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Analysis Of Health Production Function for West Africa: Implication for Achieving Sustainable Development Goal 3

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Abstract:

The contributions of health to economic prosperity of nations have been acknowledged in the literature. This informed why the sustainable development goal 3 focuses on good health and well- being. To achieve this goal, countries across the globe have been investing in health and health related activities. However, it is important to hinge health development policies on sound empirical findings. The performance of health indicators in West Africa has not been inspiring. Thus, this study analysed the health production function for West Africa over the period 2000-2021. The paper adopted Grossman health production function as theoretical foundation. It employed panel data modeling approach, using Fixed Effects (FE) and Random Effects (RE) estimating techniques for analysis. However, Hausman test confirmed the appropriateness of FE estimator. Findings of the study revealed that per capita income, human capital (education) and health expenditure per capita significantly improved life expectancy and reduced infant and under-five mortality rates in West Africa. However, malaria incidence reduced life expectancy and raised infant and under-five mortality rates in the sub-region. Population growth did not show any significant impact on the three health variables. Therefore, policies to improve health outcomes in West African countries should focus on boosting per capita income and raising health expenditure per capita. Moreover, it is imperative for West African nations to invest substantially in human capital, particularly education while concerted efforts should be made to reduce malaria incidence. Without these polices, the attainment of the SDG 3 in the sub-region by 20230 would be an illusion.

Keywords: health production function; SDG3; panel data; West Africa
JEL Classification: 112, 120

1. Introduction:

The contributions of health to economic prosperity of nations have been acknowledged and literature is fraught with theoretical and empirical discourse of the critical role it plays in every economy. In fact, the fundamental role of health in development process cannot be overemphasized. It has been shown that "poor health reduces an individual's capacity to perform and deliver effectively and efficiently in both the social and productive sectors of the economy" (Nathaniel & Khan, 2020, 1). Similarly, improved health status enhances better economic growth and development, boosts human capital formation as well as societal prosperity and advancement (Bolin, 2003; Basch, 2011; Dauda, 2023; Dauda & Balogun, 2023; and World Economic Forum, 2024).

The third sustainable development goal (SDG3), „good health and well-being" focuses strictly and directly on health while the remaining sixteen

goals also relate to health indirectly. This shows the importance of health in sustainability of development. According to Dauda (2017, 13), "health and wellbeing are very critical for economic performance and attainment of sustainable development" because "a healthy population can enhance national productivity, savings, human and physical capital formation, per capita income growth, and contribute to poverty alleviation."

Available literature has shown that advanced economies continue to enjoy better population health status than developing nations, due to greater investment in health by the former that have translated into considerable improvement in life span and drastic reduction in all forms of mortalities (see Öztürk & Topcu, 2014; Raghupathi & Raghupathi, 2020; and Hasan, Rannaware & Choudhari, 2022; World Bank, 2024). Moreover, some emerging economies of Asia and Africa appear to have succeeded in improving the health status of their population than others (LiHongyi & Liang, 2010; Coady, Clements & Gupta, 2012; and Isreal, Kaliappan & Hamzah, 2018).

Data from World Bank (2024) revealed that average life expectancy, which was around 60 years in Europe and North America in the 1960s, is currently about 80 years while various forms of mortalities have declined drastically in these continents. Similarly, in most countries in the Arab world, North Africa, Middle East, and South Asia, average life expectancy has risen from 40 years in the 1960s to well above 70 years. This has contributed substantially to improved productivity of labour, economic growth, better standard of living and economic development (Acemoglu & Johnson, 2007; Franklin 2018; and Ng, 2023).

However, the same cannot be said of most countries in West Africa, where life expectancy is still less than 60 years while other health outcomes such as infant mortality rate, under five mortality rate, crude death rate, maternal mortality and disease prevalence remain very high (World Bank, 2024). This is not unconnected with poor health status of the population of the sub-region, which is informed by low level of investment in healthcare services, poor nutrition, low income per capita, high level of poverty and low level of investment in education (Dauda, 2020a; Dauda & Balogun, 2023).

This study analyses the health production function for West Africa to establish the critical variables that influence the health status of the sub-region‟s population for the purpose of determining how this affects sustainable development, particularly SDG3. Moreover, estimating health production function for West Africa will provide better information on "how inputs to health production function affect measurable health outcomes" (Mityakov & Mroz, 2014, 1) in the sub-region in order to inform health policies required for sustainable economic growth and development.

Although there are existing studies along this line in the literature (see Kiiskinen, 2003; Fayissa & Gutema, 2005; and Bayati, Akbarian & Kavosi, 2013) the current study is distinct in on methodological ground and empirics. Apart from its being the first on West Africa as a sub-region, it employed current data. Furthermore, the study used three health measures (infant and under five mortality rates as well as life expectancy) as against life expectancy that is common in most extant literature. Moving forward, the remaining part of the paper covers overview of health indicators and SDG 3 related data in the sub-region as presented in section two. Section three focuses on literature review, section four presents the theoretical framework and methodology adopted for the study while section five details empirical results of the analyses performed in the study. Section six concludes and provides policy relevance of the work.

2. Overview of Health Indicators and Sustainable Development Goals 3 Data in West Africa

Health Indicators in West Africa

Although available facts on various health indicators across West African countries suggest some improvements, these do not match the feat achieved in other sub-regions in Sub-Saharan Africa (SSA), and other parts of the globe. As evident in Table 1, countries in the sub-region have made some progress in health outcome indicators such as average life expectancy at birth, infant mortality, and under-five mortality over the period 1990-2021.

