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# Impact of Health Indices on Economic Growth: An Empirical Analysis of Regional Differences in Africa

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## Abstract

**Background:** As a component of human capital, health has been acknowledged to play a significant role in the development process of any economy. Improved health status enhances the capacity and strength of the labour force thereby raising their work participation and productivity. This study investigated the impact of health indices proxied by life expectancy, mortality rate, and fertility rate on economic growth in Africa taking regional differences into account.
**Method:** The study covered 33 African countries which were selected based on data availability spanning from 1990 to 2017. Panel data estimation techniques in form of fixed effect and random effect models were employed. Also, to account for the regional differences in the impact of health indices on economic growth, regional dummy variables, and their interaction with the variables of health indices were included in the models.
**Results:** The random effect estimates revealed that the coefficients of the interaction terms are statistically significant indicating the existence of differences in the impact of health indices on economic growth across the regions. Specifically, life expectancy contributes positively and more effectively to the economic growth of Western Africa when compared to the Southern and Central African regions, while the reverse is the case in the Eastern African region. The mortality rate has a more negative effect on the economic growth of Eastern Africa followed by Central Africa and then Northern Africa. Finally, the fertility rate had a more negative impact on economic growth in Southern Africa, followed by Western Africa, Central Africa, and the Eastern African region while the effect is positive in Northern Africa.
**Conclusion:** To bridge the identified regional differences, we recommend that governments of the selected regional countries should pursue strong health policies and programs to create preconditions for boosting the levels of health indices for increasing economic growth and development. This can be in form of increasing access to quality education, health services, and other social amenities by adopting the “Free-Service-For-All” approach particularly for women and children who are more vulnerable. Equally, there should be rigorous commitment to creating more job opportunities particularly through Public-Private-Partnership (PPP). Otherwise, improvements in health status accompanied by high unemployment will render the former to be ineffective in determining economic growth.

**Keywords: Economic Growth, Health Indices, Impact Analysis, Random Effect, Regional Differences**

## Introduction

As a component of human capital, health has been acknowledged to play significant role in the growth and development process of any economy. Improved health status enhances capacity and strength of the labour force thereby raising their work participation and productivity. As rightly posited by [1], investment in health, raises efficiency in human capital which in turn boosts individuals' productivity and consequently economic growth. Similarly, [2] argued that productivity growth should be positively correlated with the level of health, in particular with the average level of life expectancy in a country. These have triggered the development of new theoretical models [3–6] incorporating health as a determinant of economic growth such as Grossman's Health Capital Theory and Demand for Health Model.

Also, high rate of mortality due to epidemiological and other external causes halt economic progress as evidenced by the recent case of Covid-19 pandemic. Huge resources that could have been used for investment in other productive ventures have been channeled towards curbing the spread of the disease in order to reduce fatalities. Going by the record of World Health Organization [7], increasing mortality from infectious diseases such as HIV/AIDS, Ebola, Malaria and tuberculosis have not only swept away improvements in life expectancy over the years but also contributed significantly to the slow growth of African countries. This has been buttressed by the report of the Economic Commission for Africa [8] which posited that countries affected by the Ebola epidemic like Guinea and Liberia have found it difficult to adjust the serious health crisis, which affected the social and production systems of the two countries. For instance, in 2014, the economic growth rates in the two countries were 1.1% and 1.7% respectively but dropped to 0.9% for each, in 2015. This is more intense in Sierra Leone where GDP growth rate was -21.5% in 2015, compared to 4.6% in 2014. This decline according to the report, stemmed from the closing down of two iron ore manufacturing plants, following the Ebola epidemic just to avoid fatality.

Again, high fertility rates have been reported to have significant influence on economic growth particularly in Africa. According to [9], increase in fertility rate leads to increase in population in the long-run; and where there are no job opportunities to absorb the increased population, it may result to increase in unemployment, dependency ratio, social vices and insecurity which cumulatively hamper the economic growth and development process of African economies.

Following the above line of arguments, various studies have been put forward on both single and multi-country basis to examine the contribution of health indices to economic growth particularly in Africa [10–14]. However, despite these efforts, there are at best, few studies that investigated the regional differences in the impact of health indices in Africa. For instance, [15] has analysed the dynamic relationships between healthcare spending and health indices on a panel of 41 Sub-Saharan African countries from 2000 to 2011 using fixed effect, random effect and GMM techniques. But, even this study cantered on the regional differences in the impact of healthcare spending on child mortality thereby saying nothing on the consequential effect on regional economic growth.

Going by the above submissions, it is obvious that poor health and growing burden of diseases are detrimental to economic growth and development as well as a major source of disparities between poor and rich countries. However, with the existing positive correlation between human development and economic growth, it is likely that a gradual improvement in health status in form of increase in life expectancy and decrease in mortality rates can have significant impact on the economic growth of Africa and its sub-regions, just as income brings about improved health status.

Therefore, this study intends to investigate and analyze the impact of health indices proxied by life expectancy, mortality rate and fertility rate on economic growth in Africa taking regional differences into account. This is because different countries and regions may have varied health policies, programs, and interventions as well as different socioeconomic conditions and institutional quality. All these may likely influence the extent to which health indices influence economic growth across African regions.

