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Relationship between Health and Economic Growth in Sub-Saharan African Countries: Examining the Moderating Effect of Institutional Quality

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ABSTRACT

This study investigates health-growth relationship with the moderating effect of institutional quality (control of corruption) in Sub-Saharan African countries from 2000 to 2022. Utilizing Driscoll-Kraay fixed effect regression with standard errors, the analysis addresses autocorrelation, heteroskedasticity and cross-sectional dependence. Empirical results highlight that while school enrolment and life expectancy positively impact GDP per capita, control of corruption does not have a significant direct effect. Gross fixed capital formation shows a minor negative effect, and labour force participation has a small yet significant negative impact. The interaction between health improvements and institutional quality reveals that higher life expectancy significantly boosts economic growth, especially when corruption is reduced. The study underscores the crucial role of control of corruption on health improvements and economic growth. Strong institutions are important in converting health improvements into sustainable economic benefits, indicating that improving institutional quality can amplify the positive impacts of health on economic growth. The findings emphasize the importance of addressing institutional weaknesses to fully realize the benefits of health investments in the region. These insights are crucial for policymakers aiming to foster economic growth through investments in health human capital and institutional reforms in Sub-Saharan Africa.

1. Introduction

Health constitutes a foundational component of human capital and a critical determinant of economic performance. Beyond its intrinsic value to individual well-being, health directly shapes labor productivity, cognitive capacity, and the ability of individuals to participate effectively in economic activity. Consequently, health occupies a central position in development economics and cannot be overlooked in any rigorous assessment of economic growth. Contemporary development frameworks increasingly recognize health not only as a social outcome but also as a productive asset that underpins sustained economic expansion, social cohesion, and macroeconomic stability (Bloom, 2004; United Nations Development Programme (UNDP, 2022). The World Health Organization (WHO, 2023) further emphasizes that improvements in population health enhance quality of life, strengthen societal resilience, and contribute to broader economic and human security outcomes. The centrality of health is also embedded in the human development paradigm, which identifies longevity, knowledge acquisition, and material well-being as the core dimensions of development. These dimensions are operationalized through indicators of health, education, and income, respectively (UNDP, 2022). While early growth models primarily emphasized physical capital accumulation as the engine of economic growth, subsequent theoretical and empirical advances beginning in the 1960s have highlighted the decisive role of human capital in shaping long-run growth trajectories. Within this framework, health enhances economic performance by increasing labor efficiency, reducing morbidity and mortality, encouraging human capital

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investment, and extending the productive lifespan of the workforce.

Despite notable improvements in global health outcomes over recent decades, poor health remains a binding constraint on economic growth in many developing regions, particularly in Sub-Saharan Africa (SSA). Although life expectancy has increased modestly, large segments of the population continue to experience preventable illness, limited access to quality healthcare, and exposure to recurrent epidemiological shocks. Howitt (2005) notes that inadequate sanitation, unsafe water, and limited healthcare infrastructure persist across many low- and middle-income countries, undermining productivity and human capital accumulation. The economic consequences of communicable diseases including HIV/AIDS, malaria, tuberculosis, Ebola, and, more recently, COVID-19 have been especially pronounced in Africa, imposing substantial welfare losses and constraining long-term growth (The Economist Intelligence Unit, 2011). Health shocks affect economic performance through multiple channels. At the microeconomic level, illness reduces labor supply, increases absenteeism, and lowers cognitive and physical productivity. At the macroeconomic level, poor health distorts savings and investment behavior, as scarce resources are redirected from productive investment toward healthcare expenditures. This diversion weakens capital accumulation and may entrench economies in low-growth equilibria. A growing empirical literature confirms that improvements in population health exert a positive effect on GDP per capita through productivity gains and enhanced labor participation, while persistent poor health is associated with lower savings, reduced investment, and slower growth. As a result, recent growth models increasingly conceptualize health as a core dimension of human capital and a necessary condition for sustained economic development.

Sub-Saharan Africa presents a particularly salient context for examining the health–growth relationship. The region continues to bear a disproportionate global disease burden despite gradual progress in selected health indicators. According to the World Development Indicators (2023), life expectancy at birth in SSA remains well below the global average of 71 years. In 2022, average life expectancy in the region stood at approximately 60.76 years (Statista, 2024). Communicable diseases remain widespread, while the rising prevalence of non-communicable diseases such as cardiovascular conditions has further strained already fragile health systems. These health challenges impose significant economic costs by reducing workforce productivity and increasing public and private health expenditures. SSA is also the epicenter of the global HIV/AIDS epidemic, accounting for approximately 67 percent of the world's HIV-positive population, with an estimated 25.6 million individuals living with the virus (UNAIDS, 2023). The distribution of the epidemic is highly uneven across countries, with South Africa recording the largest number of cases, followed by Nigeria, Kenya, Uganda, and Zimbabwe. The persistence of HIV/AIDS continues to weaken labor markets, erode household welfare, and place sustained pressure on public finances. Moreover, the region's vulnerability to infectious disease outbreaks is exacerbated during periods of economic stress, amplifying macroeconomic instability and undermining development gains.

