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# Causality Relationship among Healthcare Expenditure, Environmental Pollution, and Economic Growth: Evidence from West Africa (WA) Sub-Region

## BY

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***Abstract***

*The effects of economic growth on environment are continuously more evident in Africa countries most especially in West Africa sub-Region. Hence, industrialization keeps on soaring at high-speed inducing carbon-related emissions and having adverse effect on human health, thereby increasing healthcare expenditure as a result of economic activities. Given the above, the crux of the study is to investigate the causal relationship among healthcare expenditure, environmental pollution, and economic growth in West Africa sub-region. The study considered annual time series data spanning from 1980 to 2023 and sourced from World Bank, World Development Indicator 2023 edition database. Panel VAR Granger causality model as estimation technique was employed. Results showed that bi-directional relationship exists between RGDP and $CO_2$ as well as between RGDP and $N_2O$. This implies that environmental pollution indicators increase as growth rate of West Africa sub-region is enhancing and vice-versa. Thus, enhancement of West Africa sub-region growth of economy cannot increase without correspondent increase in environmental pollution indicators. But conversely, a unidirectional relationship exists from HEXP to RGDP without a feedback. This implies that healthcare expenditure is necessary for enhancing growth rate of West Africa region. While other results showed that no causal relationship exists between number of doctors as well as inflation rate and economic growth of West Africa sub-Region. The study concludes that the numbers of doctors available are not enough despite huge expenditure allocated to region's health sector as well as environmental pollution is highly pronounced in the region. Based on the findings, the study therefore recommends that successful governments in West African region should look inward for measures to reduce environmental pollution challenges affecting health status of the people. They should also jack-up the budgetary allocation to health sector so as to sustain the flows of resources that can improve health outcomes, afterwards economic growth of the region can be better enhanced.*

***Keywords***: *Economic growth, Healthcare Expenditure, Environmental Pollution, PVAR-Granger*
***JEL Classification:*** *Q4, Q, I, C23*

## 1. INTRODUCTION

Across the globe, it is affirmed that global warming is modifying African lifestyle with a deep impact on their healthcare thereby causing extra funds implementation on health facilities due to high demand of energy used causing environmental pollution to the society (WHO, 2016). On this note, the role of economic growth in determining healthcare expenditure became imperative and thus cannot be jettison. GDP growth has the propensity to enhance the healthcare expenditure of any country. This implies that the higher the GDP growth of a country, the better are the conditions for the country to actually spend her citizen's healthcare system. Thus, some researchers like Sebastan and Hafezali (2019) opined that higher economic growth of any country facilitates healthcare expenditure.

In a related development, one of the measures put in place by the government of developing countries is to improve health status of the citizenry through increase in healthcare expenditure. On this, better provision of health opportunities would manifest and afterwards, improve human capital and productivity, and hence, exacerbate economic performance. The recent work done by Chaabouni and Saidi, 2017 gesticulates that the higher is the energy consumption in country, the greater is the expenditure on health which further lead to an increase in health issues and concerns associated with environmental pollution caused by energy consumption.

In African countries generally, GDP growth is projected to have soared from 1.7% to 3.5% in the year 2018 to 2019 simultaneously. However, the economic growth can be affirmed to be obvious in countries like Angola, South Africa

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as well as Nigeria which are considered to be the largest economies in the region due to the used of energy production which is considerable sector of the World economy and human needs (World Bank, 2020). Hence, energy resources have increasingly becoming the most important and indispensable input for both production consumption which are the two determinants of human survival. Thus, higher grade of energy resources will increase the impact of technology and afterwards, create improved economic growth of the country.

After much submission of the above, the bone of contention for this study is the issue of pollutants like methane, micro mental element, carbon-dioxide emission among others that have been affecting the climate change all these while and have been destroying our environment leading to unending pollution affecting health of an individual negatively. Besides, the respiratory infections caused by air pollution from energy incomplete combustion are also the main threat to health of an individual in most of the West Africa regions (Wang, 2012). The author affirmed that 43 million people are likely to die of respiratory infection yearly if a drastic measure is not put in place so as to address the issue of environmental challenges affecting the life of the people West Africa region.

