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Enhancing population's health status in sub-Saharan Africa: does economic complexity matter?

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Abstract

This study examines the relationship between economic complexity and health outcomes for 22 Sub-Saharan African countries from 2002 to 2017. Using the Ordinary Least Squares and the Generalized Method of Moments techniques, the analysis reveals that greater economic complexity significantly reduces key health indicators such as infant mortality, undernourishment, and death rates, while also improving life expectancy. These findings are consistent across alternative estimation strategies and measures of economic complexity, highlighting the important influence of economic diversification and sophistication on population health in the region.

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1. Introduction

Sub-Saharan Africa (SSA) continues to face significant public health challenges, with poor health outcomes persisting across the region (Amu et al., 2022). Despite notable progress in recent decades, the population's health status in SSA remains a pressing concern, characterized by high infant mortality rates, widespread undernourishment, elevated death rates, and relatively low life expectancy (World Bank, 2022; WHO, 2021). These health indicators not only reflect the region's vulnerabilities but also undermine its prospects for sustainable development and inclusive growth.

Infant mortality rates in SSA remain staggeringly high, with an average of 49 deaths per 1,000 live births in 2020, more than double the global average (World Bank, 2022). This reflects the region's persistent challenges in providing adequate access to maternal and child healthcare services, as well as the prevalence of communicable diseases, malnutrition, and other social determinants of health (IGME, 2022; Kelly, 2024a). Undernourishment is also alarmingly common in SSA, with an estimated 21% of the population facing chronic food insecurity in 2020, the highest rate globally (World Health Organization, 2021; Kelly, 2024b). This high prevalence of undernourishment is driven by a complex interaction of factors, including poverty, conflict, climate change, and disruptions to agricultural production and food supply chains (Tendall et al., 2015). Furthermore, the crude death rate in SSA, at 9.3 deaths per 1,000 population in 2020, is nearly twice the global average, reflecting the region's substantial burden of communicable and non-communicable diseases, as well as the limited access to quality healthcare services (World Bank, 2022). Lastly, life expectancy in the region, at 61.2 years in 2020, lags significantly behind the global average of 72.8 years, highlighting the profound challenges the region faces in improving overall population health and well-being (DESA, 2022). While some progress has been made in recent decades, these persistent health disparities continue to undermine the region's sustainable development and socioeconomic progress (Alkire et al., 2021).

One factor that has gained attention in the literature is the potential role of economic complexity in shaping a country's health outcomes (Hidalgo & Hausmann, 2009; Hartmann et al., 2017). Economic complexity, a measure of the productive capabilities and diversification of a country's exports, has been linked to various socioeconomic and environmental outcomes (Cristelli et al., 2015; Mealy & Teytelboym, 2020; Nguéda & Kelly, 2022; Ketu et al., 2024; Kelly & Nembot Ndeffo, 2024; Kelly et al., 2024). However, the specific pathways through which economic complexity may influence a population's health status specifically in the context of SSA remain underexplored. The present study aims to address this gap by investigating the relationship between economic complexity and health outcomes in SSA countries. As such, the research question guiding this investigation is: To what extent does economic complexity affect the health status of SSA population? This question is motivated by the hypothesis that higher levels of economic complexity are associated with improved health outcomes, as more diverse and sophisticated economic structures may enable greater access to healthcare, better nutrition, and more robust public health infrastructure (Hartmann et al., 2017; Kelly, 2024).

This paper makes contributions to the existing literature in at least two significant ways. Firstly, this research expands the scholarly understanding of the linkages between economic complexity and population health, focusing specifically on the SSA region, which has been understudied in this regard. The closest study to the present one is that of Vu (2020), which examines the nexus from a global perspective; however, the present study differs by focusing on a regional analysis of SSA, a region characterized by some of the most severe health challenges globally. This distinction is crucial to avoid bias in remediation strategies that could arise from the influence of economically well-off countries, thereby ensuring a more targeted

