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Impact of Socioeconomic Factors on Life Expectancy: A Global Perspective Across Income Levels

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ABSTRACT

Socioeconomic factors influencing life expectancy are still underexplored across different income groups in global research. This study investigates the socioeconomic determinants of longevity across global income levels, drawing on World Bank data to analyze how various economic and social factors influence lifespan worldwide. A stepwise panel data regression analysis was conducted to examine the determinants. The findings indicate that increase per capita gross domestic product and health expenditure substantially enhance lifespan, whereas increase population size, death rate, and infant mortality rate adversely impact life expectancy globally. In low-income countries, increase per capita gross domestic product, population size, and death rate significantly shorten life expectancy. In lower-middle-income countries, growing population size and death rate progressively lower life expectancy. In upper-middle-income countries, higher per capita gross domestic product significantly boosts longevity, while increase carbon dioxide emissions, population size, death rate, and infant mortality rate substantially reduce life expectancy. In high-income countries, increase male education significantly raises lifespan, while increase population size and death rate reduce life expectancy. These findings can help policymakers, governments, the World Health Organisation, the United Nations, and the World Bank address key issues affecting life expectancy, promoting global health and sustainable economic growth.

1 | Introduction

Life expectancy is a crucial indicator of a country's public health and is widely used by international agencies to gauge national development (Azam et al. 2023). Significant disparities in longevity within and between nations pose a severe challenge to the global community, gaining more attention due to increasing political and public concern. Defined as the average number of years a new-born is expected to live, life expectancy is vital for understanding the health and development of societies (Heuveline 2022; Nkalu and Edeme 2019). The longer a population lives, the more advanced the society is. As such, life expectancy is a critical health indicator influencing economic growth and societal well-being (Miladinov 2020), shaped by factors such as age, sex, and geographical region. It is multidimensional, with different factors affecting various countries, often due to socioeconomic influences.

There are notable disparities in life expectancy between developed and developing countries. Earlier evidence indicates that mortality rates in countries such as India were significantly higher than in the United States and China (Nkalu and Edeme 2019; Schöley et al. 2022; Wang et al. 2023), although more recent estimates confirm that large gaps in longevity persist across income groups. Individuals facing socioeconomic deprivation are consistently shown to experience poorer health outcomes and an elevated risk of premature mortality (Ladoy et al. 2021). Global life expectancy ranges from approximately 52 years in countries such as Sierra Leone and the Central African Republic to over 84 years in Japan and Hong Kong (Freeman et al. 2020; Heuveline 2022; Jasilionis et al. 2023), highlighting stark health inequalities closely associated with income and resource distribution. According to updated World Development Indicators (WDI), high-income countries continue to have much longer life expectancy than low- and middle-income countries (Nzeh 2023). This is mostly because high-income countries invest more in social protection, healthcare, and sanitation.

The World Health Organisation (WHO) estimated that cardiometabolic diseases accounted for approximately 30% of global deaths in 2019 due to environmental pollution and poor health quality (Huang et al. 2024). The prevalence of these diseases, such as heart attack, stroke, and diabetes, has increased, affecting individuals regardless of age and leading to significant loss of life. Over the past 150 years, the expected lifespan gap between sexes has widened in many European industrialized countries. Female longevity has risen significantly in the UK and Australia, increasing from 76.6 and 78.2 years in 1980 to 83.3 and 85.4 years in 2019 (Minagawa 2022). According to Li (2024), male life expectancy has declined at a faster rate than female life expectancy in several regions, a trend attributed to higher prevalence of smoking, excessive alcohol consumption, and increased incidence of cardiovascular and diseases among men.

Increasing life expectancy requires more than just quality healthcare and financial stability; it is a complex issue. The global burden of cancer incidence and mortality is rising rapidly, mainly due to factors such as population growth and poor air quality (Rafiee et al. 2024), many of which are linked to socioeconomic development. Globally, 8.9 million deaths annually are linked to population, poverty, hunger, higher out-of-pocket (OOP) health expenses, and education inequality (Lelieveld et al. 2020). Lifelong poverty is associated with elevated stress, anxiety, and depression in later life, along with limited access to healthcare and essential resources, factors that may contribute to lower life expectancy (Azam et al. 2023). Limited education can hinder health awareness and overall well-being. Therefore, sustained improvements in population health are unlikely given socioeconomic determinants such as poverty, environmental deterioration, hunger, malnutrition, poor education, and inadequate sanitation.

Beyond direct income effects, socioeconomic conditions also influence life expectancy through intuitional quality and environmental sustainability. Economic and institutional determinants shape environmental health outcomes, which in turn affect population well-being and longevity (Dinu et al. 2024). Economic growth and employment structures influence how sustainability objectives are integrated into development strategies, with implications for long-term health outcomes (Raghu et al. 2025). Environmentally responsible behavior and the adoption of sustainability-oriented policies have been shown to mitigate environmental risks and improve public health, thereby contributing to higher life expectancy (George et al. 2020). These factors highlight that improvements in population longevity depend not only on individual income and healthcare access but also on broader institutional and environmental governance, which this study takes into account.

This study offers distinct contribution in four critical areas compared to previous research. First, this study uniquely explores the impact of socioeconomic factors on longevity across various income groups, using data from 2000 to 2022. Unlike previous research, which often focuses on specific health or demographic factors or is restricted to a limited number of countries, this study addresses a significant gap by analyzing the combined effects of socioeconomic factors on global life expectancy. It is the first to offer such extensive coverage, drawing from data across 159 countries over a substantial period. Second, while most studies on improving global life duration focus on objective health measures such as mortality and morbidity, this study considers subjective well-being, reflecting socioeconomic aspects. Employing Panel data stepwise regression offers a robust methodological approach, enabling a rigorous statistical analysis across selected global countries and providing a more comprehensive understanding of the impact of these variables over time. Third, graphical representations provide a nuanced understanding of current study, enabling readers to expeditiously identify countries at risk and those examining human longevity in relation to these factors. This infrequently utilized visual approach offers a clearer insight into the life expectancy trends, thereby garnering attention for future scholarly research. Fourth, according to World Bank and WHO data, global life expectancy increased steadily from 1960 to 2019, followed by stagnation or temporary declines in several regions during the COVID-19 period. These developments signal emerging challenges in population health, with important economic implications such as reduced productivity and rising healthcare costs, which may hinder progress toward sustainable development. Despite these concerns, the socioeconomic drivers of recent life expectancy stagnation and regional reversals remain insufficiently explored, underscoring the relevance and timeliness of the present study. The following sections of this study are structured as follows: Section 2 explores the relevant literature, while Section 3 outlines the data and methodology. Finally, Section 4 presents results and detailed discussion with conclusion, policy implications, limitations, and opportunities for future research.

2 | Theoretical Framework

Life expectancy is widely understood as a product of complex socioeconomic, demographic, and health-related determinants. A foundational lens for analyzing these determinants is the Social Determinants of Health (SDH) theory, which posits that the social conditions in which individuals are born, grow, live, work, and age fundamentally influence health outcomes and longevity (Preda and Voigt 2015). According to this framework, factors such as income, education level, employment status, and access to healthcare services shape exposure to risks and access to resources that promote health, thereby affecting population-level life expectancy trends. Empirical studies have demonstrated that socioeconomic status and related indicators are strongly associated with mortality and health inequalities globally (Marmot 2017), suggesting these variables should be central to understanding disparities in longevity across countries and over time.

In the broader demographic and development literature, economic and social development theories also offer important conceptual support for studying longevity. For example, studies in demographic economics have documented robust associations between income levels and life expectancy, such as the Preston curve, which illustrates how rising per capita income relates to higher life expectancy at the national level (Osei-Kusi et al. 2024). From a life-cycle perspective, socioeconomic status affects people's access to health resources and their health-related behaviors throughout life (Headey and Ruel 2023). This, in turn, shapes overall health and longevity. These insights justify focusing on broad socioeconomic structures, rather than only isolated health interventions, when studying differences in life expectancy across countries.

Moreover, contemporary theoretical approaches emphasize how capability and fundamental cause theories help explain persistent health inequalities (Guetterman et al. 2017). The capability approach suggests that income and education help people achieve important outcomes, like good health and longer life, by expanding their real opportunities (Azam et al. 2023). Similarly, the fundamental cause theory argues that socioeconomic resources such as wealth, knowledge, and social connections provide lasting health advantages, regardless of specific diseases (Mackenbach et al. 2017). These perspectives explain why socioeconomic factors are crucial for understanding persistent health inequality.

3 | Literature Review

3.1 | Global

The impact of carbon dioxide (CO_2) emissions on life expectancy operates through two interconnected mechanisms: an income or wealth effect related to economic activity and a health effect associated with environmental degradation (Arias et al. 2023). Economic growth often increases energy consumption and CO_2 emissions, worsening air quality and impacting population health. Recent global assessments indicate that poor air quality remained a major health risk, contributing to approximately 8.1 million deaths worldwide in 2021 and ranking as the second leading risk factor for mortality after high blood pressure (SGAR 2024). Furthermore, the most recent estimates suggest that in 2023 around 7.9 million deaths were still attributable to air pollution globally (SGAR 2025), with a large share of these deaths occurring in low- and middle-income countries due to higher exposures and limited access to healthcare.

