LIFE EXPECTANCY IN SUB-SAHARAN AFRICAN COUNTRIES: DOES ECONOMIC WELFARE MATTER?

***MOMOH, OMOWUMI AYONI**
Department of Insurance, Faculty of Financial Management Studies
The Polytechnic, Ibadan, Ibadan, Oyo State, Nigeria
PhD Candidate, Department of Economics, Babcock University, IIishan-Remo, Nigeria
momoh0414@pg.babcock.edu.ng, omowumimomoh@yahoo.com Tel: +234 8033948844

AJIBOLA, JOSEPH OLUSEGUN
Department of Economics, Babcock University, IIishan-Remo, Nigeria
ajibolao@babcock.edu.ng Tel: +234 8034409494

ONAKOYA, ADEGBEMI BABATUNDE
Department of Economics, Babcock University, IIishan-Remo, Nigeria
onakoyaa@babcock.edu.ng Tel: +234 8035550124

ABSTRACT

To achieve Sustainable Development Goal 3, improved health outcomes is very vital. However, relatively low life expectancy and high mortality rates characterized most countries in sub-Saharan Africa (SSA) region. This paper investigated the effect of economic welfare on life expectancy in sub-Saharan Africa for a panel dataset of 44 selected countries spanning between 2000 and 2021. The study decomposed economic welfare into real gross domestic product, carbon dioxide emission and secondary school enrolment rate. Cross-sectional dependence and homogeneity slope tests were conducted, Generalized Method of Moments estimation method was employed in the analysis, further robustness checks were conducted with Average Mean Group. Reduction in carbon dioxide emission and secondary school enrolment rate level significantly increased life expectancy. Real Gross Domestic Product had positive but insignificant effect on life expectancy. The panel granger causality test revealed that real GDP, secondary school enrolment rate and carbon dioxide emission had bidirectional causal relationship with life expectancy. The study recommends that policy reforms towards reducing carbo dioxide emissions, increase in income levels, and adequate investment in education should be adopted for achieving long life expectancy in Sub-Saharan African countries.

Keywords: Cross-sectional dependence, Economic welfare, Granger causality, Life expectancy, Sustainable development

JEL Codes: P46, I12, C23

1. INTRODUCTION

Health and longevity have significantly increased in most nations, particularly those with middle and high-income levels. Life expectancy, decent living, and adult literacy are fundamental instruments for human development. Health is one of the most important indicators of social welfare and a determinant of human capital accumulation necessary for economic growth and development (Guzel *et al.*, 2021). Improved health status has continued to enjoy wide discussion among academics and policymakers globally. Health capital is a crucial tool for economic growth in developed, emerging, and developing economies (Keghter *et al*., (2020). Hence the discussion on life expectancy and economic welfare has remained relevant in both theoretical and empirical literature. Health affects the enjoyment of life, the

ability to contribute to a family's well-being and to be a productive member of the workforce, and the ability to be productive in school. To mitigate the effects of poor health outcomes, most governments and the global community have advocated for Universal Health Coverage (UHC), with the goal that all people must have access to appropriate health promotion, prevention, treatment, and functional recovery at an affordable cost. UHC can be achieved by focusing on two areas: access to quality essential health services and protection from financial risk (WHO, 2020). A World Bank report claims that by 2030 non-communicable diseases are expected to cause more deaths in Africa than communicable diseases (Marquez & Farrington (2013).

Life expectancy is the number of years a newborn child could anticipate tolive if all other prevailing survival variables regarding mortality rates at the time of birth remain constant throughout a child's existence (Owumi & Eboh 2021; UNDP 2015; Bayati *et al*. 2013). It serves as a vital indicator not only of health and population outcomes but also as a measure of economic and social development within a country or region. Various factors including economic, cultural, social, and environmental aspects play significant roles in shaping life expectancy.

Sub-Saharan Africa has experienced economic growth over the past few decades, although the pace and distribution of this growth vary across countries. Despite this growth, many countries in the region continue to face challenges related to poverty, inadequate healthcare infrastructure, infectious diseases, and other socio-economic factors that influence life expectancy. Poor health has dire consequences for the individual. It not only incapacitates him/her but also prevents the person from participating effectively in the productive and social sectors of the economy (Arthur & Oaikhenan, 2017). Poor health and its attendant effects impact the individual's quality of life and productivity. Indeed, the adage 'health is wealth' captures the significance of health to the individual.
Sustainable Development Goal-3 (SDG-3) focuses on ensuring healthy lives and promoting the well-being of all, with specific targets to end preventable deaths by 2030 and to achieve universal health coverage (UHC) through access to quality, safe, effective, affordable, and essential health care services (UN, 2015). This global effort is geared towards attaining substantial progress in increasing life expectancy and reducing widespread diseases associated with early mortalities (UN, 2015). The impact of current illness on health may have large effects on prospective life spans and life cycle behavior. (Piabuo & Tieguhong, 2017; Iseghohi, 2021; Ullah & Malik, 2019). Health and longevity have significantly increased in most nations, particularly those with middle- and high-income levels. Health affects the enjoyment of life, the ability to contribute to a family's well-being and to be a productive member of the workforce, and the ability to be productive in school.