and precise policy implementation. Additionally, Vu's (2020) study limits the nexus of economic complexity only to mortality outcomes (infant mortality, under-five mortality, and neonatal mortality) and life expectancy. Our study goes further by including the prevalence of undernourishment, a critical health issue present in SSA, as it is directly impacted by economic diversity and food security. The relationship between economic complexity and undernourishment is particularly important because diversified, complex economies are better equipped to support robust agricultural sectors and food distribution systems, which are essential for reducing malnutrition and supporting overall population health. Secondly, the study employs a comprehensive approach by simultaneously examining the effect of economic complexity on multiple health indicators, providing a more nuanced and holistic understanding of the phenomenon. This approach allows for the identification of potential trade-offs or synergies between different dimensions of health status and their relationship with economic complexity. Specifically, the findings show that economic complexity is valid for Infant mortality, undernourishment, and death rate reduction in the region while accounting for an increase in life expectancy at birth.

The rest of the paper is structured as follows: Section 2 provides a review of the relevant literature, Section 3 outlines the methodology used, Section 4 presents the findings, discusses the results, and robustness checks, and Section 5 concludes the study.

2. Literature Review

The literature exploring the nexus between economic complexity and health outcomes is sparse. To bridge this gap, we review empirical studies that indirectly address this relationship by examining determinants of economic complexity and their effects on health outcomes. The existing literature can be broadly categorized into two main groups: one that advocates for a positive effect of economic complexity's determinants on health outcomes, and another that demonstrates a negative effect.

Looking at the first strand of literature, Bloom and Canning (2000) focus on the impact of economic growth and diversification on health in developing countries. Utilizing panel data analysis, they find that countries with more diversified economies experience lower infant mortality rates and higher life expectancy due to better resource allocation and improved healthcare systems. Rodrik (2004) examines the role of industrial policy in fostering economic complexity and its subsequent effects on public health in Latin America. Using a mixed-methods approach, including econometric analysis and case studies, Rodrik concludes that countries with strategic industrial policies not only boost their economic complexity but also see significant improvements in health outcomes due to enhanced economic stability and increased public health investments. From a human capital perspective, Acemoglu and Robinson (2012) explore the influence of political institutions on economic complexity and health outcomes. Their cross-country regression analysis shows that inclusive institutions that promote economic diversification and innovation lead to better health metrics, such as reduced under-five mortality and improved life expectancy, by fostering a more equitable distribution of resources and improved healthcare access.

Kahouli et al. (2024) employing the three-step approach of Baron and Kenny (1986), analyze the relationship between technological innovations and health outcomes. The result not only demonstrated that technological innovation has a direct positive impact on improving health outcomes, but equally contributes to economic growth, environmental performance, and renewable energy generation. Similarly, Murphy et al. (1991) investigate the impact of education, a critical determinant of economic complexity, on health outcomes in Africa. Their econometric analysis reveals that higher educational attainment leads to improved health indicators, such as lower infant mortality and higher life expectancy, by empowering

individuals with knowledge about health practices and increasing their access to healthcare services. Finally, Vu (2020) investigates the effect of a country's economic structures on national health status from a global perspective, using the Economic Complexity Index as the primary measure and employing instrumental variable two-stage least squares regression on an unbalanced panel of 103 countries between 1970 and 2015. The findings reveal strong evidence that countries exporting complex, high-productivity products generally experience better health outcomes compared to those reliant on unsophisticated, low-productivity exports. Furthermore, the study identifies improved employment opportunities as a key channel through which economic complexity contributes to better health, suggesting that structural transformation toward a diverse range of sophisticated products can enhance health outcomes.

Conversely, some studies suggest that certain determinants of economic complexity can adversely affect health outcomes. Frankel and Romer (2017) analyze the effect of trade openness on health outcomes across developing nations. Using instrumental variable techniques, they find that while trade openness generally enhances economic complexity, it can also exacerbate income inequality, leading to disparate health outcomes where poorer populations suffer from worse health due to inadequate access to healthcare. Pritchett and Summers (1996) explore the consequences of rapid economic transitions on health in transitioning economies. Their regression analysis indicates that countries experiencing swift shifts toward economic complexity often face disruptions in social services, including healthcare, resulting in temporary spikes in mortality rates and deteriorating public health standards.