Human capital theory provides a compelling framework for understanding the growth implications of health. Human capital encompasses the skills, knowledge, competencies, and health status of the workforce, all of which shape productive capacity and income generation (Ejere, 2011). While education and health are often treated as instrumental inputs to growth, they also represent intrinsic development outcomes that enhance individual welfare and societal well-being (Todaro & Smith, 2012). Within this framework, health is increasingly viewed as a form of capital investment that yields economic returns through higher productivity, longer working lives, and reduced mortality (World Health Organization, 2001). In recognition of this, many Sub-Saharan African countries have substantially increased public health expenditure over the past decades. These efforts reflect the growing consensus that improved health is essential for economic transformation. However, despite rising health expenditures, improvements in health outcomes particularly in life expectancy and service quality have been modest. As of 2023, life expectancy in SSA remains close to 60 years (World Development Indicators, 2023). This disconnect between increased spending and limited outcomes raises critical questions about the efficiency of health investment and the broader institutional environments within which health systems operate.

Institutional quality has emerged as a central determinant of cross-country differences in economic performance. Economies characterized by effective governance, strong rule of law, low corruption, and regulatory competence consistently outperform those with weak institutional frameworks (Iqbal & Daly, 2014). In the context of health and

growth, institutional quality influences the efficiency with which health resources are allocated, the effectiveness of service delivery, and the accountability of public officials. Weak institutions marked by corruption, bureaucratic inefficiency, regulatory capture, and weak enforcement can severely undermine the growth-enhancing potential of health investment. Weil (2014) argues that the relationship between health and economic growth is conditional on institutional quality and broader human capital conditions. This perspective offers a plausible explanation for why increased health expenditure has not translated into sustained growth in many SSA countries. Where institutional capacity is weak, the marginal returns to health investment may be low or even negative, resulting in persistent poor outcomes despite rising spending. This suggests the existence of institutional thresholds beyond which health improvements can meaningfully contribute to economic growth.

This argument aligns with a growing body of literature that attributes persistent development gaps between advanced and developing economies to differences in human capital accumulation and institutional effectiveness (Acemoglu et al., 2014; Hanushek et al., 2008; Ali & Son, 2007). Human capital theory posits that investments in education and health enhance productivity, stimulate innovation, and promote inclusive growth (Mankiw et al., 1992; Romer, 1990; Hanushek, 2016). In low-income and marginalized regions such as SSA, human capital development can drive growth through multiple mechanisms: by accelerating productivity for a given level of technology, fostering technological adoption and innovation, and strengthening resilience to socioeconomic shocks (Lucas, 1988; Castello-Climent & Domenech, 2008; UNDP, 2017). Against this backdrop, this study examines the impact of health on economic growth in Sub-Saharan Africa, with particular emphasis on the moderating role of institutional quality. By explicitly modeling the interaction between health outcomes and institutional factors, the study contributes to the literature by offering a more nuanced explanation for the heterogeneous growth effects of health investment across countries. In doing so, it advances understanding of the conditions under which health improvements translate into sustained economic growth in developing regions.

The remainder of the paper is structured as follows: Section 2 reviews the relevant theoretical and empirical literature. Section 3 describes the data and methodology. Section 4 presents results and discusses the empirical findings, while Section 5 concludes with policy implications and directions for future research.

2. Literature Review

This section provides a comprehensive review of existing literature relevant to the study, organized into two main components: theoretical and empirical literature. The theoretical literature review examines the foundational theories underpinning the relationship between health outcomes, institutional quality, and economic growth, including key assumptions, conceptual linkages, and theoretical gaps. The empirical literature review, on the other hand, synthesizes prior empirical findings, highlighting methodological approaches, key results, and areas of consensus and divergence in the literature. Specifically, the empirical review covers studies on the relationship between health and economic growth, the role of health expenditure in economic performance, and the influence of institutional quality on growth outcomes. Together, these components provide a structured understanding of the subject, identify existing research gaps, and establish the basis for the present study's contribution.

2.1 Theoretical Literature Review

The concept of human capital gained prominence with the seminal contributions of Romer (1986) and Lucas (1988), who established the theoretical foundations of endogenous growth by emphasizing the role of health and education in driving long-run economic performance. Within this framework, health and education are treated as productive assets that augment labor efficiency and enter the production function as distinct but complementary inputs. In the Lucas (1988) model, the accumulation of human capital is the central mechanism through which productivity growth is sustained, implying that differences in investment in human capital can generate persistent cross-country income disparities. Subsequent developments in endogenous growth theory, particularly Romer (1990), extended this reasoning by arguing that economic growth is not driven solely by exogenous technological progress, but also by purposeful investment in knowledge, research, and human capabilities. Human capital embodying scientific knowledge, skills, and health facilitates the creation and diffusion of new ideas, thereby enhancing innovation and total factor productivity. In this context, health plays a dual role: it directly raises worker productivity by improving physical

and cognitive capacity, and indirectly supports innovation by enabling individuals to engage more effectively in learning, research, and adaptation to technological change.