Economic welfare in Sub-Saharan African (SSA) countries has been very poor, increase in real gross domestic product (RGDP) has not translated into substantive growth which has resulted in a high rate of poverty and poor living standards (Arthur & Oaikhenan, 2017).). Health and income mutually affect each other. Poor health could cause an economy to lose the ability for competitive productivity. The Sustainable Development Goal of the United Nations emphasizes that human health is the foundation of all social progress and development. People's productivity and enjoyment of life, improvements in health and longevity, and general improvements in well-being are all closely related (Krekei, Ward, & De Neve, 2019). Ill health is a heavy financial burden. 50% of the growth differential between rich and poor countries is due to ill-health and low life expectancy (WHO, 2001). Out-of-pocket health expenditure can push households further into poverty (Adeshina & Akintunde, 2020).

Health, like education, is undeniably one of the basic capabilities that adds value to human life, as Nobel Laureate Amartya Sen (1980) stated. As a result of these considerations, promoting individual health in the economy is critical. It is believed that health status improves with disposable income since disposable income determines an individual's purchasing power, including medical ones (Odusanya & Agboola, 2017). At the macro level, the income (GDP) level determines the amount and growth of health expenditure in a country. The greater the size of the per capita income of a nation, the greater the amount spent on health care, which could lead to better health outcomes.

The impact of environmental pollution on health outcomes is uncontroversial. Almost all studies believe that pollution is a trigger of a large number of diseases and can significantly increase hospitalization and mortality (Usmani *et al*., 2020; Hashim & Boffetta, 2014; Kan *et al*., 2012). Manisalidis *et al*., (2020) documented that about 9 million people die each year from environmental pollution.

The source of health care financing in the SSA region was mainly from private sources and largely out-of-pocket health expenditure (OOPE); A greater proportion of out-of-pocket health expenditure has an impoverishing effect on households (Oyedele, 2023). WHO estimates that up to 10% of the population in the region suffers a financial catastrophe each year due to out-of-pocket health expenditure, with up to 4 % pushed under the poverty line of the region (WHO, 2016; Kiross *et al*., 2020). Few low-income countries (Malawi, Ethiopia, and Gambia) in SSA have allocated more than 15% of their public health spending to health care (WHO, 2016, 2022). Government spending on health is therefore essential for improving access and financial security and is the most important method of pooling resources for health services. However, inadequate levels of government funding create a financial burden on people in the form of out-of-pocket expenses for medical care.

Similarly, according to Byaro (2021), sub-Saharan Africa continues to struggle with the provision of healthcare services. To reduce the disease burden in the region, significant investments are needed in physical healthcare (i.e., diabetes, stroke, heart diseases, malaria, HIV, and Tuberculosis). Although sub-Saharan Africans face many challenges, their lives have improved. For instance, the average life expectancy in sub-Saharan Africa was 51.3 years in 2000 and 60.2 years in 2021 (World Bank Indicators, 2023). Increased life expectancy leads to a rise in population, initially decreasing the ratios of capital to labour and land to labour. Consequently, this diminishes income per capita in the short run. However, over time, this decline is offset by increased productivity resulting from a larger workforce entering the labour force.

The African region has seen an increase in the incidence of non-communicable diseases, in addition to infectious diseases, these have resulted in high rates of mortalities and low life expectancy. Life expectancy is on the rise across the world, but the SSA region records the least (Europe -80.4 years, USA - 76.3 years, Arab - 70.8 years, and SSA- 61.2 years in 2021 (WDI, 2023). Sub-Saharan Africa is argued to be the least-developed region in the world, with its attendant health problems (Dimbuene, 2022). Swiss Economic Institute (2020) also confirms that low-income countries suffer from bad health conditions such as communicable diseases, high mortality rates, and low life expectancy. It is suspected that the poor health status in the region might contribute to the slow pace of economic growth. Good health is an important driver of economic growth. Health is wealth, therefore investment in health is worthwhile in improving health status and productivity in any nation.

Real gross domestic product has been on the increase in most of the SSA countries without substantial growth, low level of prosperity, and poor living standards in an economy. A high

level of illiteracy is also a major characteristic of many countries in SSA which affects health care decisions and income levels. A plethora of literature investigated the relationship between financial development, globalization, economic growth, and life expectancy (Shahbaz *et al*., 2019); Guzel *et al.,* (2021) investigated the impact of economic, social, and political globalization and democracy on life expectancy in low-income countries; Carbon emissions, agricultural output and life expectancy in West Africa (Matthew *et al.,* 2020).

Hence it becomes imperative to investigate the effect of economic welfare (real gross domestic product, carbon dioxide emission, and secondary school enrolment) on life expectancy in sub-Saharan Africa which were not considered by previous studies. The research will also fill a valuable gap by examining the causal relationship between economic welfare and life expectancy between 2000 and 2021. Following the introduction, the rest of the paper is organized as follows: Section 2 presents the literature review; Section 3 presents the theoretical framework and methodology; Section 4 discusses the results of empirical findings and Section 5 comprises the conclusion and recommendations.

2. LITERATURE REVIEW

2.1 Theoretical Literature

Grossman (1972) health demand theory suggests that investing in health is a highly beneficial endeavor. Human capital investment holds significant importance across all economies as it serves as a crucial driver for enhancing productivity, thereby fostering economic growth. Grossman's (1972) health demand theory views health as a valuable long-term asset, with individuals acting as both producers and consumers of health. The model conceptualizes environmental, economic, and social factors as inputs within the production system. An initial stock of health is inherited, and it depreciates over time with age and increases with investment e.g., through investment in education.