Most of the earlier studies in developing countries (Saidi & Zaidi, 2018; Ibukun & Osinubi, 2021; Odhiambo, 2021; Ethem & Merve, 2021) on this related study focused on either relationship between environmental pollution and economic growth or relationship between healthcare expenditure and economic growth without considering the causal link among healthcare expenditure, environmental pollution and economic growth. Main while, previous studies (Zaidi & Saidi, 2019; Aghanenu & Uffie, 2018; Ogundeji, 2020; Olayiwola & Salami, 2020 and; Osinabi & Ibukun, 2020) suggest a strong association among healthcare expenditure, environmental pollution, and economic growth of a country. Further, most of these studies did not used Panel VAR Causality model considered for this study instead they used Structural Vector Autoregressive model and panel ARDL approach. This study conducted at this time of post COVID-19 pandemic era is relevant towards the consideration for value of healthcare of the people, the economy and measures needed for safety of our environment of nowadays. Hence, this will enable the government and policymakers formulate policies towards overseeing the environment for a sustainable standard of living of the people as well as technology suitable for environmental protection. Further, this present study focused on three countries from West African countries bloc using Mali, Ghana, and Nigeria while combined estimation of Panel VAR Causality approach was conducted on these bloc countries data assessed for the study.

Given the above backdrop, the study therefore fills the lacuna in the existing literature using fundamental research question of how interactive are the healthcare expenditure, environmental pollution and economic growth in West Africa region? while the study objective investigated the causal relationship among healthcare expenditure, environmental pollution, and economic growth in West Africa region. As well-structured of the foregoing introductory aspect, chapter two of the study presents the literature review. Chapter three deals with methodology used for the study while chapter four dwells on the analysis and discussion of the results. Finally, chapter five concludes and provides policy recommendations for the study.

## 2.0.Literature Review

Healthcare expenditure concept refers to total health expenditure incurred in an economy of a country which include expenditure to hospitals, managing home health agencies, nursing facilities as well as personal healthcare of an individual. It also includes all expenditures for the provision of health services, family planning activities, and emergency aid designated. Healthcare expenditure is a critical component of health systems under the purview of health sector. Aranda (2010) gesticulates that the major reason for healthcare expenditure of any country or region is the expectation of improved health status and that healthcare delivery is governed by health investment. However, the demand for healthcare is derived from the demand for health itself. Hence, both healthcare expenditure and improved health status of the people are means to an end and afterwards, the end is increased productivity and national development. Similarly, Berger and Messer (2002) explained that one of the basic ways by which governments can alter their healthcare delivery system is to increase public funding of healthcare infrastructure. Clement *et al.* (2011) identified demographic and non-demographic factors that affect healthcare expenditure. The demographic factors include changes in age distribution within the population while the non-demographic factors include rising incomes, health technology innovation, health policies and institutions. WHO (2015) defines health expenditure as a measure of final consumption of health goods and services plus capital investment in healthcare infrastructure. In this context, health is a critical component in gauging the living standards of a nation or region. When linked with improvements with other variables like water, sanitation, and nutrition, health is visualized as an input into and outcome of growth process, integrated socio-economic upliftment based on health status improvements which depicts a reflection and cause of ongoing development efforts towards human welfare. It is an established fact that improvements in health of population as a whole definitely have a positive impact by generating social returns to individuals and communities.

The second aspect of the concept in the study is environmental pollution that refers to the harmful substances or energy entering into the natural environment causing adverse effects on living organisms and non-living components. Evidence indicates that it can be caused by volcanic/wildfires or by human activities which includes but not limited to industrial production, transportation, waste management, or agriculture. Further, it can be classified by the type of pollutant e.g. solid, gas, heat, radioactivity, or sound. However, the source of pollution can be point source or non-point sources or the environment affected such as air, land, or water. Many sources of pollution were unregulated

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parts of industrialization during the 19th and 20th centuries until the emergence of environmental regulation and pollution policy in the later-half of the 20th century (Nathanson, 2024). Majority of the sites where historically polluting industries, thus, persistent pollutants may have legacy pollution long after the source of the pollution is stopped. Surface to say is that environmental pollution can have negative impact on the health and well-being of humans or individual, plants, animal, and ecosystems as well as the quality and availability of natural resources. Among of the indicators concept of environmental pollution are, air pollution, noise pollution, land pollution, light pollution, and water pollution as explained below:

(i) Air pollution is the release of harmful substances or particles into the atmosphere like carbon-dioxide, sulfur-dioxide, nitrogen-oxides, ozone, smoke, or particulate matter. It can cause respiratory problems, cancer, global warming, cardiovascular diseases, acid rain and ozone depletion

(ii) Noise pollution is the exposure to unwanted or harmful sounds like traffic, machinery, aircraft, or loud music. It can cause hearing loss, stress sleep disturbance, annoyance, and reduced labour productivity thereby affecting growth of the economy

(iii) Land pollution entails the degradation of soil quality and fertility by harmful substances or practices such as fertilizers, mining, deforestation, pesticides, solid waste or urbanization. It can cause soil erosion, desertification, salinization, nutrient depletion, and loss of habitat.