**Empirical evidence**

Various studies have been put forward on both single and multi-country basis to examine the contribution of health indices to economic growth. For instance, [10] examined the link between per capita health expenditure and health outcomes in 47 African countries from 1999 to 2004. The results of the study based on Robust OLS; Robust 2SLS; and Fixed Effect Estimator showed that total health expenditures (as well as the public component) are statistically significant contributors to improved health indices and economic growth in Africa. In another study on African countries, [11] examined how increased prevalence of HIV/AIDS and other diseases caused high mortality, retarded human capital development and consequently led to slow economic growth. Using a panel data for 38 African countries in the years 1980, 1985, 1990, 1995, 2000 and 2004, findings based on three-period Overlapping Generations Model revealed that prevalence of HIV/AIDS is responsible for a substantial decline in life expectancy in African countries which results in lower educational attainment and slow pace of economic growth.

Furthermore, [12] examined the contribution of health inputs and outcomes to the growth process in the Sub-Saharan Africa using a panel data of 30 countries spanning from 1995 to 2011. Using Dynamic Generalized Method of Moment (GMM) modeling framework, the results of the study showed that education has statistically significant positive effect on economic growth while health expenditure and mortality rate have statistically significant negative effects. Moreover, [13] analyzed the relation between economic growth and human capital between 1990 and 2011 for 15 MENA (Middle East and North Africa) countries. Using fixed effect, random effect, and Generalized Least Square (GLS), the results showed that life expectancy and fertility rate have statistically significant effect on GDP per capita while public health expenditure has no significant effect on economic growth over the study period.

More recently, [14] have empirically examined the relationship between health indices proxied by life expectancy and mortality rates, and economic growth in West African countries over the period of 1970 to 2016. However, the results obtained using panel unit root and panel co-integration

techniques developed by Pedroni revealed that there is evidence of long run relationship among life expectancy, infant mortality rates and economic growth. In addition, the results of Granger causality tests revealed the existence of unidirectional causality running from both life expectancy and infant mortality rates to economic growth in West African countries.

In another recent study, [9] empirically examined the long-run relationship among health indices proxied by life expectancy, mortality rates and fertility rates, and economic growth in African countries over the period of 1990 to 2017. The study employed both first and second generation panel unit root as well as panel ARDL co-integration techniques to examine these relationships. On the whole, the overall results revealed the existence of long-run equilibrium relationship between economic growth and health indices as indicated by the coefficient of the Error Correction Term (ECT) which was negative and statistically significant. In addition, life expectancy and mortality rate were reported to have significant impact on economic growth in Africa both in the long-run and short-run whereas fertility rate has significant impact only in the long-run based on the results of PMG estimator. Thus, the research concluded that a long-run equilibrium relationship exists between health indices and economic growth and that life expectancy, mortality rate and fertility rate are among the factors influencing economic growth in Africa.

Going by the above literatures, it is obvious that health indices play significant role in the development process of Africa. However, this role may significantly differ across countries and regions mainly due to varied socioeconomic conditions and institutional quality among other factors which are critical in ensuring quality of life and individuals' productivity. Thus, the novelty of this study is to examine and analyze these differences in the impact of health indices on economic growth across African regions.

**Methods**

The main objective of this study is to examine and analyze the regional variations in the impact of health indices on economic growth in Africa. The data of the study were sourced from the World Bank's publication of World Development Indicators [16] and the International Country Risk Guide [17] spanning from 1990 to 2017. Based on data availability, the study selected Thirty Three (33) countries to form the sample size of the study. Out of this sample, Five (5) countries were from Central Africa namely: Angola, Cameroon, Congo, Democratic Republic of Congo, and Gabon. Eight (8) countries were from Eastern Africa which comprised: Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Uganda, Zambia, and Zimbabwe. Northern Africa consists of Five (5) countries namely: Algeria, Egypt, Morocco, Sudan, and Tunisia. On the other hand, Three (3) countries were chosen from Southern Africa comprising Botswana, Namibia and South Africa. Finally, Twelve (12) countries were drawn from Western Africa which comprised: Burkina Faso, Ivory Coast, Gambia, Ghana, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo.

Therefore, in order to achieve the stated objective, the model below is specified following the work of Odhiambo [15]:

$$LRGDP_{it} = \alpha_i + \beta_{1i} LEXP_{it} + \beta_{2i} MORT_{it} + \beta_{3i} FERT_{it} + Z'_{it}\psi_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots 1$$

Where $LRGDP_{it}$ stands for economic growth for country *i* at time *t*, $LEXP_{it}$ represents life expectancy for country *i* at time *t*, $MORT_{it}$ stands for mortality rate for country *i* at time *t*, and $FERT_{it}$ stands for fertility rate for country *i* at time *t*. However, $Z'_{it}\psi_{it}$ is the vector of control variables representing Quality of Government Index (QOG) and Socioeconomic Conditions (SOCIOECO).