Rosenzweig and Schultz's Child Health Production Function (1983) underscored the significance of forecasting the demand for inputs associated with health production, such as parental actions and comprehending the production function that links behavior to health results. Their model incorporated a health production function into a structure that aims to maximize utility and differentiate between various types of goods.

The Cebu Child Health Production Function (1992) developed an estimation of a child health production function building upon the earlier work of Rosenzweig & Schultz (1983), Schultz (1984), and Rosenzweig & Wolpin (1988). This model incorporates the production of child health during pregnancy into the mother's behavior aimed at maximizing utility. The primary focus of the Cebu (1992) model was to analyze the influence of immediate behavioral and biological factors, as well as underlying social factors, on infant growth, morbidity, and mortality.

2.2 Empirical Literature

Life expectancy at birth reflects the overall mortality level of a population and summarizes the mortality pattern that prevails across all age groups—children and adolescents, adults, and the elderly (World Health Organization, 2014, Miladinov, 2020). Woolf *et al*., (2015) examined the relationship between income, wealth, health, and longevity. They found that individuals with higher financial resources are less likely to experience disease and premature death. The significant health disparities observed among many minority groups can largely be attributed to differences in income. The study revealed that adults with family incomes equal to or exceeding 400 percent of the federal poverty level (FPL) are nearly five times more likely to report being in fair or poor health and almost three times more likely to have activity limitations due to chronic illness. The researchers concluded that improving the economic circumstances of Americans across all income levels, including the poor and middle class, could have positive

effects on health outcomes and help mitigate the escalating costs of healthcare. Factors such as employment, education, and other economic aspects substantially impact public health.

A longitudinal study conducted in Canada spanning from 1981 to 2011 by Dutton, Forest, Kneebone, and Zwicker, (2018) examined the impact of provincial spending on social services and healthcare on health outcomes using Ordinary Least Squares (OLS) regression. The study found that an increase in social spending on health was associated with a decrease in potentially avoidable mortality and an increase in life expectancy. The study concluded that reallocating government funds from healthcare spending to social spending could potentially improve population health outcomes. These findings align with previous studies conducted in the United States and Canada.

Furthermore, Neumayer & Plumper (2016) focused on a cross-country study to examine the relationship between income inequality and longevity inequalities. The study utilized a cross-sectional time-series sample spanning 37 years (1974-2011) and included 28 Western developed countries. The findings indicated that income inequality, before taxes and transfers, was positively associated with inequalities in the number of years lived. However, income redistribution, which represents the difference between market income inequality and income inequality after accounting for taxes and transfers, was found to be negatively associated with longevity inequality. In summary, the study revealed that income inequality has a detrimental impact on longevity inequalities, while income redistribution has a mitigating effect on such inequalities.

Using multivariate logistic regression analysis, Zaman *et al*., 2017) determined the association between total health expenditure, life expectancy, and gross domestic product in Bangladesh between 1996 and 2006. The empirical research found that no significant relationship exists between total health expenditure and life expectancy. Results further revealed that a direct or positive relationship exists between GDP and total health expenditure. However, there is no statistically significant relationship between total health expenditure and improved health outcomes (life expectancy). Total health expenditure is also more sensitive to GDP than life expectancy.

Meanwhile, Arthur & Oaikhenan (2017) discovered in their analysis that public health spending has a positive and significant influence on baby and under-five mortality rates but has no effect on life expectancy at birth. Private health spending has a positive and statistically significant effect on life expectancy and a negative but statistically insignificant effect on baby and under-five mortality rates. Health outcomes in SSA are significantly influenced by public and private health spending. At the 5% level of significance, the coefficient is positive for life expectancy at birth (LEB) and negative for IMR and UM5R. The study also reveals that GDP per capita significantly and negatively affects IMR, malaria (MAL) decreases LEB and increases U5MR, and education (EDU) boosts LEB.

In a study focusing on healthcare expenditures and health outcomes in Ghana spanning the years 1995 to 2014, Adua *et al*., (2017) observed significant improvements in baby and under-5 mortalities, which decreased by 50 percent and 25 percent, respectively, by 2014. Additionally, life expectancy showed an increase from 60.7 to 64.8 years. Despite a decrease in private health expenditures, particularly out-of-pocket expenses, they still exceeded the recommended budgetary level set by the World Health Organization. The study also highlighted a growing prevalence of non-communicable diseases (NCDs) and projected that healthcare expenses would escalate, leading to potentially catastrophic financial burdens in the future. It was evident that, despite the government's efforts in the healthcare sector, the improvement in health outcomes could not be primarily ascribed to higher health spending.

In a supporting study on 31 developing countries conducted by Sabir & Aziz (2018), the impact of health and education on income inequality was examined. The study utilized panel data and

the System Generalized Method of Moments (System-GMM) technique. The findings indicated that life expectancy had a negative and statistically significant effect on income inequality. This implies that as life expectancy or overall health improves, income inequality tends to decrease. The results suggested that higher life expectancy contributes to increased productivity and income among the labor force, thereby reducing economic inequality. The study also discovered that secondary education has a detrimental and statistically significant effect on income inequality.