Table 1: Health Outcome Indicators in West Africa, 1990-2021

Country	Life Expectancy					Infant Mortality					Under Five Mortality				
	1990	2000	2010	2020	2021	1990	2000	2010	2020	2021	1990	2000	2010	2020	2021
Benin	53.29	56.58	58.36	60.09	59.82	104.4	85.0	69.6	56.6	55.2	172.7	136.8	109.1	86.0	83.5
Burkina Faso	49.44	50.85	56.48	59.73	59.27	98.7	90.8	68.3	53.0	51.8	199.1	178.7	121.9	85.4	82.6
Cape Verde	65.02	68.62	73.50	74.81	74.05	46.6	31.0	22.3	12.2	11.7	60.4	38.1	26.5	14.2	13.5
Cote d'Ivoire	52.60	50.84	55.02	59.03	58.60	104.3	95.6	74.9	57.5	55.9	153.4	142.9	106.4	77.3	74.8
Gambia, The	51.32	56.94	60.72	62.61	62.08	81.2	61.7	45.9	34.9	34.0	166.5	113.7	74.0	49.6	47.9
Ghana	55.62	58.20	61.16	64.11	63.80	80.0	64.6	47.4	33.5	32.6	127.7	100.1	69.8	45.5	44.0
Guinea	47.00	52.48	56.72	59.33	58.89	137.5	100.6	76.8	65.4	63.8	232.7	165.6	121.9	101.6	98.7
Guinea-Bissau	47.08	50.12	56.23	60.01	59.65	131.7	105.3	72.6	51.5	50.0	222.8	174.5	114.4	77.0	74.3
Liberia	36.69	51.36	59.43	60.95	60.75	175.8	127.6	71.9	58.2	56.7	263.6	189.2	99.9	78.3	76.0
Mali	46.62	50.54	56.38	58.63	58.94	120.4	101.7	78.4	63.0	61.6	231.4	187.7	134.1	100.1	97.1
Mauritania	59.77	61.03	63.11	64.53	64.36	71.2	62.7	41.6	33.0	32.2	117.2	98.8	56.7	41.8	40.5
Niger	41.85	49.32	58.37	61.45	61.58	133.8	98.2	65.8	59.9	59.5	331.6	228.5	133.3	116.3	115.2
Nigeria	46.04	47.19	50.95	52.89	52.68	124.2	109.6	84.4	72.3	70.6	209.3	182.4	135.7	113.8	110.8
Senegal	56.95	56.94	64.62	68.01	67.09	71.0	67.7	42.7	30.0	29.1	138.6	129.7	66.4	40.1	38.6
Sierra Leone	44.06	45.05	53.69	59.76	60.06	154.8	138.6	107.6	80.5	78.3	260.5	225.9	161.4	108.5	104.7
Togo	54.37	54.74	57.30	61.04	61.62	90.9	75.7	58.3	44.5	43.4	147.5	120.0	89.1	64.6	62.6

Source: Generated by Author from World Bank (2024)

The achievements notwithstanding, some of the nations are still struggling to improve on these indicators. Out of the sixteen countries, only Cape Verde has so far reached the threshold of 70 years average life expectancy in the entire sub-region. Infant and under five mortality rates have been lowest in the country, put at 11.7 and 13.5, respectively as at 2021. The least performing country in life expectancy is Nigeria, which recorded 52.68 years. Notwithstanding, apparent progress can be noticed considering the values of the indicators across time. In 1990, only one country, Cape Verde had her life expectancy reached 65.02 years; others had theirs below 60 years, with Liberia, having her average life expectancy as 36.69 years. However, by 2020, the least value was 52.89years while ten countries already recorded 60 years and above. Nevertheless, in 2021 the number dropped to 9 countries as many countries in the sub-region experienced decline in their life expectancy due to the menace of Covid-19 virus.

Regarding infant and under-five mortality rates, a lot of progress occurred between 1990 and 2021. In 1990 infant mortality rate was triple digits in nine out of the sixteen countries; whereas, by 2021, it had reduced to double digits in all the countries with the highest been 78.30 deaths per 1,000 live births in Sierra Leone while the least, 11.70 occurred in Cape Verde. Under-five mortality was triple digits in fifteen and fourteen out of the sixteen countries in the sub-region in 1990 and 2000, respectively. Whereas, by 2021 the value has declined to double digits, with only three countries (Niger, Nigeria and Sierra Leone), still having triple digits.

The above achievements in the three indicators of health presented in the table however, are far from what has been recorded elsewhere. For instance average life expectancy has reached 80 years in several countries across the globe with the highest being 85.49 in Hong Kong while infant and under-five mortality rates are already approaching 1.00 per 1,000 live births in many countries (World Bank, 2024).