The choice of these control variables is based on their role in enhancing quality of life and per capita output. For instance, both the two variables depict not only different regional characteristics but also determine the conduciveness of the environment in which we live and standard of living which are critical to achieving economic growth [9] and [15].

The above equation is known as additive model which investigates only the "main" effects of the predictors. It assumes that the relationship between each variable of health indices and economic growth is independent of the other predictor variables in the model. In other words, the model assumes that the slope coefficient for each variable of health indices is the same for all countries across all regions. Hence, there is no any difference in the impact of life expectancy, mortality rates, and fertility rates on the economic growth across African regions. But this assumption might not be true simply because of differences in regional characteristics which may positively or negatively influence the effectiveness of health indices in impacting on economic growth.

To account for the regional differences, equation (1) above can be estimated separately for each region and then compare the results. However, running separate models for each group can be quite unwieldy because it results to estimating many coefficients than may be necessary. As a result, to account for the differences, the study introduced regional dummy variables and their interaction terms with independent variables. This is in line with the work of [18] who argued that to avoid the difficulties involved in estimating separate models, an alternative approach for testing whether parameter coefficients differ across groups is to introduce dummy variables and their interaction terms with independent variables.

Therefore, in line with the above argument, equation (1) is extended to include regional dummy variables as well as their interaction terms with health indices (life expectancy, mortality rates and fertility rates) across African sub-regions, to yield equation (2) as follows:

$$\begin{aligned} LRGDP_{it} &= \alpha_i + \beta_{1i} LEXP_{it} + \beta_{2i} MORT_{it} + \beta_{3i} FERT_{it} + \beta_4 CA_i + \beta_5 EA_i \\ &+ \beta_6 NA_i + \beta_7 WA_i + \beta_8 [CA_i * LEXP_{it}] + \beta_9 [EA_i * LEXP_{it}] + \beta_{10} [NA_i * LEXP_{it}] \\ &+ \beta_{11} [WA_i * LEXP_{it}] + \beta_{12} [CA_i * MORT_{it}] + \beta_{13} [EA_i * MORT_{it}] + \beta_{14} [NA_i * MORT_{it}] \\ &+ \beta_{15} [WA_i * MORT_{it}] + \beta_{16} [CA_i * FERT_{it}] + \beta_{17} [EA_i * FERT_{it}] + \beta_{18} [NA_i * FERT_{it}] \\ &+ \beta_{19} [WA_i * FERT_{it}] + Z'_{it}\psi + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2 \end{aligned}$$

Equation (2) above is the baseline model for examining the regional difference in the impact of health indices on economic growth in Africa. This is because it allows the slope coefficients of health indices to differ across the regions. In this case, the model relates economic growth ($LRGDP_{it}$) to health indices, the regional dummy variables: Central Africa (CA), Eastern Africa (EA), Northern Africa (NA), and Western Africa (WA), the interactions between regional dummy variables and health indices, and a vector of control variables ($Z_{it}$) which are: Quality of Government Index (QOG) and Socioeconomic Conditions (SOCIOECO) as earlier defined.

In terms of measurement, the dependent variable of this study is economic growth which is proxied by Real Gross Domestic Product (RGDP) and measured in US Dollars at constant price taking 2015 as the base year. For independent variables, life expectancy is measured as the average number of years a new-born infant would live if prevailing patterns of mortality of the total population at the time of his/her birth were to stay the same throughout his/her life. Also, total mortality rate is measured as the number of deaths occurring during a given year per 100,000 populations estimated at midyear. Again, fertility rate is measured as the average number of children a woman would bear during her lifetime, assuming her childbearing conforms to her age-specific fertility rate every year (i.e. 15 to 44 years). Finally, the regional dummy is measured as a binary variable between 0 and 1. The dummy variable is 1 if a selected country falls within the region of interest, otherwise it is 0.

For control variables, quality of government is measured as the mean value of three indicator variables: “Corruption”, “Law and Order” and “Bureaucracy Quality”, scaled between 0–1. Higher values indicate higher quality of government, and vice versa [17]. On the other hand, socioeconomic condition is measured as the sum of three sub-components: unemployment, consumer confidence, and poverty. The socioeconomic condition is scaled between 0 and 12. According to [17], each component has a maximum score of 4 points and a minimum score of 0 points. A score of 4 points equates to Very Low Risk (high socioeconomic condition) and a score of 0 points to Very High Risk (low socioeconomic condition).

Note that the coefficients of the interaction terms ($\beta_4$, $\beta_5$, …, and $\beta_{19}$) indicate how the effect of life expectancy, mortality rates, and fertility rates differs across African sub-regions. For example, if the coefficient of the interaction term between Central Africa dummy and life expectancy is positive, this means that life expectancy has a larger effect (i.e. more positive or less negative) in Central Africa than it does in the other regions. This can be interpreted as the increase or decrease in the effectiveness of life expectancy on economic growth in Central Africa when its regional dummy is 1. Where the regional dummy is 0, it is said to have no any influence on the effectiveness of life expectancy on economic growth in Central Africa. The same applies to other regions in the model. It should be noted that, sometimes, it may be the interaction term that is significant but not the main effects. However, the hierarchical principle states that, if we include an interaction in a model, we should also include the main effects, even if the p-values associated with their coefficients are not significant [18].