In an empirical study conducted by Immurana (2021), the influence of foreign direct investment (FDI) on health outcomes in Africa was investigated. The study found that school enrollment had a positive and statistically significant effect on life expectancy, indicating that increased education positively influenced life expectancy. Additionally, FDI net inflows were found to significantly increase life expectancy in Africa. The analysis utilized different estimators, including the panel fixed effects, random effects, and pooled OLS estimators. Good health outcomes were associated with a positive effect on life expectancy and a negative effect on the death rate, while bad health outcomes were associated with a negative effect on life expectancy and a positive effect on the death rate.

Also, for the United States, Hendi (2017) focused on life expectancy and lifespan variation by education. The study found that life expectancy increased from 1990 across various education-race-sex groups, except for non-Hispanic white women lacking a high school education. Notably, there was a significant robust increase in life expectancy for white high school graduates and a smaller increase for black female high school graduates. Lifespan variation showed minimal change among high school graduates, and its impact on explaining educational disparities in mortality was found to be limited.

Similarly, Edeme *et al*., (2017) conducted a study examining the impact of public health expenditure on health outcomes in Nigeria, specifically focusing on life expectancy at birth and infant mortality rates. The ordinary least squares technique was employed for analysis. The research concluded that there exists a long-term equilibrium relationship between public health expenditure and health outcomes. Additionally, the study demonstrated that an increase in public health expenditure is associated with improvements in life expectancy and a reduction in infant mortality rates. Consequently, the results indicate the essential role of public health expenditure in enhancing health outcomes in Nigeria.

Bul & Moracha (2020) conducted a panel study on 28 countries in SSA on the effects of economic growth on health outcomes between 1991 and 2015 using two-way fixed effects and pooled OLS. Results revealed that economic growth improved life expectancy and decreased infant mortality rates and fertility rates. The study concluded that economic growth remains a crucial determinant in improving health outcomes in SSA. The region is further characterized by a highly unstable trend of growth and poor health outcomes.

2.3 Gaps in Literature and Value Addition

An obvious gap in the literature has given rise to the investigation of economic welfare and life expectancy in sub-Saharan Africa. A plethora of literature investigated the relationship between financial development, globalization, economic growth, and life expectancy (Shahbaz *et al*., 2019); Guzel *et al*., (2021) investigated the impact of economic, social, and political globalization and democracy on life expectancy in low-income countries; Iyakwari *et al*., (2023); Sango-Coker & Bein (2018), Nkemgha *et al.*, (2021) examined the effect of Health Expenditure on Life Expectancy in Nigeria; West Africa; Cameroon respectively; the dynamics of financial development, globalization, economic growth, and life expectancy in sub-Saharan Africa (Shahbaz *et al.*, 2019) without considering the role of an environmental factor (carbon dioxide emission) as one of the measures of economic welfare. In addition, the causal relationship between economic welfare and life expectancy was also considered.

3. METHODOLOGY

3.1 Theoretical Framework and the Model

The study is anchored on the Grossman (1972) theory of health. The theory is a micro theory but has been expanded and adapted in this panel study. The theory states that demand for health is a function of income and other inputs for health production. The theory also posits that human beings are both producers and consumers of health. Health investment is crucial in increasing health stock which depreciates with time. Therefore, life expectancy is a function of income, economic growth, education, and pollution, and the model with control variables: income inequality, public current health expenditure as a percentage of GDP, and out-of-pocket expenditure. The theoretical framework is in line with human capital theory (Oyedele, 2023).

System Generalized Method of moments was adopted for analysis due to the persistence in the series and cross-sectional data of 44 countries in SSA being greater than the time series of 22-year period between 2000 and 2021. Economic Welfare is decomposed into real gross domestic product (RGDP), carbon dioxide emission (CO2), and Secondary school enrolment (SSER).

We therefore present life expectancy as a function of real gross domestic product for economic growth, carbon dioxide emission (CO2) for pollution, and Secondary school enrolment (SSER) for pollution. Other control variables included are the Gini coefficient, current health expenditure, and out-of-pocket health expenditure.

The model is presented as:

$$LE = f(RGDP, SSER, CO2, GINI, CHE, OOPE) \quad (1)$$

The above functional relationship is expressed in econometric form as given below:

$$le_{i,t} = \delta_0 + \delta_1 le_{i,t-1} + \delta_2 rgdp_{i,t} + \delta_3 sser_{i,t} + \delta_4 co2_{i,t} + \delta_5 gini_{i,t} + \delta_6 che_{i,t} + \delta_7 oope_{i,t} + \varepsilon_{i,t} \quad (2)$$

Where:

le = life expectancy; $le_{i,t-1}$ = one-period lagged value of life expectancy; r$gdpc_{i,t}$ = real gross domestic product; $sser_{i,t}$ = secondary school enrolment rate; $co2_{i,t}$ = pollution; $gini_{i,t}$ GINI coefficient index; $che_{i,t}$ = current health expenditure; $oope_{i,t}$ = out of pocket health expenditure; *i* and *t* denote the respective cross section and time series dimensions of the data set for the analysis;

δ_0 denotes constant or the intercept; $\delta_1 - \delta_7$ depict slopes of the parameter of the model.

We expect positive relationship to exist between life expectancy and RGDP, SSER, and CHE and negative relationship with CO2, GINI, and OOPE. A robustness check was conducted with the use of the Average Mean Group. The Granger causality test was based on examining the causal relationship among the variables.

