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Factors Influencing Life Expectancy in Low-Income Countries: A Panel Data Analysis

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Abstract. Understanding the factors influencing life expectancy in low-income countries is crucial for formulating effective health and economic policies. This study aims to explore the determinants of life expectancy in these countries by analyzing panel data from 2004 to 2021. The hypothesis posits that economic indicators, healthcare expenditure, and agricultural land significantly affect life expectancy, while high HIV prevalence negatively impacts it. The research procedure involved using Ordinary Least Squares (OLS) regression analysis with life expectancy at birth as the dependent variable and GDP per capita (PPP, constant 2021 international $), government health expenditure per capita (current international $), agricultural land (% of land area), HIV prevalence (% of population ages 15–49), and current health expenditure per capita (current international $) as independent variables. The main results indicate that GDP per capita, government health expenditure, and agricultural land positively influence life expectancy, highlighting the importance of economic growth, healthcare investment, and food security. In contrast, HIV prevalence has a significant negative effect on life expectancy, underscoring the health burden of the epidemic. Statistical tests for heteroskedasticity and normality reveal some deviations, but the robustness of the analysis is maintained through appropriate econometric techniques. Theoretically, this study contributes to the literature by providing a nuanced understanding of how economic and health-related factors interact to affect life expectancy in low-income countries. Practically, the findings suggest that policies aimed at boosting economic growth, increasing healthcare spending, improving agricultural practices, and addressing HIV/AIDS are vital for enhancing life expectancy. This research offers valuable insights for policymakers in low-income countries striving to improve population health outcomes.

Key words: life expectancy; low-income countries; health expenditure; GDP per capita; HIV prevalence.

JEL O11, I15, H51, I31

1. Introduction

Life expectancy at birth serves as a critical indicator of a population's overall health and well-being, reflecting the average lifespan of individuals within a given country or region. In low-income countries, where health disparities and socioeconomic challenges are often pronounced, understanding the determinants of life expectancy is of paramount importance for policymakers, healthcare professionals, and development practitioners. Improvements in life expectancy not only signify advancements in healthcare and public health interventions but also reflect broader socioeconomic progress and development.

This study investigates the factors influencing life expectancy at birth in 19 low-income countries over the period from 2004 to 2021. These countries represent diverse regions with varying levels of economic development, healthcare infrastructure,

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and social conditions. By analyzing panel data encompassing variables such as GDP per capita, government and current health expenditures, agricultural land percentage, HIV prevalence, and others, this research aims to uncover the complex interplay between economic, health, and environmental factors that shape life expectancy outcomes. The importance of understanding the determinants of life expectancy in low-income countries cannot be overstated. These nations often face formidable challenges such as limited access to healthcare services, inadequate nutrition, high prevalence of infectious diseases, and socioeconomic inequalities. By identifying the key drivers of life expectancy improvements, policymakers can develop targeted interventions and policies to address these challenges effectively.

The central research questions guiding this study are:

RQ1: How do GDP per capita and healthcare expenditure impact life expectancy in low-income countries?

RQ2: What is the role of agricultural land in determining life expectancy?

RQ3: How does the prevalence of HIV affect life expectancy in these regions?

By addressing these questions, the study aims to provide empirical evidence that can inform policy decisions to enhance population health outcomes in low-income countries.

The purpose of this study is to identify and quantify the key determinants of life expectancy in low-income countries. Specifically, the research aims to investigate how economic factors, healthcare expenditures, agricultural practices, and disease prevalence influence life expectancy over time.

Research hypotheses:

H1: The higher GDP per capita, increased government health expenditure, and greater agricultural land area positively affect life expectancy, while higher HIV prevalence negatively impacts it.

H2: The economic growth and healthcare investments are critical for improving life expectancy, whereas the health burden of HIV remains a significant challenge.

Structure of the article. This paper begins with a review of relevant literature, highlighting previous research on life expectancy determinants and the methodologies employed. Subsequently, the data and methodology section outline the panel dataset used in the analysis and describes the econometric techniques employed to assess the relationships between independent variables and life expectancy. The empirical results section presents the findings of the regression analysis, elucidating the significant determinants of life expectancy in low-income countries. Through this comprehensive analysis, this study aims to contribute to the ongoing discourse on population health and development in low-income countries, ultimately guiding efforts to improve life expectancy and well-being for all.

2. Literature review

A substantial body of literature establishes a strong positive correlation between economic performance, typically measured by GDP per capita, and life expectancy.

Preston [1] was among the first to demonstrate this relationship, showing that higher national income levels are generally associated with longer life spans. This connection is attributed to mechanisms such as improved access to healthcare, better nutrition, and enhanced living conditions that accompany higher income levels.

Bloom & Canning [2] emphasized that economic growth facilitates increased investments in health infrastructure and services, thereby improving health outcomes. Wealthier countries are better positioned to afford advanced medical technologies, comprehensive public health programs, and robust healthcare systems, all of which contribute to higher life expectancy. However, the marginal benefits of increased GDP on life expectancy tend to diminish as countries become wealthier, indicating that oth-

er factors also play significant roles in determining life expectancy.

Pritchett & Summers [3] further examined the relationship between wealth and health, suggesting that income is a powerful determinant of health outcomes. Their analysis indicated that a significant portion of the variance in life expectancy across countries could be explained by differences in income levels.

