Co integration Rank Test (Trace and Maximum Eigen Value)				
Hypothesized No. of CE(s)	**Fisher stat* (From trace test)**	**Prob.**	**Fisher stat* (From max-Eigen test)**	**Prob.**
None	46.5	0.0000	89.04	0.0000
At most 1	66.76	0.0000	36.16	0.0001
At most 2	35.55	0.0001	13.91	0.1770
At most 3	23.86	0.0080	7.175	0.7088
At most 4	20.39	0.0258	10.28	0.4163
At most 5	15.32	0.1209	11.52	0.3432
At most 6	9.651	0.4716	11.19	0.3432
At most 7	4.584	0.9172	4.584	0.9172

Individual Cross Section Results

Cross Section	Trace Test Statistic	Prob**	Max-Eigen Test Statistic	Prob**
Hypothesis of no Co integration				
Benin	208.9712	0.0000	70.1303	0.0003
Cote d'Ivoire	232.4998	0.0000	96.0449	0.0000
Ghana	173.3031	0.0071	52.4560	0.0489
Mali	243.1380	0.0000	81.7745	0.0000
Nigeria	232.7893	0.0000	63.4515	0.0026
Hypothesis of at most 2 co integration relationship				
Benin	92.9084	0.0773	29.5110	0.4564
Cote d'Ivoire	85.9817	0.1943	28.7051	0.5120
Ghana	79.5473	0.3799	27.6673	0.5856
Mali	107.4357	0.0062	39.8884	0.0525
Nigeria	118.7738	0.0005	36.0559	0.1325
Hypothesis of at most 3 Co integration relationship				
Benin	63.3974	0.1461	23.2263	0.5132
Cote d'Ivoire	57.2766	0.3284	24.5066	0.4191
Ghana	51. 8800	0.5547	16.2230	0.9480
Mali	67.5473	0.0749	21.3537	0.6574
Nigeria	82.7179	0.0033	28.1569	0.2064
Hypothesis of at most 4 Co integration relationship				
Benin	40.1711	0.2165	17.6588	0.5237
Cote d'Ivoire	32.7700	0.5696	19.7872	0.3560
Ghana	35.6570	0.4138	14.1959	0.8089
Mali	46.1936	0.0710	19.8607	0.3509
Nigeria	54.5611	0.0103	24.7456	0.1107
Hypothesis of at most 5 Co integration relationship				
Benin	22.5122	0.2709	14.2594	0.3441
Cote d'Ivoire	12.9828	0.8924	8.1644	0.8921
Ghana	21.4610	0.3295	12.5101	0.4982
Mali	26.3329	0.1190	17.4254	0.1529
Nigeria	29.8154	0.0498	17.8635	0.1350
Hypothesis of at most 6 Co integration relationship				
Benin	8.2529	0.4388	8.1250	0.3661
Cote d'Ivoire	4.7984	0.8299	4.1431	0.8440
Ghana	8.9509	0.3699	4.1431	0.3629
Mali	8.9076	0.3740	8.9074	0.2939
Nigeria	11.9519	0.1593	11.9385	0.1130
Hypothesis of at most 7 Co integration relationship				
Benin	0.1279	0.7207	0.1279	0.7207
Cote d'Ivoire	0.6553	0.4182	0.6553	0.4182
Ghana	0.7934	0.3731	0.7934	0.3731
Mali	0.0002	0.9905	0.0002	0.9905
Nigeria	0.0134	0.9076	0.0134	0.9076

**Mackinnon-Haug-Michelis (1999) P-Values

Source: Authors' Computation using E-VIEW 11.0

The Johansen Fisher panel Co integration shows 7 Co integrating characteristics of the variables indicating the existence of the long-run relationship between U5MR and the co integrating variables of GDPCUR, FPI, ELCON, C02EM, GHEXP, GEEXP and POVHC.

Panel VAR Lag Order Selection Criteria Test

The correct lag-length selection in essence for panel VAR since excessively short lags may fail to capture the system's dynamics, leading to omitted variables and biasing of the coefficients. However, too many lags lead to rapid less of degrees of freedom and to over parameterization. Given that the number of variables included in PVAR and the time dimension of the series, the system cannot be tested for a lag length more than 3 (IMF, 2000). From the results presented in Table 7, the lag length is 2 which are acceptable.