Table 2: Sustainable Development Goals for West Africa, 2017-2023

	2017					2019					2021					2023				
Country	**SDI**	**GR**	**SR**	**SDG3**	**SDG3R**	**SDI**	**GR**	**SR**	**SDG3**	**SDG3R**	**SDI**	**GR**	**SR**	**SDG3**	**SDG3R**	**SDI**	**GR**	**SR**	**SDG3**	**SDG3R**
Cape Verde	Na	Na	Na	na	na	65.1	96	1	73.30	1	68.1	86	1	73.90	1	68.8	89	1	75.5	1
Ghana	59.9	109	1	54.9	2	63.8	104	2	54.39	2	62.5	114	2	53.52	3	61.8	122	3	52.8	3
Senegal	56.2	119	2	55.8	1	57.3	124	3	54.25	3	58.4	126	4	57.52	2	61.8	121	3	57.8	2
Cote d'Ivoire	53.3	127	3	37.3	3	55.7	129	4	34.82	11	57.6	131	5	39.35	10	62.3	120	2	43.1	8
Mauritania	51.1	133	4	47.5	5	53.3	134	6	47.17	5	55.5	133	6	41.84	8	57.2	133	6	45.7	7
Togo	50.2	137	5	42.2	7	51.6	144	9	42.97	8	53.2	143	8	42.29	7	56.3	136	7	51.8	4
Burkina Faso	49.9	138	6	44.3	6	52.4	141	8	47.99	4	53.5	139	7	47.23	4	52.4	153	12	46.6	6
Benin	49.5	142	7	47.7	4	50.9	151	10	47.15	6	49.9	155	12	46.30	5	55.1	140	9	42.0	9
Guinea	48.8	144	8	32.6	9	52.8	138	7	33.28	12	51.0	153	11	31.58	13	54.9	142	10	32.3	15
Nigeria	48.6	145	9	27.6	13	46.4	159	15	28.04	14	48.9	160	14	28.90	14	54.3	146	11	36.2	13
Mali	48.5	146	10	30.4	11	50.2	152	11	32.33	13	52.2	146	9	35.01	12	58.0	131	5	40.7	10
The Gambia	47.8	148	11	49.3	3	55.0	131	5	43.18	7	59.3	123	3	45.01	6	58.3	129	4	48.6	5
Sierra Leone	47.1	149	12	28.2	12	49.2	155	13	26.73	15	51.7	148	10	28.80	15	55.7	137	8	36.6	12
Niger	44.8	151	13	34.3	8	49.4	154	12	39.09	10	49.5	156	13	40.52	9	48.3	161	14	37.6	11
Liberia	42.8	154	14	31.0	10	48.2	157	14	39.20	9	48.6	161	15	36.58	11	49.9	157	13	32.8	14

Note that SDI implies sustainable development index, which ranges between the lowest score of 0 and the highest of 100. GR is sustainable development Global index rank, SR stands for sustainable development sub-regional (West Africa) rank, SDG3 signifies sustainable development goal 3 (Good Health and Well-being) while SDG3R is the sustainable development goal 3 ranking in West Africa. Note that the 2017 data cover 157 of the 193 UN member states/countries while data for 2019, 2021 and 2023 cover all the 193 UN member states/countries.

Source: Generated by Author from Sachs, Schmidt-Traub, Kroll, Durand-Delacre, & Teksoz (2017); Sachs, Schmidt-Traub, Kroll, Lafortune & Fuller (2019); Sachs, Kroll, Lafortune, Fuller & Woelm (2021); and Sachs, Lafortune, Fuller & Drumm (2023).

The performance of West African countries in sustainable development goals shows the sub- region among the least globally. In 2017, the best performing country in the sub-region, Ghana (as data was not available for Cape Verde), was 109th world wide out of 157 UN member states/countries while the worst, Liberia, occupied 154th position. In 2019, Cape Verde was ranked first in West Africa, followed by Ghana while Senegal took the third position. These countries however were ranked globally, 96th, 104th and 124th, respectively. In 2023, Cape Verde still maintained her leading position while the least was Niger.

With respect to SDG 3, most West African countries appear to be struggling. Apart from Cape Verde, which had a score of 75.5/100 in 2023, only three other countries (Ghana, Senegal and Togo) scored a little above 50%. Others such as Guinea and Liberia scored as low as 32.3% and 32.8%, respectively.

Furthermore, a cursory look at the performances of these countries in SDG 3 between 2017 and 2023 showed that Cape Verde, Mali and Ghana have consistently improved from year to year. The only difference is that while Cape Verde‟s scores hover around 73.30% minimum and 75.5% maximum, Mali had a minimum of 30.4% and a maximum 40.7%; whereas, Nigeria recorded 27.6% least score and 36.2% highest score. The performances in the remaining countries of the sub-region have been low and fluctuating. From this information, it is evident that with the exception of Cape Verde, West African countries have not been doing well in their efforts to attain the SDG 3.

3. Literature Review

Until the work of Grossman (1972), health has been treated as just a form of human capital not markedly different from other forms (Mushkin, 1962; Becker, 1964; Fuchs, 1966; Bolin, 2011; and Schneider-Kamp, 2021). However, Grossman in his work argues for a distinct health capital due to its role in the determination of the time an individual spends in income generation and commodities. His "health capital and the associated model of the demand for health have, spawned one of today"s main recognized paths of research into the economics of health" (Schneider-Kamp, 2021, 207). Moreover, his study does not only reveal health as commodity being demanded and consumed by individuals, it is also a produced good and thus health can be produced, which necessitates health production function. Since then, several theoretical and empirical studies have been conducted on health, covering cross-sectional, country-specific and cross-country works on the role of health as it affects every segment of the society, particularly economic growth and development.

Some of these studies incorporate health variables into growth and development models (Bloom, Canning & Sevilla, 2001; Dauda, 2011; Maitra & Mukhopadhyay, 2012; Strittmatter & Sunde, 2013; Alvi & Ahmed, 2014; and Somé, Pasali & Kaboine, 2019) while others treat health as a form of human capital, affected by its determinants (Becker, 2007; Martin, Rice & Smith, 2008; Zivin & Neidell, 2013; Dauda, 2018; Biadgilign *et al.*, 2019; and Dauda & Balogun, 2023). Findings of these studies are mixed. However, majority of them reported that health has played highly significant role in enhancing economic outcomes.

Apart from the above, other works have focused strictly on the analysis of health production functions for various economies in order to inform health promotion policies with different conclusions. This is the crux of the present study. Prominent among studies in this category are Thornton (2002) who estimated health production function for the United States using medical care, socioeconomic, lifestyle and environmental factors. The findings indicated that medical care was not effective in reducing mortality, and could not improve life expectancy in the country. However, socioeconomic status and lifestyle contributed significantly into decline in mortality. Indicating how important these factors are for health policy in the US.

