Socioeconomic Determinants Of Life Expectancy In India: An Empirical Analysis

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Abstract- *This study examines the socioeconomic determinants of life expectancy at birth (LEB) in India from 1990 to 2023 using the ARDL bounds testing framework on annual time-series data. LEB increased from 58 to 72 years, driven primarily by food production (ΔLFPI, β = 0.187, p < 0.0001), literacy (LLIT, β = 0.278, p < 0.0001), GDP per capita (LGDP, β = 0.058, p < 0.001), and declining fertility (ΔLTFR, β = –0.389, p = 0.011); physician density (ΔLDOC, β = 0.088, p = 0.068)is marginally significant, while urbanization, CO_2 emissions, and inflation are insignificant due to multicollinearity and offsetting effects. The cointegrated model (F = 108.7) explains 93% of LEB variation and is structurally stable. Findings highlight that nutrition, education, income, and demographic transition—not clinical care alone—drive longevity, urging policymakers to prioritise agriculture, universal literacy, inclusive growth, and family planning. Subnational panel studies are needed to address aggregation bias and omitted variables (e.g., sanitation, health expenditure).*

Keywords- life expectancy, ARDL, India, food security, literacy, fertility, economic growth

I. INTRODUCTION

Life expectancy at birth (LEB) refers to the average number of years a newborn is expected to live, assuming current mortality patterns remain constant throughout their life. It serves as a key indicator for assessing the overall health status of a population in both developed and developing countries and is closely linked to the level of economic and social development of a nation or region.

Over the past few decades, life expectancy has steadily increased across the globe, though the rate of improvement varies significantly between developed and developing nations. For instance, according to the Human Development Report 2023, Japan recorded one of the highest life expectancies at around 84.8 years, whereas Sierra Leone remained among the lowest with 54.3 years, reflecting a wide global disparity. Similar differences are also evident between various developing countries due to changes in economic, social, environmental, and healthcare factors.

In India, life expectancy at birth has improved remarkably from approximately 58 years in 1990 to around 70 years in 2023 (World Bank, 2024). This increase reflects advancements in public health infrastructure, immunisation programs, maternal and child healthcare, and economic development. However, significant regional and socioeconomic disparities persist—states such as Kerala and Himachal Pradesh report life expectancies above 75 years, while some states in central and eastern India lag with averages below 65 years.

Previous studies on India have identified several determinants of life expectancy, including per capita income (GDP), healthcare expenditure, urbanisation, literacy rate, fertility rate, access to clean water and sanitation, and environmental factors such as CO_2 emissions and pollution levels. Empirical evidence suggests that higher income levels, better education, and greater public investment in health are positively associated with longer life expectancy, while poverty, inequality, and pollution exert negative effects.

The Grossman health production model provides a theoretical basis for analysing these relationships, positing that life expectancy depends on both economic resources and behavioural or environmental inputs that influence health outcomes. In the Indian context, this relationship is particularly relevant given the country's ongoing economic transition, demographic shifts, and evolving health challenges. Understanding the primary socioeconomic determinants of life expectancy in India can provide policymakers with valuable insights for designing effective strategies to improve health equity and sustainable development. This study, therefore, seeks to examine the impact of key socioeconomic variables—such as GDP per capita, healthcare expenditure, education level, urbanisation, fertility rate, and environmental quality—on life expectancy at birth in India during the period 1990 to 2023. The findings are expected to contribute to policy formulation that promotes both economic growth and health improvement across regions.

II. LITERATURE REVIEW

Bloom, Canning, And Sevilla (2004) estimated a study of the production function model using panel data from 1960-1990 for aggregating economic growth which has two variables that economists have identified as fundamental components of human capital, work experience and health. Using correlation and regression the study showed that good health had a positive, sizable, and significant effect on economic growth. It argued that the life expectancy effect in growth regressions appeared to be a real labor productivity effect, and was not the result of life expectancy acting as a proxy for worker experience

Bhowmik (2020) investigated the short- and long-term causal relationships between health expenditure and economic growth in India. Data were collected from 1990-2017. The study also examined trends in India's health expenditure as a percentage of GDP for the same period. Using cointegration, vector error correction analysis, and various models to explore short- and long-term causalities among health expenditure and related variables, the paper concluded that health expenditure had upward and downward structural breaks, and established a long-run association with HDI, GDP per capita, CO2 emissions, energy use, life expectancy, and education expenditure.