(iv) Light pollution is the excessive or inappropriate use of artificial light such as street lamps, billboards, or buildings. It can cause glare, skyglow, light trespass, and reduced visibility of stars. It can also affect the circadian rhythms and behavior of humans and wildlife

(v) Water pollution as to do with water contamination of bodies like lakes, oceans, rivers, or groundwater, by harmful substances or microorganisms such as sewage, industrial waste, agricultural runoff, oil spills, plastics or pathogens. It can cause waterborne diseases, hypoxia, marine debris, eutrophication, ocean acidification, and biodiversity loss.

However, the concept of pollution has widespread consequences on human and environmental health, having systematic impact on social and economic systems. In 2019, pollution killed nine million people worldwide (one in six deaths), a number unchanged since 2015. Air pollution accounted for ¾ of these earlier deaths. Literature review in 2022 indicates that levels of anthropogenic chemical pollution have exceeded planetary boundaries and now threaten entire ecosystems around the world. Pollutants frequently have outsized impacts on vulnerable populations, such as children and the elderly, and marginalized communities, because polluting industries and toxic waste sites tend to be collocated with populations with less economic and political power. This outsized impact is a core reason for the formation of the environmental justice movement, and continues to be a core element of environmental conflicts, particularly in the Global South. Because of the impact of these chemicals, local, country and international policy have increasingly sought to regulate pollutants, resulting in increasing air and water quality standards, alongside regulation of specific waste streams. Regional and national policy is typically supervised by environmental agencies or ministries while international efforts are coordinated by the United Nation Environmental Program and other treaty bodies. Pollution mitigation is an important part of all of the Sustainable Development Goals (SDGs).

Taking look at another concept of the study is the economic growth which is the process by which a nation's wealth increases over time. It is also an increase in an economy's productivity compared to the past periods production. Although the term is often used in discussions of short-term economic performance, in the context of economic theory it generally refers to an increase in wealth over an extended period. It can be measured by measuring the percentage in real gross domestic product (GDP) of a country. According to economics, productivity is an increase in the capacity of an economy to produce goods and services, compared from one period of time to another. Such growth is measurable in nominal terms which include inflation or in real terms which are adjusted for inflation (Adeyemi & Ogunsola, 2019). Due to inflation, economists and analysts frequently prefer to measure economic growth by the annual percentage change in real GDP per capita. Growth in real GDP measures how fast an economy is expanding while growth in GDP per capita measures the ability of people to purchase goods and services in a country. This brings to the fore the application of the purchasing power parity (PPP) across countries, with PPP, the effect of inflation is removed from calculating growth. Real GDP *is* an inflation-adjusted measure that reflects the value of all goods and services produced by an economy in a given year, expressed in base-year prices. Quite often economists refer to it as "constant-price" or inflation-corrected GDP or constant dollar GDP. Real GDP takes care of the defect inherent in the nominal GDP by its ability to account for changes in price level, thus providing a more accurate figure of economic growth.

Economic growth is often associated with technological changes. It is no longer restricted to production capacity but improved quality of life of the people in the economy. Further, growth can also best be described as a process of transformation. Whether one examines an economy that is already modern and industrialized or an economy at an earlier stage of development, one finds that the process of growth is uneven and unbalanced. Economic historians have attempted to develop a theory of stages through which each economy must pass as it grows. Early writers, given to metaphor, often

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stressed the resemblance between the evolutionary character of economic development and human life such as growth, maturity, and decadence. Later writers, such as the Australian economist Colin Clark, have stressed the dominance of different sectors of an economy at different stages of its development and modernization. For Clark, development is a process of successive domination by primary (agriculture), secondary (manufacturing), and tertiary (trade and service) production. For the American economist W.W. Rostow, growth proceeds from a traditional society to a transitional one (in which the foundations for growth are developed), to the "take-off" society (in which development accelerates), to the mature society.