However, for the purpose of this study, $\beta_1$ is the coefficient of life expectancy which is expected to be positive. $\beta_2$ is the coefficients of mortality rates which is expected to be negative. Equally, $\beta_3$, $\beta_4$, $\beta_5$, …, and $\beta_{19}$ are the coefficients of fertility rates, regional dummy variables, and the interaction terms between regional dummy and health indices respectively and each can take positive or negative sign. $\psi$ is the coefficient of the vector of control variables. $\varepsilon_{it}$ is the composite error terms which consists of country specific effects and time-specific effects. In addition, the composite error terms are assumed to be normally distributed and homoskedastic.

It should be noted that the Southern Africa (SA) dummy variable and its interactions were dropped from the model (that is, equation 2) to avoid the dummy variable trap and to serve as reference point. Taking a region with higher number of countries (sample size) will significantly reduce the total observations which may affect the accuracy and reliability of the overall results. Hence, being a region with lowest number of countries in the study, Southern Africa was chosen as a reference point in order to avoid small sample bias.

Finally, giving the baseline model above, the study employed Fixed-Effect (FE) and Random-Effect (RE) estimation techniques to estimate and analyse the regional differences in the impact of health indices on economic growth in Africa. However, to choose the most preferred model between the two estimators, the study used Hausman test. The test examines the null hypothesis ($H_0$) that random effects are consistent and efficient, versus the alternative ($H_1$) that random effects are inconsistent (as the fixed effects will be always consistent). This choice strongly depends on the behaviour of the coefficients of country-specific effect and time-specific effect. According [19], where time-specific effects are absent but there is a country-specific effect, the estimation results obtained using FE is more appropriate. However, if the time-specific effects are absent but the country-specific effects are characterized as random term, the results of RE model will be chosen.

## Results

### Descriptive analysis of the data

This section describes the basic statistical elements of all variables used in the study across the African regions as shown in Table 1.

The result shows that the mean value of log of real GDP was US$ 23.33 across the regions with a standard deviation of US$ 1.52; whereas US$19.30 and US$26.8 represent the minimum and maximum values of log of real GDP respectively and both were in Western Africa (specifically in Liberia and Nigeria). Also, the average life expectancy across the regions was about 56 years with a standard deviation of about 8 years. Over the study period, the highest life expectancy of about 76.1 years was recorded in Northern Africa (in Algeria) while the minimum expected years of life was about 35.7 which was recorded in Western Africa (in Sierra Leone).

Furthermore, the average mortality rate in the regions was about 11.92 per 100,000 populations. Interestingly, Northern Africa experienced the lowest mortality rate of about 4.71 (precisely in Algeria again) which justify its position of being the region with highest life expectancy on the African continent.

**Table 1: Descriptive Analysis of Variables for All Regions (Combined Panel)**

| **Time Period: 1990 – 2017** | | | | | |
|---|---|---|---|---|---|
| **Variables** | **Obs.** | **Mean** | **Std. Dev.** | **Minimum** | **Maximum** |
| *LRGDP* | 924 | 23.33 | 1.52 | 19.30 | 26.86 |
| *LEXP* | 924 | 56.45 | 8.06 | 35.71 | 76.08 |
| *MORT* | 924 | 11.92 | 4.33 | 4.74 | 27.54 |
| *FERT* | 924 | 5.14 | 1.36 | 1.99 | 7.77 |
| *QOG* | 924 | 0.41 | 0.14 | 0.04 | 0.90 |
| *SOCIOECO* | 924 | 3.86 | 1.61 | 0.50 | 8.00 |
| **Regions with Minimum/Maximum Values** | | | | | |
| **Variables** | **Minimum** | | **Maximum** | | |
| *LRGDP* | Western Africa | | Western Africa | | |
| *LEXP* | Western Africa | | Northern Africa | | |
| *MORT* | Northern Africa | | Western Africa | | |
| *FERT* | Northern Africa | | Western Africa | | |
| *QOG* | Western Africa | | Southern Africa | | |
| *SOCIOECO* | Eastern Africa | | Western Africa | | |

Source: World Bank's World Development Indicators (2017); International Country Risk Guide, (2017). Computed using STATA version 14.

Similarly, Western Africa with the lowest life expectancy has equally experienced the highest mortality rate of about 27.54 (again in Sierra Leone). This has buttressed the assertion that the lower the mortality rate, the more chances to live long. In relation to fertility rate, the minimum and maximum rates were respectively recorded in Northern Africa (in Tunisia) and Western Africa (in Niger) with about 1.99 and 7.77 rates of fertility. However, the mean fertility rate across the regions was about 5.14 rates with a standard deviation of about 1.36 rates.