Deaton [4] echoed this sentiment, arguing that higher income not only improves health through direct spending on healthcare but also through improved living standards and reduced stress levels.

Government health expenditure is another critical determinant of life expectancy. Numerous studies indicate that higher public spending on health correlates with better health outcomes.

Gupta [5] analyzed the impact of public health expenditure on health indicators in developing countries and found that increased government spending significantly improved life expectancy. They suggested that government investment in health infrastructure, preventive care, and health education can substantially enhance population health. In low-income countries, where healthcare systems often suffer from underfunding and inefficiencies, government health expenditure becomes even more vital.

Sachs [6] highlighted the importance of public health investment in combating infectious diseases and reducing mortality rates. Targeted government spending on health programs, especially those focusing on maternal and child health, can lead to substantial improvements in life expectancy.

Bokhari [7] conducted a cross-country analysis that confirmed the positive impact of public health expenditure on health outcomes. They found that an increase in public health spending was associated with a decrease in child and maternal mortality, underscoring the critical role of government intervention in health.

This finding was supported by Anyanwu [8], who demonstrated that government health expenditure significantly reduced infant mortality rates in African countries.

Current health expenditure per capita, encompassing both public and private spending on health services, is a direct measure of resources devoted to healthcare. Studies consistently show that higher health expenditure is associated with better health outcomes and increased life expectancy.

Novigon et al. [9] conducted a cross-country analysis in sub-Saharan Africa and found that health expenditure significantly improved life expectancy and reduced mortality rates. They argued that increased spending on health services leads to better healthcare delivery, more effective disease prevention, and improved health infrastructure. However, the effectiveness of health expenditure depends on resource utilization efficiency.

Farag et al. [10] emphasized that merely increasing health spending is not sufficient; the quality of spending matters. Health expenditure should be targeted towards primary healthcare, preventive services, and health system strengthening to achieve optimal outcomes. In low-income countries, where healthcare systems are often strained, efficient resource allocation is crucial for maximizing the impact of health expenditure on life expectancy.

Wagstaff [11] emphasized the need for efficient use of health funds, arguing that resources should be allocated based on health needs rather than political considerations. They suggested that prioritizing cost-effective interventions, such as immunizations and maternal health services, can lead to significant improvements in life expectancy.

Rajkumar [12] also highlighted the importance of governance in determining the effectiveness of health expenditure, noting that countries with better governance struc-

tures tend to achieve better health outcomes from their health spending.

The percentage of agricultural land as part of total land area significantly influences life expectancy, particularly in low-income countries where agriculture is central to the economy and livelihoods. Agricultural land availability and utilization affect food security, nutrition, and overall health.

The World Bank [13] highlighted that agricultural productivity and food availability are closely linked to nutritional status, which in turn impacts health outcomes and life expectancy.

Maxwell & Smith [14] explored the relationship between agricultural land use and food security, arguing that access to sufficient and nutritious food is essential for maintaining good health and prolonging life expectancy. They noted that in many low-income countries, subsistence agriculture is a primary source of food, and fluctuations in agricultural productivity can have direct consequences on health and mortality rates. Moreover, the transition from subsistence to commercial agriculture has implications for health and nutrition.

Pingalli [15] discussed the "nutrition transition" in developing countries, where shifts in agricultural practices and diets can lead to improved or deteriorating health outcomes. Policies promoting sustainable agricultural practices, diversified diets, and food security are crucial for enhancing life expectancy in low-income countries.

Bezuneh et al. [16] emphasized that food security is a vital determinant of health, noting that agricultural policies that improve food availability and accessibility can have significant health benefits.

Sahn & Steifel [17] found that improvements in agricultural productivity and food security were associated with better nutritional status and lower mortality rates among children in African countries. Similarly, Alderman et al. [18] demonstrated that food security interventions, such as school feeding programs and nutrition education, could substantially improve health outcomes and life expectancy.

HIV prevalence remains a significant determinant of life expectancy, particularly in sub-Saharan Africa, where the burden of the disease is highest. The HIV/AIDS epidemic has had a devastating impact on population health, reducing life expectancy and reversing health gains in many affected countries.

Unaids [19] reported that despite progress in combating HIV, the disease continues to pose a major public health challenge, particularly in low-income countries with limited healthcare resources.

Trickey et al. [20] showed that access to antiretroviral therapy (ART) significantly improves the survival of HIV-positive individuals, thereby enhancing life expectancy. They emphasized the importance of early diagnosis, timely treatment, and sustained access to ART in reducing HIV-related mortality and extending life expectancy. However, disparities in access to HIV treatment and healthcare services remain a challenge in many low-income countries, limiting the potential benefits of ART. Moreover, the impact of HIV on life expectancy extends beyond direct mortality. HIV/AIDS affects economic productivity, social stability, and healthcare systems, further exacerbating health disparities and reducing life expectancy.

De Walque [21] highlighted the socioeconomic consequences of HIV, including increased healthcare costs, loss of labor productivity, and heightened poverty levels, all of which contribute to lower life expectancy.

Fox & Rosen [22] discussed the broader implications of HIV on public health, noting that high prevalence rates can strain healthcare systems and divert resources away from other critical health services. They argued that comprehensive HIV programs that include prevention, treatment, and support services are essential for mitigating the impact of HIV on life expectancy.