Stiglitz (2017) assesses the impact of globalization, a driver of economic complexity, on health outcomes in emerging economies. Through a combination of case studies and quantitative analysis, Stiglitz argues that globalization can lead to adverse health effects by promoting practices that undermine local health systems, such as the prioritization of export-oriented agriculture over subsistence farming, leading to food insecurity and malnutrition. In the same light, Gallup and Sachs (2000) investigate the link between infrastructure development and health outcomes in SSA. Their empirical analysis reveals that while infrastructure improvements can support economic complexity, poorly managed projects often lead to displacement of communities and inadequate urban planning, resulting in negative health impacts like increased exposure to diseases and lack of access to clean water. Sen (1999) explores the relationship between economic policies aimed at increasing complexity and their health implications in India. His qualitative and quantitative analyses highlight that policies focusing on rapid economic transformation without adequate social safety nets can lead to increased health disparities, with marginalized populations facing heightened health risks due to insufficient access to healthcare and nutrition.

Despite the potential significance of economic complexity in influencing health outcomes, there is a notable lack of research directly examining this relationship, particularly within the context of SSA. Existing studies predominantly address this nexus indirectly by focusing on various determinants of economic complexity, such as industrial diversification, technological innovation, and trade openness, and their mixed effects on health outcomes. However, a direct, comprehensive analysis of how economic complexity affects health metrics specifically in SSA remains unexplored, leaving a critical gap in understanding the unique health and economic dynamics of the region. This study aims to fill this gap by providing targeted insights into the effect of economic complexity on health outcomes in SSA, thus contributing to more effective policy formulation and implementation.

3. Materials and Methods

3.1. Data

The data used are from secondary sources, obtained mainly from the World Development Indicators (WDI), and the Observatory of Economic Complexity's (OEC) repository[1]. The data are for 22 SSA countries[2], covering the period 2002-2017. The study area is well-suited, as the region has experienced significant economic transformations and persistent healthcare challenges over the past few decades. The study period provides an opportunity to analyze how the evolving patterns of economic complexity have influenced health outcomes during a time of dynamic economic and social change in the region, marked by improved macroeconomic stability, increased foreign investment, and healthcare reforms aimed at improving public health outcomes.

Table 1: Descriptive statistics

Variable	Source	Obs	Mean	Std. Dev.	Min	Max
ECI	OEC	394	-0.972	0.548	-2.791	.304
Undernourishment	WDI	416	30.522	10.541	8.6	54.7
Infant Mortality	WDI	416	52.195	21.016	14.7	114.7
Death rate	WDI	416	9.596	2.923	4.437	17.805
Life expectancy	WDI	416	60.133	6.921	43.393	75.845
Trade	WDI	407	70.27	23.605	20.723	156.862
GDP (log)	WDI	416	24.043	1.234	21.956	26.924
Financial Development	WDI	358	25.274	27.709	0.491	142.422
Prevalence of HIV	WDI	384	2.414	3.069	0.01	16.5
Investment (log)	WDI	399	3.083	0.419	0.693	4.395
FDI (log)	WDI	399	0.934	1.123	-6.089	3.684

Source: *Author's construction*

In view of the various dimensions of human health, this study focuses on four dimensions as the main dependent variable (Vu, 2020); Infant mortality rate (*the number of infants dying before reaching one year of age per 1,000 live births in a given year*), Prevalence of undernourishment (*the percentage of the population whose habitual food consumption is insufficient to provide the dietary energy levels that are required to maintain a normal active and healthy life*), Crude death rate (*the number of deaths that occur during the year per 1,000 estimated population*), and finally, Life expectancy at birth (*representing the number of years a newborn infant would live if the prevailing patterns of mortality at the time of its birth were to remain the same throughout its life*).