Kiiskinen (2003) examines issues relating to health promotion policy in Finland using health production function within the context of household production framework. The aim was to identify the role played by health-specific knowledge and participation of an individual in health education activities. The findings show that individual"s health knowledge has a health promoting effect on consumption choices, which helps to improve "individuals" ability to produce health in the long run." Moreover, as individuals participate in health education, their level of health knowledge improves; however, the willingness of individuals to invest "in knowledge of healthy life-styles" declines with age.

Fayissa & Gutema (2005) estimated a health production function for Sub-Saharan Africa, using fixed and random effects over the period 1990-2000, with focus on social, economic, and environmental factors as regressors while life expectancy was employed as a measure of health.

The results revealed positive association of income per capita and food availability with life expectancy while decrease in illiteracy rate improves life expectancy in the region. The import of this is that income per capita, food availability and literacy rate are critical for health production in the SSA region.

Fayissa & Traian (2013) also extend Fayissa & Gutema (2005) work to 13 East European countries, covering the period 1997-2005 with economic, demographic, environmental, and lifestyles as health determinants and infant mortality as health measure. The findings show that "GDP per capita, number of doctors, investment in human capital formation, reduction of air pollution, and residence in urban areas significantly reduce infant mortality." It is not clear while the authors limit the period covered in the study to 2005 when as at the time of the study, 2013 data were available at the same source of the variables employed up to 2012. This is not made clear, which might have influenced the outcome. This notwithstanding, these factors are important for health production the 13 East European countries.

Similarly, Bayati, Akbarian & Kavosi (2013) employ health production function to analyse factors that determine health in 21 Eastern Mediterranean countries between 1995 and 2007. The authors measure health using life expectancy with socioeconomic factors as health determinants. It adopts the Grossman model with fixed effects as the panel estimating technique. The results revealed that income per capita, education index, food production, urbanisation and employment have positive and significant effects on life expectancy, which make them vital for the production of health in the Eastern Mediterranean countries of focus.

In another study conducted by Rayhan, Hasan & Akter (2019) to estimate the health production function for seven South Asian countries with economic factors (health expenditure per capita and food production index), social factors (education and access to improved water facilities), and environmental factor (urbanization) as health determinants. The outcome shows positive and significant influences of health expenditure per capita, education, access to improved water sources and urbanization on life expectancy while food production index has negative and significant effect on life expectancy in the region. Although the study employed the right variables; however, health expenditure per capita and food production index may not be considered as economic factors that affect health rather they appear as social factors.

Moreover, Hemsley & Hollanda (2020) estimated a health production function for Brazil over the period 2006-2009 with mixed findings. The authors found that additional health care decreases child mortality while rising number of health centers per capita reduces child mortality in the country.

A latest study carried out by Sielska & Nojszewska (2022) in Polish county hospitals employs production function to model hospital activities. This is to inform rational decision making by hospital managers in Poland to achieve economic efficiency. The authors used number of patient-days as health measure and dependent variable while part of the independent variables include total number of beds, and number of doctors and nurses (in full time equivalents, FTEs) among other variables. The results show

that number of nurses and costs of electricity are significant and thus important for rational decision making by hospital managers in the country to achieve economic efficiency. The major issue with this study is that the number of beds, and number of doctors and nurses used as part of explanatory variables are also health measures, This could bias the findings and make them unsuited and reliable for policy.

It is apparent from the empirical works reviewed above that empirical literature is scanty globally on health production function. Moreover, out of the studies reviewed, only four are cross country in nature while the remaining are country-specific. Furthermore, majority of the existing studies measure health using life expectancy. In addition, there is no work on West Africa, which the current paper focuses on. The only study that included some West African countries is the one by Fayissa & Gutema (2005), 19 years ago with the data employed covering 1990-2000. Between 2000 and now (24 years ago), several health policies have been implemented, which have impacted on the population health status of the region. Moreover, the work of Fayissa & Gutema (2005), which focuses on the Sub-Saharan Africa, used only life expectancy to measure health. The current study employed three health outcome measures- life expectancy, infant mortality and under-five mortality, which makes it distinct from the foregoing works.

4. Theoretical Framework and Methodology

In microeconomic literature, production function specifies a technological/mathematical relationship that exists between inputs into production process and the resultant outputs. In view of this, a health production function relates health inputs and outputs, which is also adopted in macroeconomic literature. Specifically, it describes the relationship between health variables and their determinants.

The theoretical foundation for this study is the Grossman health production theory, upon which the estimated model in the paper is based. Grossman (1972) in his study shows that individuals produce health based on certain inputs that go into the health production process, including initial health conditions. According to him, health is a durable capital stock that can be invested in using medical treatments and also employed for the production of healthy time required for lifetime earnings and production of other goods. Thus, individual‟s health status can be affected not only by medical treatments but also be several other factors such as income, level of education, social status, level of employment, their environment, habits, available healthcare services, nutrition and food intakes, and social support networks. These factors can also be considered at macro level.

In view of the above, the health production function considered in this study is given below as:

$$het = f(gdp, ppg, hci, hep, mal) \quad (1)$$

Where *het* signifies health stock, *gdp* implies gross domestic product which captures income (an economic factor that affects health status), *ppg* is population growth a demographic factor affecting health status, *hci* stands for human capital index strictly computed using education variables which can be viewed as social factor that affects health and *mal* is malaria to account for epidemiological variable.

Model Specification

$$het = f(gdp, ppg, hci, hep, mal)$$

The panel data model employed for this study is semi-logged and it follows from (1), and it is given as:

$$\ln het_{it} = \psi_0 + \psi_1 \ln gdp_{it} + \psi_2 ppg_{it} + \psi_3 \ln hci_{it} + \psi_4 \ln hep_{it} + \psi_5 \ln mal_{it} + \upsilon_i + \nu_{it} \quad (2)$$

Where all the variables stand as earlier defined with i capturing counties and t implying time. Furthermore, $i = 1, \ldots, N$; and $t = 1, \ldots, T$. Similarly, υ_i is country specific effects while ν_{it} means error term while $\upsilon_i \sim IID(0.\sigma^2_\upsilon)$, $\nu_{it} \sim IID(0.\sigma^2_\nu)$ with both being "independent of each other and among themselves" (Baltagi, 2005, 135).