**Theoretical Underpinning**

For the robustness of the work, the study takes a look at endogenous theories which includes the Romer growth (1986) and Lucas growth (9193) models as well as each theory of Baumol's Cost Disease (1993) and Environmental Kuznets Curve of 1995 proposed by Grossman and Krueger) for healthcare expenditure and environmental pollution theories respectively. The theories are discussed thus:

**The Romer Endogenous Growth Model**

This endogenous growth model is characterized by the assumption of non-decreasing returns to set of reproducible factors of production. The implication of this assumption is that countries that save more grow faster indefinitely and that countries need not converge in income per capita, even if they have the same preference and technology. Basically, the Romer endogenous growth model addresses technological spillover in which the productivity of one firm or industry has a multiplier effect on productivity in other firms or industries. The model advocates a perfect market setting which allows each industry to produce with constant returns to scale. To this extent, there is assumption concurrence between the Romer and Solow model. The Romer model however departs from the line of argument of the Solow postulation by assuming that the aggregate capital stock, positively affects output at the industry level thus giving room for increasing returns to scale on the aggregate. Romer identifies the knowledge aspect or portion of the firm's capital stock essentially as public good like A in the Solow model. He opines that this knowledge part or public good has the tendency to spill over instantly to the other firms in the economy. (Romer, 1987, 1989) suggests that saving has too large an influence on growth and takes this to be evidence for positive externalities from capital accumulation. In its simplified form having taken care of the various assumptions upon which the model is based, the Romer model is represented by a technological production function thus:

$$\Delta T = f(K_T, H_T, T) \qquad (1)$$

Where the increasing technology is represented by $\Delta T$, the amount of capital invested to produce the new technology or design is represented by $K_A$, human capital required for new technology is $H_T$ while T represents the existing technology. $f$ stands for the technology production function.

**Lucas Endogenous Growth Model**

Lucas (1993) merely modified the endogenous growth model earlier developed by Uzawa (1961). The Uzawa growth model explained long-term economic growth as consequence of human capital accumulation. Lucas agreed that the process of production depends on human capital. The model assumed human capital to be a product of investment on education. Lucas however drew a line of demarcation between internal and external effects of human capital for the internal effect, Lucas posits that individual worker undergoing training becomes more productive while the external effect is associated with a situation where the worker not only become useful to his employer but helps top increase the productivity of capital and that of the workers in the economy. According to Lucas, it is the investment in human capital and not physical capital that has spillover effects that increase the level of technology. For firm i, the output based on Lucas position will take the form:

$$Y_i = A(K_i).(H_i).H^e \qquad (2)$$

Where A = technical Coefficient, $K_i$ means physical input, while $H_i$ = human capital input, and $H^e$is the economy's average level of Human capital, also e is the degree of external effects from human capital to each firm's productivity, while the constant return to scale is assumed for this model to thrive.

**"Baumol's Cost Disease" Theory of Healthcare Expenditure**

Baumol (1967); Baumol (1993): The so-called Baumol effect is the tendency for relative prices of some services to increase vis-à-vis other goods and services in the economy, reflecting a negative productivity differential and the equalization of wages across sectors. In particular, prices for health services will rise relative to other prices because wages in low productivity sectors must keep up with wages in high productivity sectors. With a price-inelastic demand, the share health care expenditure in GDP would tend to increase over time (Hartwig, 2008). Therefore, the Baumol effect may also be an important factor for the growth of health care expenditures, but not necessarily for their levels, although it seems natural to assume that the costs of health care, which is a labour-intensive good, will be higher in high wage economies. However, the Baumol effect is a phenomenon that affects mainly developed economies and it seems to be logical not to include it in studies on developing countries. Again, Pomp and Vujic (2008) in their study on the rising health spending, new medical technology, and the Baumol effect noted that the rise in health expenditure as a share of GDP in most OECD countries is possibly caused by so-called Baumol effect, which may arise if labour productivity in health care grows more slowly than in the overall economy. If in addition demand for health care is inelastic, then the share of health spending in GDP will rise over time. Their study estimated the Baumol effect in health spending, using a panel data set of OECD countries.

**The Environmental Kuznets Curve (EKC) via Pollution Haven Theory**

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The environmental Kuznets curve (EKC) is a conceptual model that suggests that a country's pollution concentrations rise with development and industrialization up to a turning point, after which they fall again as the country uses its increased affluence to reduce pollution concentrations, suggesting that the cleaner environment in developed countries comes at the expense of a dirtier environment in developing countries. In this sense, the EKC is potentially a reflection of the Pollution Haven Hypothesis, because one of the factors that may drive the increase in environmental degradation seen in pre-industrial economies is an influx of waste from post-industrial economies. This same transfer of polluting firms through trade and foreign investment could lead to the decrease in environmental degradation seen in downward-sloping section of the EKC, which models post-industrial (service) economies. This model holds true in cases of national development, but cannot necessarily be applied at a local scale. While the pollution haven hypothesis posits that, when large industrialized nations seek to set up factories or offices abroad, they will often look at the cheapest option in terms of resources and labor that offers the land and material access they required. However, this often comes at the cost of environmentally unsound practices. Developing nations with cheap resources and labor tend to have less stringent environmental regulations, and conversely, nations with stricter environmental regulations become more expensive for companies as a result of the costs associated with meeting these standards. Thus, companies that choose to physically invest in foreign countries tend to relocate to the countries with the lowest environmental standards or weakest enforcement.