Bor et al. [23] also emphasized the importance of integrating HIV services with other health programs to enhance overall health outcomes and extend life expectancy.

Anand & Ravallion [26] find that both private incomes and public services significantly improve human development indicators, including life expectancy, in poor countries, highlighting the crucial role of public health services in enhancing life outcomes even when private incomes are low.

Cutler et al. [27] reveal that economic improvements, reductions in infectious diseases, and advancements in medical technology are major determinants of declining mortality rates, with education and income also playing critical roles in increasing life expectancy.

Houweling et al. [28] demonstrate that using different economic indicators can lead to varying conclusions about health inequalities among children in developing countries, concluding that a multidimensional approach is necessary to accurately assess the impact of economic status on health outcomes, including life expectancy.

Jamison et al. [29] show that significant investments in health and economic policies can lead to a convergence in global health outcomes by 2035, identifying increased health expenditure and economic growth as critical factors for improving life expectancy in low-income countries.

O'Donnell et al. [30] provide robust methodologies for analyzing health equity and demonstrate the importance of household economic status in determining health outcomes, emphasizing that equitable distribution of health resources is essential for improving life expectancy.

Reyes & Cornia [31] find that structural adjustment policies in sub-Saharan Africa have often led to deteriorations in health outcomes, including reduced life expectancy, arguing that these policies can undermine health systems and economic stability.

Schultz [32] highlights that investments in health and education significantly enhance economic development and life expectancy in Africa, emphasizing the interdependence of health and education policies in achieving improved life outcomes.

Smith [33] demonstrates a strong, dual relationship between economic status and health, where better health leads to higher economic productivity and vice versa, concluding that improving economic conditions is crucial for enhancing life expectancy.

Strauss & Thomas [34] find that improved nutrition and health are key drivers of economic development, which in turn positively affect life expectancy, underscoring the importance of health and nutrition investments for sustained economic growth.

Wang [35] shows that maternal education, household wealth, and access to healthcare are critical determinants of child mortality in low-income countries, suggesting that improving these factors can significantly enhance life expectancy in these regions.

In conclusion, the substantial body of literature highlights the multifaceted relationship between economic performance, public health expenditure, agricultural productivity, and HIV prevalence on life expectancy in low-income countries. Studies consistently demonstrate that higher GDP per capita and increased public health spending are positively correlated with improved health outcomes and longer life spans, attributed to better access to healthcare, nutrition, and living conditions.

However, the diminishing marginal benefits of GDP growth in wealthier nations suggest the importance of efficient resource allocation and governance. Agricultural productivity and food security are also critical, as they directly impact nutrition and health, particularly in regions reliant on subsistence farming.

Furthermore, the high prevalence of HIV/AIDS remains a significant barrier to increasing life expectancy, with the need

for comprehensive prevention, treatment, and support programs being paramount. Effective policies must therefore focus on economic growth, healthcare investment, efficient resource utilization, agricultural development, and robust HIV/AIDS interventions to enhance life expectancy and overall health outcomes in low-income countries.

3. Research Data and Methodology

The econometric estimation was based on a balanced panel of 19 low-income countries covering the period 2004–2021 ($n = 19$ and $t = 18$)[2]. The data collected from World Data Indicators website and the countries used for our analysis are Afghanistan, Burkina Faso, Burundi, Central African Republic, Chad, Congo, Ethiopia, Gambia, Guinea, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Rwanda, Sierra Leone, Togo, Uganda

Our model includes several variables that represent different aspects of socio-economic development and healthcare provision (Table 1).

In this analysis, we employed an Ordinary Least Squares (OLS) regression model to examine the relationship between life expectancy at birth and the set of the key independent variables in low-income countries. The OLS model allows us to estimate the linear association between life expectancy and the socio-economic and health-related factors.

$$\begin{aligned} LifeExp_{it} = b_0 + b_1 \cdot GdpPc_{it} + \\ + b_2 \cdot GovHealthExp_{it} + \\ + b_3 \cdot ArgLand_{it} + b_4 \cdot Hiv_{it} + \\ + b_5 \cdot HealthExp_{it} + e_{it}, \end{aligned} \quad (1)$$

Where: i is the country and t is the year ($i = 1, 2, 3, \ldots, 19$ and $t = 1, 2, 3, \ldots, 18$).

Summary statistics for the panel are presented in Table 2.

In this panel summary, the key variables show notable variation across countries and over time. The mean life expectancy of 58.085 years signifies the overall health status across the panel, with a notable variation from 46.038 to 66.774 years, indicating diversity in health outcomes among nations. Examining GDP per capita, which ranges from 860.9989 to 3054.452 constant 2021 international dollars, reflects the economic heterogeneity and potential disparities in resource allocation for healthcare.