The augmented Solow model proposed by Mankiw, Romer, and Weil (1992), building on Solow (1956), formally incorporated human capital into the neoclassical growth framework. Using school enrolment as a proxy for human capital, the MRW model demonstrated that differences in human capital accumulation significantly explain cross-country variation in income per capita. This finding challenged the view that the neoclassical model lacked empirical relevance and showed that, when human capital investment is considered, the model performs remarkably well in explaining observed growth patterns. However, the reliance on education-based proxies raised concerns about measurement accuracy, particularly with respect to health as a complementary dimension of human capital. Mankiw (1997) further noted that improvements in health can translate into higher wages, although wages may not fully capture the social productivity gains associated with better health. Labor market outcomes often reflect private returns such as social status linked to education or physical attributes while ignoring positive externalities arising from healthier populations. Empirical evidence demonstrating that health improvements raise aggregate output therefore strengthens the argument that health is a productive form of capital, warranting sustained public and private investment.

Earlier human capital theorists, including Schultz (1960, 1961, 1971) and Becker (1975), emphasized education and health as investments that enhance individual productivity and economic efficiency. Romer (1986) reinforced this perspective by highlighting how human capital accumulation fosters technological progress and knowledge spillovers. Barro and Sala-i-Martin (1995) further extended endogenous growth models by incorporating labor supply decisions, open-economy considerations, migration, fertility, and technology diffusion, thereby broadening the channels through which human capital influences growth. Nelson and Phelps (1966) provided an important theoretical link between education and technological diffusion, arguing that more educated individuals are better equipped to adopt and implement new technologies. By extension, healthier individuals are likely to be more adaptable, resilient, and receptive to innovation. Health and education therefore reinforce one another in shaping the capacity of economies to absorb technological change and sustain productivity growth. Dinopoulos and Thompson (1999), however, questioned the robustness of the MRW model, showing that its estimated factor shares were sensitive to the choice of human capital proxies, thereby underscoring the need for more accurate measures particularly for health capital.

Health human capital occupies a central position in the growth process, as productivity depends not only on physical capital, raw labor, and education, but also on the health status of workers, which affects energy levels, effort, reliability, and longevity. Economic development, in turn, promotes further accumulation of health capital through improved living standards, nutrition, and access to healthcare, suggesting a bidirectional relationship between health and growth (Barro, 2013). Stark global disparities in life expectancy illustrate the development relevance of health: while life expectancy at birth exceeds 80 years in advanced economies such as Japan, it remains below 55 years in several Sub-Saharan African countries, including Nigeria, with a substantial proportion of life spent in poor health (World Development Indicators, 2015). These disparities highlight the critical role of health human capital in shaping long-term economic outcomes.

2.2 Empirical Literature

2.2.1 Health and Economic Growth

A large body of empirical literature confirms that health, as a core component of human capital, significantly influences labor productivity, labor supply, and innovative capacity, thereby affecting economic growth. Early empirical extensions of the MRW framework incorporated health indicators into growth regressions, reflecting the transition from purely exogenous to endogenous growth models that explicitly recognize human capital dynamics. Studies by Knowles and Owen (1995), Mayer (2001), Webber (2002), Narayan et al. (2010), Peykarjou et al. (2011), and Chen et al. (2015) consistently report a strong and robust association between health proxies and economic growth. Bernanke and Gürkaynak (2002) and Weil (2001, 2003) examined the hypothesis that long-run growth is driven primarily by exogenous technological change, while capital accumulation affects income levels rather than growth rates. Their findings nonetheless indicate that physical capital investment, human capital development, and population growth are closely associated with output per worker, suggesting that health and education remain central to explaining cross-

country income differences. Bhargava et al. (2001), using adult survival rates (ASR) to address endogeneity and reverse causality, found that health improvements significantly raise GDP growth in low-income countries, although the effects were weaker or insignificant in higher-income contexts.

Subsequent studies adopting the Knowles and Owen (1995) augmented framework such as Acaroglu and Ada (2014), Pocas (2014), and Daniel et al. (2016) report mixed results. While public spending on education and health does not always exhibit a statistically significant direct effect on growth, improvements in health outcomes consistently demonstrate positive growth effects. This suggests that the effectiveness of health investment depends not only on spending levels, but also on institutional efficiency and policy implementation. Despite extensive empirical evidence on the health–growth nexus, many studies overlook the role of institutions in conditioning this relationship. Research by Gebrehiwot (2015), Pelinescu (2015), Mackenbach and McKee (2015), Hakooma and Seshamani (2017), Bloom et al. (2019), and Hadipour et al. (2023) largely focuses on the direct impact of health on growth, with limited attention to institutional quality as a moderating factor. This omission is particularly consequential in Sub-Saharan Africa, where weak institutions may constrain the productivity gains from health improvements.