Financial development has been linked to higher life expectancy by improving access to nutrition, healthcare, and medical technologies (Olshansky et al. 2024). However, persistent economic instability in many developing regions continues to constrain these potential benefits. Recent World Bank data show that per capita incomes in regions such as South Asia remain significantly below those in East Asia and Europe, even after adjusting for inflation and post-pandemic economic changes, which reinforces inequalities in health outcomes and life expectancy (Osei-Kusi et al. 2024). Adjusting per-capita income for inflation is crucial, as sustained high inflation erodes purchasing power, reduces household welfare, and increases social stress. These factors often translate into higher out-of-pocket health expenditures and diminished access to essential services, thereby negatively affecting population health and life expectancy. The role of inflation in shaping well-being and social stability has been documented across multiple studies. Abdalali and Abolfazl (2015) highlight the long-term effects on household welfare. Minagawa and Saito (2023) discuss the links with health access and Movsisyan et al. (2024) examine broader population-level consequences. Food security and nutrition also shape life expectancy. About one-third of global food is lost or wasted, with 670 million tons squandered in HICs and UMICs and 630 million tons in LICs and LMICs (Miyamoto et al. 2019). Meanwhile, persistent hunger continues to threaten health outcomes. Healthcare spending improves life expectancy in developed countries but shows weaker effects in developing regions (Obrizan and Wehby 2018). For instance, OECD countries, with less than 20% of the global population, account for over 85% of healthcare spending, achieving an average life expectancy of 81 years (Linden and Ray 2017). The global literacy rate is about 90% for males and 84% for females (Cheng et al. 2022). Nearly a billion people (95%) are illiterate in developing countries; two-thirds of women cannot read or write (70%) (Azam et al. 2023); educated people tend to have longer life expectancy.

Population growth further complicates health outcomes. Global population increased from 2.5 billion in 1950 to 8 billion in 2022 (Azam et al. 2023), straining sanitation, disease control, and access to clean water and healthcare. Cancer deaths are projected to rise from 8.2 million in 2012 to 14.6 million by 2035, particularly in developing regions (Cao et al. 2017). Although longevity growth has slowed, falling below 2 years in 2020, similar to the early 1990s AIDS crisis (Liou et al. 2020; Miladinov 2020), reduction in IMR remains crucial for improving lifespan.

3.2 | Low-Income Countries

Life expectancy in low-income countries (LICs) remains substantially lower than in high-income countries (HICs). LICs record an average life expectancy of approximately 53 years, compared with about 70 years in HICs (Ebhota et al. 2023; Mahalik et al. 2022; Nkalu and Edeme 2019; Nwude et al. 2020). Although Africa's life expectancy increased from 37 years in 1960 to 53 years in 2017, the region continues to perform poorly on the Environmental Performance Index, reflecting persistent environmental and health challenges (Islam et al. 2018). In some LICs, economic growth has been accompanied by environmental degradation. For example, industrial expansion and urbanization in Niger have worsened air quality (Sultana et al. 2024), while Zimbabwe's hyperinflation and economic crisis between 2007 and 2009 severely undermined public health outcomes (Thabani and Wellington 2017). Unlike HICs, many LICs struggle to manage inflation, resulting in rising prices for basic necessities and increased vulnerability among households.

Agricultural productivity in many LICs remains low, constraining food availability and nutritional outcomes (Ouellette et al. 2021). Several countries face worsening droughts and planting delays due to erratic and poor rainfall. Nevertheless, some LICs have made notable progress. Ethiopia's life expectancy rose from 38 years in the 1960s to 66 years in 2018, partly due to improvements in nutrition and public health interventions (Freeman et al. 2020; Wuletaw 2018). Despite this progress, challenges such as environmental degradation, food insecurity, and rapid population growth persist (Abduselam 2017; Zacarias 2019). High burdens of infectious diseases, malnutrition, unsafe water, poor sanitation, and limited access to healthcare continue to contribute to elevated morbidity and mortality rates. The WHO identifies factors such as underweight, overweight, smoking, alcohol consumption, hypertension, and risky sexual behavior as major contributors to disease burden and healthcare costs in these settings.

Demographic pressures further exacerbate health challenges in LICs. Rapid population growth and high fertility rates in countries such as Chad, Nigeria, and Lesotho place significant strain on food systems and healthcare infrastructure (Guzel et al. 2021; Torres et al. 2019). Education levels also remain low, particularly among women. In Sub-Saharan Africa, female illiteracy rates exceed 90% in countries such as Niger and Burkina Faso, contributing to poorer health outcomes and reduced longevity (Luy et al. 2019; Timonin et al. 2017). Gender disparities in healthcare access are pronounced, with maternal mortality rates reaching 1 in 41 women in LICs, compared with 1 in 3300 in HICs (Aladejare 2023). Many LICs have fewer than four nursing and midwifery personnel per 1000 people (Azam et al. 2023), and despite reductions in global child mortality, progress in tackling child diarrheal deaths remains slow.

3.3 | Lower-Middle-Income Countries

Environmental degradation plays a significant role in shaping life expectancy in lower-middle-income countries (LMICs). Pollution contributes to chronic conditions such as asthma, cardiovascular disease, and lung cancer, leading to premature mortality. Rising CO_2 emissions increase exposure to air and water pollution and intensify extreme weather events, further undermining population health (Mahalik et al. 2022). Countries such as India, Pakistan, Nepal, and Sri Lanka face adverse effects on life expectancy due to environmental factors (Siddique and Kiani 2020). Alongside environmental conditions, food security, education, fertility, and income levels remain key determinants of life expectancy (Alkire et al. 2018; Guzel et al. 2021). However, inflation exacerbates these challenges by reducing purchasing power (Headey and Ruel 2023), leading to malnutrition, poor health, and limited access to quality food, education, and healthcare.

Country-specific evidence highlights persistent vulnerabilities. Pakistan ranks 99th out of 129 countries in the Global Hunger Index (GHI), with a serious level of hunger and high levels of cardiovascular and cancer-specific mortality (Qing-xiao et al. 2021). In India, structural factors such as widespread poverty, limited employment opportunities, and gender inequality have been associated with increased participation in sex work in specific regions (Lalhruaimawii et al. 2022). These vulnerabilities contribute to elevated rates of HIV/AIDS, higher healthcare costs, and increased mortality. Poor sanitation also significantly affects health, with approximately 432,000 deaths annually linked to inadequate sanitation (Radmehr and Adebayo 2022). India's ratio of one doctor per 2083 people creates long wait times and limited resources, while the U.S.'s ratio of one doctor per 500 people improves healthcare access and potentially increases longevity (IPS 2022). In Pakistan, 22.5 million children are out of school, with 87% of girls leaving before ninth grade, which leads to low health awareness (Azam et al. 2023; McLoughlin 2024), while Sri Lanka's greater education provides individuals with resources to build a healthier lifestyle.

Demographic and spatial factors also affect longevity in LMICs. Urbanization is rising, with over 55% of the population in these countries living in urban areas, and it is projected to reach nearly 70% by 2050 (Bilal et al. 2021). High fertility rates are associated with lower educational attainment, increased deprivation, and elevated health risks for mothers and children (Islam et al. 2018). Rural areas often face lower living standards, limited healthcare access, and higher neonatal mortality, which reduce overall life expectancy. Recent shocks, such as the COVID-19 pandemic, have further affected mortality trends; for example, Bangladesh's mortality rate increased from 5.3 per 1000 people in 2019 to 5.5 per 1000 in 2020 (Uddin et al. 2024). Evidence also shows that younger maternal age and multiple births are associated with higher infant mortality rates, further constraining longevity gains in these countries.

3.4 | Upper-Middle-Income Countries

Upper-middle-income countries (UMICs), together with LMICs, account for a substantial share of global carbon emissions. In 2019, these groups contributed approximately 53% of global emissions, releasing about 8.4 billion metric tons of CO_2 from power generation, industrial activity, forest fires, and agricultural waste burning (Mahalik et al. 2022). Elevated pollution levels increase the prevalence of chronic diseases and infant mortality, thereby reducing life expectancy. In highly polluted countries like China, air pollution, particularly from industrial sources, further diminishes life expectancy (Siddique and Kiani 2020), highlighting the need for emission reductions.

Economic conditions play a central role in shaping longevity outcomes in UMICs. Higher per capita income is generally associated with longer life expectancy. For example, in Russia, a doubling of per capita GDP between 2005 and 2015 coincided with an increase of approximately 6 years in life expectancy (Andres et al. 2023; Vladimir et al. 2019). Similarly, Brazil experienced improvements in access to food, education, and healthcare as per capita income rose from about USD 3000 to over USD 11,000 between 2000 and 2014, contributing to longer lifespans (Almeida et al. 2021). Macroeconomic stability, including low inflation, is crucial for maintaining purchasing power and health outcomes (Kabir and Ahmed 2019), especially in poorer households.