Table 1. **Variables**

Variable Type	Variable Symbol	Variable Definition
Dependent Variable	LifeExp	Life expectancy at birth, total (years)
Independent Variable	GdpPc	GDP per capita, PPP (constant 2021 international $)
	GovHealthExp	Domestic general government health expenditure per capita, PPP (current international $)
	ArgLand	Agricultural land (% of land area)
	Hiv	Prevalence of HIV, total (% of population ages 15–49)
	HealthExp	Current health expenditure per capita, PPP (current international $)

Table 2. **Panel Summary Statistics**

Variable		Mean	Std	Min	Max	Observations
LifeExp	overall	58.08532	4.40689	46.038	66.774	N = 342
	between		3.438821	50.62683	63.44689	n = 19
	within		2.860897	50.01298	63.67899	T = 18
GdpPc	overall	1803.258	541.1289	860.9989	3054.452	N = 342
	between		492.2519	949.5221	2614.764	n = 19
	within		250.1771	970.9818	2713.17	T = 18
GovHealthExp	overall	16.95455	10.68771	0.8824918	73.5307	N = 342
	between		7.650567	3.655804	35.22091	n = 19
	within		7.655973	–3.459767	55.26435	T = 18
ArgLand	overall	47.0661	21.07321	7.825291	81.89252	N = 342
	between		21.49536	7.888518	78.71698	n = 19
	within		2.250415	34.89548	54.40428	T = 18
Hiv	overall	2.895906	3.180307	0.1	12.6	N = 342
	between		3.223361	0.1	11.8	n = 19
	within		0.4922137	0.3625731	5.462573	T = 18
HealthExp	overall	88.26301	52.52018	20.54935	363.6112	N = 342
	between		39.21742	30.65338	198.9078	n = 19
	within		36.01441	–16.69177	281.3309	T = 18

Note: Provided by Author, Calculated in STATA 14.2

Moreover, the considerable variability in government health expenditure, ranging from 0.8824918 to 73.5307 PPP (current international $) per capita, underscores the differential prioritization of public health initiatives among these nations. The proportion of agricultural land, spanning from 7.825291 % to 81.89252 % of total land area, highlights the varying reliance on agriculture and its potential implications for food security and nutrition, vital factors influencing population health.

Additionally, the prevalence of HIV, ranging from 0.1 % to 12.6 % of the population aged 15–49, underscores the complex interplay between disease burden and life expectancy.

The detailed summary statistics for the dependent variable, LifeExp (life expectancy at birth), offer a comprehensive snapshot of the distribution and variability of life expectancy across the panel of low-income countries (Table 3).

With a mean life expectancy of 58.08532 years and a median of 58.788 years, the data suggests a relatively stable average lifespan, albeit with notable variations among countries. The standard deviation of 4.40689 underscores the degree of dispersion around the mean, indicating diverse life expectancy outcomes within the dataset.

Table 3. **Detailed Summary Statistics (Dependent Variables)**

LifeExp				
Percentiles		Smallest		
1 %	47.426	46.038		
5 %	49.948	46.433		
10 %	52.044	46.851	N	342
25 %	55.025	47.426	Sum of Wgt.	342
50 %	58.788		Mean	58.08532
		Largest	Std. Dev.	4.40689
75 %	61.315	66.072		
90 %	63.136	66.251	Variance	19.42068
95 %	64.838	66.437	Skewness	–0.4494857
99 %	66.072	66.774	Kurtosis	2.665577

Note: Provided by Author, Calculated in STATA 14.2

Examining percentiles reveals a range of values from 46.038 years at the 1st percentile to 66.072 years at the 99th percentile, highlighting the presence of outliers and extreme values. The negative skewness (–0.4494857) suggests a slight leftward skew in the distribution, while the positive kurtosis (2.665577) indicates a relatively peaked distribution with heavier tails.

Overall, these statistics paint a nuanced picture of life expectancy dynamics in low-income countries, showcasing both the central tendencies and the variability of outcomes across the panel.

Correlation Coefficients Formula is given in equation (2):

$$\rho = \frac{\sum (x_i - \bar{x}) \cdot (y_i - \bar{y})}{\sum (x_i - \bar{x})^2 \cdot \sum (y_i - \bar{y})^2}. \quad (2)$$

Positive correlations are observed between life expectancy and several variables, albeit with varying strengths. Notably, life expectancy exhibits moderate positive correlations with GDP per capita (correlation coefficient = 0.4048) and government health expenditure per capita (correlation coefficient = 0.4624), indicating that higher economic prosperity and increased investment in public health are associated with longer life expectancies (Table 4).

Similarly, life expectancy also shows a moderate positive correlation with agricultural land (correlation coefficient = = 0.4336), suggesting a potential link between agricultural productivity, food security, and population health outcomes. Conversely, a negative correlation is observed between life expectancy and HIV prevalence (correlation coefficient = = –0.2090), indicating that higher prevalence rates of HIV are associated with lower life expectancies. This underscores the significant impact of infectious diseases on population health outcomes, particularly in low-income countries where HIV/AIDS remains a significant public health challenge.

Table 4. **Correlation Coefficients and Significance**

	LifeExp	GdpPc	GovHealthExp	ArgLand	Hiv	HealthExp
LifeExp	1					
GdpPc	0.4048*	1				
	0.0000					
GovHealthExp	0.4624*	0.3753*	1			
	0.0000	0.0000				
ArgLand	0.4336*	0.2920*	0.4534*	1		
	0.0000	0.0000	0.0000			
Hiv	–0.2090*	–0.1922*	–0.0087	0.1280*	1	
	0.0001	0.0003	0.8731	0.0179		
HealthExp	0.3613*	0.5091*	0.2981*	0.2568*	–0.1012	1
	0.0000	0.0000	0.0000	0.0000	0.0616	

Notes: * Coefficients below the Correlation Coefficients indicate the P-Value significance; Provided by Author, Calculated in STATA 14.2

The correlation matrix also reveals positive correlations between life expectancy and current health expenditure per capita (correlation coefficient = = 0.3613), highlighting the importance of healthcare investment in improving overall population health. However, the strength of this correlation is relatively weaker compared to GDP per capita and government health expenditure per capita.