In this study, health is measured using life expectancy, infant mortality rate and under-five mortality rate. Thus, the model specified as equation (2) can be represented as three models based on the three explained variables that measure health.

Model One

$$\ln lep_{it} = \psi_0 + \psi_1 \ln gdp_{it} + \psi_2 ppg_{it} + \psi_3 \ln hci_{it} + \psi_4 \ln hep_{it} + \psi_5 \ln mal_{it} + \upsilon_i + \nu_{it} \quad (3)$$

Where *lep* means life expectancy and other variables remain as earlier defined.

Model Two

$$\ln ifm_{it} = \psi_0 + \psi_1 \ln gdp_{it} + \psi_2 ppg_{it} + \psi_3 \ln hci_{it} + \psi_4 \ln hep_{it} + \psi_5 \ln mal_{it} + \upsilon_i + \nu_{it} \quad (4)$$

Where *ifm* is infant mortality rate while other variables remain as earlier defined.

Model Three

$$\ln ufm_{it} = \psi_0 + \psi_1 \ln gdp_{it} + \psi_2 ppg_{it} + \psi_3 \ln hci_{it} + \psi_4 \ln hep_{it} + \psi_5 \ln mal_{it} + \upsilon_i + \nu_{it} \quad (5)$$

Where *ufm* implies under-five mortality rate and other variables remain as earlier defined.

Technique of Estimation

The study used two panel estimating techniques. These are Fixed Effects (FE) and Random Effects (RE). In order to decide among these estimators, the Hausman test was carried out.

3.6 Scope of the Study

The study analyses health production function for West Africa, with data covering the sixteen countries in the sub-region over the period 2000-2021.

Table 3: Variables, Definitions and Sources

Variable	Definition	Source
lep	Life expectancy at birth, total (years)	World Bank (2023)
ifm	Infant mortality rate (per 1,000 live births)	World Bank (2023)
ufm	Under-five mortality rate (per 1,000 live births)	World Bank (2023)
gdp	GDP per capita (constant 2015 US$)	World Bank (2023)
ppg	Population growth (annual %)	World Bank (2023)
hci	Human capital index[1]	Feenstra, Inklaar & Timmer (2023). Penn World Table 10.01
hep	Current health expenditure per capita (current US$)	World Bank (2023)
mal	Incidence of malaria (per 1,000 population at risk)[2]	World Bank (2023)

Source: Compiled by Author.

[1] Human capital index was computed based on years of schooling and returns to education in PWT9.

2 Incidence of malaria is the number of new cases of malaria in a year per 1,000 population at risk (World Bank, 2023).

5. Empirical Results

Table 4: Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
lep	58.64	5.86	45.05	76.59
ifm	65.56	23.97	11.70	138.60
ufm	104.46	43.54	13.50	228.50
gdp	1078.49	682.28	356.30	3318.93
ppg	2.66	0.66	0.80	5.79
hci	1.59	0.51	1.00	3.00
hep	46.88	31.84	7.37	181.44
mal	296.90	156.34	0	599.75

Source: Author‟s Computation.

From Table 4, life expectancy in West Africa averaged 58.84 years within the period 2000 and 2021. This however, ranges between a minimum and maximum of 45.05 and 76.59 years, respectively while its spread from the average value stood at 5.86. The mean values of infant and under five mortality rates are 65.56 and 104.46, in that order. This suggests that both variables are still issue in the sub-region, considering their high values.

Gross domestic product per capita for West Africa between 2000 and 2021 averaged US$1078.49 with the minimum value being US$356.30 while the maximum during the period stood at US$3318.93. The deviation from the mean value however was US$682.28. Growth rate of the sub-region‟s population during the period of reporting was 2.66%; whereas it hovers between 0.80% and 5.79% minimum and maximum rates, respectively. The implication of the maximum value is that there are still some countries in the sub-region battling with high rate of population growth.

Human capital index has its mean as 1.59 while health expenditure per capita during the period under consideration averaged US$46.88. Malaria still remains a public health challenge in West Africa and this is reflected in the mean value of its incidence, put at 296.90 per 1,000 population at risk. This ranges between a minimum of 0 and a maximum of 599.75. This reflects the position of Cape Verde, which was recently certified malaria free in West Africa by WHO while others countries of the sub-region are still grappling with high incidence as reflected in the results.

Table 5: Correlation Matrix

	lep	ifm	ufm	gdp	ppg	hci	hep	mal
lep	1							
ifm	-0.90	1						
ufm	-0.90	0.93	1					
gdp	0.02	-0.17	-0.28	1				
ppg	-0.16	0.23	0.36	-0.39	1			
hci	0.30	-0.29	-0.48	0.42	-0.40	1		
hep	0.18	-0.20	-0.35	0.66	-0.40	0.44	1	
mal	-0.69	0.67	0.66	-0.30	0.18	-0.29	-0.22	1

Source: Author‟s Computation.

Results of the correlation analysis as presented in Table 5 shows no evidence of high multicollinearity among the explanatory variables. The highest coefficient is 0.69, which is less than the threshold of 0.8 allowed in econometric literature. The high correlation displayed by the three explained (dependent) variables-life expectancy, infant mortality and under-five mortality is an indication that they are related health measures. This justifies the employment of the three to capture health in the study.