**Empirical Evidences**

Aghanenu and Uffie (2018) examined the relationship between economic growth and pollution in Nigeria: an econometric assessment using annual time series data collected from World Development Indicators (WDI). The study employed descriptive statistics and cointegration as estimation technique. The Johansen cointegration test indicates that long-run equilibrium relationship existed among the variables utilized in the study. Normalized cointegration showed that carbon dioxide ($CO_2$), nitrogen oxide $NO_2$ emissions insignificantly influence GDP per capita in the long run while methane $CH_4$ promote it significantly. The study recommended that carbon dioxide should be abated by the firms and companies by installing sequestration machines and adopt pollution emissions friendly production techniques.

Zaidi and Saidi (2019) investigate the nexus between environmental pollution, health expenditure, and economic growth in SSA countries. The study used time series data between 1990 and 2015. Pooled panel data technique was employed to assess the relative importance of health expenditure. Result indicates that economic growth exhibits a positive influence on health expenditure in the region.

Osinabi and Ibukun (2020) examined the impact of environmental quality and economic growth on health expenditure in 47 African countries using annual data covering between 2000 and 2018. Pooled OLS and fixed/random effect as well as system GMM estimation techniques were employed. Result indicates that there is positive and significant relationship between environmental quality and health expenditure. Further, economic growth exhibited positive impact on health expenditure in Africa.

Iyoboyi, Ademola, and Muftau (2014) assessed the relationship between $CO_2$ emissions and economic growth in Western African countries. Time series data spanning between 1970 and 2011 were used for the study. Estimation technique of vector autoregressive (VAR) model was employed. Findings from the study showed that growth domestic product per capita shocks to electricity consumption exhibits a positive response for both short and long runs of the estimate.

Siti, Hussin, and Muhammad (2016) investigate the impact of environmental quality on public health expenditure in Malaysia using annual time series data from 1980 to 2015. The ARDL cointegration approach was used. $SO_2$ fertility and infant mortality rate indicates a significant impact on the country's health expenditures.

Abu and Ominyi (2017) examined the relationship between economic progress and $CO_2$ emissions through the hypothesis of Environmental Kuznets Curve (EKC). The study used ordinary least square OLS panel data regression. The study found that there is an existence of EKC between $CO_2$ and ($SO_{2)}$ Sulfur dioxide.

Ogundeji (2020) investigated the relationship among investment expenditure, environmental pollution, and economic growth in Nigeria. The study used time series data and analyzed using E-View statistical package. Results indicates that a positive and significant relationship exists between economic growth and environmental pollution and that net foreign direct investment was unexpectedly found to be negatively correlated with environmental pollution in the study. The study therefore recommended that government should pay more attention to the health sector in terms of allocating more resources for preventive purposes. In addition, government should also ensure environmentally friendly production and consumption so as to minimize environmental pollution and there is need for better enforcement of existing pollution policies, which in turn drive investment for economic growth, mass consumption, and welfare of the society.

Melina and Chaido (2023) examines the relationship among health expenditure, CO2 emissions, and economic growth in G7: evidence from heterogeneous panel data. The long-run panel cointegration coefficients were analyzed using augmented mean group (AMG) estimators. Cointegration test by Westerlund approach showed that there is a stable and long-run relationship between variables. Result indicates that long-run coefficients estimated with the AMG approach are found to be statistically significant and positive for the GDP per capita, and negative in the case of greenhouse gas emissions per capita.

Olayiwola and Salami (2020) examined the implication of foreign direct investment, government expenditure on health

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and economic growth on the level of environmental pollution in Nigeria. Time series data were collected and analyzed using e-view statistical package. The study showed that a positive and significant relationship exists between economic growth and environmental pollution and also foreign direct investment exhibits negative correlation with environmental pollution. The study therefore recommended that government should pay more attention to the health sector in terms of allocating more resources for preventive.