Several studies highlight the broader importance of institutions for economic performance. Acemoglu et al. (2005), Novignon et al. (2015), Boachie and Ramu (2016), Rauf et al. (2018), and Opeloyeru et al. (2023) show that institutional factors influence labor participation, public spending efficiency, and growth outcomes. However, these studies often stop short of explicitly modelling institutional quality as an interaction term in the health–growth relationship. More recent work emphasizes governance as a critical enabler of human capital effectiveness in Africa, yet the precise mechanisms through which institutions mediate health-led growth remain underexplored (Musa et al., 2023). Emerging evidence links governance quality particularly control of corruption to improved health outcomes. Rahman et al. (2022) show that good governance and economic growth enhance life expectancy in ANZUS-BENELUX countries, while Socoliuc et al. (2022) find that stronger institutions in the European Union are associated with lower child mortality and longer life expectancy. Koller et al. (2020) demonstrate that anti-corruption measures improve access to healthcare resources, supporting progress toward Universal Health Coverage (UHC). Similarly, Achim et al. (2020) and Vian (2020) document the detrimental effects of corruption on health systems and development outcomes. These findings underscore the relevance of institutional quality in translating health investments into economic growth. Mackenbach and McKee (2015) further identify a strong positive association between democratic quality, government effectiveness, and successful health policy outcomes. Makuta and Bernadette (2015) show that public health spending is more effective in Sub-Saharan Africa when governance quality is high. Building on this literature, the present study focuses on control of corruption as a key institutional quality indicator and examines its moderating role in the relationship between health and economic growth in selected Sub-Saharan African countries.

2.2.2 Health Expenditure and Economic Growth

A growing strand of the literature conceptualizes health expenditure as an investment in human capital rather than a consumption cost. Empirical studies by Oloo et al. (2013), Hakooma and Seshamani (2017), Maduka et al. (2016), Wang and Lee (2018), and Bloom et al. (2019) report a positive association between health expenditure and economic growth. Targeted health interventions such as vaccination programs, micronutrient supplementation, and disease prevention initiatives are shown to yield substantial productivity and growth dividends. Nonetheless, empirical findings are not uniformly positive. Eggoh et al. (2015) and Adeyemi and Ogunsola (2019) report negative or insignificant relationships between public health expenditure and growth, while Udeorah et al. (2018) find no statistically significant effect. These mixed results suggest that the growth impact of health spending depends critically on institutional quality, efficiency of resource allocation, and the broader macroeconomic environment.

2.2.3 Institutional Quality and Economic Growth

Theoretical and empirical literature overwhelmingly supports the view that institutions are fundamental to economic growth, although their effectiveness depends on quality rather than mere existence. Alonso and Garcimartín (2013) argue that institutions fail when they cannot credibly shape agents' behavior, implying that weak or poorly enforced rules undermine economic performance. Pande and Udry (2005) provide influential evidence that strong institutions characterized by effective law enforcement, secure property rights, efficient bureaucracies, and well-functioning financial markets are associated with faster long-term growth. Iqbal and Daly (2014) contend that weak institutions

divert scarce resources toward rent-seeking and unproductive activities, while high-quality institutions constrain such behavior and enhance the productivity of growth-enhancing factors. Empirical evidence from West Africa by Chimere et al. (2017) shows that institutional quality indicators exert a positive and significant effect on economic performance, with government effectiveness playing a particularly important role.

Country-specific studies reinforce these findings. Yusuf and Malarvizhi (2014), using an ARDL framework for Nigeria, show that sustained improvements in institutional quality raise growth and per capita income. Udah and Ayara (2014) find that government effectiveness and voice and accountability significantly enhance economic performance, while Sule (2020) demonstrates that economic growth in Nigeria responds positively to institutional quality, proxied by contract-intensive money. Despite this extensive literature, a critical gap remains in understanding how institutional quality interacts with health human capital to influence growth in Sub-Saharan Africa. Most existing studies focus either on health expenditure or institutional quality in isolation, without modeling their interactive effects. By integrating health indicators with institutional quality specifically control of corruption this study addresses this gap and provides policy-relevant insights into how strengthening institutions can amplify the growth returns to health investments in Sub-Saharan Africa.