4. Results

The results of the regression analysis by formula (1) are presented in Table 5.

GDP per capita (GdpPc) is positively and significantly associated with life expectancy, with a coefficient of 0.00101, significant at the 5 % level ($p < 0.05$). This suggests that economic prosperity plays a crucial role in enhancing population health. A higher GDP per capita indicates better living standards, improved access to healthcare, education, and nutrition, all of which are essential for extending life expectancy.

Economic growth likely provides the resources needed for governments and individuals to invest in health-promoting activities and services, ultimately leading to longer lifespans. Government health expenditure per capita (GovHealthExp) emerges as a critical factor in improving life expectancy, with a highly significant coefficient of 0.103 ($p < 0.01$). This strong positive relationship underscores the importance of public health investment in enhancing population health outcomes.

Increased government spending on health can lead to better healthcare infrastructure, more comprehensive healthcare services, and greater accessibility to medical care for all segments of the population. These improvements are essential for preventing and treating diseases, reducing mortality rates, and promoting overall health, thereby extending life expectancy.

Table 5. **Regression Analysis**

VARIABLES	LifeExp
GdpPc	0.00101**
	(0.000434)
GovHealthExp	0.103***
	(0.0209)
ArgLand	0.0579***
	(0.0104)
Hiv	–0.284***
	(0.0621)
HealthExp	0.0111***
	(0.00426)
Constant	51.65***
	(0.752)
Observations	342
R-squared	0.376

Notes: LifeExp — Life expectancy at birth, total (years); GdpPc — GDP per capita, PPP (constant 2021 international $); GovHealthExp — Domestic general government health expenditure per capita, PPP (current international $); ArgLand — Agricultural land (% of land area); Hiv — Prevalence of HIV, total (% of population ages 15–49); HealthExp — Current health expenditure per capita, PPP (current international $); Standard errors in parentheses — *** p<0.01, ** p<0.05, * p<0.1; Provided by Author, Calculated in STATA 14.2

The percentage of agricultural land (ArgLand) also shows a significant positive impact on life expectancy, with a coefficient of 0.0579, significant at the 1 % level ($p < 0.01$). This finding highlights the role of agricultural productivity and food security in determining population health. Greater agricultural land use can enhance food availability and nutrition, which are fundamental to maintaining good health and preventing malnutrition-related illnesses. Access to sufficient and nutritious food supports healthy growth and development, reduces the incidence of food-related diseases, and contributes to longer, healthier lives. Conversely, HIV prevalence (Hiv) has a negative and highly significant effect on life expectancy, with a coefficient of –0.284 ($p < 0.01$).

This negative relationship reflects the severe health burden posed by HIV/AIDS in low-income countries. High HIV prevalence is associated with increased morbidity and mortality, reducing life expectancy. The epidemic strains healthcare systems, diverts resources from other health priorities, and affects the most productive age groups, exacerbating its impact on population health. Addressing the HIV/AIDS epidemic through effective prevention, treatment, and care strategies is crucial for improving life expectancy in affected regions.

Current health expenditure per capita (HealthExp) positively influences life expectancy, with a coefficient of 0.0111, sig-

nificant at the 1 % level ($p < 0.01$). This variable captures the total resources allocated to healthcare services, including both public and private spending. Higher health expenditure per capita signifies more comprehensive and accessible healthcare services, better medical technology, and higher quality of care. Such investments are vital for preventing and managing diseases, promoting health, and ultimately increasing life expectancy.

The significant positive impact of health expenditure on life expectancy underscores the need for sustained and enhanced investment in healthcare systems to achieve better health outcomes. The constant term of 51.65, significant at the 1 % level, represents the baseline level of life expectancy when all independent variables are zero.

This baseline provides a reference point for understanding the additional contributions of each independent variable to life expectancy. The R-squared value of 0.376 indicates that approximately 37.6 % of the variability in life expectancy can be explained by the independent variables included in the model. While this suggests that other factors not captured by the model also play a role in determining life expectancy, the included variables provide a substantial and meaningful explanation of the differences in life expectancy across low-income countries.

The Breusch-Pagan / Cook-Weisberg test for heteroskedasticity is used to determine whether the variance of the errors in a regression model is constant, which is an important assumption of the Ordinary Least Squares (OLS) regression. The null hypothesis (Ho) for this test is that the variance of the errors is constant (homoscedasticity) (Table 6).

In the given results, the test statistic (chi-squared) is 3.25 with 1 degree of freedom. The p-value associated with this test statistic is 0.0714. Since the p-value (0.0714) is greater than the common significance level of 0.05, we do not reject the null hypothesis of constant variance. This suggests that there is no strong evidence of heteroskedasticity in the regression model at the 5 % significance level.

Table 6. **Heteroskedasticity Test**

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of LifeExp
chi2(1) = 3.25
Prob > chi2 = 0.0714

Note: Provided by Author, Calculated in STATA 14.2

However, it's worth noting that the p-value is relatively close to 0.05, indicating that heteroskedasticity might be an Issue at a slightly less stringent significance level (e. g., 10 %).