3.2 Data and Source

Data for this study were sourced for the World Development Indicators (WDI, 2023). Forty-four of the forty-eight countries in sub-Saharan Africa were covered by the study leaving out Eritrea, Somalia, Reunion, Swaziland, and Western Sahara due to internal crises and war. The panel data for this study spanned between 2000 and 2021 and was determined by data availability and consistency.

4. RESULTS AND DISCUSSION OF FINDINGS

Table 1: Descriptive Statistics of Economic Welfare and Life Expectancy

The descriptive statistics for the study is presented in Table 1 including mean, minimum, maximum, standard deviation.

Variables	Mean	Maximum	Minimum	Std. Dev.	Obs
LE	58.82	77.24	41.96	6.83	678
CHE	5.11	20.41	1.26	2.29	678
CO2	8887.68	62719.43	3.83	13793.72	678
SSER	43.02	114.71	6.20	21.76	678
RGDP	28937.55	518476.80	645.25	72895.05	678
OOPE	40.89	84.18	2.99	20.96	678
GINI	44.83	64.90	32.40	6.88	678

Source: Researchers' Computation (2023)

Table 2: Test of Correlation of Residuals

Variables	LE	CHE	LCO2	SSER	LRGDP	OOPE	GINI	VIF
LE	1.000							N/A
CHE	-0.176	1.000						1.21
LCO2	-0.459	-0.048	1.000					3.07
SSER	0.595	0.097	-0.364	1.000				1.82
LRGDP	-0.101	-0.195	0.696	0.063	1.000			2.78
OOPE	-0.164	-0.303	0.017	-0.395	-0.063	1.000		1.68
GINI	-0.227	0.188	0.140	0.155	0.183	-0.512	1.000	1.42

Source: Researchers' Computation (2023)

All the values were calculated from the 678 country-year observations for forty-four sub-Saharan African countries.

Table 2 revealed that the problem of multicollinearity of the independent variable does not exist, and it is further confirmed by the variance inflation factor (VIF). The VIF for each of the explanatory variables is less than 10, the VIFs are 1.21, 3.07, 1.82, 2.78, 1.68, and 1.42 for current health expenditure, carbon dioxide emissions, secondary school enrollment rate, real GDP, out-of-pocket expenditure, and GINI coefficient index respectively. This implies that the explanatory variables included in all the specified and estimated models are not correlated with one another.

4.1 Cross-Sectional Dependence Test Results

Prior to examining the panel data unit root, it is customary to test for cross-sectional dependence amongst the cross-sectional units included in the study. Specifically, three (3) cross-sectional dependence tests were conducted, as shown in Table 3. The null hypothesis of cross-sectional independence is rejected, thus accepting the alternative hypothesis of cross-sectional dependence among the selected sub-Saharan African countries in Africa. This suggests that the macroeconomic challenges encountered in these countries can be traced and linked to their similar economic conditions. Based on this presence of cross-sectional dependence amongst the selected sub-Saharan African countries, it is pertinent to conduct both the first-generation and second-generation panel unit root tests. It should be noted that the second-generation unit roots tests of Cross-Sectional Augmented IPS (CIPS) which account for cross-sectional dependence were conducted and this is reported in Table 3 alongside the Levin, Lin, and Chu (LLC) and the Im, Pesaran, and Shin (IPS) first generation panel unit root tests.

Table 3 Panel Data Cross-Sectional Dependence Test Results

Test	Statistics	Prob
Life Expectancy Equation		
Breusch-Pagan LM	9033.88***	0.000
Pesaran scaled LM	185.94***	0.000
Pesaran CD	63.26***	0.000

Source: Researchers' Computation (2023)
Note: * and ** indicate significance at the 1% and 5% levels, respectively.**

First, two categories of panel data unit root tests are employed: first-generation (panel data unit root test without cross-sectional dependence) and second-generation (with cross-sectional dependence) tests. Table 3 presents the results. From the table, all the series become stationary in their first differences using the first-generation tests (LLC and IPS). The second-generation panel unit root test of (CIPS) which accounts for cross-sectional dependence showed that all the series were stationary after 1st differences. However, because the variables have the same order of integration it is necessary to use the generalized method of moments (GMM) to test the hypotheses of the study.

Another rationale for using the GMM estimation technique was based on the data set where the time series is less than 25 and the cross-sectional units are greater than 25, for this study the time series observation is 22 and the cross-sectional units are 44. However, both sys-GMM and diff-GMM procedures suffered from two sources of persistence. First was the autocorrelation that came from the inclusion of a lagged dependent variable as an independent variable in the model. The second potential source of persistence was the unobserved main and interaction effects among the heterogeneous units in the cross-section (Blundell & Bond, 1998; Arellano & Bond, 1991). OLS estimator cannot solve the potential source of the persistence.

In addition, a sensitivity analysis was also used to ascertain the results of each model using the Augmented Mean Group (AMG) that accounts for autocorrelation, heteroscedasticity, and cross-sectional dependence.