3. Methodology of the Study

3.1 Theoretical Framework

This section focusses on the theories used in this study. The theories are from growth theory to analyze the impact of health-related human capital on economic growth. Numerous scholars have developed frameworks that consider human capital as one of the determinants of growth, such as Mankiw et al. (1992), who extended Solow's (1956) neoclassical growth model to include a proxy for human capital. By augmenting Solow's model to include health capital, which is a component of human capital, we arrive at an extended Cobb-Douglas production function:

$$Y_{it} = K_{it}^{\alpha} E_{it}^{\beta} X_{it}^{\psi} (A_{it} L_{it})^{1-\alpha-\beta-\psi} \tag{1}$$

Converting the equation into log-linear form:

$$lnY_{it} = \alpha lnK_{it} + \beta lnE_{it} + \psi X_{it} + (1-\alpha-\beta-\psi) ln(A_{it} L_{it}) \tag{2}$$

Where, Y represents the output level, K denotes the level of physical capital, E indicates the stock of educational human capital, X refers to the stock of health capital, and L signifies the labor input, while A represents the technological level of a country. The subscript i refers to the country, and t refers to the time period. Below is the extended version of MRW's equation:

$$ln\left(\frac{Y_{it}}{L_{it}}\right) = lnA_0 + g_t - \frac{\alpha+\beta}{1-\alpha-\beta} ln(n_i + g + \delta)_t + \frac{\alpha}{1-\alpha-\beta} ln(s_{ki}) + \frac{\beta}{1-\alpha-\beta} ln(s_{ei}) \frac{\psi}{1-\alpha} ln(x_i^*) \tag{3}$$

As ln A_0 is unobservable, it will be incorporated into the error term (Mankiw, Romer, and Weil, 1992). Similarly, g_t is also unobservable, and its parameter cannot be empirically separated from the constant term. Therefore, the regression model for equation (3) is constructed using the available data, incorporating steady-state values of physical and human capital as measured by education and health, along with the moderating effect of institutional quality.

3.1.1 Model specification

This study is grounded in the Augmented Solow (1956) model and the Mankiw-Romer-Weil (MRW) model introduced by Mankiw et al. (1992). These models posit that shared prosperity is a multidimensional concept that requires investments in human capital, and more importantly, institutions that facilitate the efficient allocation of resources (Acemoglu & Autor, 2012; Canlas, 2016). According to these theories, the critical drivers of shared growth include human capital accumulation, physical capital, technological progress, and institutions. Focusing on these perspectives of shared growth, our study aligns with the empirical contributions of Ofori and Grechyna (2021), in which we model

economic growth as:

$$lnY_{it} = \alpha_0 + \beta_1 lnSES_{it} + \beta_2 CORR_{it} + \beta_3 GFCF_{it} + \beta_4 LE_{it} + \beta_5 LFT \ + \varepsilon_{it} \quad (4)$$

Where Y or GDP represents economic growth, i refers to countries, and t denotes years; SES stands for secondary school enrollment, GFCF represents gross fixed capital formation, LE indicates life expectancy, LFT refers to the total labor force, and CORR is the control of corruption index, which measures institutional quality and serves as the interaction term for human capital and governance. Finally, ε represents the error term.

Incorporating the interaction term, we have model (5):

$$lnY_{it} = \alpha_0 + \beta_1 lnSES_{it} + \beta_2 CORR_{it} + \beta_3 GFCF_{it} + \beta_4 LE_{it} + \beta_4 LFT_{it} + \beta_5 (LE \ \times \beta_2 CORR_{it}) + \varepsilon_{it} \quad (5)$$

Table: 3.1: Variable measurements

Variable	Measurement	Data source
Y (Output)	GDP per capita (Constant 2015 US $)	World Bank
SES	School enrollment, secondary gender parity index (GPI)	World Bank
CORR	Control of corruption (Institutional quality)	World Bank
GFCF	Share of physical capital measured by Gross Fixed Capital formation (% of GDP)	World Bank
LE	Life expectancy at birth, total (years)	World Bank
LFT	Labor force, Total	World Bank

Source(s): Authors' formulation base on theoretical and empirical literature.

3.2 Estimation Techniques

In this study, we are particularly focused on examining the mediating role of institutional quality in the relationship between health and economic growth in Sub-Saharan Africa. The first issue to address is the spatial dependence or cross-sectional dependence among countries that share similar characteristics or coalitions. Using conventional ordinary panel OLS for estimation in this context could result in inconsistent standard error estimates (Driscoll & Kraay, 1998). To address this, Driscoll and Kraay (1998) developed a nonparametric covariance estimation method that provides robust standard errors. This method is particularly useful when the model is susceptible to heteroscedasticity and autocorrelation problems (Hoechle, 2007). Therefore, we adopt this method in conjunction with the fixed effects estimation approach. The model allows the disturbance term ε_{it} to be cross-sectionally dependent, autocorrelated, and heteroscedastic. Assuming that Θ can be reliably estimated using OLS, the outcome will be: $\hat{S}_T = \widehat{\Omega}_0 + \sum_{j=1}^{m(T)} w(j,m)[\widehat{\Omega}_j + \widehat{\Omega}_j']$ Where, ŜT is defined as per Newey and West (1987). In the equation above, m(T) denotes the lag length at which the residuals may exhibit autocorrelation. The modified Bartlett weights W (j, m(T)) = 1 - j/(m(T) + 1) ensure a smooth sample autocovariance function and the positive semi-definiteness of ŜT, allowing for higher-order lags receive fewer weights. The (K + 1) * (K + 1) matrix $\widehat{\Omega}_j$ is $\widehat{\Omega}_j = \sum_{t=j+1}^{T} h_t(\hat{\theta}) h_{t-j}(\hat{\theta}) \ with \ h_t(\hat{\theta}) = \sum_{i=1}^{N(t)} h_{it}(\hat{\theta})$ Where $h_{it}(\hat{\Theta})$ represent the sum of specific moment conditions at time t, ranging from 1 to N(t), where N can vary with t.