The results further revealed that the average quality of government across the regions was about 0.41 with a standard deviation of about 0.14. While the highest quality of government was recorded in Southern Africa given by a scale of about 0.90 (precisely in Namibia), the lowest quality of government was recorded in Western Africa (in Liberia) which was scaled about 0.04. This shows that corruption was rampant in Western Africa which may be due to lack of adherence to law and order as well as poor bureaucracy quality and vice versa in the case of Southern Africa. Finally, the average socioeconomic status across the African regions was about 3.85 with a standard deviation of about 1.61, and the minimum and maximum values of about 0.50 and 8.0 were respectively found in Eastern Africa (in Zimbabwe) and Western Africa (in Cote D'ivoire).

**Inferential analysis**

The econometric results of equations (1) and (2) are presented in table 1 based on the estimation of fixed effect and random effect panel models. However, the interpretations of the results were conducted based on the dictates of the Hausman test which identify

**Table 2: Results of Fixed Effect and Random Effect Models**

| **Dependent Variable:** Log of Real Gross Domestic Product (RGDP) | | | | |
|---|---|---|---|---|
| | **Model 1** | | **Model 2** | |
| **Independent Variables** | **Fixed Effect** | **Random Effect** | **Fixed Effect** | **Random Effect** |
| LEXP | 0.04 | 0.04 | 0.07 | 0.07 |
| | (0.01)*** | (0.01)*** | (0.02)*** | (0.02)*** |
| MORT | -0.01 | -0.01 | 0.11 | 0.11 |
| | (0.01) | (0.01) | (0.04)*** | (0.04)*** |
| FERT | -0.34 | -0.34 | -0.51 | -0.52 |
| | (0.02)*** | (0.02)*** | (0.04)*** | (0.04)*** |
| QOG | -0.40 | -0.40 | -0.31 | -0.31 |
| | (0.09)*** | (0.09)*** | (0.08)*** | (0.08)*** |
| SOCIOECO | 0.02 | 0.02 | 0.02 | 0.02 |
| | (0.01)** | (0.01)*** | (0.01)** | (0.01)** |
| Central Africa | – | – | – | 4.22 |
| | | | | (2.51)* |
| Eastern Africa | – | – | – | 9.32 |
| | | | | (2.08)*** |
| Northern Africa | – | – | – | -2.93 |
| | | | | (2.11) |
| Western Africa | – | – | – | -3.10 |
| | | | | (2.13)* |
| LEXP*Central Africa | – | – | -0.05 | -0.06 |
| | | | (0.03)* | (0.03)* |
| LEXP*Eastern Africa | – | – | -0.13 | -0.13 |
| | | | (0.02)*** | (0.02)*** |
| LEXP*Northern Africa | – | – | 0.04 | 0.04 |
| | | | (0.02)* | (0.02)* |
| LEXP*Western Africa | – | – | 0.05 | 0.05 |
| | | | (0.02)** | (0.02)** |
| MORT*Central Africa | – | – | -0.17 | -0.17 |
| | | | (0.05)*** | (0.05)*** |
| MORT*Eastern Africa | – | – | -0.29 | -0.29 |
| | | | (0.04)*** | (0.04)*** |
| MORT*Northern Africa | – | – | -0.15 | -0.15 |
| | | | (0.05)*** | (0.05)*** |
| MORT*Western Africa | – | – | -0.03 | -0.03 |
| | | | (0.04) | (0.04) |
| FERT*Central Africa | – | – | 0.29 | 0.29 |
| | | | (0.07)*** | (0.07)*** |
| FERT*Eastern Africa | – | – | 0.31 | 0.31 |
| | | | (0.05)*** | (0.05)*** |
| FERT*Northern Africa | – | – | 0.54 | 0.54 |
| | | | (0.06)*** | (0.06)*** |
| FERT*Western Africa | – | – | 0.24 | 0.24 |
| | | | (0.05)*** | (0.05)*** |
| Constant | 23.06 | 23.01 | 21.64 | 20.65 |
| | (0.40)*** | (0.47)*** | (0.50)*** | (1.83)*** |
| No. of Observations | 924 | 924 | 924 | 924 |
| No. of Countries | 33 | 33 | 33 | 33 |
| R-Squared | 0.78 | 0.78 | 0.85 | 0.85 |
| F-Statistics | 628.78 | – | 282.16 | – |
| | [0.00] | | [0.00] | |
| Wald Test ($\chi^2$) | – | 3165.54 | – | 4847.94 |
| | | [0.00] | | [0.00] |
| Hausman Test ($\chi^2$) | 0.98[0.97] | | 8.28 [0.94] | |

*Source: Author's computation using STATA version 14.*

*Note: Figures in '()' and '[]' are standard errors and probability values respectively.*

***, ** and *indicate significance at the 1%, 5% and 10% levels respectively.*

*Dummy variables for the region take the value of 1; 0 otherwise*.

the most preferred model between fixed effect and random effect estimations.

Table 2 shows the estimated effects of health indices on economic growth in Africa as well as their regional effects on the economic growth of African sub-regions. As can be seen, model 1 measures the main effects of life expectancy, mortality rates and fertility rates on the economic growth regardless of any regional variation among African sub-regions. Model 2, has an additional variables of regional dummy, and their interactions with health indices in order to examine the regional differences in the effects of life expectancy, mortality rates, and fertility rates on economic growth among African sub-regions. It should be noted that interpretation of results is based on the chosen model by the Hausman test between fixed and random effect estimates.