Empirical Results of Panel Econometric Estimation

Table 6: Results of Health Production Function Analysis for West Africa Dependent variable = life expectancy

Models	**1**		**2**		**3**		**4**		**5**	
Variable	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**
lngdp	0.27*** (0.00)	0.24*** (0.00)	0.27*** (0.00)	0.23*** (0.00)	0.20*** (0.00)	0.16*** (0.00)	0.08*** (0.00)	0.05*** (0.01)	0.08*** (0.00)	0.02 (0.29)
ppg			-0.001 (0.83)	-0.002 (0.71)	-0.003 (0.51)	-0.004 (0.46)	-0.004 (0.33)	-0.004 (0.31)	-0.01 (0.19)	-0.01 (0.12)
lnhci					0.21*** (0.00)	0.22*** (0.00)	0.26*** (0.00)	0.26*** (0.00)	0.22*** (0.00)	0.20*** (0.00)
lnhepc							0.05*** (0.00)	0.04*** (0.00)	0.05*** (0.00)	0.05*** (0.00)
lnmal									-0.02*** (0.01)	-0.03*** (0.00)
Constant	2.24*** (0.00)	2.44*** (0.00)	2.26*** (0.00)	2.48*** (0.00)	2.64*** (0.00)	2.88*** (0.00)	3.25*** (0.00)	3.42*** (0.00)	3.40*** (0.00)	3.83*** (0.00)
R-Squared	0.49	0.49	0.49	0.49	0.58	0.58	0.68	0.68	0.69	0.68
F-Statistics	316.40*** (0.00)		157.77*** (0.00)		123.74*** (0.00)		137.85*** (0.00)		114.25*** (0.00)	
Wald-Stat.		272.61*** (0.00)		265.18*** (0.00)		311.43*** (0.00)		505.48*** (0.00)		470.77*** (0.00)
Haus. Stat.	48.60*** (0.00)	48.60*** (0.00)	57.11*** (0.00)	57.11*** (0.00)	50.99*** (0.00)	50.99*** (0.00)	-51.83	-51.83	78.16*** (0.00)	78.16*** (0.00)

Note: *** denote significance at 1% level respectively while probabilities are in parenthesis.
Source: Author‟s Computation.

The results presented in Table 6 above employed life expectancy as a measure of health. Five models were estimated using two panel estimating techniques, Fixed Effects (FE) and Random Effects (RE). The findings showed that per capita income, human capital and health expenditure per capita are important for improving life expectancy in West Africa. This is evident by the positive and significant relationship between coefficients of the variables and life expectancy across the estimated models. However, malaria incidence depresses life expectancy significantly while population growth does not have any significant effect on lifer expectancy.

The findings are consistent with other empirical studies such as Fayissa & Gutema (2005); Bayati, Akbarian & Kavosi (2013); Bilas, Franc & Bosnjak (2014), Rahman, Khanam & Rahman (2018) Dauda (2020b) who reported positive and significant impact of per capita income on life expectancy in European Union, Eastern Mediterranean, South Asian Association for Regional Cooperation (SAARC) and Association for South East Asian Nations (ASEAN) regions, and West Africa, respectively. Also, the direct and significant influence of per capita health expenditure on life expectancy is in tandem with the conclusions of Rahman, Khanam & Rahman (2018) and Rayhan, Hasan & Akter (2019) for SAARC & ASEAN, and for the South Asian countries in that order.

Concerning human capital in the area of education, which significantly improves life expectancy in this paper, the outcome conforms to the findings of Fayissa & Gutema (2005), Bayati, Akbarian & Kavosi (2013) and Rayhan, Hasan & Akter (2019), which all reported that education significantly raises life expectancy in their study areas. With respect to insignificant effect of population growth on life expectancy, the outcome is in consonant with findings of Bilas, Franc & Bosnjak (2014) but at variance with Ali & Ahmad (2014), which discovered a negative and statistically significant impact of population growth on life expectancy. The negative and significant effect of malaria on life expectancy reported in this study is also consistent with the finding of Bawah & Binka (2007).

Table 7: Results of Health Production Function Analysis for West Africa

Dependent variable = Infant mortality rate

Model	**1**		**2**		**3**		**4**		**5**	
Variable	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**
lngdp	-1.00*** (0.00)	-0.94*** (0.00)	-1.00** (0.00)	-0.92*** (0.00)	-0.55*** (0.00)	-0.50*** (0.00)	-0.08 (0.16)	-0.06 (0.27)	-0.06 (0.22)	-0.02 (0.69)
ppg			0.01 (0.72)	0.01 (0.62)	-0.0002 (0.99)	0.001 (0.97)	0.003 (0.77)	0.004 (0.75)	0.01 (0.15)	0.01 (0.12)
lnhci					-1.10*** (0.00)	-1.11*** (0.00)	-1.27*** (0.00)	-1.25*** (0.00)	-0.94*** (0.00)	-0.90*** (0.00)
lnhepc							-0.18*** (0.00)	-0.18*** (0.00)	-0.17*** (0.00)	-0.18*** (0.00)
lnmal									0.15*** (0.01)	0.17*** (0.00)
Constant	10.94*** (0.00)	10.50*** (0.00)	10.89*** (0.00)	10.37*** (0.00)	8.37 *** (0.00)	8.05*** (0.00)	5.99*** (0.00)	5.77*** (0.00)	4.72*** (0.00)	4.36*** (0.00)
R-Squared	0.50	0.50	0.50	0.50	0.69	0.68	0.80	0.80	0.85	0.85
F-Statistics	338.29*** (0.00)		168.77*** (0.00)		195.29*** (0.00)		258.57*** (0.00)		287.50*** (0.00)	
Wald-Stat.		317.88*** (0.00)		312.42*** (0.00)		548.50*** (0.00)		990.67*** (0.00)		*** (0.00)
Haus. Stat.	20.49*** (0.00)	20.49*** (0.00)	24.80*** (0.00)	24.80*** (0.00)	13.57*** (0.00)	13.57*** (0.00)	-9.66	-9.66	-321.06	-321.06

Note: *** and ** denote significance at 1% and 5% levels respectively while probabilities are in parenthesis.