As income levels rise, dietary patterns and health investments tend to improve. UMICs often experience shifts toward healthier food consumption, which positively influences life expectancy (Erdogan 2022; Mimi et al. 2024; Templin et al. 2019). In Chile, investments in food production technology improved nutritional outcomes and contributed to longevity gains (Neumayer and Plümper 2015). Increased healthcare spending has also supported improvements in life expectancy. In several Arab UMICs, life expectancy rose from approximately 51–71 years over the past two decades, although per capita health expenditure remains below levels observed in high-income countries (Barkat et al. 2019). For example, Qatar, the UAE, and Kuwait spent $1776, $1500, and $1640, respectively, spending significantly less than $4593 in OECD countries (Jayadevan and Trung Hoang 2024). Evidence from China further suggests that rising medical expenditure has had a positive effect on lifespan (Uddin et al. 2024). Education plays a complementary role by improving socioeconomic conditions and reducing mortality. In the 1940s, only 25% of Brazilian children aged 5–14 attended school; between 1997 and 2005, college enrolment rose from 2 million to 4.5 million (Turra et al. 2016). This shift has contributed to a decline in adult female mortality in 2010.

Demographic transitions further influence life expectancy in UMICs. In China, mortality declined prior to fertility reductions, resulting in an initial period of rapid population growth followed by ageing, lower fertility, and longer life expectancy (Crimmins et al. 2016). Women generally outlive men but experience a higher burden of chronic conditions (Abalos and Booth 2020). Thailand experienced a rapid decline in fertility and infant mortality during the 1980s due to changes in reproductive behavior (Kochanek et al. 2016). In 2020, life expectancy in Brazil fell to 74.8 years due to COVID-19 mortality but recovered to 75.4 years by 2022 (McLoughlin 2024). Despite differences in healthcare, economic, and behaviors like smoking, these factors are closely linked to life expectancy.

3.5 | High-Income Countries

Although high-income countries (HICs) account for a smaller share of the global population, environmental degradation particularly in HICs and UMICs poses significant risks to human health and ecosystems. These countries contribute more than 80% of global CO_2 emissions, largely due to energy-intensive production and transportation systems (Emodi et al. 2022). In 2019, aircraft produced an estimated 15.6 million tonnes of CO_2, while petrol cars generated 3.7 million tonnes across regions such as the U.S. (69%), Canada, Germany and the UK (Nadeem et al. 2020). Exposure to air pollution has been associated with adverse health outcomes, including impaired fetal development, respiratory disease, cardiovascular conditions, and mental health effects. From 2001 to 2014, higher incomes in Australia, Singapore, and Sweden were linked with a longer lifespan due to better access to healthcare, clean water, and economic resources (Kontis et al. 2017; Sultana et al. 2024). These countries typically enjoy higher longevity due to superior living standards, robust healthcare systems, and better infrastructure.

Macroeconomic stability and access to resources further support longevity in HICs Countries such as Norway, with life expectancy approaching 83 years, benefit from stable economic conditions that support access to quality nutrition and healthcare services (Wirayuda and Chan 2021). However, the specific pathways through which inflation affects health outcomes in high-income settings remain insufficiently examined. High levels of food production and dietary quality are also associated with longer life expectancy (Freeman et al. 2020; Reynolds and Avendano 2018). For example, in the U.S., where protein-rich diets make up 47.3% of the intake, the average lifespan is 76 years; in France, with 36.5% protein, it is 82 years; in Italy, with 38.2% protein, it is 83 years; and in the Czech Republic, with 38.5% protein, it is 77 years (Wang et al. 2022). Despite significant healthcare spending, the U.S. ranks 42nd globally for life expectancy, with poorer health outcomes than most industrialized countries (Reynolds and Avendano 2018). Education and demographic factors further shape life expectancy patterns in HICs. Higher educational attainment has been shown to reduce mortality risk in countries such as the United Kingdom and the United States (Luy et al. 2019), while lower education levels are associated with poorer long-term health outcomes.

Countries like Hong Kong demonstrate how low population growth, BR, and mortality can enhance longevity (Hiam et al. 2021). However, Japan and Finland are increasingly adopting the child-free lifestyle, with many choosing to deter childbearing, contributing to challenges related to an ageing population (Nomura and Koizumi 2016). Evidence from Sweden and Scotland highlights the importance of reducing mortality in early childhood and middle age to sustain high life expectancy (Canudas-Romo et al. 2019; Torres et al. 2019). From 2005 to 2015, 98.5% of all deaths in Norway were due to health issues (Kinge et al. 2019). High IMR and mortality in Appalachia have been linked to poverty and poor economic conditions (Singh et al. 2017). Australia's life expectancy of 82–84 years is supported by financial stability, a robust education system, and low birth and IMR (Ye et al. 2016), enabling better healthcare and resources.

4 | Data and Methodology

This study systematically conducted a panel data regression analysis to examine the impact of socioeconomic factors on global life expectancy, using gathered secondary data in the Appendix S1.

The analysis drew its data from the World Bank, as indicated in Table 1. Some countries were omitted from the dataset due to the absence of data for several variables. STATA statistical software was utilized for data analysis, and graphical representations were crafted using MapChart and OriginLab.

4.1 | Stationarity and Stability Assessment

Stationarity ensures that a time series maintains consistent statistical properties like mean and variance over time, while stability guarantees that the model's predictions remain reliable across different periods (Jin 2017). The Levin-Lin-Chu unit-root test shows that CO_2, PGDP, FPI, BR, IMR and inflation are stationary. After generating the second difference between life expectancy and population and first difference between health expenditure, death rate, male education, and female education, all 12 variables are stationary, as detailed in the Appendix S2. However, PGDP, FPI, and inflation were generated for the first differences to ensure stability. To achieve stability, variables were generated with lags one lag for CO_2, PGDP, FPI, health expenditure, population, death

TABLE 1 | Data sources and variables.

Variable	Definition	Measure	Source
Dependent variable			
LE	Life expectancy	Life expectancy at birth, total (years)	The World Bank https://data.worldbank.org/indicator/SP.DYN.LE00.IN
Independent variables (socioeconomic factors)			
CO_2	Carbon dioxide emissions	CO_2 as a percentage of population (annual %)	The World Bank https://data.worldbank.org/indicator/EN.ATM.CO2E.PC
PGDP	Per capita gross domestic product	GDP per capita (current U.S.$)	The World Bank https://data.worldbank.org/indicator/NY.GDP.PCAP.CD
FPI	Food production index	Food production index (2014–2016 = 100)	The World Bank https://data.worldbank.org/indicator/AG.PRD.FOOD.XD
HE	Health expenditure	Current health expenditure (% of GDP)	The World Bank https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS
POPU	Population	Population, total (annual %)	The World Bank https://data.worldbank.org/indicator/SP.POP.TOTL
BR	Birth rate	Birth rate, crude (per 1000 people)	The World Bank https://data.worldbank.org/indicator/SP.DYN.CBRT.IN
DR	Death rate	Death rate, crude (per 1000 people)	The World Bank https://data.worldbank.org/indicator/SP.DYN.CDRT.IN
IMR	Infant mortality rate	Mortality rate, infant (per 1000 live births)	The World Bank https://data.worldbank.org/indicator/SP.DYN.IMRT.IN
INF	Inflation	Inflation, consumer prices (annual %)	The World Bank https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG
ME	Male education	Literacy rate, adult male (% of male ages 15 and above)	The World Bank https://data.worldbank.org/indicator/SE.ADT.LITR.MA.ZS
FE	Female education	Literacy rate, adult female (% of female ages 15 and above)	The World Bank https://data.worldbank.org/indicator/SE.ADT.LITR.FE.ZS

Source: Compiled by authors.

rate, male education, and female education; two lags for IMR and inflation; and three lags for BR. Life expectancy also required one lag. Appendix S3 confirms that the eigenvalues of the predictors fall within the unit circle, meeting the stability criterion. To account for differences in scale and units, PGDP, population, and CO_2 emissions were log-transformed prior to differencing. All other variables, measured in percentages or counts, were used in their original units after differencing. This ensures that regression coefficients are comparable and that no single variable dominates the model due to scale differences.

4.2 | Stepwise Model Equation and Visual Overview

The stepwise method adds or removes predictor variables in a regression model based on statistical criteria like *p*-values, *t*-statistics, or *F*-statistics. It aims to identify the most accurate and economical subset of predictors to explain the relationship between the dependent and predictor variables (Zhang 2016). The study utilized maps for each income category to depict lifespan visually. Life expectancy average value was calculated for each country over the specified period.

The mathematical framework begins with a comprehensive model including all candidate variables (Equation 1). For each income group, stepwise regression was used to select only statistically significant predictors, resulting in Equations (2–6). Differences in variable inclusion across models reflect this data-driven selection process.

$$LE_{it} = \beta_0 + \beta_1(CO2_{it}) + \beta_2(PGDP_{it}) + \beta_3(FPI_{it}) + \beta_4(HE_{it}) + \beta_5(POPU_{it}) + \beta_6(BR_{it}) + \beta_7(DR_{it}) + \beta_8(IMR_{it}) + \beta_9(INF_{it}) + \beta_{10}(ME_{it}) + \beta_{11}(FE_{it}) + \varepsilon_{it} \quad (1)$$

In Equation (1), LE_{it} represents the value of the dependent variable at time "t" for the "i" countries, while ε_{it} represents the residual error term for time t. The coefficients "betas" denote the intercept and slopes of the regression line, illustrating the impact of the independent variables on the dependent variable LE_{it}.