For model 1, the Hausman test revealed that random effect estimates are more appropriate with a p-value of greater than 0.05. Also, the Wald test p-value of 0.00 indicates that the null hypothesis of no joint significance is rejected. However, the results represent the impact of health indices on economic growth in Africa as a whole and Southern Africa in particular which the reference point region. From the findings, the estimated coefficient of life expectancy is positive and significant which conformed to the a priori expectation. The result indicated that an increase in life expectancy by 1 year would increase economic growth in Africa by about 0.04%. On the other hand, the coefficient of mortality rate is negative as expected but statistically insignificant. Also, the result shows that fertility rate has negative and statistically significant impact on economic growth. Specifically, a 1% increase in fertility rates would bring about 0.34% decrease in African economic growth. For control variables, the coefficient of quality of government (which implies lower level of corruption, increase in bureaucracy quality and adherence to low and order) is negative and statistically significant. The result revealed that a 1% increase in the quality of government index would reduce economic growth by about 0.40%. This is contrary to the a priori expectation of the study. Finally, the estimated coefficient of socioeconomic status is found to have a significant and correct sign in the model, indicating that a 1% increase in socioeconomic status in Africa would increase economic growth by about 0.02%, though the magnitude is very small similar to that of life expectancy.

However, model 2 repeated the estimation but included the regional dummy variables and their interaction terms with life expectancy, mortality rates and fertility rates. This is to investigate whether the impact of these health indices on economic growth differs across African sub-regions. Thus, the life expectancy, mortality rates and fertility rates were interacted with four dummy variables for Central Africa, Eastern Africa, Northern Africa and Western Africa respectively. Southern Africa dummy was omitted not only to avoid dummy variable trap but also to serve as a reference point. Similarly, the Hausman test shows that random effect estimates are more appropriate.

From the overall results, it can be observed that all the coefficients, including the interaction terms coefficients, are statistically significant except coefficient of Northern Africa dummy and that of interaction between mortality rates and Western Africa dummy. This suggests that there is an

interactive relationship between the variables of health indices (life expectancy, mortality rates and fertility rates) and regional characteristics in at least some, if not all regions. This is further buttressed by comparing the two models (additive and the interaction models, that is, model 1 and model 2) in terms of their diagnostic tests. For instance, although the Wald test p-value of 0.00 in both models indicates that the null hypothesis of no joint significance is rejected, the value of $\chi^2$ in the interaction model (4847.94) is higher than that of the additive model (3165.54). Additionally, the R-square ($R^2$) value of the interaction model is about 85% compared to only 78% for the additive model. These results suggest that the model with the interaction term is better than the model that contains only main effects.

From the respective results, it can be seen that there is significant difference in the values of the coefficients of health indices in model 2 (interaction model) compared to model 1 (additive model). For instance, the coefficient of life expectancy is still positive and significant with relatively higher magnitude. Specifically, the results showed that a 1 year increase in life expectancy increases economic growth by about 0.07% in Africa. On the contrary, the coefficient of mortality rates is now positive and statistically significant. The result showed that a 1% increase in mortality rate would increase economic growth in Africa by about 0.11% which is against the a priori expectation of this study. For fertility rates, the coefficient is still negative and significant, showing that a 1% increase in fertility rates reduces economic growth in Africa by about 0.51%. Furthermore, all coefficients of regional dummy variables as well as the coefficients of their interaction with health indices exhibited varying signs and are significant except coefficients of Northern Africa dummy and that of interaction between mortality rates and Western Africa dummy. This indicates the existence of interactive relationship between regional characteristics and the variables of health indices. Last but not the least, the coefficients of the control variables still maintained their signs and significantly influence economic growth in Africa as whole and across regions in particular.

However, the fact that coefficient of interaction terms are statistically significant except coefficient of interaction between mortality rates and Western Africa dummy, this suggests that regional characteristics significantly influence the effectiveness of life expectancy, mortality rates and fertility rates on economic growth in nearly all regions. Therefore, the task now is to examine the efficacy of regional dummy variables in influencing the impact of health indices on economic growth among African sub-regions. This is simply done by adding the coefficient of the interaction term in each region with the main effect. The coefficient of the interaction term captures the additional effect of a given variable of health indices on economic growth in a particular region when regional dummy is 1, while the main effect is when regional dummy is 0. This is presented in table 3.

From table 3, the coefficients of LEXP, MORT, and FERT were taken from model 1 in table 2 which represent their respective impacts on economic growth in Africa as a whole and Southern Africa in particular which is the reference point region as earlier interpreted. Therefore, the first part of table 3 presents the results of regional differences in the impact of life expectancy on economic growth in Africa.