Table 4: 1st and 2nd Generation Panel Data Unit Root Test Results

Variables	LLC	IPS	CIPS	Variables	LLC	IPS	CIPS	Remarks
LE	-1.053	-1.616	-1.356	ΔLE	-9.633***	-4.101***	-3.441***	I(1)
LRGDP	-1.273	-1.184	-1.611	ΔLRGDP	-6.012***	-3.707***	-3.535***	I(1)
SSER	-0.732	-1.216	-1.332	ΔSSER	-5.513***	-4.109***	-4.099***	I(1)
LCO2	-1.813	-1.357	-1.651	ΔLCO2	-14.736***	-6.000***	-5.033***	I(1)
OOPE	-1.283	-1.276	-1.609	ΔOOPE	-11.452***	-4.785***	-4.284***	I(1)
CHE	-0.471	-1.231	-1.853	ΔCHE	-13.766***	-5.074***	-4.836***	I(1)
GINI	-0.890	-1.211	-0.999	ΔGINI	-4.912***	-4.146***	-2.183**	I(1)

Source: Researchers' Computation (2023)
Notes: *** and ** indicate 1% and 5% respectively and the respective critical values are CIPS -2.23 and -2.11, IPS = -2.02 and -1.87 and LLC = -3.10 and 3.10 at 1% and 5% respectively.

4.2 Homogeneity Test Results

Using the Blomquist and Westerlund (2013) homogeneity test results from Table 5, the null hypothesis of slope homogeneous coefficients is strongly rejected, in favour of the alternative hypothesis of heterogenous slope coefficients, thus, there is the presence of heterogeneity amongst the selected sub-Saharan countries in Africa. This is because the homogeneity test statistic is statistically significant at a 1 percent level, this further confirms the choice of the dynamic model.

Table 5 Blomquist and Westerlund (2013) Homogeneity Test Results

Test	Statistics	Prob
Life Expectancy Equation		
Δ	19.099***	0.000
Δ adj	25.265***	0.000

Source: Researchers' Computation (2023)
Note: *** represents a 1% level of significance

4. 3 RESULTS

$$le_{i,t} = 0.3870 + 0.819le_{i,t-1} + 0.0004rgdp_{i,t} + 0.002sser_{i,t} - 0.0026co2_{i,t} - 0.0349gini_{i,t} + 0.003che_{i,t} + 0.0055oope_{i,t} + \varepsilon_{i,t} \quad (4)$$

Table 6: Economic Welfare and Life Expectancy
Dependent Variable: LE

Variables	GMM	AMG
LE (-1)	0.8195***	
	(27.674)	
LRGDP	0.0004	0.0282
	(0.132)	(1.174)
SSER	0.0002**	-0.0001
	(2.543)	(-0.733)
LCO2	-0.0026**	0.0399**
	(-2.228)	(2.019)
OOPE	0.0055**	0.0091
	(2.253)	(0.953)
CHE	0.0003	0.0017*
	(1.428)	(1.721)
GINI	-0.0349**	-0.4188
	(-2.329)	(-1.085)
Constant	0.3870***	1.9912***
	(6.039)	(2.784)
Observations	678	678
Number of group	22	
Wald chi-square	90165.78 (0.000)	
AR1 test	-2.36 (0.018)	
AR2 test	-0.14(0.891)	
Hansen test	3.05 (0.226)	
Sargan test	3.85(0.219)	

Source: Researcher`s Computation (2023)
Notes: * Significant at 10%, ** Significant at 5%, *** Significant at 1%. The *z*-statistics in parentheses. The previous value of Life Expectancy (LE (-1)),

From Table 6, the study examined the effect of economic welfare on the life expectancy of Sub-Saharan African countries, four types of post-estimation tests were considered, and they are as follows; first, the serial correlation of the first autoregressive order, with the null hypothesis that there is no serial correlation. Second, the serial correlation test of the second autoregressive order; with the null of serial correlation. Third, the *Hansen test* of over-identifying restrictions with the null that the model specified has valid instrumentation. Lastly, the *Sargan test* that the specified variables are proper instruments, with the null that the model specified are proper instruments.

From the results in Table 6, there is evidence that the lag of life expectancy has a positive and significant relationship with life expectancy (LE (-1) = 0.8195, Z-test= 27.674, $p < 0.05$). Thus, a 1 percent increase in previous values of life expectancy will lead to a 0.8195 percent increase in life expectancy. This implies that the previous values of life expectancy are a significant factor influencing changes in life expectancy of the selected sub-Saharan African countries.

The results also show that the real GDP has a positive and insignificant relationship with life expectancy (LRGDP = 0.0004, Z-test= 0.132, $p > 0.05$). Thus, a 1 percent increase in real GDP will lead to a 0.0004 percent increase in life expectancy. This implies that the real GDP is not a significant factor influencing changes in life expectancy of the selected sub-Saharan African countries.

Furthermore, there is evidence that the secondary school enrollment rate has a significant positive relationship with life expectancy (SSER = 0.0002, Z-test= 2.543, $p < 0.05$). Thus, a 1 percent increase in secondary school enrollment rate will lead to a 0.0002 percent increase in life expectancy. This implies that the secondary school enrollment rate is a significant factor influencing changes in life expectancy of the selected sub-Saharan African countries.

Carbon dioxide emission has a negative and significant relationship with life expectancy (LCO2 = 0.0026, Z-test = -2.228, $p < 0.05$). Thus, a 1 percent increase in carbon dioxide emission will lead to a 0.0026 percent decrease in life expectancy. This implies that carbon dioxide emission is a significant factor influencing changes in life expectancy of the selected sub-Saharan African countries.