4.2.1 | Global Model Equation

$$LE_{it} = \propto_0 + \propto_1(CO2_{it}) + \propto_2(PGDP_{it}) + \propto_3(FPI_{it}) + \propto_4(POPU_{it}) + \propto_5(BR_{it}) + \propto_6(DR_{it}) + \propto_7(HE_{it}) + \propto_8(ME_{it}) + \propto_9(FE_{it}) + \varepsilon_{it} \quad (2)$$

At a global level, Equation (2) has been formulated the impact of 10 independent variables on the dependent variable LE_{it} within the context of time "t" and "i" countries. LE_{it} represents the dependent variable for each period, while ε_{it} captures the residual error. The coefficients "alphas" denote the intercept and slopes of the regression line.

4.2.2 | Model Equation for Low-Income Countries

$$LE_{it} = \psi_0 + \psi_1(PGDP_{it}) + \psi_2(FPI_{it}) + \psi_3(POPU_{it}) + \psi_4(BR_{it}) + \psi_5(DR_{it}) + \psi_6(HE_{it}) + \psi_7(ME_{it}) + \psi_8(FE_{it}) + \varepsilon_{it} \quad (3)$$

In Equation (3) has been derived from an analysis focusing on LICs. Here, LE_{it} symbolizes the value of the dependent variable each period, while ε_{it} characterizes the residual error term. The intercept ψ_0 signifies the anticipated value of the dependent variable when all independent variables equal zero. The slopes "psis" depict the alteration in the dependent variable linked with a unitary shift in each independent variable, holding all other independent variables constant.

4.2.3 | Model Equation for Lower-Middle Income Countries

$$LE_{it} = \infty_0 + \infty_1(CO2_{it}) + \infty_2(PGDP_{it}) + \infty_3(FPI_{it}) + \infty_4(POPU_{it}) + \infty_5(BR_{it}) + \infty_6(DR_{it}) + \infty_7(HE_{it}) + \varepsilon_{it} \quad (4)$$

In essence, Equation (4) furnishes a mathematical framework illustrating the impact of independent variables on the dependent variable specifically within the LMICs. Here, ε_{it} is the residual error term. The coefficients "infinities" encapsulate both the intercept and slopes of the regression.

4.2.4 | Model Equation for Upper-Middle Income Countries

$$LE_{it} = \wp_0 + \wp_1(CO2_{it}) + \wp_2(PGDP_{it}) + \wp_3(FPI_{it}) + \wp_4(POPU_{it}) + \wp_5(BR_{it}) + \wp_6(DR_{it}) + \wp_7(HE_{it}) + \wp_8(ME_{it}) + \varepsilon_{it} \quad (5)$$

Equation (5) serves as a tool to understand how various independent factors impact the dependent variable within the UMICs. The residual error term, ε_{it} captures any differences between the observed and predicted values of the dependent variable based on the independent variables. The coefficients "script ps" signify both the intercept and slopes of the regression line.

4.2.5 | Model Equation for High-Income Countries

$$LE_{it} = \forall_0 + \forall_1(CO2_{it}) + \forall_2(PGDP_{it}) + \forall_3(POPU_{it}) + \forall_4(BR_{it}) + \forall_5(DR_{it}) + \forall_6(HE_{it}) + \forall_7(ME_{it}) + \varepsilon_{it} \quad (6)$$

In simpler terms, Equation (6) mathematically represents the impact of independent variables on the dependent variable life expectancy for each period at the HICs. It captures the expected value of LE_{it} and the influence of each independent variable. Here, ε_{it} is the residual error term, and "universal quantifiers" represent the intercept and slopes of the regression line.

Multicollinearity is a statistical issue when the independent variables in a regression model are highly correlated. This can result in both consistent and reliable outcomes, making it challenging to interpret the individual impacts of each independent variable.

The correlation metric was used to evaluate the presence of multicollinearity among the variables in all countries, as shown in Appendix S4. The results show that IMR, defined as the number of infant deaths per 1000 live births, is highly inversely correlated with life expectancy ($r = -0.94$). This strong correlation indicates a serious multicollinearity risk if both variables are included in the same regression model (Sarıyıldız 2025). Therefore, to avoid multicollinearity and ensure reliable estimation, IMR was excluded from all regression models where life expectancy is the dependent variable. In Equations (2–6), the inflation variable was omitted due to its high correlation with other variables. The study utilized the stepwise method to analyze and identify the most suitable variables for the global final models and for each income level. The procedure involved executing Panel data regression models, employing both the FEM and REM, which were then used to compute the "t" and "z" values for each variable. These values were individually sorted in descending order based on their magnitudes. Subsequently, the Panel data regression models were rerun for both FEM and REM, incorporating the sorted variables in descending order, one by one. If a variable's coefficient sign differed from previous literature findings, it was excluded from the model (Ratan et al. 2019), and the process was repeated until the best model was obtained for each income level and globally.

In the Panel data regression, the CO_2 and IMR variables were eliminated in LICs; the male education and female education variables were excluded in LMICs, and female education was excluded in UMICs. Finally, FPI and female education were removed in HICs due to changes in the sign of the coefficient values.

Various tests were conducted to determine the most appropriate model for the analysis. These tests include the *F* test, Breush-Pagan Lagrange Multiplier (LM), and Hausman tests. The *F* test is a statistical method employed to assess the overall significance of a model. It is utilized to evaluate the null hypothesis that all regression coefficients are equal to zero. In this case, the Pooled Ordinary Least Squares and FEM were employed to identify the optimal method via the *F* test. The Breusch-Pagan LM test is utilized to identify heteroscedasticity, which occurs when the variance of the errors is not constant. This test determines the best method between the Pooled Ordinary Least Squares and the REM. The Hausman test serves to ascertain the most suitable model, whether it be FEM or REM, for the given dataset. The Hausman test was conducted to determine the best method to use between FEM and REM. The results of the specification tests are shown in the Appendix S5. These tests will offer crucial information on the suitability of the different models and help to determine the most effective approach for analysis.

5 | Results and Discussion

The study's primary purpose is to examine the impact of socioeconomic factors on life expectancy. The research analyzed 3180 observations across global LICs, LMICs, UMICs, and HICs. The results indicate that HICs have the highest life expectancy, while LICs, LMICs, and UMICs have the lowest. Appendix S6 presents predictors of life expectancy in low, lower-middle, and upper-middle-income countries, while Appendix S7 focuses on high-income countries. Table 2 presents the best model fit for panel data analysis across different income groups. It includes a combined analysis for all countries and a separate evaluation for each income group.

The *F*-test results rejected the null hypothesis (H_0) for all five income levels, indicating that the FEM is more appropriate at a 1% significance level. The FEM is suitable over the Pooled Ordinary Least Squares model, which was deemed inappropriate due to a *p*-value below 0.05 (Mahalik et al. 2022). The Breush-pagan LM test showed a value of 0.00 with a *p*-value above 0.05, indicating that the H_0 cannot be rejected (Gujarati 1995) and the REM is unsuitable. Thus, the Pooled Ordinary Least Squares model is preferred. Consequently, the Breush-pagan LM test was excluded from Table 2 due to its zero value. The Hausman test further validated the FEM for global and HICs, with a *p*-value under 0.05 (Siddique and Kiani 2020), at a 5% significance level. However, the REM proved more appropriate for LICs, LMICs, and UMICs, as the H_0 could not be rejected. These findings underscore the need to consider income levels when choosing the most suitable panel data model.

TABLE 2 | Specification tests for the final stepwise panel regression model.

	Tests	
	***F* test**	**Hausman test**
	H_0: Pooled ordinary least squares	**H_0: Random effect**
Income levels	**H_1: Fixed effect**	**H_1: Fixed effect**
Global	3576.00***	26.90**
LICs	993.22***	2.23
LMICs	2608.33***	4.98
UMICs	3362.27***	10.26
HICs	5195.02***	21.06**

Note: The symbols **, and *** represent 5%, and 1% significance level, respectively.

As depicted in Table 3, the final selection between REM and FEM, detailing their coefficients, Robust Standard Error (RSE) values, significant groups and R^2 outcomes for global and each income level. IMR was initially considered as an explanatory variable. However, the pre-regression correlation analysis (Appendix S4) shows that IMR is highly inversely correlated with life expectancy ($r = -0.94$). To avoid multicollinearity, IMR was therefore excluded from the regression results reported in Table 3.