Table 7: PVAR Lag Selection Criteria Test

Lag	Logl	LR	FPE	AIC	SC	HQ
0	-3934.303	NA	1.45e+12	45.03204	45.14054	45.07605
1	-3190.267	1428.549	4.45e+08*	36.94020	37.69975	37.24821
2	-3101.846	69.51928*	4.38e+084*	36.92249*	38.33308	37.4946
3	-3152.78	90.6972	3.71e+084	36.75253	38.81416	37.58879*
4	-3078.530	39.97040	4.31e+08	36.89749	39.61016	37.9973

Note: *Indicates lag Order selected by the criteria
LR: Sequential modified LR test statistics (test at 5% level)
FPE: Final prediction error
AIC: Akaike information criteria
SC: Schwarz information criteria
HQ: Hannan-Quim information criteria

Source: Researchers' computation using E-view 11.0

Impulse Response Function Results

Figure 1 show the results of the impulse response function of the model relationship between under-five mortality, health human capital and the drivers.

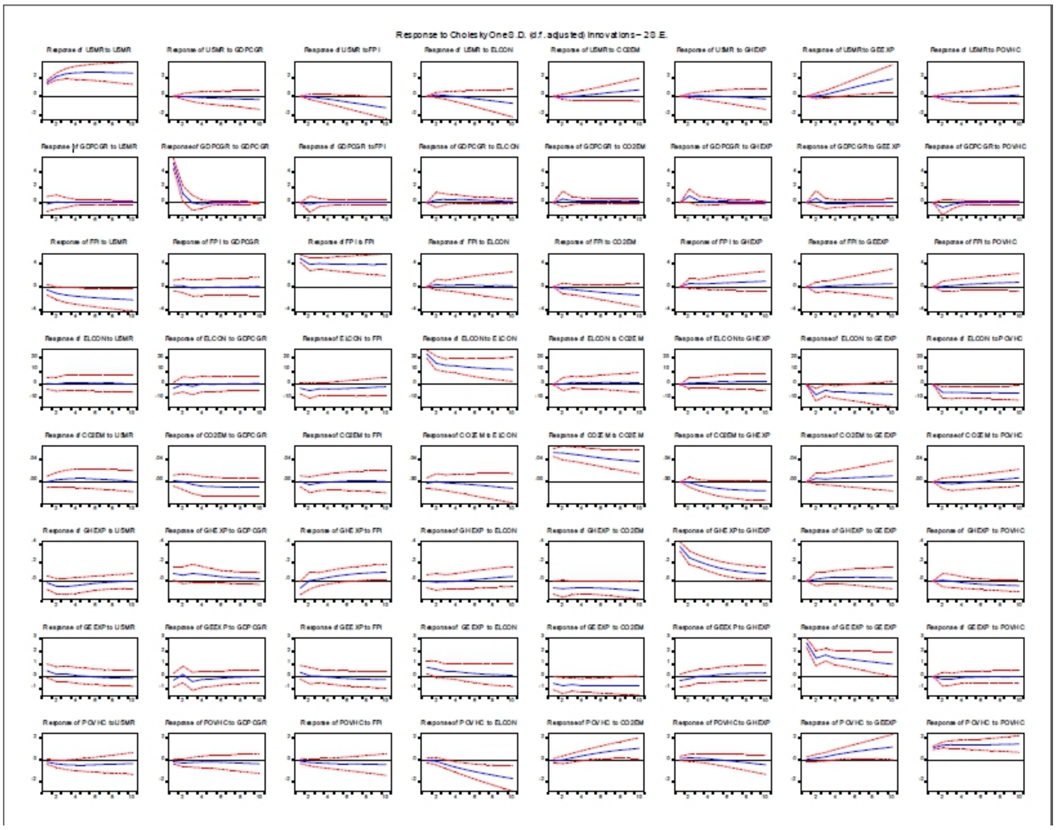

Fig. 1
Source: Researcher's' computation using EView 10

The generalized impulse response functions, traces out the responsiveness of the dependent variables: under-five mortality rate in the selected SSA countries to show its own self and the variables, i.e., the effect of one standard deviation shock to one of the innovation-on current and future values of the variable. The impulse response graph is presented in Figure 1 (presented in the appendix). The impulse response function enables us to forecast the behaviour of the variables to a standard deviation shock on the under-five mortality rate. The impulse response graphs of under-five mortality rate cover a ten period of forecast. For each equation, a unit stock is applied to the error, and the effect upon the system over the 10-horizon noted. Since the study has 8 variables, a total of 64 impulses could be generalized this follows Sims (1980) Cholesky decomposition. Figure 4 shows that a standard deviation shock in under-five mortality rates results to a relatively gradual and positive increase in under-five mortality rate (U5MR) in the ten periods observed. This means that under-five mortality rate continues to increase, all things being equal, and it is always elastic to itself by the variables influencing it. The responses reveal that under-five mortality rate did not respond to one standard deviation in GDPCGR in the early periods as low as zero and negative level throughout the ten period. Meanwhile, the rest of the variables-FPI, ELCON, C02EM, GHEXP, GEEXP and POVHC are relatively stable, low and negative throughout the 10-year period. Therefore, changes in those variables are responsible for changes in U5MR over the period observed.