## (III) Methodology

**Data Sources and Variables**

The study specifically considered annual time series data spanning from 1980 to 2023 and sourced from World Bank, World Development Indicator 2023 edition database out of Africa countries economic blocs

**Model specification**

The study was hinged on the work of Zaidi & Saidi (2018) as well as Yaghobo *et al.*, (2012) as justified by theoretical exposition of Romer (1986) and Lucas (1993) growth models, likewise as Baumol's cost disease (1993) and Environmental Kuznets Curve (1995) theories. However, some of these works were adapted and modified in our functional study model thus given;

$$RGDPgr = f(HEXP, ENVPOL) \quad (3a)$$

$$RGDPgr = f(MDHCD) \quad (3b)$$

Where; RGDPgr = Real gross domestic product growth rate; and MDHCD = Macroeconomic determinants of human capital development

$$RGDPgr = f(SENROL, GEXEDU, GEXHE, LABF, INFR) \quad (4)$$

Based on equation (3), the operational and explicit forms of the model can be expressed as:

$$RGDPgr_t = \gamma_0 + \gamma_1 SENROL_t + \gamma_2 GEXEDU_t + \gamma_3 GEXHE_t + \gamma_4 LABF_t + \gamma_5 INFR_t + \psi_t \quad (5)$$

Where; $RGDPgr_t$means Real gross domestic product growth rate in the country at time t; $SENROL_t$ = school enrollment; $GEXEDU_t$ = government expenditure on education; $GEXHE_t$ = government expenditure on health; $LABF_t$ = Labour force; $INFR_t$ = Inflation rate

a-priori, it is expected that; $\gamma_1 > 0; \gamma_2 > 0; \gamma_3 > 0; \gamma_4 > 0; \gamma_5 < 0$

**Estimation Techniques**

**Panel Unit Root Test**

Here we test for the stationarity of each variable using panel unit root testing before proceeding to the panel cointegration test. As earlier noted by Engel and Granger (1997), a variable may not be stationary but linear combination of the non-stationary variables maybe stationary. Hence, call for cointegration approach. However, the study adopted IM, Pesaran and Shin (IPS) test. The test is suitable for verifying stationarity in panel data (Im, Peransan, & Shin, 2003; Maddala & Wu, 1999). Explicitly, the IPS specification is given thus: $y < 0$, where, Y is the time series be tested $\lambda_0$ is a constant, $\beta_t$ is the coefficient on a time trend, P is lag order of the autoregressive process, and $\lambda$ is difference operator. The unit root test is then carried out under the null hypothesis $y = 0$ against the alternative Hypothesis of $y < 0$, for at least one i

**Panel VAR Granger-Causality Procedure**

As noted by Granger (1969), causality test was applied for the study to ascertain the short run causality relationship among the variables as well as if historical values of one variable can forecast or predict the relationship among other variables? For instance, if variable M Granger causes another variable N, then the past value of M should contain information that are useful in predicting N, over and above the information contain in the past value of N alone. Thus, the mathematical formulation is based on linear regression modelling of stochastic process as given:

$$= a_0 + a_1 M_{t-1} + \ldots + a_p M_{t-1} + b_1 N_{t-1} + \ldots + b_p N_{t-p} + \Pi_t \ldots\ldots\ldots (6)$$

$$N_t = c_0 + c_1 N_{t-1} + \ldots + c_p N_{t-1} + d_1 M_{t-1} + \ldots + d_p M_{t-p} + \Sigma_t \ldots\ldots\ldots\ldots (7)$$

Here we assume that $\prod_t$ and $\Sigma_t$ is uncorrelated. A unidirectional causality exists when from N to M if the estimated coefficients on the lagged N in the first equation are statistically different from zero as a group and the set of estimated coefficients on the lagged M are not statistically different from zero and vice versa (Gujarati, 2012). Dumittrescu and Hurlin (2012) also affirmed that the test has flexible properties because it can be used for unbalanced and heterogeneous panels with T < N and T > N. However, a standard regression of Granger causality is incorporated for individually testing of cross-section. This test allows differences among all coefficients by cross-section and takes average values of test statistics through all unit of cross-sections. A causality test for panel data among healthcare expenditure, environmental pollution and economic growth will be or normally based on bivariate model or equation form as given thus;

$$GDP_t = \sum_{i=1}^{n} \lambda_i HEXP_{t-1} + \sum_{i=1}^{n} \lambda_i ENVPO_{t-1} + \varpi_{1t} \quad (8)$$

$$HEXP_t = \sum_{i=1}^{n} \lambda_i GDP_{t-1} + \sum_{i=1}^{n} \lambda_i ENVPO_{t-1} + \varpi_{2t} \quad (9)$$

$$ENVPO_t = \sum_{i=1}^{n} \lambda_i GDP_{t-1} + \sum_{i=1}^{n} \lambda_i HEXP_{t-1} + \varpi_{3t} \quad (10)$$

Where; Y is the time series be tested $\lambda_0$ is a constant, $\beta_t$ is the coefficient on a time trend, P is lag order of the autoregressive process and $\lambda$ is difference operator.