Data analysis from 159 countries reveals that PGDP, health expenditure, population, death rate, and IMR significantly impact global lifespan, while CO_2, FPI, BR, male education, and female education show insignificant effects. The overall model fit, indicated by an R^2 value 0.9212, means 92.12% of the variance in the output variable is explained by the variance in the input variables. The results suggest that a 1% increase in the change of PGDP from the previous period raises longevity by 0.0868 at the 5% significant level. This finding supports Miladinov (2020), who documents a positive and statistically significant relationship between GDP per capita and life expectancy across European countries, and Wang and Lejia (2021), who report that income growth improves longevity in middle-income countries through better access to healthcare and nutrition. Higher PGDP increases life duration by promoting economic growth and development. While higher income generally improves living conditions and access to healthcare, boosting life expectancy and increase PGDP can also elevate CO_2 emissions, which may reduce life expectancy (Vladimir et al. 2019). Thus, PGDP alone can only increase lifespan if environmental protection is vital. Here, a 1% increase in the change of health expenditure from the previous year modestly boosts longevity by 0.0010 at the 10% significant level. This supports findings (Al-Azri et al. 2020; Jakovljevic et al. 2016; Polcyn et al. 2023; Uddin et al. 2024) that connect improved healthcare spending with more outstanding

TABLE 3 | Selected fixed and random effect estimates for the final stepwise model.

	Global	LICs	LMICs	UMICs	HICs
Equations	$Y=f(CO_2$; PGDP; FPI; POPU; BR; DR; HE; ME; FE)	$Y=f$(PGDP; FPI; POPU; BR; DR; HE; ME; FE)	$Y=f(CO_2$; PGDP; FPI; POPU; BR; DR; HE)	$Y=f(CO_2$; PGDP; FPI; POPU; BR; DR; HE; ME)	$Y=f(CO_2$; PGDP; POPU; BR; DR; HE; ME)
Variables	D2. LE_{t-1}	D2. LE_{t-1}	D2. LE_{t-1}	D2. LE_{t-1}	D2. LE_{t-1}
	FEM	REM	REM	REM	FEM
CO_{2t-1}	−0.0001		−0.0013	−0.0022*	−0.00004
	(0.0001)		(0.0025)	(0.0012)	(0.00006)
D.$PGDP_{t-1}$	0.0868**	−0.0645*	0.0278	0.0549**	0.02490
	(0.0290)	(0.0376)	(0.0534)	(0.1565)	(0.0286)
D.FPI_{t-1}	0.0001	0.0004	0.0003	0.00004	
	(0.0001)	(0.0005)	(0.0004)	(0.00007)	
D.HE_{t-1}	0.0010*	7.59e−06	−0.0004	0.0044	0.0004
	(0.0005)	(0.0005)	(0.0018)	(0.0042)	(0.0003)
D2. $POPU_{t-1}$	−1.8468***	−1.9952***	−1.7317***	−2.8987***	−3.9916***
	(0.0134)	(0.0262)	(0.0206)	(0.0202)	(0.0266)
BR_{t-3}	−0.0006	−0.0019	0.0005	0.0019	−0.0001
	(0.0007)	(0.0024)	(0.0074)	(0.0027)	(0.0078)
D.DR_{t-1}	−0.2888***	−0.1619***	−0.2192***	−0.0669***	−0.0203*
	(0.0145)	(0.0292)	(0.0312)	(0.0123)	(0.0111)
D.INF_{t-2}					
D.ME_{t-1}	0.0036	0.0003		0.0087	0.0457**
	(0.0104)	(0.0072)		(0.0251)	(0.0174)
D.FE_{t-1}	0.0008	0.0007			
	(0.0031)	(0.0037)			
Constant	0.0255*	0.0350	−0.0006	0.0636	0.0003
	(0.0131)	(0.0949)	(0.1654)	(0.0575)	(0.0119)
N	3180	480	900	760	1040
No. of countries	159	24	45	38	52
No. of years	23	23	23	23	23
R^2 Within	0.9222	0.9466	0.9610	0.9770	0.9765
R^2 Between	0.6259	0.8062	0.6122	0.5318	0.9756
R^2 Overall	0.9212	0.9462	0.9604	0.9736	0.9765

Note: The symbols *, **, and *** represent 10%, 5%, and 1% significance level, respectively. Parentheses represent the RSE. FE and RE represent the Fixed effect and Random effect, respectively.

lifespan. SAARC and Asian countries demonstrate that higher health spending, both public and private, has reduced IMR over the past 20 years (Owumi and Eboh 2022; Ray and Linden 2020). However, developed countries benefit significantly from substantial healthcare investments, while developing countries face shorter life expectancy due to less robust health systems and higher OOP expenses.

Furthermore, a 1% rise in the population change and death rate from the past year decreases longevity by 1.8468 and 0.2888, respectively, at the 1% significant level. This aligns with (Apte et al. 2018; Heuveline 2022) findings that mortality is significantly impacted by lifespan, which is exacerbated by overpopulation, leading to increased environmental pollution and a higher incidence of diseases such as ischemic heart disease, strokes, lung cancer, and respiratory infections. Over 55% of the world's population currently faces overpopulation issues, a figure expected to reach nearly 70% by 2050 (Bilal et al. 2021). The global population will grow from 7.8 billion in 2020 to 10.9 billion by 2100, impacting economic factors, education, and the environment (Cheng et al. 2022). Global deaths rose from 50.7 million in 2000 to 56.5 million in 2019 (Liou et al. 2020), partly due to population and disease spread. For example, COVID-19 has further decreased global lifespan. IMR, commonly associated with negative impacts on life expectancy, reflects the number of deaths in children under 1 year per 1000 live births (Miladinov 2020). Polluted drinking water transmits illnesses and contributes significantly to high IMR and lower life expectancy. The WHO reports 485,000 diarrheal deaths annually, primarily due to unsafe drinking water (Rahman et al. 2022). Additionally, pregnancies in teenagers under 18 pose risks to both mother and child, further affecting life expectancy.

The study shows that in 24 LICs, PGDP, population and death rate significantly influence life expectancy, while FPI, health expenditure, BR, male education, and female education are insignificant. Its overall R^2 value is 0.9462, which means the model was fitted by 94.62%. A 1% increase in the change of PGDP from the previous period reduced longevity by 0.0645 at the 10% significant level. These findings correspond with previous research (Nketiah-Amponsah 2019), which shows that higher PGDP can increase environmental degradation, reducing lifespans in Chad. Economic growth often triggers rapid urbanization, resulting in overcrowding and ecological harm, including air and water pollution. The most common explanation for the relationship between PGDP and longevity is that rising inequality and increased psychosocial stress harm population health by intensifying competition (Blázquez-Fernández et al. 2018). A 1% rise in the change of population and death rate from the prior period leads to a substantial decrease in life expectancy by 1.9952 and 0.1619, respectively, at the 1% significant level. Despite steady progress, infectious diseases still account for 30% of deaths in Sudan; 26% of the population practized open defecation, and 30% relied on unimproved sanitation (Charani et al. 2019). Overpopulation has strained government resources, resulting in insufficient facilities and services. The major life expectancy issue is most people die from HIV/AIDS-related illnesses (Torres et al. 2019). The situation is worsened by a severe shortage of medical resources, with just one doctor for every 38,000 people. This result is consistent with Torres et al. (2019), who show that rapid population growth increases mortality pressures in Sub-Saharan Africa, and with Apte et al. (2018), who demonstrate that higher population density exacerbates pollution-related mortality, thereby reducing life expectancy. As indicated in Figure 1, Central Africa, Chad, South Sudan, Sudan, Mozambique and Sierra Leone fall into the risk category, with average life expectancy of 49.90, 50.21, 53.25, 53.25, 55.23, and 53.67 years, respectively. In contrast, Syria has the highest average life expectancy at 70.65 years. This suggest that LICs face challenges in economy, managing overpopulation, and addressing high HIV mortality, exacerbated by limited resources.

The results for the 45 lower-middle-income countries (LMICs) indicate that changes in population size and death rate are the most