**Table 3: Regional Differences in the Impact of Health Indices on Economic Growth**

| **Interaction:** Regional Dummy*Life Expectancy | | | | |
|---|---|---|---|---|
| | **Coefficients** | | | |
| **Variables** | **CA** | **EA** | **NA** | **WA** |
| LEXP | 0.07 | 0.07 | 0.07 | 0.07 |
| Regional Dummy*LEXP | -0.06 | -0.13 | 0.04 | 0.07 |
| **Total Effect** | 0.02 | -0.06 | 0.11 | 0.12 |
| **Interaction:** Regional Dummy*Mortality Rates | | | | |
| MORT | 0.11 | 0.11 | 0.11 | 0.11 |
| Regional Dummy*MORT | -0.17 | -0.29 | -0.15 | -0.03[a] |
| **Total Effect** | -0.07 | -0.19 | -0.04 | 0.08 |
| **Interaction:** Regional Dummy*fertility Rates | | | | |
| FERT | -0.52 | -0.52 | -0.52 | -0.52 |
| Regional Dummy*FERT | 0.29 | 0.31 | 0.54 | 0.24 |
| **Total Effect** | -0.22 | -0.21 | 0.02 | -0.27 |

*Source: Author's computation, extracted from table 1 above.*

*Note: Computations are based on Random effect estimates in Model 2.*
*Dummy variables for the region take the value of 1; 0 otherwise.*
*a. Interaction term is NOT significant.*

The coefficient of life expectancy (that is 0.07) shows its impact on economic growth in Southern Africa and Africa in general. However, when the respective regional coefficients of interaction terms are added which are significantly different from zero, it can be seen that the total effect of life expectancy on economic growth significantly differs across the regions. The positive coefficient means that a variable of health indices has larger effect (more positive or less negative) in a given region and vice versa. For instance, the results revealed that for every increase in life expectancy, Northern and Western Africa would expect an additional increase in economic growth by about 0.04% and 0.0.05% respectively on top of the main effect (that is, 0.07+0.04 for Northern Africa and 0.07+0.05 for Western Africa). On the other hand, Central Africa and Eastern Africa would have less economic growth from the main effect by about 0.06% and 0.13% respectively (that is, 0.07+ (-0.06) for Central Africa and 0.07+ (-0.13) for Eastern Africa).

Therefore, cumulatively, a 1 year increase in life expectancy leads to increase in economic growth in Western Africa by about 0.12%, followed by Northern Africa (0.11%), Southern Africa (0.07%), and Central Africa (0.02%). For Eastern Africa, the result shows a negative impact on economic growth, indicating that a 1 year increase in life expectancy reduces economic growth in Eastern Africa by about 0.06%. On the whole, the results show that life expectancy contributes positively and most effectively on the economic growth of Western Africa when compared to Southern and Central African region, while the reverse is the case in Eastern African region.

The second part of the table presents the results of regional differences in the impact of mortality rates on economic growth in Africa. In a similar way, the results revealed that for every 1% increase in mortality rates,

Central Africa, Eastern Africa, and Northern Africa would cumulatively expect less economic growth by about 0.07%, 0.18%, and 0.04% respectively. This clearly shows that mortality rate has more negative effect on the economic growth of Eastern Africa followed by Central Africa and then Northern Africa. On the other hand, the effect of mortality rates in Southern and Western regions shows unexpected positive sign, indicating that for every 1% increase in mortality rate, economic growth increases by about 0.11% and 0.08% respectively.

The third and also last part of the table presents the results of regional differences in the impact of fertility rate on economic growth in African regions. Again, it can be seen from the overall results that for every 1% increase in fertility rate, economic growth decreases in Central Africa by about 0.22%, in Eastern Africa by 0.21%, in Western Africa by 0.27%, and Southern Africa by 0.52%. Comparatively, fertility rate is said to have more negative impact on economic growth in Southern Africa, followed by Western Africa, Central Africa and then Eastern African region. However, the effect of fertility rate in Northern Africa though very small in magnitude, is found to be positive which indicate that for every 1% increase in fertility rate, economic growth in Northern Africa rises by about 0.02%.

**Discussion**

The results of Random Effect estimates in model 2 confirmed the existence of significant regional differences in the impact of health indices (proxied by life expectancy, mortality rate and fertility rate) on economic growth across African regions as evidenced by the coefficients of interaction terms between respective regional dummy variable and the variables of health indices which were mostly found to be statistically significant. This suggests that there is an interactive relationship between the variables of health indices and regional characteristics in at least some, if not all regions which further indicates that the impact of life expectancy, mortality rate and fertility rate on economic growth differs across African sub-regions as presented in table 2. This has buttressed the work of (15) who also found regional variations in the impact health expenditure on child mortality rate in Africa.