The primary explanatory variable in this study is economic complexity, represented by the Economic Complexity Index (ECI) and sourced from the OEC database. This index measures the interconnectedness of an economy's capabilities (knowledge) to facilitate diversification into related complex productions, as outlined by Hidalgo and Hausmann (2009) through the concept of the Product Space.

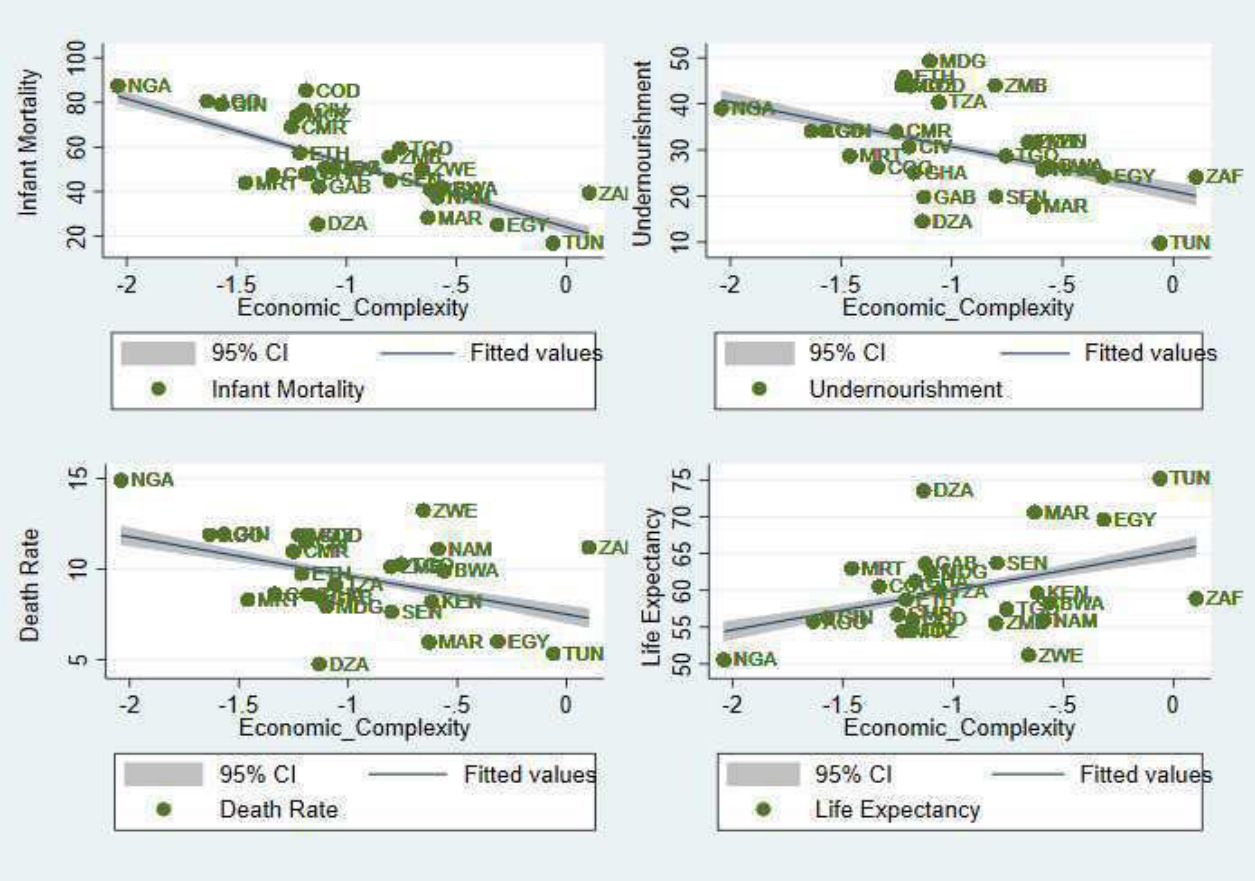
Following the determinant of health outcomes, we introduce control variables in our analysis to account for other factors that may influence health status aside from economic

[1] Accessible at: https://oec.world/

[2] Angola, Botswana, Cameroon, Congo, Dem, Rep, Congo, Rep, Cote d'Ivoire, Ethiopia, Gabon, Ghana, Kenya, Madagascar, Mauritania, Mozambique, Namibia, Nigeria, Senegal, South Africa, Sudan, Tanzania, Togo, Zambia, Zimbabwe

complexity. They include GDP (Kelly et al., 2023), trade (Levine & Rothman, 2006), financial development (Ketu et al., 2022), and HIV Prevalence (Rueda et al., 2016).