Variance Decomposition

Variance decomposition measures the relative importance of each random innovations or shock to the variables in the panel VAR. It decomposes the variation in each variable into the component shock of other variables. This gives a better explanation of the relationship which exists among the major variables of the study. The results of the variance decomposition are analyzed further. Table 4. Variance Decomposition for the recursive PVAR ordered as U5MR, GDPCUR, FPI, ELCON, $C0_2EM$, GHEXP, GEXP, POVHC.

Table 8: Variance Decomposition Results

a) Variance Decomposition of U5MR

		Variance Decom position (Percentage Point)							
Forecast Horizon	**Forecast standard Error (S.E)**	**U5MR**	**GDPCUR**	**FPI**	**ELCON**	**$C0_2EM$**	**GEXP**	**GEEXP**	**POVHC**
1	1.45	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2.55	99.45	0.00	0.05	0.31	0.07	0.45	0.02	0.04
4	4.30	97.54	0.13	0.66	0.14	0.06	0.05	1.30	0.12
6	5.76	91.92	0.26	2.06	0.28	0.40	0.03	5.00	0.09
8	7.16	83.61	0.42	4.01	0.86	1.05	0.13	9.91	0.06
10	8.58	74.37	0.58	6.17	1.82	1.85	0.21	14.92	0.08

b) Variance Decomposition of GDPCGR

		Variance Decompo sition (Percentage Point)							
Period	S.E	U5MR	GDPCGR	FPI	ELCON	$C0_2EM$	GEXP	GEEXP	POVHC
1	5.18	0.12	99.88	0.00	0.00	0.00	0.00	0.00	0.00
2	5.47	0.13	93.80	0.14	0.39	0.71	2.55	1.01	1.26
4	5.55	0.14	91.71	0.15	1.69	1.06	2.74	1.09	1.43
6	5.59	0.15	90.41	1.15	2.58	1.35	2.81	1.14	1.41
8	5.61	0.16	89.58	0.17	2.99	1.73	2.85	1.13	1.39
10	5.63	0.16	88.98	0.18	3.17	2.15	2.84	1.13	1.39

c) Variance Decomposition of FSEC

		Variance Decomposition (Percentage Point)							
Period	S.E	U5MR	GDPCGR	FPI	ELCON	C0EM	GEXP	GEEXP	POVHC
1	4.94	1.03	0.23	98.74	0.00	0.00	0.00	0.00	0.00
2	6.43	3.54	0.21	94.73	0.38	0.25	0.86	0.01	0.02
4	8.91	7.51	0.17	89.67	0.37	0.85	1.13	0.06	0.24
6	10.94	10.43	0.12	85.01	0.37	1.79	1.49	0.20	0.59
8	12.76	12.69	0.09	80.77	0.34	2.88	1.89	0.37	0.97
10	14.56	14.51	0.07	76.88	0.31	4.04	2.31	0.54	1.33

d) Variance Decomposition of ELCON

		Variance Decomposition (Percentage Point)							
Period	S.E	U5MR	GDPCGR	FPI	ELCON	GEXP	GEXP	POVHC	$C0_2EM$
1	23.89	0.14	1.38	1.39	97.10	0.00	0.00	0.00	0.00
2	30.39	0.10	0.82	3.07	85.73	0.15	6.36	3.77	0.02
4	38.61	0.33	0.64	3.37	80.59	0.36	7.40	6.10	0.31
6	44.85	0.40	0.49	3.43	76.64	0.65	9.03	8.87	0.50
8	49.97	0.41	0.42	3.24	73.48	0.85	10.73	10.82	0.64
10	54.47	0.40	0.40	2.93	7.78	0.98	12.44	11.35	0.71