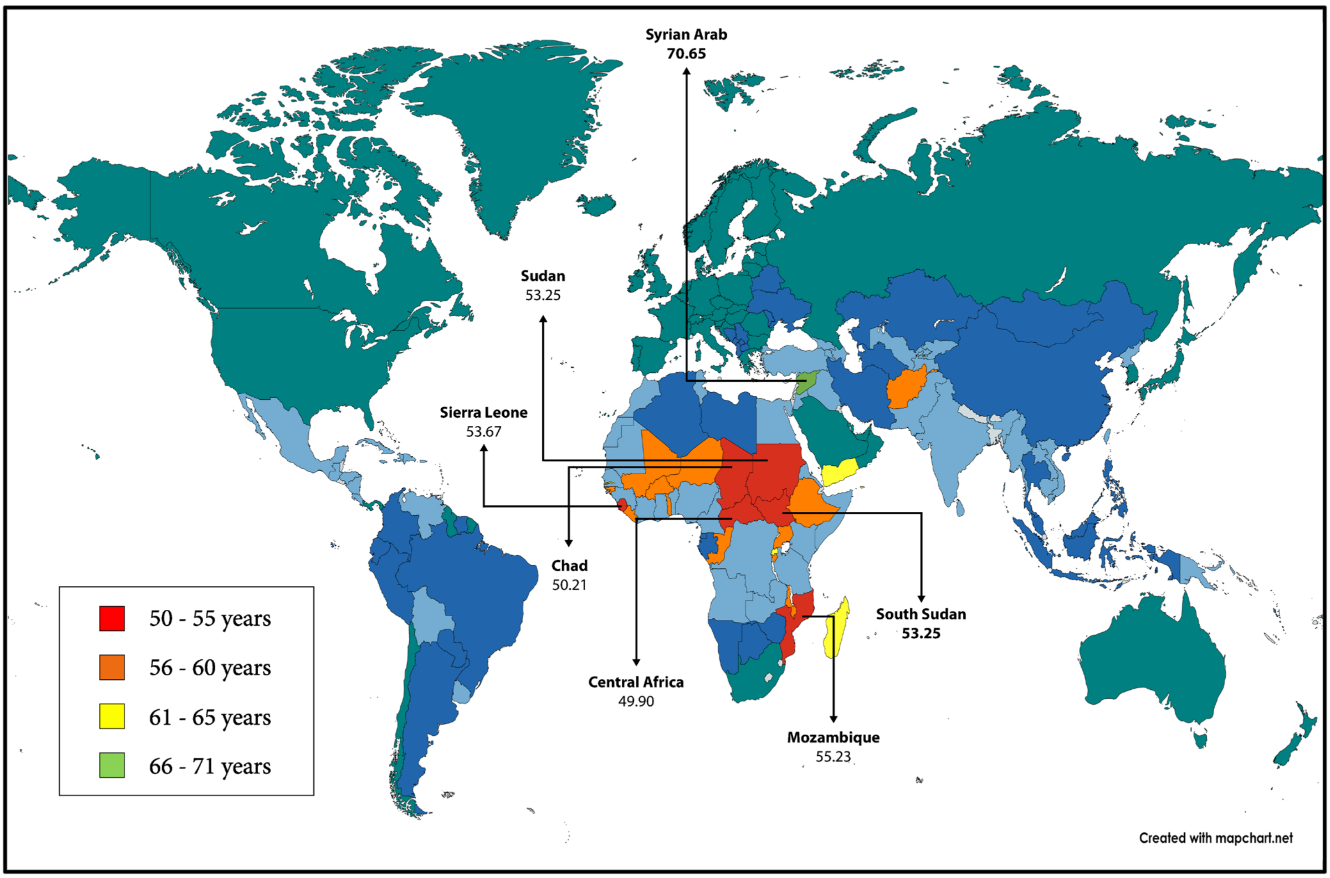

FIGURE 1 | Ordered predictors of life expectancy in low-income countries. *Source:* Authors' illustration based on data.

significant short-run determinants of life expectancy, while CO_2 emissions, per-capita GDP, food production index, health expenditure, birth rate, and infant mortality rate do not show statistically significant effects in the final stepwise model. The high within-R^2 value (96.04%) reflects the strong persistence of life expectancy over time and the use of a dynamic panel framework with differenced and lagged variables, rather than the explanatory power of only two covariates. A 1% rise in the change of population and death rate from the previous period caused life cycle to plummet by 1.7317 and 0.2192, respectively, at the 1% significance level. The findings are consistent with (Arias-Meza et al. 2023) India, now the world's most populous country, which faces challenges due to its rapid growth population of over 1.4 billion people, with an annual growth rate of around 1%. Lesotho experienced the most significant decline in life expectancy, dropping from 57.68 years in 1995 to 54.66 years in 2017 (Xinxi et al. 2020), primarily due to overpopulation. This put immense pressure on healthcare systems, education, and infrastructure, resulting in limited access to essential services. These limitations disproportionately affect poor and vulnerable groups (Azam et al. 2023), particularly women and children. Bangladesh and India high water-borne diseases mortality such as diarrhea, cholera and typhoid negatively impact life expectancy (Rahman et al. 2015). An increase in this pattern of deaths may unfortunately lead to premature loss of life. Figure 2 identifies Lesotho, Eswatini, Niger, Zimbabwe, and Cote d Ivoire as high-risk countries, with average lifespan of 48.20, 50.05, 50.73, 52.46, and 55.17 years, respectively, while Morocco, Nicaragua, Samoa, Sri Lanka, Iran, Vietnam, Jordan, Tunisia, and Lebanon reach the highest longevity, at 71.05, 71.14, 72.02, 73.20, 73.22, 73.48, 73.94, 74.95, 77.18 years, respectively. This highlights that an increasing population and the rise of communicable disease mortality can result in premature death in LMICs.

This study shows that in 38 UMICs, increasing longevity is associated with reductions in CO_2, population, death rate, and IMR, while increases in PGDP contribute positively. FPI, health expenditure, birth rate, and male education were not statistically significant in the final stepwise model. The overall model fit, with an R^2 of 97.36%, reflects the dynamic panel framework, which accounts for lagged effects and the persistence of life expectancy over time, rather than implying that only a few variables determine longevity. A 1% rise in CO_2 from the previous period resulted in a 0.0022 reduction in lifespan at the 10% significant level. This aligns with Baek et al. (2019), who find that increased CO_2 emissions significantly reduce life expectancy in upper-middle-income countries by increasing the prevalence of chronic respiratory and cardiovascular diseases. Air pollution is a major environmental threat in UMICs, with CO_2 emissions significantly degrading the environment in China (Nica et al. 2023; Rahman et al. 2022). The burning of coal in industry and transport, along with using solid fuels for household cooking, has dramatically increased pollution. A 1% increase in the change of PGDP from the past year leads to a 0.0549 increase longevity, with a 5% significance level. Economic prosperity significantly contributes to better health outcomes and overall well-being. Despite being classified as a UMIC, Namibia still struggles with lower PGDP (Shafuda and De 2020). Consequently, economic growth plays a crucial role in extending human life expectancy.

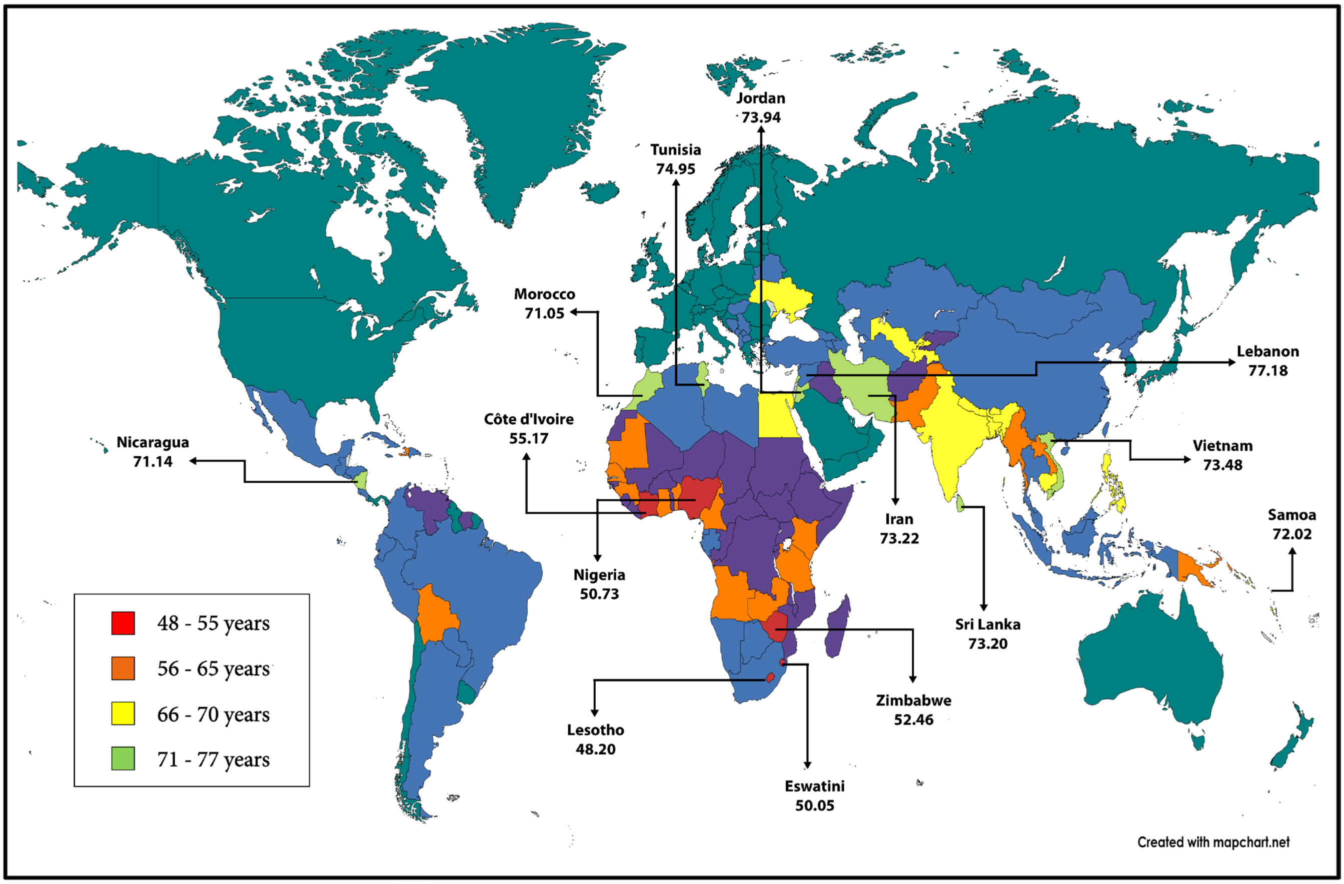

FIGURE 2 | Ordered predictors of life expectancy in lower-middle-income countries. *Source:* Authors' illustration based on data.