Source: Author‟s Computation

The findings displayed in Table 7 employed infant mortality rate as a measure of health. From the results per capita GDP relates negatively with infant mortality in the sub-region. Moreover, six out of the coefficients were significant, which means that increasing per capita income in West Africa can help to reduce infant mortality rate significantly. This outcome agrees with the finding of Fayissa & Traian (2013), Rahman, Khanam & Rahman (2018) and Rahman, Alam & Khanam (2022) for East European countries, SAARC & ASEAN and selected African countries, respectively in which per capita income led to a significant reduction in infant mortality.

Moreover, human capital and per capita health expenditure significantly reduce infant mortality in the sub-region; implying that raising human capital and per capita health expenditure can contribute to reduction in the rate of infant mortality in West African countries. These results are in agreement with the findings of Fayissa & Traian (2013) and Rahman, Alam & Khanam (2022), which reported a significant decline in infant mortality in East European countries and selected African countries, respectively due to investment in human capital (education). Sharma & Bothra (2017), Rahman, Khanam & Rahman (2018) and Rahman, Alam & Khanam (2022) also found that per capita health expenditure correspondingly contributed to significant reduction in infant mortality in South-Asian countries, SAARC & ASEAN regions and selected African countries. Moreover, Murad *et al.* (2023) also discovered that health expenditure contributed to significant decline in infant mortality rate in Bangladesh. The effect of population growth on infant mortality was insignificant across all estimations.

Malaria still remains a challenge in the sub-region as the results show positive and significant relationship with infant mortality, which means that malaria is still contributing to rising infant mortality in the sub-region of West Africa. This finding confirms the result obtained by Bardají *et al*. (2011) in Mozambique.

Table 8: Results of Health Production Function Analysis for West Africa
Dependent variable= Under five mortality rate

Model	**1**		**2**		**3**		**4**		**5**	
Variable	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**
lngdp	-1.24*** (0.00)	-1.15*** (0.00)	-1.24*** (0.00)	-1.11*** (0.00)	-0.69*** (0.00)	-0.60*** (0.00)	-0.13 (0.10)	-0.09 (0.24)	-0.10 (0.14)	0.01 (0.86)
ppg			0.01 (0.82)	0.01 (0.63)	-0.01 (0.76)	0.004 (0.85)	-0.002 (0.91)	-0.001 (0.96)	0.01 (0.28)	0.02 (0.18)
lnhci					-1.4*** (0.00)	-1.47*** (0.00)	-1.68*** (0.00)	-1.65*** (0.00)	-1.20*** (0.00)	-1.12*** (0.00)
lnhepc							-0.21*** (0.00)	-0.21*** (0.00)	-1.20*** (0.00)	-0.21*** (0.00)
lnmal									0.22*** (0.01)	0.25*** (0.00)
Constant		12.37*** (0.00)	12.96*** (0.00)	12.07*** (0.00)	9.96*** (0.00)	9.30*** (0.00)	7.00*** (0.00)	6.71*** (0.00)	5.26*** (0.00)	4.34*** (0.00)
R-Squared	0.49	0.49	0.49	0.49	0.67	0.67	0.77	0.77	0.83	0.83
F-Statistics	323.52*** (0.00)		161.33*** (0.00)		182.87*** (0.00)		212.90*** (0.00)		249.71*** (0.00)	
Wald-Stat.		304.81*** (0.00)		293.90*** (0.00)		502.71*** (0.00)		811.55*** (0.00)		1143.25*** (0.00)
Haus. Stat.	19.78*** (0.00)	19.78*** (0.00)	28.27*** (0.00)	28.27*** (0.00)	9.23** (0.03)	9.23** (0.03)	37.31*** (0.00)	37.31*** (0.00)	30.23*** (0.00)	30.23*** (0.00)

Note: *** and ** significance at 1% and 5% levels respectively while probabilities are in parenthesis..
Source: Author‟s Computation

Table 8 presents findings involving under-five mortality rate as the dependent variable and a measure of health. Clearly, the results did not diverge from the one reported for infant mortality. As evident in the Table, per capital income, human capital index and health expenditure per capital reduced under-five mortality rate significantly. The findings are consistent with outcomes of other studies elsewhere. For instance, Houweling, Kunst, Looman & Mackenbach (2005) found that income and health expenditure reduced under-five mortality significantly in developed and developing countries. Agbatogun & Opeloyeru (2020) and Murad *et al.* (2023) have also reported significant reduction in under-five mortality in Nigeria due to increase in health expenditure in Nigeria and Bangladesh, respectively.

Malaria still poses a threat to under-five morality as the coefficients remained positive and highly significant while the magnitude of the coefficients is also high. Population growth is not an issue and does not pose any significant threat to under-five mortality given that all the coefficients were statistically insignificant.

Diagnostic/Post Estimation Tests

Results of the diagnostic and post estimation tests conducted in the study are shown in the later end of Tables 6-8. As apparent in the tables, the F-statistics and Wald Chi-Squared statistics remained significant across all estimations. This implies that the regressors of the models are joint significant. The Hausman test results, which determine the choice of model/estimator are statistically significant for nearly all the estimated models. The import of this is that the Fixed Effects modeling/estimating technique is more appropriate as against the Fixed Effects.