e) Variance Decomposition of $C0_2EM$

		Variance Decomposition (Percentage Point)						
Period	S.E	U5MR	GDPCGR	FPI	ELCON	GHEXP	GEEXP	POVHC
1	0.05	0.00	0.21	0.05	0.28	0.00	0.00	0.00
2	0.07	0.26	0.11	0.48	0.14	0.01	0.76	0.11
4	0.10	0.73	0.77	0.28	0.18	1.16	1.01	0.22
6	0.12	0.93	1.50	0.21	0.40	92.60	1.40	0.16
8	0.14	0.90	2.08	0.18	0.90	89.40	1.93	0.24
10	0.15	0.78	2.53	0.15	1.72	85.97	2.56	0.57

f) Variance Decomposition of GHEXP

		Variance Decomposition (Percentage Point)						
Period	S.E	U5MR	GDPCGR	FPI	ELCON	GHEXP	GEEXP	POVHC
1	0.39	0.19	4.31	3.69	6.68	1.12	0.00	0.00
2	0.48	1.48	4.66	2.48	7.87	1.01	0.16	0.03
4	0.58	2.73	6.65	2.30	6.95	0.68	0.10	0.09
6	0.64	2.76	6.93	3.92	6.18	0.85	1.73	0.53
8	0.68	2.48	6.62	6.42	5.51	1.25	2.17	1.20
10	0.73	2.19	6.13	8.96	4.99	1.69	2.40	1.93

g) Variance Decomposition of GEEXP

		Variance Decomposition (Percentage Point)							
Period	S.E	U5MR	GDPCGR	FPI	ELCON	$C0_2EM$	GEXP	GEEXP	POVHC
1	2.95	2.56	0.92	1.46	6.68	3.12	1.12	84.14	0.00
2	3.45	2.23	0.97	1.12	7.87	6.43	1.01	80.04	0.31
4	4.33	1.76	1.64	0.74	6.95	8.79	0.68	79.04	0.40
6	4.89	1.39	1.46	0.70	6.19	11.06	0.85	78.03	0.32
8	5.31	1.22	1.26	0.84	5.51	12.95	1.25	76.70	0.27
10	5.63	1.18	1.12	1.05	4.99	14.64	1.70	75.07	0.24

h) Variance Decomposition of POVHC

		Variance Decomposition (Percen tage Point)							
Period	S.E	U5MR	GDPCGR	FPI	ELCON	$C0_2EM$	GHEXP	GEEXP	POVHC
1	1.16	2.42	1.57	0.58	0.09	0.49	1.69	0.40	92.75
2	1.89	4.25	2.49	1.42	0.31	0.20	1.96	1.08	88.30
4	3.06	5.83	1.72	2.27	6.09	2.23	1.20	4.08	76.57
6	4.22	5.22	1.29	2.49	13.65	5.59	0.66	7.88	63.12
8	5.43	4.13	1.00	2.43	20.04	8.55	0.66	10.92	52.05
10	6.70	3.19	1.22	2.32	24.84	10.46	1.08	13.16	43.73
Cholesky Ordinary: U5MR GDPCGR FPI ELCON $C0_2EM$ GHEXP GEEXP POVHC									

Table 8 (a-h) suggests considerable interactions among the variables. The variance decomposition of under-five mortality shows that U5MR contributed 100 percent of variations in the first period. It gradually started decreasing from the second period to the 10th period with forecast stand errors of 99 to 74. The variance decomposition of GDPCGR shows that the contribution of GDPCGR to variations in U5MR accounted for 0.12 percent from the first period to 0.16 in the 10th period. This implies that per capita income accounted for approximately 2 percent of the changes in U5MR. The results further show that food production index, proxy for food security accounted for 1.03 percent in the first quarter to 14.5 percent in the 10th quarter. Similarly, electricity consumption (kilowatt per capita) accounted for 0.14 percent which is less than 2 percent of the changes in U5MR in the first quarter to 0.40 in the 10th period. Furthermore, the VDC result also showed that carbon emission accounted for 0.00 percent in the period one to 0.78 percent in period 10, while Government health expenditure as percentage of GDP accounted for 0.19 percent variation in U5MR in the first quarter to 2.19 percent in the 10th period. Meanwhile, total government education expenditure accounted for 2.56 percent in the first period to 1.18 percent in the 10th quarter. Intuitively, aside its own shock (U5MR own shock), poverty headcount ratio accounted for much of the variations in under-five mortality rate ranging from 2 percent in the first quarter which decreased to 4 percent, which latter increased to 5 percent.