Moreover, a 1% increase in the population change and death rate from the previous period shrank life expectancy 2.8987 and 0.0669, respectively, with a significance level of 1%. The findings are congruent with (Swanson and Tedrow 2018) fact that overpopulation, inadequate health facilities, and poor nutrition have reduced life expectancy in Equatorial Guinea. Rapid population growth strains healthcare systems, increasing death and IMR, often due to malaria and poor sanitation. South Africa's population grew from 51.7 million in 2011 to over 62 million in 2022, straining healthcare and death rate increased by 0.6 per 1000 (Hajdu et al. 2024). Conversely, lower population growth and reduced mortality, as seen in Turkey, boost years of life (Şentürk and Ali 2021). COVID-19 has decreased significantly in survival rate in recent years due to complications like septic shock, multi-organ failure, and respiratory failure. In 2020, it killed over 1 million people in China in just a month (Du et al. 2023). This issue is more pronounced when compared to historical death. In Africa, countries in the northern region, such as Tunisia, Egypt, Algeria, and Morocco, are less affected by malnutrition and have the lowest IMR estimated at 18.4, 21.4, 23.8, and 43.2, respectively (Djoumessi 2022). In contrast, South Africa has a higher IMR. Figure 3 presents that Namibia, Equatorial Guinea, Botswana, South Africa, and Gabon have low average life expectancy of 56.60, 57.96, 58.64, 59.85, and 63.93 years, respectively. In comparison, Algeria, Thailand, Tonga, Bosnia, and Herzegovina, Maldives and Costa Rica have higher average life expectancy of 73.90, 76.13, 76.13, 76.13, 77.19, 78.49 years, respectively. This provides evidence that economic growth can enhance human lifespan, while rising environmental pollution, overpopulation, chronic illness mortality and infant mortality significantly reduce longevity.

The study demonstrates that increasing longevity in 52 HICs requires reducing population, death rate, and increasing male education, while CO_2, PGDP, health expenditure, BR, and IMR are insignificant. The model's overall R^2 value of 0.9765 indicates it explains 97.65% of the variance in life expectancy. A 1% increase in the change of male education from the previous period increases life expectancy by 0.0457 at the 5% significance level. This finding is similar (Hambleton et al. 2015): education is crucial in increasing male life expectancy by empowering individuals to make informed health decisions and engage with healthcare effectively. In Australia, 50% of women aged 25–34 hold a bachelor's degree, compared to just over 33% of men in the same age group. In the Caribbean, Guyana, Haiti, Suriname, and Trinidad and Tobago have not reached an overall life expectancy of 70 years (Enroth et al. 2022), due to lower education. Conversely, Norway's 53.4% male education is linked to longer lifespan and robust healthcare systems (Luy et al. 2019). Despite this, a 62% longevity gap between men and women in the U.S. remains (Sasson 2016), influenced by lower male education and higher smoking rates.

Nevertheless, a 1% rise in the population change from the past period reduces longevity by 3.9916 at the 1% significance level. A view shared by previous studies such as that of (Davoudpour and Davis 2022) is the idea that overpopulation can reduce life duration in the U.S. While HICs generally avoid severe overpopulation

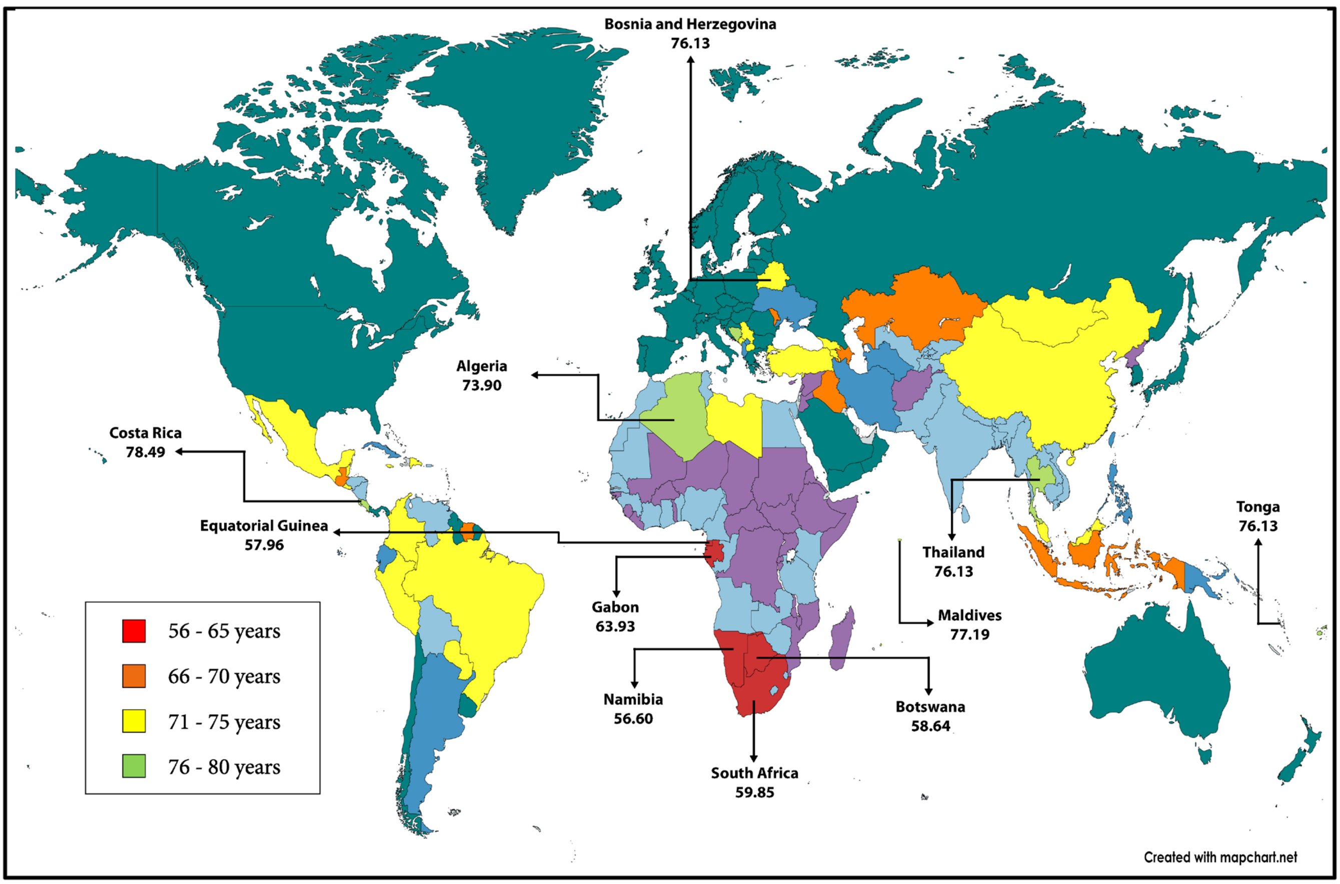

FIGURE 3 | Ordered predictors of life expectancy in upper-middle-income countries. *Source:* Authors' illustration based on data.

issues, some U.S. cities like New York and Los Angeles face significant population increase pressure. Each New Yorker produces 30% of the CO_2 emissions of the average U.S. resident, resulting in reduced life expectancy. Similarly, a 1% rise in the change of death rate from the past year decreases life expectancy by 0.0203, at the 10% significance level. The findings substantiate (Woolf and Schoomaker 2019) that increasing cardiovascular diseases mortality reduced life expectancy in the U.S. Life expectancy rose from 69.9 to 78.9 years between 1959 and 2016; it fell for three consecutive years after 2014 in the U.S. This decline coincides with rising mortality among adults aged 25–64, driven by drug overdoses, alcohol abuse, suicides, and various diseases. However, Australia has a high life expectancy, with women living an average of 83.8 years and men 83.6 years due to lower mortality (Tickle 2016). Figure 4 reveals that only Nauru and Guyana have low lifespan, at 60.60 and 66.79 years, respectively, while Canada, Norway, Israel, France, Singapore, Sweden, Australia, Spain, Italy, Iceland, Switzerland, and Japan report higher average longevity at 81.10, 81.23, 81.37, 81.43, 81.47, 81.51, 81.67, 81.79, 81.91, 81.97, 82.30, and 83.04 years, respectively. The study finds that HICs generally have higher lifespan than other income groups, and education supports longer life expectancy, while factors like urbanization and rising cardiovascular mortality contribute to premature death.