3.3 Data Sources

To address the study's core objective, an unbalanced panel dataset spanning 2000–2022 is employed to estimate the relationship between health human capital and economic growth, with institutional quality explicitly modeled as a moderating factor. The sample period is chosen to capture major health-sector reforms, governance transitions, and macroeconomic shocks affecting Sub-Saharan African economies during the post–Millennium Development Goals and Sustainable Development Goals eras. Consistent with the human capital literature, health indicators are classified into health inputs and health outputs. Health inputs typically reflect policy effort and system capacity such as public health expenditure, access to healthcare services, and infrastructure quality while health outputs capture realized population health outcomes. Given cross-country comparability and data availability, this study focuses on health

output indicators as proxies for health human capital. Specifically, life expectancy at birth and the total fertility rate (births per woman) are employed to reflect population health status and demographic pressures on economic performance.

Educational human capital is proxied by secondary school enrolment, capturing the accumulation of skills and knowledge relevant for productivity enhancement and technological absorption. Economic growth, the dependent variable, is measured using GDP per capita (constant 2015 US dollars), which reflects changes in average income and living standards over time. In line with augmented growth models, physical capital accumulation is controlled for using gross fixed capital formation (percentage of GDP), while labor input is captured by the total labor force. All data are sourced from the World Development Indicators (WDI) of the World Bank, ensuring methodological consistency, international comparability, and reliability. The WDI database is widely used in empirical growth and development research and provides harmonized macroeconomic, demographic, and institutional indicators suitable for panel-data analysis. This data structure allows for the examination of both within-country dynamics and cross-country heterogeneity in the health–growth–institutions nexus.

4. Results and Discussion

4.1 Descriptive Statistics

This sub-section provides a descriptive analysis highlighting the key features of the data utilized in the study. The summary statistics include the mean, minimum, maximum, and standard deviation. Table 4.1 presents the summary statistics for all variables used in the study across the selected Sub-Saharan African countries from 2000 to 2022.

Table 4.1: Descriptive Statistics

Variable	Mean	Minimum	Maximum	Std. Dev.
GDPper_con	2506.708	390.424	11318.6	2587.434
SES	46.4742	6.17638	115.370	26.17638
C_COR	-0.3687	-0.61887	-0.11424	0.238728
GFCF_GDP	22.0093	12.6161	47.5589	6.227353
LE	60.2897	47.928	74.5146	6.324023
LFT	1.099	519867	7.5777	1.633333

Note: GDP denotes gross domestic product per capita, SES denotes school enrollment, secondary (gross) gender parity index (GPI), C_CORR denotes control of corruption, GFCF_GDP denotes Gross Fixed Capital formation (% of GDP), LE denotes Life expectancy at birth, total (years), LFT denotes Labor force, Total. Source: Authors' computation (2024)

The descriptive statistics provide an overview of the economic and social conditions represented by the sample. Each variable has 242 observations, indicating that the sample size is consistent across all variables. The average GDP per capita is 2506.71. This is the central value around which the GDP per capita values are distributed. The negative mean for Control of corruption suggests a tendency towards higher perceived corruption. The data shows considerable variability in GDP per capita, life expectancy, and labor force total, suggesting significant differences across the countries selected. These descriptive statistics will serve as a foundation for further analysis, potentially leading to insights into the relationships between these variables.

4.2 Unit Root Test for Stationarity

The stationarity properties are examined within the Breitung and using the dynamic linear heterogeneous model simple form. The result of the framework of which is given in Table 4.2. This test was undertaken to check the other of integration of the variables.

Table 4.2: Breitung Panel Unit Root Test

	Level	First Difference	Order of Integration
Variable	**Zt-bar**	**Zt-bar**	**0 or I**

GDPper_ann	-4.1454	0.0000***	-5.1890	0.0000***	1(1)
SES	1.5358	0.9377	-5.2195	0.0000***	1(0)
C_COR	0.2189	0.5866	-3.6714	0.0001***	1(0)
GFCF_GDP	-0.2797	0.3898	-3.7893	0.0001***	1(0)
LE	2.1725	0.9851	-2.4621	0.0069**	1(0)
LFT	10.2908	1.0000	-3.7746	0.0001***	1(0)

Note: *, **, * denotes the level of significance at 1%, 5% & 10% respectively.** ***Source*: *Authors' computation (2024)***

The variables mentioned above have been found to be stationary. A stationary process is characterized by constant mean, variance, and autocorrelation structure over time. (Woodridge, 2002) Both the original series (GDPper_ann) and its first difference (D. GDPper_ann) are stationary, as indicated by the rejection of the null hypothesis in both tests. This suggests that the data does not contain unit roots and is suitable for further panel data analysis that assumes stationarity. SES, C_COR, GFCF_GDP, LE and LFT are stationary at the first difference, as indicated by the significant test results. This suggests that the variables at their level contain a unit root (are non-stationary) but become stationary when first differenced.