As shown respectively by Figure 1 and Table 2, preliminary findings posit a reducing effect of economic complexity on Infant mortality, undernourishment, and death rate and a positive effect on life expectancy. Subsequent sections will delve deeper into these correlations for precise effect.



Source: *Author's construction*

Figure 1: Trend of Economic complexity and health outcomes variables

Table 2: Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) ECI	1.000								
(2) Undernourishment	-0.396	1.000							
(3) Infant Mortality	-0.574	0.706	1.000						
(4) Death Rate	-0.331	0.579	0.823	1.000					
(5) Life expectancy	0.338	-0.688	-0.818	-0.939	1.000				
(6) Trade	0.087	-0.356	-0.325	-0.280	0.275	1.000			
(7) GDP (log)	0.119	-0.191	-0.128	0.005	0.125	-0.427	1.000		
(8) Financial Dev (log)	0.675	-0.439	-0.482	-0.141	0.288	-0.007	0.506	1.000	
(9) Prevalence of HIV	0.410	0.066	-0.043	0.415	-0.426	0.049	0.097	0.420	1.000

Source: *Author's construction*

3.2. Model and Estimation technique

Following the works of Vu (2020), we specify the following empirical model to quantify the effect of economic complexity on health outcomes in SSA:

$$Health_{it} = \alpha_0 + \alpha_1 ECI_{it} + \delta_k X_{it} + \mu_{it} \quad (1)$$

Where *Health* is the dependent variable representing the vector of Health outcomes variables for country i at time t. *ECI* stands for the economic complexity index, X is the vector of control variables, and μ is the stochastic error term.

The literature recommends estimating equation 1 using ordinary least squares (OLS) effects given the panel nature. However, this model does not address the endogeneity of the explanatory variables, and the heteroskedasticity that Baum et al. (2003) argue is common in empirical research. To address these issues, we reformulate equation 1, incorporating methods to tackle the endogeneity and heteroskedasticity concerns. This adjustment is summarized in the following equation:

$$Health_{it} = \alpha_0 + \alpha_1 Health_{i(t-\tau)} + \alpha_2 ECI_{it} + \sum_{h=1}^{k} \delta_h X_{h,i(t-\tau)} + v_i + \theta_t + \mu_{it} \quad (2)$$

Two estimation methods are utilized to ensure valid statistical inference and robust standard errors in the panel: the OLS estimator and the two-step system Generalized Method of Moments (GMM) estimator.

We begin with the OLS method. However, OLS does not account for country-specific factors that are generally time-invariant, such as a country's history or land-locked position, which can lead to inconsistent estimates. This inconsistency may result from the presence of a lagged dependent variable among the regressors (Wooldridge, 2010). Additionally, there is likely endogeneity between economic complexity and health variables, which theoretically may stem from reverse causality, omitted variable bias, or measurement errors, issues that are common in the developing world due to low statistical capacity.

To address the aforementioned issues, the study utilizes the two-step system GMM approach. The use of the two-step system GMM estimator is justified for several reasons. Firstly, it effectively addresses the issue of endogeneity by using internal instruments derived from the lagged values of the explanatory variables, which helps mitigate the potential bias arising from reverse causality, omitted variable bias, and measurement errors commonly found in developing countries (Arellano & Bover, 1995). Secondly, the system GMM approach combines equations in both levels and first differences, enhancing efficiency and providing more robust and reliable estimates, especially in dynamic panel data settings (Blundell & Bond, 1998). Lastly, the two-step system GMM estimator corrects for heteroskedasticity and serial correlation, ensuring robust standard errors and valid statistical inferences, which is crucial for accurate empirical analysis (Roodman, 2009).