Furthermore, out-of-pocket expenditure has a positive and significant relationship with life expectancy (OOPE = 0.0055, Z-test= 2.253, $p < 0.05$). Thus, a 1 percent increase in out-of-pocket expenditure will lead to a 0.0055 percent increase in life expectancy. This implies that out-of-pocket expenditure is a significant factor influencing changes in life expectancy of the selected sub-Saharan African countries.

Moreover, there is evidence that current health expenditure has a positive relationship with life expectancy. This implies that increases in the current health expenditure will lead to an increase in life expectancy. Thus, a 1 percent increase in current health expenditure will lead to a 0.0003 percent increase in life expectancy. The results revealed that the current health expenditure has no significant relationship with the life expectancy of the selected sub-Saharan African countries (CHE = 0.0003, Z-test= 1.428, $p > 0.05$). This evidence implies that current health expenditure is not a significant factor influencing changes in Life expectancy in the selected sub-Saharan African countries.

Finally, there is evidence that the GINI coefficient index has a negative relationship with life expectancy. This implies that increases in the GINI coefficient index will lead to a decrease in life expectancy. Thus, a 1 percent increase in the GINI coefficient index will lead to a 0.0349 percent decrease in life expectancy. The results revealed that the GINI coefficient index has a significant relationship with the life expectancy of the selected sub-Saharan African countries (GINI = - 0.0349, Z-test= -2.329, $p < 0.05$). That evidence implied that the GINI coefficient index (income inequality) is a significant factor in the changes in Life expectancy of the selected sub-Saharan African countries.

Therefore, the results provided empirical evidence that the lag value of life expectancy, education (SSER), pollution (CO2), income inequality (GINI), and current health expenditure (CHE) components of economic welfare significantly enhanced life expectancy in the SSA region.

4.4 Robustness Checks- Sensitivity Analysis

The average Mean Group was also used for robustness check and sensitivity analysis. The AMG also produces reliable and consistent results when there is cross-sectional dependence. All these results conform with the elasticities of the SGMM results. The model's overall fit is indicated by the Wald test, which tests the null hypothesis that all coefficients in the model are zero. In this case, the Wald test is significant at the 1% level, indicating that the model as a whole is a good fit for the data. Alternatively, the Wald test statistic of 90165.78 with a probability value of 0.000 implies that the previous values of life expectancy, secondary school enrollment rate, carbon dioxide emissions, out-of-pocket expenditure, current health

expenditure, and GINI coefficient index are joint significant factors influencing changes in life expectancy of the selected sub-Saharan African countries.

Therefore, the results provided empirical evidence that the secondary school enrollment rate, carbon dioxide emissions, out-of-pocket expenditure, current health expenditure, and GINI coefficient as components of economic welfare had significant effects on the previous values of life expectancy in the SSA countries.

4.5 Discussions of Findings

The result of Chewe & Hangoma (2020) confirms the findings of our study where the real GDP has a positive and significant relationship with life expectancy. This implies that increases in the real GDP will lead to an increase in life expectancy. Thus, a 1 percent increase in real GDP will lead to a 0.0004 percent increase in life expectancy. Chewe & Hangoma (2020) applied Dynamic Generalized Methods of Moments to determine the drivers of health in 30 sub-Saharan countries between 1995 and 2014. The findings of Nkalu & Edeme (2019) also confirm that increased income extends life expectancy by 1 year and 6 months.

The study confirms that an increase in per capita income, higher number of schooling, and urban location lead to an increase in life expectancy. Zamani *et al*., (2017) determined the association between total health expenditure, life expectancy, and gross domestic product in Bangladesh between 1996 and 2006. Results revealed that a direct or positive relationship exists between GDP and total health expenditure. However, no statistically significant relationship between total health expenditure and life expectancy which aligns with the result of the current study. Total health expenditure is also more sensitive to GDP than life expectancy.

An increase in the secondary school enrollment rate caused an increase in the life expectancy of individuals thereby improving their health outcome for the period. Thus, improvement in education through secondary school enrolment rate improved life span in sub-Saharan Africa. This is confirmed by Ibrahim & Ditep (2022) who found a positive and significant relationship between literacy level and health indicator (life expectancy). The current study found that the secondary school enrollment rate has a positive and significant relationship with life expectancy. This implies that increases in the secondary school enrollment rate will lead to an increase in life expectancy.

The estimation result of the findings of Nkalu & Edeme (2019) also confirms environmental hazards in terms of Carbon dioxide emission reduced life expectancy by 1 year and 3 weeks with a statistically significant result. The result corroborates the findings of this study whereby CO2 has a negative and significant relationship with life expectancy. This implies that increases in carbon dioxide emissions will lead to a decrease in life expectancy. Thus, a 1 percent increase in carbon dioxide emission will lead to a 0.0026 percent decrease in life expectancy. Ibrahim and Ditep (2022) also found that an inverse and significant relationship exists between CO2 and life expectancy.

The study by Owumi & Eboh (2021) found that a $1% increase in out-of-pocket health expenditure would lead to a 63% enhancement in life expectancy. Their findings corroborate the result of our research where out-of-pocket expenditure has a positive and significant relationship with life expectancy. This implies that increases in out-of-pocket expenditure will lead to an increase in life expectancy. Iyakwari et al, 2023 in their study between 1990 and 2021 using ARDL and ECM models also found similar results.