Discussion of Result

The findings of the study showed that per capita income, per capita health expenditure, and human capital (education) are important

for health production in West Africa. These variables significantly raised life expectancy, and reduced infant and under five mortality rates in the sub- region. Malaria incidence however, contributed significantly to declining life expectancy and upsurge in both infant and under five mortality rates.

Beginning with per capita income, it is important that per capita GDP across countries that make up West Africa be increased to enhance population health and contribute to growth, development and attainment of SDG3. Currently, per capita GDP in the sub-region is low. Data from World Bank (2024) shows that the highest per capita income in West Africa as at 2022 was US$3,754.31, and this was recorded by Cape Verde while Sierra Leone had the lowest, put at US$475.80. This is a far cry compared to achievements in some countries in other sub-regions in Africa and nations outside Africa. For instance, in 2022, per capita GDP in some North African countries such as Egypt and Libya stood at US$4295.41 and US$6716.10, respectively while the figure the same year in Namibia and South Africa, which are located in Southern Africa were US$5031.12 and US$6766.48 in that order. Moreover, East African country like Mauritius posted US$10256.23 while Gabon, a country in Central Africa recorded US$8820.35 in 2022 (World Bank, 2024).

Several developed and developing countries outside Africa enjoy very high per capita GDP, with some of them recording well above US$100,000.00. In fact, oil rich economies like Saudi Arabia; Kuwait; United Arab Emirates; and Qatar, in 2022 posted per capita GDPs of US$30,447.88, US$41,079.52, US$53,707.98 and US$87,661.45, respectively while Nigeria, the leading oil producing nation in Africa (a West African country) and the 7th oil exporting country globally posted just US$2,162.63. It is observed that most of the economies with high per capita income also have better health outcomes. Available information from World Bank (2024) showed that life expectancy in such countries is very high while infant and under-five mortalities have declined substantially, with some being single digit while in some of the countries, the figures are approaching zero.

Per capita GDP is critical for improved health status of nations‟ population. In fact, beginning at the level of households, “a high income will provide access to better healthcare services”, … “quality nutrition, and raise the level of household consumption” while at the national level, it “will enhance investment in health and education infrastructure and facilities, the provision of better healthcare services, boost the level of living and enhance economic development” (Dauda, 2020b).

The results also showed per capita health expenditure contributing significantly to improved life expectancy and declines in infant and under-five mortality rates in West Africa. This is very important if a nation would experience improved health outcomes. West African countries should devote substantial proportion of their income on health care provision. Currently, the percentage of budget devoted to the health sector by most countries in the sub-region is far below the 15% benchmark recommended by the African Union member states in Abuja, Nigeria, in April 2001.
Investment in human capital (education) is also important for health production and improvement in population health status of every nation as confirmed by the significance of the results with respect to how the variable relates with the three health measures. While the findings showed significant positive relationship between human capital and life expectancy, it relates negatively and significantly with infant and under five mortalities. Human capital has long been advanced as critical for health improvement. Apart from education being a vital instrument provision and teaching of the information required for health, it is also employed to produce health personnel (Todaro & Smith, 2020; Dauda & Balogun, 2023). Moreover, education is key for instructions on how to use and administer medical products. Furthermore, educated people have been observed to enjoy better health status than those without education. A part from this, educated persons adhere to better hygiene practices than those who are not educated. So, investment in education human capital is strategic for health production and improvement in West Africa.

The results of the study also confirmed that malaria has contributed significantly to reduced life expectancy in West Africa while it has been responsible for high rates of infant and under five mortalities. Globally, West Africa accounts for the highest infant and under five mortality rates worldwide as well as the highest malaria incidence (UNICEF, 2023 and World Bank, 2024).

Implications for Achieving Sustainable Development Goal (SDG) 3

The outcome of the study, which analysed health production function for West Africa revealed that per capita income, human capital (education) and health expenditure per capita significantly improved life expectancy and reduced infant and under five mortality rates in West Africa. However, malaria incidence reduced life expectancy and raised infant and under five mortality rates in the sub-region while population growth did not post any danger to the three health variables. The implications of these findings for the achievement of SDG 3 are that West African countries need to put in place better policies towards the attainment of SDG3. From the findings of the study, the sub-region still has a very long way to go in achievement of the goal, with the target date of 2030, six years from now. It is therefore imperative for countries of the sub-region to boost their per capita income as well as raise health expenditure per capita. Moreover, it is important that countries of the sub-region invest substantially in human capital, particularly education. Concerted efforts should also be put in place to reduce malaria incidence in the countries. Currently, only Cape Verde has succeeded in eradicating malaria in West Africa while The Gambia, Mauritania and Senegal have made appreciable progress. The other twelve countries are still grappling with the menace of the disease, with the incidence remaining triple digits. Without the suggested policies, the dream of achieving SDG 3 by 2030 will remain a mirage in the sub-region.

6. Summary, Conclusion and Policy Recommendation

This study analysed the health production function for West Africa within the period 2000–2021. It employed panel data econometric modeling approach, with Fixed and Random Effects estimating techniques. Nevertheless, the Hausman test results supported Fixed Effects estimator. Three health outcome variables were used as in

the study, which are average life expectancy at birth, infant mortality rate and under-five mortality rate. The results revealed that per capita income, human capital (education) and health expenditure per capita significantly improved life expectancy and reduced infant and under-five mortality rates in West Africa. However, malaria incidence reduced life expectancy and raised infant and under-five mortality rates in the sub- region while population growth did not show any significant impact on the three health variables.

The implications of the findings are that to improve health outcomes in West Africa, policies should focus on boosting per capita income as well as raising health expenditure per capita. In addition, it is imperative that countries of the sub-region should invest substantially in human capital, particularly education while concerted efforts should be geared towards reduction in malaria incidence in countries of the sub-region. Without these policies, the attainment of SDG3 by 2030 in West African countries would be an illusion.

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