The Breusch and Pagan Lagrangian Multiplier (LM) test for random effects provides critical information on whether a random effects model is more appropriate than a simple OLS regression model for the given dataset (Table 7).

The key aspect of this test is to determine if the variance of the random effects (Var(u)) is significantly different from zero. The null hypothesis (Ho) posits that the variance of the random effects is zero, implying that individual-specific effects are not significant and that a pooled OLS model would suffice.

In the provided results, the variance of life expectancy (LifeExp) is reported as 19.42068 with a standard deviation of 4.40689. The variance of the error term (e) is 2.339935 with a standard deviation of 1.529685, and the variance of the random effects (u) is 10.48759 with a standard deviation of 3.238455. These variances indicate the distribution and variability of the life expectancy data, the error term, and the random effects, respectively.

Table 7. **Test for Random Effects**

Breusch and Pagan Lagrangian multiplier test for random effects		
	Var	sd = sqrt(Var)
LifeExp	19.42068	4.40689
e	2.339935	1.529685
u	10.48759	3.238455
	Test: Var(u) = 0	
		chibar2(01) = 1076.19
		Prob > chibar2 = 0.0000

Note: Provided by Author, Calculated in STATA 14.2

The test statistic for the LM test is chibar2(01) = 1076.19, which is associated with a p-value of 0.0000. This extremely low p-value is highly significant and leads to the rejection of the null hypothesis that Var(u) = 0. The significant result indicates that the random effects model is indeed more appropriate than the pooled OLS model for this dataset.

This finding suggests that there are significant individual-specific effects that influence life expectancy, which need to be accounted for to improve the model's accuracy and fit. By rejecting the null hypothesis, the test confirms that the random effects model, which accommodates individual-specific heterogeneity, is better suited for analyzing the determinants of life expectancy in these low-income countries.

The Variance Inflation Factor (VIF) analysis reveals important insights about the multicollinearity present in the regression model. Multicollinearity refers to the situation where independent variables are highly correlated, potentially compromising the stability and interpretability of the regression coefficients. In this analysis, the VIF values for the independent variables are relatively low, suggesting that multicollinearity is not a significant concern (Table 8).

Table 8. **Variance Inflation Factor (VIF) Test**

Variable	VIF	1/VIF
GdpPc	1.53	0.653619
HealthExp	1.39	0.721304
GovHealthExp	1.38	0.723847
ArgLand	1.34	0.744634
Hiv	1.08	0.925096
Mean VIF	1.34	

Note: Provided by Author, Calculated in STATA 14.2

The highest VIF value in this model is 1.53 for GDP per capita, indicating only a mild degree of correlation with other variables. The reciprocal of the VIF (1/VIF) further confirms the absence of severe multicollinearity. Values closer to 1 indicate low multicollinearity, and in this case, the 1/VIF values range from 0.653619 for GDP per capita to 0.925096 for HIV prevalence.

These values suggest that the independent variables are sufficiently independent of one another, ensuring that the regression coefficients are stable, and the results of the model are reliable. The mean VIF is 1.34, reinforcing the overall conclusion that multicollinearity is not a significant Issue in this dataset.

This low mean VIF value indicates that, on average, the independent variables do not exhibit strong correlations with each other, allowing for a clearer interpretation of their individual effects on life expectancy. In conclusion, the VIF analysis supports the robustness of the regression model by demonstrating that multicollinearity is not a problem.

The Figure 1 clearly illustrates a positive trend in life expectancy at birth, total (years) across all the low-income countries under study from 2004 to 2021.

This upward trajectory indicates significant improvements in public health, healthcare access, and overall living conditions over the period. Each country, despite its unique challenges and starting points, demonstrates a consistent rise in the average lifespan of its population. This trend highlights the effectiveness of health interventions, economic development, and policy measures aimed at enhancing health outcomes.