The result of Akintunde & Olaniran (2022) using ARDL on financial development, public health expenditure, and health outcomes in Nigeria found that government health expenditure on health worsens life expectancy in the short run but improves life expectancy in the long run. The findings in the short run contrast with the findings of this current study whereby current

health expenditure has a positive but insignificant relationship with life expectancy. This implies that increases in the current health expenditure will lead to an increase in life expectancy. Thus, a 1 percent increase in current health expenditure will lead to a 0.0003 percent increase in life expectancy. But the findings of Dutton *et al*., (2018) corroborate our current study. Dutton *et al*., (2018) found that an increase in social spending on health was associated with a decrease in potentially avoidable mortality and an increase in life expectancy.

Edeme *et al*., (2017) conducted a study examining the impact of public health expenditure on health outcomes in Nigeria, specifically focusing on life expectancy at birth and infant mortality rates. The ordinary least squares technique was employed for analysis. The research concluded that there exists a long-term equilibrium relationship between public health expenditure and health outcomes. Additionally, the study demonstrated that an increase in public health expenditure is associated with improvements in life expectancy and a reduction in infant mortality rates. Consequently, the results indicate the essential role of public health expenditure in enhancing health outcomes in Nigeria.

In the study of Neumayer & Plumper (2016), income inequality and income inequality after accounting for taxes and transfers, was found to be negatively associated with longevity inequality. The GINI coefficient index has a negative and significant relationship with life expectancy. This implies that increases in the GINI coefficient index will lead to a decrease in life expectancy. Thus, a 1 percent increase in the GINI coefficient index will lead to a 0.0349 percent decrease in life expectancy.

Mensch *et al*., (2019) found a significant impact of maternal education on child mortality. The result supports the Grossman model that documented an inverse relationship between years of schooling and health. It is also in conformity with the previous study by Gakidou, Cowling, Lozano & Murray, (2010) that about half the reduction in child mortality could be attributed to the increase in years of schooling of young women globally.

Table 7: Panel Data Causality Test

Null Hypothesis	W-Stat.	Zbar-Stat.	Prob.
LRGDP ≠ LE	7.28234	12.2451	0.000
LE ≠ LRGDP	4.89978	6.38040	0.000
SSER ≠ LE	4.44188	5.25329	0.000
LE ≠ SSER	4.58488	5.60528	0.000
LCO2 ≠ LE	5.06320	6.78267	0.000
LE ≠ LCO2	7.07426	11.7329	0.000

Source: Researcher`s computation (2023)
Notes: ***, ** and *indicate 1%, 5% and 10% levels of significance respectively.

Table 7 shows that there is evidence of bi-directional causality between life expectancy and real GDP, life expectancy and secondary school enrollment rate, and life expectancy and carbon dioxide emissions. The economic intuition for the causal relationship is that economic welfare tends to stimulate the life expectancy of the selected sub-Saharan African countries. Therefore, the results provided by the empirical evidence that economic welfare stimulates life expectancy.

5. CONCLUSION AND POLICY RECOMMENDATIONS

The study used panel data to examine the effect of economic welfare on life expectancy in sub-Saharan Africa. Decomposing economic welfare into real GDP, carbon dioxide, and secondary school enrolment in 44 selected countries in sub-Saharan Africa. Current health expenditure, the GINI coefficient, and out-of-pocket expenditure were introduced as control variables based

on health theories. The System Generalized Method of Moments model was used on panel data between 2000 and 2021. Data were sourced for the World Bank's World Development Indicators (WDI, 2023). The average mean group was used for a robustness check, and the causal relationship among variables was examined with the use of the Granger casualty test.

Real GDP measured economic growth and was found to increase life expectancy, though insignificantly. The educational level measured by secondary school enrolment significantly increased life expectancy, while pollution proxied by carbon dioxide emissions significantly caused a reduction in life expectancy. The result implies that an increase in economic growth will provide more income to the population of sub-Saharan Africa and will aid in an improved life span; therefore, substantive economic growth in this region is very vital. An improved educational level impacts life expectancy positively because it makes people better informed and makes adequate health decisions. Pollution has significant and negative effects on life expectancy, and efforts should be made to reduce it. Out-of-pocket expenditure had significant positive effect on life expectancy while that of GINI coefficient which measure income inequality is negative and significant.

A bi-directional relationship was found to exist between economic welfare and life expectancy, which indicates that improved economic growth, pollution reduction, and higher educational attainment could increase life span and vice versa. The findings of this study contribute to healthcare system improvement and socio-economic developmental plans to address low life expectancy in SSA. From the empirical findings, the study concludes that economic welfare has significant effects on life expectancy.

Based on the findings of this study, the following are therefore recommended: Governments and other policymakers in SSA should implement policies to: promote education and skill development to enhance employability; implement and strengthen healthcare systems to ensure universal access to quality healthcare services; provide financial support or insurance mechanisms to reduce the economic burden of healthcare on individuals; implement policies that promote sustainable economic growth; address poverty and income inequality to raise and redistributes income levels, as these factors are closely linked to health disparities, social safety nets and focus on job creation programs, and fair wage policies can contribute to poverty reduction; promote healthy work environment, social infrastructural development, and promote environmentally sustainable economic practices to safeguard public health to improve the standard of living and contribute to long-term economic growth.

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