PVAR Residual Serial Correlation LM Tests

The serial autocorrelation LM test reports the multivariate LM test statistics for residual serial correlation up to the specified order. It is sensitivity check to ensure that the successive values of our error terms are not serially correlated at the level of lag(s), two, chosen in the regression.

Table 9: VAR Residual Serial Correlation LM Tests

Null hypothesis: No serial correlation at Lag h						
Lag	LRE*stat	df	Prob.	Rao-f-stat	df	Prob.
1	69.75	64	0.2902	1.096900	(64,485.2)	0.2929
2	68.64	64	0.3231	1.078141	(64,4852)	0.3288
Null hypothesis: No serial correlation at lag 1 to h						
1	69.75429	64	0.2902	1.096900	(64,485.2)	0.2929
2	135.6896	128	0.3041	1.064610	(125.553)	0.3146
*Edgeworth expansion corrected likelihood ratio statistic						

Source: Researchers' Computation using E-View 11.0

From the result presented in Table 9, the model is free from any form of serial correlation and hence the estimates obtained are useful for policy inference and forecasting. The research hypotheses are evaluated in the preceding section.

Discussion of Findings

From the descriptive/summary statistics the average value for the included variables shows some level of significance as key drivers of under-five mortality rate in the selected SSA countries. From the mean/average, standard deviation to the Jarque-Bera statistics, the null hypothesis of normal distribution for the included variables at the 5% critical value was rejected. This is supported by the multicollinearity tests (correlation matrix). From the result, no variable was found to be not basically related to under-five mortality rate in the countries of interest. This implies that the variables were all related to under-five mortality rate either negatively or positively in line with the theoretical postulations. From the panel unit root test, it was concluded that there is existence of panel non-stationary. This implies that the included variables are free from spuriously results. This is supported by the various co integration tests, meaning that there exists a long run dynamic relationship between the variables-under-five mortality rate and the determinants. From the panel least square, there is a positive relationship between per capita income and under-five mortality, such that 1% increase in per capita income results to a 15% decrease in U5MR, a finding that is in consonance with earlier findings including (Anyanwu and Erhijakpor, 2007). In other words, per capita income is a positive driver of under-five mortality as espoused in the development literature in the selected SSA countries. Again, electricity consumption was found to negatively influence under-five mortality rate, which is against the theoretical postulation. The result could be explained in reference to the infrastructural deficit challenge in the selected countries. This result is in sync with that obtained by Shobande (2020) that reported a negative relationship between electricity consumption and infant mortality. Carbon emission was found to exhibit a positive relationship with under-five mortality rate during the reviewing period. This is in contrast to the theoretical postulations. This could be related to the effects of environmental policy in the selected countries.

Both government health expenditure, education expenditure and the poverty head count ratio were all positively and significantly related to under-five mortality, a result that is in line with previous findings. This could be as a result of policy responses to the education and health sectors of the selected countries. Most of these selected countries have initiated policy measures to improve education, health and poverty reduction measures, following the urgent of these two sectors in human capital development and the need to reduce poverty. This result is in line with that obtained by Anyanwu and Erhijakpor (2007).

From the impulse response function, it was observed that the included variables have shock effects on under-five mortality rate. For example, food production index, electricity consumption, carbon emission, government health expenditure among others were relatively stable, however, negative over the 10-year horizon. Moreover, outside under-five mortality rate explaining about 100 percent variation in itself, poverty head count explained about 2 percent of the variations in under-five mortality rate in quarter one to 4 over the period. The reliability test shows that the result is free from autocorrelation and therefore useful for policy inference and forecasting, with LRE* stat values of 69.75 and 68.64 with probability values of 0.29 and 0.32 respectively. The serial correlation LM test confirmed the absence of serial correlation in the residuals of Panel VAR estimates.

Policy Implication of Findings

Some notable policy implications can be drawn based on the conclusions from the empirical results.

1. This paper points clearly to the significant drivers of under-five mortality rate in sub-Saharan Africa. The results show that the selected determinants as drivers of under-five mortality rate have a close, consistent relationship with under-five mortality rate in the SSA countries. Indeed, the panel VAR presented and estimated in the study improves upon previous studies. The results support the view that GDP per capita (income) can be more effective in reducing under-five mortality in the SSA countries. Thus, increase in per capita income through provision of employment opportunities suggested by the magnitude of the estimated coefficient would be greatly helpful in moving the SSA countries toward the achievement the health goal of the Sustainable Development Goal (SDGs).
2. The negative effects of food security and electricity consumption confirmed the important role of reforms aimed at improving food security and availability of electricity. If fiscal measures for food security and electricity are to reduce under-five mortality rate in SSA, policy makers need to pay attention to food security and energy consumption. Those fiscal measures-both in size and efficiency for food security and electricity are important vehicles for improving under-five mortality rate challenges in SSA countries.
3. The strong effects of carbon-emission, government health expenditure, government education expenditure and poverty reduction measures also confirm the important roles of these variables as significant and positive drivers of under-five mortality rates in SSA countries. This has major implications for international assistance policy for sub-Saharan African Countries. The findings call for an