## (IV) Analysis and Discussion of Results

**Descriptive Analysis**

**Table 1: Descriptive Statistics of Variables**

| Variables | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| RGDPgr | 28.24 | 90.23 | 9.20 | 703.35 |
| HEXP | 4.23 | 5.22 | 4.52 | 32.40 |

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| | | | | |
|---|---|---|---|---|
| NOD | 3.31 | 2.12 | 0.42 | 5.31 |
| $CO_2$ | 507.56 | 262.63 | 0.120 | 1602.73 |
| $N_2O$ | 102.34 | 115.25 | 45.23 | 501.48 |
| INFR | 358.41 | 4.57 | -3.73 | 38.12 |

**Source:** Author's Computation

Table 1 showed summary of descriptive statistic of variables employed in the estimation of the data. Estimation in the model which includes mean, standard deviation, minimum, and maximum value respectively. As reported in table 1, carbon dioxide emission of 507.56 recorded the highest mean value while number of doctors got the lowest mean value of 3.31. This implies that number of doctors exhibits lowest level of distribution. A critical examination of standard deviation of variable of interest showed that $CO_2$ (262.63), $N_2O$ (115.25) and RGDPgr (90.23) exhibits very high variability performance in West Africa region while other variables; HEXP (5.22), NOD (2.12) and INFR (4.57) have low standard deviations values. This implies that these variables showed very low variability performance in the region under study.

## Correlation Analysis

**Table 2: Correlation Statistics**

| | RGDPgr | HEXP | NOD | $CO_2$ | $N_2O$ | INFR |
|---|---|---|---|---|---|---|
| RGDPgr | 1.0000 | | | | | |
| HEXP | 0.7312 | 1.0000 | | | | |
| NOD | 0.9254 | 0.4183 | 1.0000 | | | |
| $CO_2$ | -0.5843 | 0.5335 | -0.702 | 1.0000 | | |
| $N_2O$ | 0.1745 | 0.5087 | -0.3726 | 0.5546 | 1.0000 | |
| INFR | -0.2070 | -0.5078 | 0.4216 | -0.2621 | -0.4548 | 1.0000 |

**Source: Author's Computation**

Correlation analysis of Table 2. indicates the possible direction and magnitude of relationship between pairs of variables in the model. A cursory look at the Table 2 indicates that a positive relationship exists between RGDPgr and variables interest such as HEXP, NOD and $N_2O$ with correlation coefficient of 0.7312, 0.9254 and 0.1745 respectively while indirect relationship exists between RGDPgr and few variables such as $CO_2$ (-0.5843) and INFR (-0.2070) in the model. Summarily from the correlation analysis is that there seems no likelihood multi-collinearity presence among the explanatory variables, as reflected by the interrelationship between pairs of variables used in the model.

## Panel Unit Root Test

**Table 3: Panel Unit Root Test Result**

| | @ level | | | @ 1st Diff. | | | |
|---|---|---|---|---|---|---|---|
| **Variables** | **LLC** | **IPS** | **BT** | **LLC** | **IPS** | **BT** | **Integr. order** |
| RGDPgr | -11.345* | -13.123* | -3.516* | -16.202* | -25.322* | -21.211* | I(0) |
| HEXP | 1.0626 | 1.3002 | 3.213 | -10.122* | -6.212* | -5.634* | I(1) |
| NOD | -0.713* | 5.824* | -1.313 | -41.015* | -13.536* | -12.652* | I(0) |
| $CO_2$ | -0.552 | 0.143 | -0.916 | -14.461* | -13.322* | -17.249* | I(1) |
| $N_2O$ | -6.354 | -5.673 | -2.135* | -1965* | -17.479* | -19.441* | I(2) |
| INFR | -6.134* | -7.375* | -7.944* | -19.632* | -22.812* | -21.733* | I(0) |

**(*)** connote rejection of unit root at (5%) significance level
**Source:** Author's Computation

Result of the unit root test using Levin-Lin-Chu (LLC), Im-Pesaran-Shin (IPS) and Breitung test (BT) are presented in Table 3. Panel unit test results showed that RGDPgr, NOD, and INFR were stationary at level I(0); HEXP and $CO_2$ became stationary at first difference I(1), while the remaining variable $N_2O$ exhibits stationarity at second difference I(2).