4.3 Correlation Analysis

Correlation analysis is used to assess the strength and direction of the relationships between the independent variables. The results of the correlation among the variables are shown in Table 4.3.

Table 4.3: Correlation analysis

	SES	**C_COR**	**GFCF_GDP**	**LE**	**LFT**	LE*C_COR
SES	1.0000					
C_COR	0.4617	1.0000				
GFCF_GDP	0.2442	0.0013	1.0000			
LE	0.4537	0.5067	0.2638	1.0000		
LFT	0.0825	-0.4453	-0.1927	-0.470	1.0000	
LE*C_COR	-0.123	0.2680	0.1655	-0.069	-0.076	1.0000

Note: GDP denotes gross domestic product per capita, SES denotes school enrollment, secondary (gross) gender parity index (GPI), C_CORR denotes control of corruption, GFCF_GDP denotes Gross Fixed Capital formation (% of GDP), LE denotes Life expectancy at birth, total (years), LFT denotes Labor force, Total.

An examination of the pair-wise correlation coefficient matrix in Table 4.3 shows that there is a positive and highest correlation between C_COR and LE (0.5067), suggesting a moderate to strong positive relationship. LFT seems to have a generally negative relationship with most of the other variables. The variables SES, C_COR, and LE are somewhat correlated with each other, indicating they may be related in the context being studied.

Table 4.4: Westerlund ECM panel cointegration test

Statistics	**Value**	**z-value**	**p-values**

Gt	-4.717	-7.206	0.000
Ga	-5.269	3.905	1.000
Pt	12.200	-4.005	0.000
Pa	-5.970	2.128	0.983

Note: *, **, * denotes the level of significance at 1%, 5% & 10% respectively. *Source*: *Authors' computation (2024)***

The p-values for the Ga (1.000) and Pa (0.983) tests are quite high, indicating that these tests do not reject the null hypothesis of no cointegration. This suggests that, based on these tests, there is no evidence of cointegration. In contrast, the Gt and Pt tests indicate the presence of cointegration, rejecting the null hypothesis of no cointegration. Meanwhile, the Ga and Pa tests fail to provide evidence of cointegration, as they do not reject the null hypothesis. In practice, you might consider the Gt and Pt results as more indicative of the presence of cointegration, especially since their p-values are strongly significant. However, the mixed results suggest that further analysis or robustness checks could be necessary to confirm the findings.

4.5 Regression with Driscoll-Kraay standard errors

Table 4.4 provide the outcome from a regression analysis using a fixed effect regression method with Driscoll-Kraay standard errors. This technique is often used in panel data to correct for heteroskedasticity, autocorrelation, and cross-sectional dependence.

Table 4.5: Direct relationship Driscoll and Kraay's estimation results

Variable DV = logGDP_n	**Coefficient**	**Drisc/Kraay Std. Err.**	**t-Statistics**	**Prob-Value**
SES	0.0026168	0.0013546	1.93	0.082
C_COR	0.1562324	0.0482526	3.24	0.009
GFCF_GDP	-0.0009513	0.0008139	-1.17	0.270
LE	0.0230284	0.0030613	7.52	0.000
LFT	6.2222209	3.2555509	1.91	0.085
_cons	5.7942	0.1397936	41.45	0.000
R-squared	0.6081			

_GDP denotes Gross Fixed Capital formation, LE denotes Life expectancy at birth, total, LFT denotes Labor force, Total. *, **, * denotes the level of significance at 1%, 5% & 10% respectively.**

Table 4.5 presents the results of the Driscoll and Kraay estimation examining the direct relationship between the dependent variable, logGDPper_con, and the independent variables. With 188 observations, the F-statistic is 139.97, testing the overall significance of the model. A p-value of Prob > F = 0.0000 indicates the model is highly significant. The R-squared value is 0.6081, meaning the model explains approximately 60.81% of the variation in the dependent variable. The coefficient for SES is 0.0026168, which indicates that a one-unit increase in SES corresponds to an approximate 0.262% increase in GDP per capita. This implies that higher secondary school enrollment positively influences GDP per capita. The C_COR coefficient is 0.1562324, showing that a one-unit increase in the control of corruption index is associated with an approximate 15.62% increase in GDP per capita. A higher control of corruption index, indicating less corruption, significantly enhances GDP per capita. The coefficient for GFCF_GDP is -0.0009513, suggesting that a one-unit increase in the growth rate of GFCF is linked to an approximate 0.095% decrease in GDP per capita, indicating a minor negative effect of GFCF growth on GDP per capita in this context. LE (Life Expectancy) has a coefficient of 0.023084, indicating that a one-unit increase in life expectancy is associated with an approximate 2.31% increase in GDP per capita, demonstrating a significant positive effect of life expectancy on economic growth.