opportunity for the international community, especially the international organization and institutions to come to the aid of SSA countries in accordance with some agreements-Monterrey (2002) and Gleneagles (2005) to improve these drivers and to reduce under-five mortality rates. Thus, there is need for sub-Saharan African countries to consolidate and sustain the education and health expenditures, to the agreed standards as vital component for health human capita.

Conclusion and Policy Recommendation

Conclusion

From the study which examined the drivers of under-five mortality rate in sub-Saharan Africa, the key finding revealed as follows: a significant positive relationship was observed between real GDPs per capita growth (Annual %) and under-five mortality rate during the reviewing period, such that 1 percent point increase in per capita income brings about 15% decrease in under-five mortality rate. This result is in conformity with (Anyanwu & Erhijakpor, 2007; Ehiokiya & Mohammed, 2013). However, it was in variance with (Rad *et al*., 2013; Kim and Shannon, 2013). Food production index, a proxy for food security was found to be negatively but significantly related to under-five mortality rate, such that a percentage point decrease in food security contributes to 83% increase in under-five mortality rate. The result supports earlier findings of Chewe and Hangoma (2020). The negative but significant result is applicable to electricity consumption (Kw per capita).

The estimates of carbon emission, government health expenditure, and government education expenditure and poverty head count ratio were found to be positively and significantly related to under-five mortality rate as such, one percentage point increase in government health expenditure, education expenditure and poverty head count ratio contributes to 8 percent reduction in U5MR, 4% reduction in U5MR, 2 percent reduction in U5MR and 62 percent in U5MR. The finding shows that these variables significantly explain U5MR in the focused countries. This is supported by the coefficient of determination (R^2). From the impulse response function; the variables exhibit changes responsible for the changes in under-five mortality rate. This is supported by the variance decomposition. The under-five mortality rate contributed 100 percent of the variations in the first period and then gradually started decreasing from the second period to the 10^{th} period with forecast standard errors of 99 to 74 percentages. Moreover, it was observed that the poverty head count ratio accounted for much of the variations in under-five mortality rate of 2 percentages to 5 percent. The model reliability check conducted using the PVAR residual serial correlation (LM) test revealed from the estimates that there is no trace of serial correlation. These key findings were used to test the hypotheses at the 5% level of significance. The three formulated hypotheses and their alternates were tested at the 5% level of significance and the null hypotheses were rejected for the alternate hypotheses and concludes that the variables of GDP per capita, government health expenditure, health expenditure, carbon emission and poverty headcount ration are significant in explaining changes in under-five mortality rate in sub-Saharan African countries of Benin, Cote d'Ivoire, Ghana, Mali and Nigeria within the reviewing period.

Policy Recommendations

The following are recommended as policy measures based on the findings:

1. Since GDP per capita was observed to relate positively to U5MR in the selected countries, Government and policymakers should initiate expansionary fiscal and restrictive monetary policy strategies to sustain personal income promotion via investment in the economy for promoting employment generation and for reducing under-five mortality health changes.

2. Electricity consumption was found to have negative significant relationship with U5MR. Therefore, sub-Saharan African policymakers need to intensify policy effort in the promotion of accessible electricity. This also means the strengthening of the energy sector reforms embarked upon by these countries. This will definitely improve the health sector services and under-five mortality rate reduction.

3. Food security was observed to be negatively but positively related to under-five mortality rate. This means that the agricultural sector reforms and policies for improving food availability across the selected countries must be encourage by the policy-makers. Again, environmental policies for mitigating climate change needs to be strengthened through the fiscal measures.

4. The estimates of C02EM, GHEXP and GEEXP were all found to be positively and significantly related to U5MR. This implies that government policy measures to contain the ozone depletion should be sustained. Again, government health/education expenditures need to be sustained.

5. The estimate of poverty head count ratio was found to be positive. This implies that poverty reduction measures in the SSA needs to be improved upon and sustained for the reduction in under-five mortality rate

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