5.1 | Conclusion and Policy Implications

This empirical study's primary objective is to analyze socioeconomic factors' impact on global life expectancy. Studies on the effects of socioeconomic factors on life expectancy by economic group have yet to be fully explored globally. While health and demographic factors influencing human lifespan have been studied, the global impact of socioeconomic factors on longevity has yet to receive sufficient attention as a single comprehensive study. Therefore, this study will provide the critical factors behind global disparities in lifetime and how these disparities affect the development of countries. This effort will hopefully highlight the need to prevent premature deaths, attract global attention, increase life expectancy, and enhance sustainability, particularly in countries with lower life expectancy. The findings of this study will be helpful for the WHO, the UN, and the World Bank. Improving global life expectancy is challenging due to socioeconomic inequality, healthcare access limitations, chronic diseases, environmental issues, and political instability.

The study highlights that promoting PGDP and health expenditure and managing population, mortality, and IMR are crucial global policy areas. Many deaths are due to poverty, OOP health expenses, a shortage of doctors, and the use of low-quality medicine. Overpopulation and urbanization can spread viruses quickly, as seen with COVID-19, which has significantly reduced longevity in recent years. Additionally, inadequate healthcare facilities and a lack of health awareness among parents have increased the global child mortality rate. In LICs, the negative impact of PGDP, population, and mortality on lifespan highlights the need for policies to manage these factors. While increasing PGDP can boost longevity, it often involves environmental health risks. Economic growth can lead to rapid urbanization, causing

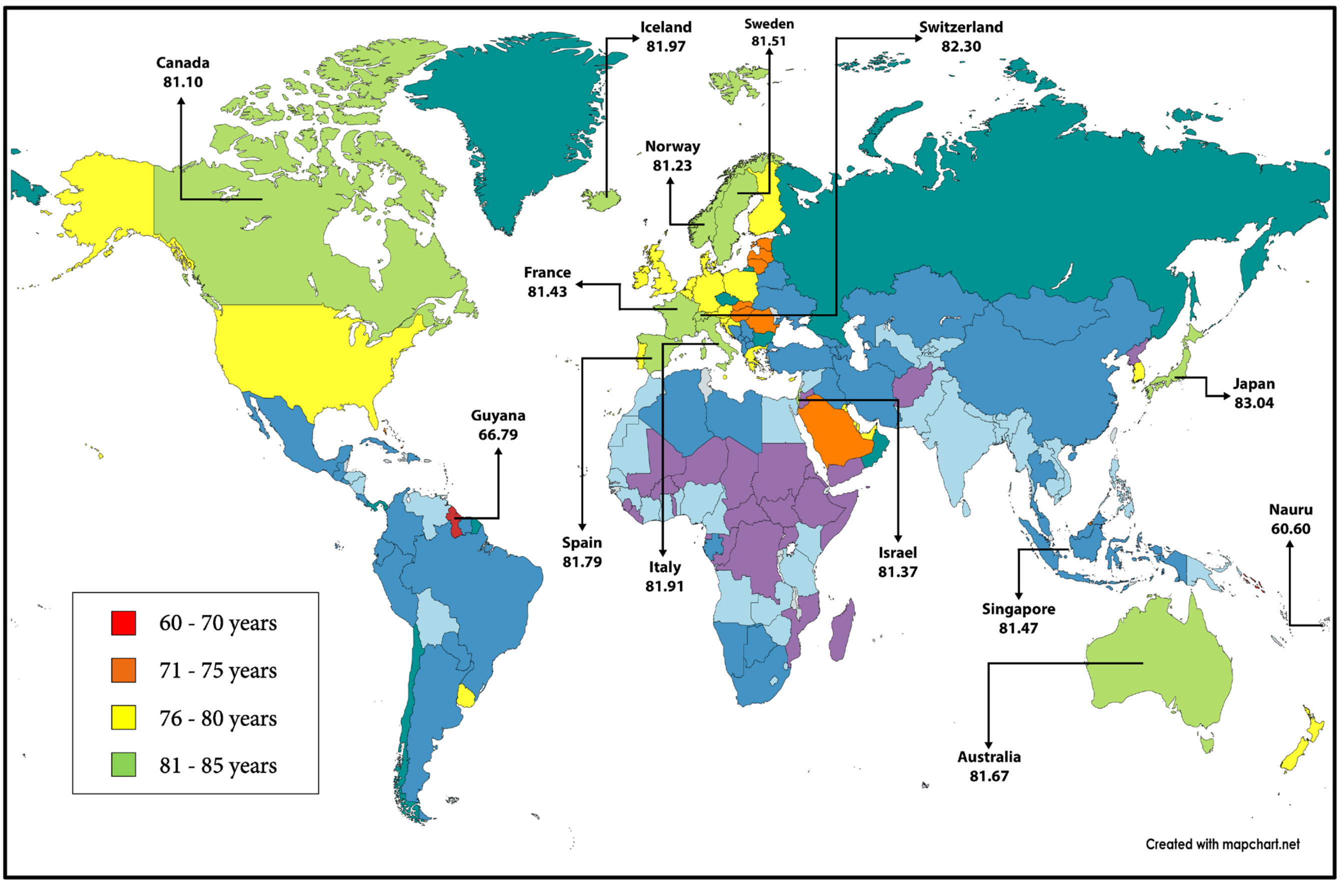

FIGURE 4 | Ordered predictors of life expectancy in high-income countries. *Source:* Authors' illustration based on data.

overcrowding and pollution, which reduce life expectancy. The relationship between PGDP and longevity is complex and can have positive and negative effects. Without robust environmental protections, the benefits of increased PGDP are limited. Overpopulation strains resources, increases pollution, and results in inadequate services. Many deaths are due to HIV/AIDS.

For LMICs, policies should focus on managing population growth and mortality to improve lifespan. Rapid population growth strains government resources, impacting healthcare, job opportunities, and food supply. This results in high mortality from inadequate health services, doctor shortages, lack of medicine, malnutrition, and water-borne diseases. At the UMICs level, policies should focus on boosting PGDP by creating employment opportunities, fostering business development, and supporting innovation and technology while managing CO_2, population, mortality and IMR. Pollution and environmental degradation from rapid urbanization impact air and water quality, while cardio-metabolic disease and high rates of teenage pregnancies and multiple births contribute to reduce longevity. In HICs, policies should continue to enhance male education while managing population and mortality. Although overpopulation is less of a concern overall, cities like those in the U.S. face challenges such as urbanization and air pollution. Chronic diseases can still impact life expectancy.

Meanwhile, this evidence-based study can guide policymakers and governments in addressing critical socioeconomic issues, improving global lifespan, and promoting sustainable economic growth. Policymakers should implement updated policies and regulations to address socioeconomic factors and enhance human longevity. Moreover, governments should increase budget allocations for healthcare services and education. Investing in human resources is essential for improving health outcomes in developing countries. Governments should prioritize hiring and training more health workers to strengthen their healthcare systems and enhance public health. Expanding maternal and child health services is essential. Ensuring equal educational opportunities for both genders is crucial.

The study confirms that environmental degradation and overpopulation reduce longevity, and effective measures to combat environmental pollution should be adopted. This can be achieved by implementing regulations that discourage the use of fossil fuels, such as reducing fossil fuel subsidies. Additionally, promoting renewable energy by redirecting subsidies from fossil fuels to renewable sources and adopting green innovation practices can help protect the environment, making these sustainable alternatives more affordable and accessible. Increasing population and urbanization significantly contribute to environmental pollution. Significant contributors to global population growth include India and several African regions. This imbalance creates economic challenges, including food shortages, inadequate healthcare, and limited education. To address these overpopulation issues, expanding access to family planning services is crucial. Implementing macroeconomic stabilization measures is essential to control rising costs, create job opportunities, and support the growth of small and medium-sized enterprises. These actions will enable individuals to afford better nutrition, enhance living conditions, meet healthcare needs, and increase their income potential.

5.2 | Limitations and Further Research

Some limitations of this study need to be acknowledged. First, this study classifies countries based on income levels, but these classifications can change over time. For instance, in 2019, Sri Lanka became a UMIC. However, due to the financial crisis, it reverted to a LMIC. Future researchers could classify countries by continent, as these classifications remain consistent. Second, although the study includes 11 independent variables, the stepwise regression model omitted factors like inflation in five categories. Consequently, the impacts of inflation on longevity were missed. Future studies could use different methodologies, such as the ARDL bounds test, Vector Error Correlation Model (VECM), Vector Auto-Regression (VAR), and Granger Causality.

Author Contributions

All authors contributed to the conception and design of the project. S.K. composed the writing of the manuscript. S.K. and R.J. carried out a significant share of tasks on statistical work in the manuscript. R.J. provided critical knowledge in drafting the paper and supervised the entire study. The authors have read and approved the final manuscript.

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The authors have nothing to report.

Ethics Statement

The data used in this study are publicly available; this study was reviewed and approved by the Ethics Committee of the Sri Lanka Institute of Information Technology, Business School.

Consent

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

All data generated or analyzed during this study are included in this published article and its Supporting Information files.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** Data file. **Data S2:** Stationary. **Data S3:** Stability. **Data S4:** Stationary insignificant mask. **Data S5:** Specification test results for global and different income groups. **Data S6:** Predictors of life expectancy in low, lower-middle, and upper-middle-income countries. **Data S7:** Predictors of life expectancy in high-income countries.