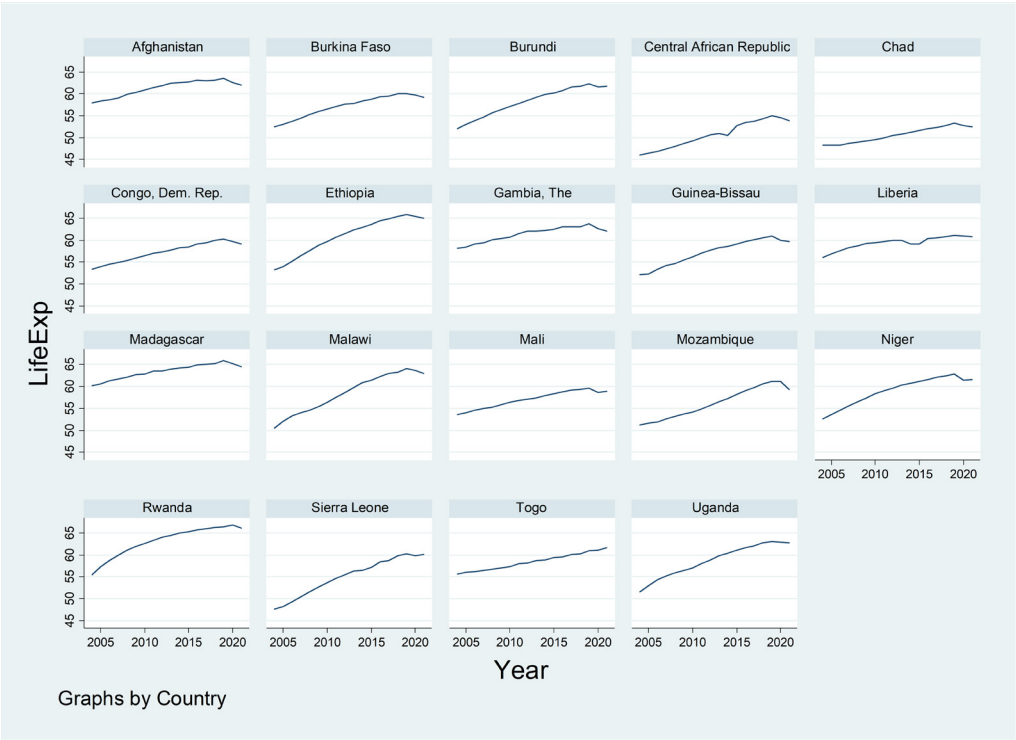

Figure 1. Life Expectancy-Years Diagram

Note: Provided by Author, Calculated in STATA 14.2

The consistent increase in life expectancy across diverse nations suggests a broader, regional improvement in health standards and quality of life, showcasing progress in combating diseases, improving nutrition, and expanding healthcare services. This figure underscores the critical importance of sustained efforts and investments in health and development sectors to continue this positive momentum in life expectancy.

5. Discussion

The analysis of life expectancy in low-income countries from 2004 to 2021 provides significant insights into the key factors that influence population health and longevity. The results of the regression analysis highlight the multifaceted nature of life expectancy determinants and align with existing literature on the topic. The positive relationship between GDP per capita (gdppc) and life expectancy underscores the importance of economic growth in improving health outcomes. Higher GDP per capita provides more resources for healthcare, better living conditions, and improved nutrition, all of which contribute to longer life expectancy.

This finding is consistent with previous studies that have shown economic prosperity to be a critical driver of health improvements Preston [1] and Bloom & Canning [2]. Both government health expenditure per capita (govhealthexp) and current health expenditure per capita (healthexp) are positively associated with life expectancy.

These results indicate that investments in healthcare are crucial for enhancing population health. Increased health expenditure translates to better healthcare services, more medical facilities, and improved access to treatments, which in turn reduce mortality rates and extend life expectancy. This is supported by literature emphasizing the role of health expenditure in improving health outcomes Nixon & Ulmann [24] and Gupta & Verhoeven [5].

The percentage of agricultural land (argland) also shows a positive association with life expectancy. This variable likely captures the importance of food security and nutrition. In low-income countries, where a significant portion of the population depends on agriculture for livelihood, a higher percentage of agricultural land can lead to better food availability and quality, thus improving health and longevity. Studies have highlighted the link between agriculture, food security, and health, corroborating this result Pongou et al. [25].

The negative impact of HIV prevalence (hiv) on life expectancy is significant and expected. High HIV prevalence rates are associated with increased mortality, particularly among the working-age population, thereby reducing the overall life expectancy. This finding is consistent with the extensive literature documenting the devastating effects of the HIV/AIDS epidemic on population health in many low-income countries Bor et al. [23].

The positive relationship between GDP per capita (gdppc) and life expectancy confirms that economic growth plays a crucial role in improving health outcomes. Higher income levels allow for better living conditions, improved nutrition, and greater access to healthcare services, contributing to longer life expectancy. This finding is consistent with previous studies that have demonstrated the impact of economic prosperity on health Bloom & Canning [2] and Preston [1].

The significant positive association between government health expenditure per capita (govhealthexp) and life expectancy underscores the importance of public investment in healthcare. Increased health expenditure ensures better healthcare services, more medical facilities, and improved access to treatments, which enhance population health and longevity. This aligns with

literature emphasizing the critical role of health expenditure in improving health outcomes (Nixon & Ulmann [24] and Gupta & Verhoeven [5]). The positive impact of the percentage of agricultural land (argland) on life expectancy highlights the importance of food security and nutrition.

In many low-income countries, agriculture is a primary source of livelihood, and higher agricultural productivity can lead to better food availability and quality, thereby improving health and extending life expectancy. Studies have highlighted the link between agriculture, food security, and health, corroborating this result Pongou [25].

The negative effect of HIV prevalence (hiv) on life expectancy is significant and expected. High HIV prevalence rates are associated with increased mortality, particularly among the working-age population, thereby reducing the overall life expectancy. This finding is consistent with extensive literature documenting the devastating effects of the HIV/AIDS epidemic on population health in many low-income countries Bor et al [23].

Thus, we make an exception for the complete fastening of hypotheses *H1* and *H2*.

Overall, the findings of this study align with existing research and provide a comprehensive understanding of the factors influencing life expectancy in low-income countries. The results highlight the need for integrated and sustained efforts to enhance economic conditions, expand healthcare services, and combat infectious diseases to achieve better health outcomes and extend life expectancy in these regions.