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Suggesting they all retain innovative shocks passed on them for a short period of time. Summarily, the panel unit root test conducted in the study indicates that series in the model are integrated of mixed orders, that is, I(0), I(1) and I(2) as earlier proposed by Sim (1980) when series are beyond I(1). Thus, call for the use of panel VAR Granger causality model for short run analysis according to Pesaran, Shin & Smith (2001).

Estimation result of PVAR Granger causality test is presented for combined West Africa region bloc using three countries in Western Africa. Results are presented thus:

**Combined Estimation**

**Table 4: PVAR Granger Causality / Block Exogeneity Wald Test**

| RGDPgr | | | | |
|---|---|---|---|---|
| **Excluded** | **Df** | **Chi-sq.** | **Prob.** | **Decision** |
| RGDPgr → HEXP | 2 | 0.71098 | 0.0314** | Reject |
| RGDPgr → NOD | 2 | 4.43058 | 0.04121* | Reject |
| RGDPgr → $CO_2$ | 2 | 0.71733 | 0.0012* | Reject |
| RGDPgr → $N_2O$ | 2 | 0.31930 | 0.0449** | Reject |
| RGDPgr → INFR | 2 | 0.5574 | 0.5375 | Accept |
| HEXP → RGDPgr | 2 | 1.62424 | 0.0784** | Reject |
| NOD → RGDPgr | 2 | 4.38457 | 0.7346 | Accept |
| $CO_2$ → RGDPgr | 2 | 0.21650 | 0.0381** | Reject |
| $N_2O$ → GDPgr | 2 | 0.14032 | 0.00351* | Reject |
| INFR → RGDPgr | 2 | 2.37328 | 0.1406 | Accept |

**Source: Extracted from regression output**

**Notes:** * (**) indicates significant level @ 1% and 5% respectively

Table 4, showed the result of VAR granger causality test conducted for the region. The result indicates the evidence of rejection of null hypotheses for HEXP, $CO_2$ and $N_2O$ not granger cause RGDPgr in both cases each for combined estimate in West Africa region at either 1% or 5% significance level. Therefore, bi-directional causality relationship exists between RGDPgr and HEXP; $CO_2$, and $N_2O$ in each case at their conventional levels. While NOD and INFR appeared not to granger-cause economic growth in both cases. It is striking to note that a uni-directional relationship running from RGDPgr to NOD without a feedback. That is, they exhibited zero predictive content or power for RGDPgr within the study period. Summarily, the result showed that increase in gross domestic product growth rate is necessary for enhancing healthcare expenditure, carbon-dioxide emission, and nitro-oxide just as enhancement of healthcare expenditure, carbon-dioxide emission, and nitro-oxide were needed to improve economic growth in West Africa region.

Holistically, these results have some interesting implications on the growth of West Africa region's economy. First of all, the fact that RGDPgr and HEXP are bi-causal showed that as the economy is growing healthcare expenditure is increasing. Likewise, environmental variables of $CO_2$and $N_2O$ exhibited bi-directional relationship with RGDPgr in each case with different magnitude. This implies that improvement in growth rate in the region spurred carbon-dioxide emission and nitro-oxide.

**Discussion of Results**

The results of the study have some interesting implications on the growth of West Africa region's economy. The fact that RGDPgr and HEXP are bi-causal showed that as the economy is growing healthcare expenditure is increasing. Again, environmental variables such as $CO_2$ and $N_2O$ exhibited bi-directional relationship with RGDPgr in each case with different magnitude. This implies that improvement of growth rate in the region spurred carbon-dioxide emission and nitro-oxide. This is in concordance with the work of Piabuo & Tieguhong (2017).

The short-run causality relationship indicates that a uni-directional relationship running from RGDPgr to NOD without a feedback. This implies that there is less supply of doctors as the economy is growing. However, this maybe accounted for as a result of brain-drain of physicians in the region according to the findings of Rahman & Alam, 2021

Above all, the result indicates that increase in gross domestic product growth rate is necessary for enhancing healthcare expenditure, carbon-dioxide emissions, and nitro-oxide just as enhancement of healthcare expenditure, carbon-dioxide emissions, and nitro-oxide are needed to improve economic growth in West Africa region within the period of the study.

## (V) Conclusion and Policy Recommendations

The study concludes based on the combined countries selected in West Africa bloc that the numbers of doctors available are not enough despite huge expenditure allocated to region's health sector as well as environmental pollution is still highly pronounced in the region. Based on the findings, the study therefore recommends that successful governments in West African region should look inward for measures to reduce environmental pollution challenges affecting health status of the people. They should also jack-up the budgetary allocation to health sector so as to sustain the flows of resources that can improve health outcomes, afterwards economic growth of the region can be better enhanced.

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