4. Findings

4.1. Baseline Results

The empirical results as shown in Table 3 indicate that economic complexity is negatively related to infant mortality, undernourishment, and death rate, but positively related to life expectancy in SSA, thus corroborating with Figure 1. More precisely, a unit increase in economic complexity in the region led to a 9.866 per thousand decrease in infant mortality, a 2.053 percent decrease in the prevalence of undernourishment, and a 1.908 per thousand decrease in crude death rate everything being equal. Similarly, a unit increase in economic complexity in the region other factors held constant may lead to an increase in life expectancy up to 4.278 years. These results tie with those of Vu (2020) and Kahouli et al. (2024). A higher economic complexity often reflects a more robust and diverse economy capable of generating

greater wealth and providing better public services, including healthcare and nutrition programs. Similarly, a reduction in the overall death rate can be attributed to better disease management and health infrastructure that accompanies economic growth and complexity. Conversely, the positive relationship between economic complexity and life expectancy underscores how advancements in economic capabilities contribute to longer, healthier lives through enhanced medical technologies, increased investments in healthcare, and improved living standards.

These results highlight essential policy implications for SSA, where advancing economic complexity could be instrumental in improving public health. Tailored policies should focus on diversifying economies by investing in sectors with high value-added potential, promoting education and skill development, and supporting innovation. This could reduce infant mortality, undernourishment, and crude death rates while extending life expectancy across the region. Additionally, enhancing healthcare and nutrition programs linked to economic growth would strengthen SSA's capacity to manage diseases effectively and support longer, healthier lives, ultimately leading to sustainable social and economic development.

Table 3: Economic complexity and health outcomes in SSA

	(1)	(2)	(3)	(4)
	Infant Mortality	Undernourishment	Death rate	Life expectancy
ECI	-9.866***	-2.053*	-1.908***	4.278***
	(1.932)	(1.059)	(0.280)	(0.594)
GDP (log)	-0.436	-1.688***	-0.0612	1.033***
	(0.817)	(0.448)	(0.118)	(0.251)
Trade (log)	-19.99***	-14.02***	-2.583***	7.597***
	(2.566)	(1.407)	(0.371)	(0.789)
Financial dev (log)	-11.90***	-5.251***	-0.870***	2.220***
	(1.271)	(0.697)	(0.184)	(0.391)
Prevalence of HIV	1.782***	1.056***	0.644***	-1.602***
	(0.269)	(0.147)	(0.0389)	(0.0826)
Constant	164.6***	138.3***	20.75***	5.741
	(25.20)	(13.82)	(3.648)	(7.751)
Observations	299	299	299	299
R-squared	0.622	0.548	0.595	0.681

Source: *Author's construction*

*Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.*

The introduction of control variables in the various models leaves the signs and statistical significance of our interest variables unchanged. Consistent with Alam (2013), GDP mitigates health outcomes in SSA. This can be channeled through greater investments in healthcare, nutrition, and infrastructure, thereby improving overall living conditions and access to essential services in SSA. The effect is the same when Trade openness and financial development are considered in the economic complexity-health outcomes nexus, thus corroborating Levine and Rothman (2006) and Ketu et al. (2022) respectively. However, the prevalence of HIV is seen to exacerbate health status in the region. Specifically, Infant mortality, Prevalence of undernourishment, and death rate tend to increase with an increase in the prevalence of HIV, accompanied by a drop in life expectancy.

4.2. Endogeneity Account

In response to potential biases affecting the OLS outcomes as discussed earlier, the system GMM estimator is employed to address these concerns, with the results of this analysis depicted in Table 4. The results indicate that greater economic complexity has a reducing effect on key health outcomes of infant mortality, undernourishment, and death rates in the region, consistent with previous findings. Additionally, the analysis reveals that economic complexity has a positive and significant influence on improving life expectancy. These effects remain robust and statistically significant across the different model specifications employed in the study. The positive and significant coefficient on the lagged dependent variable, across all model specifications and health outcome measures, suggests that previously achieved levels of health status play a crucial role in a country's capacity to further generate positive health outcomes in the current period. This indicates the persistent and path-dependent nature of health progress, where past health achievements help facilitate continued improvements in health indicators.