6. Conclusions

The regression analysis underscores the significant positive impact of economic prosperity on life expectancy. GDP per capita emerges as a crucial determinant, highlighting how increased economic resources translate into better living conditions, healthcare access, and overall health improvements. Similarly, both government health expenditure per capita and current health expenditure per capita are found to significantly enhance life expectancy, emphasizing the vital role of sustained investments in healthcare infrastructure and services.

Agricultural land percentage also shows a positive relationship with life expectancy, suggesting that agricultural productivity and food security are essential for improving health outcomes. This finding aligns with the understanding that adequate nutrition and food availability are fundamental for preventing malnutrition and related health issues, thereby contributing to longer lifespans.

Conversely, the prevalence of HIV negatively impacts life expectancy, reflecting the substantial health burden posed by the HIV/AIDS epidemic in these countries. The negative coefficient for HIV prevalence underscores the importance of continued efforts in HIV prevention, treatment, and care to mitigate its adverse effects on population health.

The Breusch and Pagan Lagrangian Multiplier test confirms the appropriateness of using a random effects model, indicating significant individual-specific effects across countries. This finding highlights the necessity of accounting for country-specific heterogeneity to obtain more accurate and reliable estimates of the factors affecting life expectancy. The analysis of variance inflation factors (VIF) reveals that multicollinearity is not a significant Issue in the model, ensuring the stability and reliability of the regression coefficients. The absence of high multicollinearity among the independent variables reinforces the robustness of the findings.

Theoretically, this research contributes to the existing body of literature by offering a nuanced understanding of how economic and health-related factors interplay

to influence life expectancy in low-income countries. It extends previous studies by integrating multiple determinants and employing a robust panel data approach, providing a more comprehensive picture of the factors driving life expectancy. The findings reinforce theories that link economic prosperity and health investment to improved health outcomes, and they illustrate the critical role of disease burden in shaping population health.

Practically, the study's findings have significant implications for policymakers in low-income countries. The positive impact of GDP per capita and government health expenditure on life expectancy suggests that policies aimed at boosting economic growth and increasing healthcare spending are essential for improving health outcomes. Enhancing agricultural productivity is also crucial, as it contributes to food security and better nutrition, which are vital for population health. Furthermore, the negative effect of HIV prevalence on life expectancy highlights the need for continued efforts in HIV/AIDS prevention and treatment programs. By addressing these key areas, policymakers can formulate strategies that effectively enhance life expectancy and overall well-being in low-income countries.

Overall, the results demonstrate the multifaceted nature of life expectancy determinants in low-income countries. Economic development, health investments, agricultural productivity, and disease burden all play crucial roles in shaping life expectancy. Sustained efforts and investments in these areas are essential to continue the positive momentum in life expectancy improvements observed over the study period.

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Факторы влияния на ожидаемую продолжительность жизни в странах с низким уровнем дохода: панельный анализ данных

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Аннотация. Понимание факторов, влияющих на ожидаемую продолжительность жизни в странах с низким уровнем дохода, имеет решающее значение для разработки эффективной политики в области здравоохранения и экономики. Данное исследование направлено на изучение детерминант ожидаемой продолжительности жизни в странах с низким уровнем дохода путем анализа панельных данных с 2004 по 2021 г. Гипотеза заключается в том, что экономические показатели, расходы на здравоохранение и сельскохозяйственные угодья существенно влияют на продолжительность жизни, в то время как высокая распространенность ВИЧ оказывает на нее негативное влияние. Процедура исследования включала в себя использование регрессионного анализа по методу наименьших квадратов (МНК) с ожидаемой продолжительностью жизни при рождении в качестве зависимой переменной и ВВП на душу населения (ППС, доллар в ценах 2021 г.), государственные расходы на здравоохранение на душу населения (в текущих ценах), сельскохозяйственные земли (процент от площади земель), распространенность ВИЧ (процент населения в возрасте от 15 до 49 лет) и текущие расходы на здравоохранение на душу населения (в текущих ценах) в качестве независимых переменных. Основные результаты показывают, что ВВП на душу населения, государственные расходы на здравоохранение и сельскохозяйственные угодья положительно влияют на ожидаемую продолжительность жизни, подчеркивая важность экономического роста, инвестиций в здравоохранение и продовольственной безопасности. Напротив, распространенность ВИЧ оказывает значительное негативное влияние на ожидаемую продолжительность жизни, подчеркивая бремя эпидемии для здоровья. Статистические тесты на гетероскедастичность и нормальность выявляют некоторые отклонения, но надежность анализа подтверждается с помощью соответствующих эконометрических методов. Теоретически исследование вносит вклад в литературу, обеспечивая детальное понимание того, как экономические факторы и факторы, связанные со здоровьем, взаимодействуют друг с другом, влияя на ожидаемую продолжительность жизни в странах с низким уровнем дохода. На практике полученные данные свидетельствуют о том, что политика, направленная на стимулирование экономического роста, увеличение расходов на здравоохранение, совершенствование методов ведения сельского хозяйства и борьбу с ВИЧ/СПИДом, имеет жизненно важное значение для увеличения продолжительности жизни. Это исследование дает ценную информацию для лиц, ответственных за разработку политики в странах с низким уровнем дохода, стремящихся улучшить показатели здоровья населения.

Ключевые слова: ожидаемая продолжительность жизни; страны с низким уровнем дохода; расходы на здравоохранение; ВВП на душу населения; распространенность ВИЧ-инфекции.

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