The coefficient for LFT (Labor Force Total) is 6.22, indicating that a one-unit increase in the labor force corresponds to a 6.22% increase in GDP per capita. However, given the small size of this coefficient, the effect of labor force changes on GDP per capita in this model is minimal.

Table 4.6: Driscoll and Kraay's estimation results and the interaction

Variable DV = logGDP_n	Coefficient	Drisc/Kraay Std. Err.	t-Statistics	Prob-Value
SES	0.0023087	0.0034876	0.66	0.523
C_COR	-0.450129	0.1610181	-2.80	0.019
DFCF_GDP	-0.0038667	0.0068628	-0.56	0.586
LE	0.071982	0.0171943	4.19	0.002
LFT	1.0333308	8.5111109	1.21	0.253
LE*C_COR	0.0153083	0.0067916	2.25	0.048
_cons	2.649611	0.9617889	2.75	0.020
R-squared	0.5778			

Note: GDP denotes gross domestic product per capita, SES denotes school enrollment, secondary gender parity index, C_CORR denotes control of corruption, GFCF_GDP denotes Gross Fixed Capital formation, LE denotes Life expectancy at birth, total, LFT denotes Labor force, Total. *, **, * denotes the level of significance at 1%, 5% & 10% respectively. Source: Author's computation. (2024)**

Table 4.6 presents the regression results examining the relationship between health and economic growth, moderated by institutional quality. Life Expectancy (LE) has a coefficient of 0.071982 and is significant at the 1 percent level as indicated by probability value 0.002. This indicates that life expectancy has a positive and statistically significant effect on economic growth. This shows that better health outcomes, as indicated by higher life expectancy, contribute positively to economic growth. C_COR (Control of Corruption Index) shows a negative coefficient at -0.450129 and statistically significant at 5 percent level. The corruption index (C_COR) has a significant negative effect on economic growth. This implies that higher levels of corruption are linked to slower economic growth. As corruption is reduced economic growth tends to increase. Change in Life Expectancy Index (LE*C_COR) with the coefficient 0.0153038 and p-value 0.048 implies that the change in the life expectancy index (LE*C_COR) has a positive and significant relationship with economic growth. This indicates that improvements in health outcomes as measured by changes in life expectancy as a result of the moderating effect of Institutional Quality (LE*C_COR) are associated with higher economic growth.

4.6 Diagnostic Tests

Table 4.7: Diagnostic Tests

Test	F-statistic	Chi-square	Probability
Breusch-Pagan/Cook-Weisberg		10.24	0.0014

Note: *, **, * denotes the level of significance at 1%, 5% & 10% respectively. *Source*: *Author's computation (2024)***

The chi-squared value of 10.24 serves as the test statistic to evaluate whether the null hypothesis should be rejected. The p-value associated with this chi-squared statistic is 0.0014. Since the p-value is significantly smaller than the conventional significance level of 0.05, we reject the null hypothesis of constant variance. This finding indicates evidence of heteroskedasticity in the model, meaning that the error variance is not consistent across the range of fitted

values for logGDPper_con. The presence of heteroskedasticity may result in biased standard errors for the regression coefficients, which could lead to incorrect conclusions. Therefore, the use of Driscoll-Kraay standard errors in the regression is justified, as they are robust to heteroskedasticity.

5. Conclusion

The centrality of human capital in the growth of any economy has long been identified in the economic literature. However, the critical role of institutional quality in moderating the impact of human capital most especially the health component is evolving. In addition, empirical findings on the issue appear mixed in the extant literature. It is on this premise that the current study tends to contribute to the literature. To achieve the main objective of this study, a fixed effects regression was performed using Driscoll-Kraay standard errors to address heteroskedasticity, autocorrelation, and cross-sectional dependence. Key factors such as school enrollment, gross fixed capital formation, life expectancy, and labor force participation significantly impact economic growth. However, control of corruption did not show a significant direct effect on economic growth in this analysis.

The key finding of the study is that a relationship exists between health and economic growth in Sub-Saharan Africa. There is also positive impact of interaction between health and control of corruption on economic growth which could be stronger or more pronounced when institutional quality is high, that is when corruption is low. Conversely, the presence of high corruption (i.e., low institutional quality) could dampen the positive effects of health improvements on economic growth. Institutional quality as captured by the corruption index is crucial. Even with improvements in health, high corruption can undermine economic growth, indicating that effective institutions are necessary for translating health gains into economic growth. The findings suggest that, firstly, human capital contributes to economic growth in Sub-Saharan Africa, whereas institutional quality has a diminishing impact. Second, institutional quality counteracted the positive impact of human capital on growth. This means that negative institutional quality dynamics completely weaken the positive impact of human capital on economic growth which may remain elusive unless significant improvements are made to Sub-Saharan Africa's weak institutional quality. The policy direction is that strengthening of institutions should be prioritized to sustain the positive economic-growth effect of health.

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