Specifically, compared to the reference point, that is, Southern Africa in which the coefficient was 0.07%, the results have shown that life expectancy has larger positive and statistically significant impact on economic growth in Western Africa (0.12%) and Northern Africa (0.11%) and less positive impact in Central Africa (0.02%). The positive and significant impact of life expectancy on economic growth in these regions have supported the work of [2] that productivity growth should be positively correlated with the level of health particularly the average level of life expectancy in a country. On the contrary, the results revealed that life expectancy has negative and statistically significant impact on economic growth in Eastern Africa by about -0.06%. This has not only contradicted the works of [1] and [2] but also the a priori expectation of this study. However, the positive results are not surprising for the case of Western Africa and Northern Africa being the second and third regions with largest population respectively in Africa. Hence, all things being equal, increase in life expectancy in these two regions may imply increase in human resource availability and cheap labour which consequently attracts more investment and output at lower cost. Being the region with

lowest population, the relatively high positive impact of life expectancy on economic growth in Southern Africa may be due to its high quality of government compared to other regions which in turn, provides high quality labour force in terms of education, health and skills and consequently increased productivity and economic growth. For the case of Central Africa where the impact of life expectancy on economic growth is of smaller magnitude compared to other regions, may be due to the low per capita health expenditure in the region. As rightly posited by [1], investment in health, raises efficiency in human capital which in turn boosts individuals' productivity and consequently economic growth. Thus on the contrary, lower spending on health may be detrimental to quality of life of the labour force and its productivity thereby retarding the speed of economic growth. However, the negative impact of life expectancy on economic growth in Eastern Africa, despite being the region with largest population, may not be unconnected with poor socioeconomic conditions which may result to high number of uneducated, unskilled and low productivity of the labour force in the region.

Similarly, the results revealed that mortality rate has negative and statistically significant impact on economic growth in Central Africa, Eastern Africa and Northern Africa. However, the impact is more devastating on the economic growth of Eastern Africa (by about 0.19%) followed by Central Africa (0.07%) and then Northern Africa (0.04%). This conformed to the a priori expectation of this study and also attested the reports of [7] and [8] that increasing mortality from infectious diseases such as HIV/AIDS, Ebola, Malaria and tuberculosis have not only swept away improvements in life expectancy over the years but also contributed significantly to the slow growth of African countries. Contrarily, the results showed that mortality rate has positive impact on economic growth in Southern Africa (by about 0.11%) and Western Africa (0.08%) but the impact is insignificant in the case of the later region because of the insignificant coefficient of the interaction term. This positive impact was highly unexpected. However, this could be buttressed by the theoretical argument of [20] who stated that increase in mortality has been an important incentive to increase investment in education and health which consequently promote economic growth, saying that the post war experience of India is consistent with this incentive.

Finally, the results further reported the impact of fertility rate on economic growth across African sub-regions. The results showed that fertility rate has negative and statistically significant impact on the economic growth of all regions except Northern Africa where the impact was reported positive and equally significant by about 0.02%. In terms of magnitude, fertility rate has more negative impact on economic growth in Southern Africa (by about -0.52%) followed by Western Africa (-0.27%), Central Africa (-0.22%) and then Eastern Africa (-0.21%). This has corroborated the findings [9] that increase in fertility rate raises population growth in the long-run; and where there are no job opportunities to absorb the increased population, it may result to increase in unemployment, dependency ratio, social vices and insecurity which cumulatively hamper the process of growth and development of African economies.

Based on the above discussions, the major findings obtained from the study are summarized as follows:

a. The study confirmed the existence of significant differences in the impact of life expectancy, mortality rate and fertility rate on economic growth across African regions based on the results of Random Effects estimates presented in model 2 of table 2.
b. Life expectancy has more positive impact on economic growth in Western Africa and less positive in Central Africa; while in Eastern Africa, the impact of life expectancy on economic growth is negative.
c. Mortality rate has more negative impact on economic growth in Eastern Africa and less negative in Northern Africa; while in Southern Africa, mortality rate has positive impact on economic growth.
d. Fertility rate has more negative impact on economic growth in Southern Africa and less negative in Eastern Africa; while in Northern Africa, fertility rate has positive impact on economic growth.

**Policy implication and recommendations**

The overall results of the study have shown the existence of significant regional differences in the impact of health indices (life expectancy, mortality rate and fertility rate) on economic growth in Africa. Thus, it becomes apparent that each region has its own peculiar characteristics such as population size, socioeconomic conditions, political stability, quality of institutions, etc. which will undoubtedly influence the impact of health indices on economic growth compared to other regions. The implication here is that, each region may require distinct policies, programs and interventions necessary to improve the level of its health indices for the purpose of achieving economic growth and development. Therefore, the study recommended that policy makers at various levels of government, international donor agencies; regional and continental organizations should take note of these regional differences in the levels of health indices and degree of economic growth in each region when designing health-related development policies and programs for Africa in order to bridge the regional differences. Also, governments and health related donor agencies should specifically increase the level their spending on community health and medical services as this may improve the efficiency and effectiveness in relation to prevention, diagnosis and treatment of diseases that bedeviled some of the studied countries like Sierra Leon, Nigeria, and Niger which cause higher mortality and hampered human capital development.

Above all, since improvement in health indices is believed to increase labour participation rate, productivity and income which in turn, leads to greater economic growth, the study recommends that governments of the selected regional countries should pursue strong health policies and programs in order to create preconditions for boosting the levels of health indices for increasing economic growth and development. This can be in form of increasing access to quality education, health services, and other social amenities by adopting “Free-Service-For-All” approach particularly on women and children who are more vulnerable. Equally, there should be rigorous commitment to create more job opportunities particularly through Public-Private-Partnership (PPP). Otherwise, improvements in health status accompanied by high unemployment will render the former to be ineffective in determining economic growth.

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