For further robustness of the results, we estimate equation 1 using an alternative measure of Economic complexity, ECI+, an improved ECI corrected for difficulties in exporting goods in a given country. The findings remain consistent with previous results as shown in Table A1 of the Appendix.

Table 4: Economic complexity and health outcomes (s-GMM)

	(1)	(2)	(3)	(4)
	Infant Mortality	Undernourishment	Death rate	Life expectancy
L.Infant Mortality	0.852***			
	(0.161)			
L.Undernourishment		0.964***		
		(0.0111)		
L.Death rate			0.774***	
			(0.0397)	
L.Life expectancy				0.959***
				(0.00910)
ECI	-4.216***	-0.327**	-0.289***	0.0136***
	(0.826)	(0.130)	(0.0426)	(0.00153)
GDP (log)	-0.656***	-0.0869*	-0.430**	0.00157***
	(0.0112)	(0.0483)	(0.178)	(0.000448)
Trade (log)	-0.672***	-0.844***	0.217***	0.00375**
	(0.0456)	(0.142)	(0.0497)	(0.00174)
Financial dev (log)	-0.376**	-0.281***	-0.188	-0.00470***
	(0.0983)	(0.0709)	(0.141)	(0.000795)
Prevalence of HIV	0.191***	0.213***	0.0441*	-0.000508**
	(0.0972)	(0.0706)	(0.0254)	(0.000239)
Constant	2.613***	6.061***	11.47***	0.150***
	(0.498)	(1.367)	(4.397)	(0.0423)
Observations	263	281	281	281
Number of id	22	22	22	22
AR(1)	0.0043	0.100	0.0630	0.008
AR(2)	0.461	0.815	0.538	0.597
Hansen OIR	0.319	0.147	0.520	0.888
Instruments	17	21	21	21

Source: *Author's construction*

*Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.*

5. Conclusion and Policy Implication

The present research investigates how economic complexity relates to health outcomes in 22 Sub-Saharan African countries from 2002 to 2017. Employing both OLS and GMM estimations, the study reveals that higher economic complexity notably decreases significant health indicators like infant mortality, undernourishment, and crude death rates, while simultaneously enhancing life expectancy. These results hold true across different estimation techniques and metrics of economic complexity, highlighting the substantial effect of economic diversification and advancement on public health within the region. As such, Sub-Saharan African countries are encouraged to prioritize policies and strategies that foster economic diversification and sophistication as a means to enhance the overall health and well-being of their populations. Policies geared towards enhancing health outcomes should take into account economic complexity.

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Appendix

Table A1: Alternative Independent Variable in the Economic complexity-Health nexus

	(1)	(2)	(3)	(4)
	Infant Mortality	Undernourishment	Death rate	Life expectancy
ECI+	-5.393***	-1.939***	-0.938***	2.523***
	(1.727)	(0.350)	(0.257)	(0.543)
GDP (log)	-0.612	-1.419**	-0.146	0.502*
	(0.855)	(0.666)	(0.127)	(0.269)
Trade (log)	-24.01***	0.162	-3.166***	8.556***
	(2.828)	(1.377)	(0.420)	(0.890)
Financial dev (log)	-12.35***	-1.287	-1.084***	2.378***
	(1.436)	(1.536)	(0.213)	(0.452)
Prevalence of HIV	1.334***	1.396***	0.571***	-1.428***
	(0.274)	(0.110)	(0.0407)	(0.0863)
Constant	162.6***	-23.14	19.85***	12.24
	(27.72)	(13.51)	(4.119)	(8.724)
Observations	259	259	259	259
R-squared	0.615	0.995	0.570	0.655

Source: *Author's construction*
*Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.*