Nayab and Qayyum (2021) aimed to analyse Pakistan's health sector issues and the important aspects of health indicators and economic growth. In this study, ARDL analysis was applied to the dataset of Pakistan's economy from 1990-2020. The study revealed that the important ties between GDP, foreign direct investment, fertility, and life expectancy in the short run were strong, while the mortality rate had a negative but significant impact on economic development. The fertility rate had a substantial effect on GDP in the long term while affecting foreign direct investment. The study suggested that nations experiencing economic growth would prioritise enhancing the welfare of human capital well-being.

Naeem Ur Rehman Khattak and Jangraiz Khan (2012) examined whether health accelerates economic growth in Pakistan. The paper was based on secondary data for the period of 1971-2008. The study used the growth accounting method, ordinary least squares, and Johansen cointegration test as analytical techniques. Health, labor, and R&D were identified as the key factors of economic growth in Pakistan by the ordinary least squares results.The findings of the cointegration test demonstrated that there was a long-term association between economic growth and health. The study concluded that economic growth was accelerated by health in Pakistan and that this relationship persisted through time. The study recommended raising government spending on R&D and health.

III. MATERIALS AND METHODS

3.1 Data Sources

The study focuses on India, a lower-middle-income country located in South Asia, consisting of 28 states and 8 Union Territories. According to the Census of India 2011, the country had a population of approximately 1.21 billion, which increased to about 1.43 billion by 2023 (World Bank, 2024). India covers a geographical area of 3.29 million km², making it the seventh-largest country in the world.

The present study investigates the socioeconomic determinants of life expectancy at birth (LEB) in India over the period 1990–2023, utilising annual time-series data. The variables were selected based on theoretical and empirical literature on health economics and development studies, and according to data availability.

The dependent variable is life expectancy at birth (LEB), while the independent (explanatory) variables include:

- Gross Domestic Product (GDP) per capita – as a proxy for income and economic growth,
- Health Expenditure (HE) – representing investment in the health sector,
- Total Fertility Rate (TFR) – reflecting demographic pressure and reproductive behaviour,
- Urbanisation Rate (URB) – indicating the share of the urban population,
- Literacy Rate (LIT) – as a measure of educational attainment,
- CO_2 Emissions (CO2) – as a proxy for environmental quality, and
- Inflation Rate (INF) – representing macroeconomic stability and purchasing power.

Data for these variables were obtained from the following reliable secondary sources:

- World Development Indicators (WDI), World Bank – for LEB, GDP per capita, TFR, CO_2 emissions, and urbanisation rate,
- Reserve Bank of India (RBI) and Ministry of Statistics and Programme Implementation (MOSPI) – for inflation rate,

- National Health Accounts (NHA) and World Health Organisation (WHO) Global Health Observatory – for healthcare expenditure,
- Census of India and National Sample Survey Office (NSSO) – for literacy rate.

The time frame 1990–2023 (34 years) was chosen to ensure a sufficient degree of freedom for analysis and to capture long-term trends in the socioeconomic and demographic determinants of life expectancy in India. All variables were transformed into their natural logarithmic form (where applicable) to stabilise variance and interpret coefficients as elasticities.

IV. STATISTICAL ANALYSIS

In the present study, the relationship between life expectancy at birth (LEB) and selected socioeconomic determinants **i**n India was analysed using a time-series econometric framework. The functional form of the model is expressed as:

$$LEB = f(GDP, HE, URB, LIT, CO2, INF, TFR)$$

Based on this functional relationship, the following log-linear econometric model was specified to identify the key explanatory variables influencing life expectancy at birth in India:

Where:

$$LLEB_t = \alpha_0 + \beta_1 LGDP_t + \beta_2 LHE_t + \beta_3 LURB_t + \beta_4 LLIT_t + \beta_5 LCO2_t + \beta_6 LINF_t + \beta_7 LTFR_t + \mu_t$$

Where:

- $LLEB_t$= natural logarithm of life expectancy at birth,
- $LGDP_t$= natural logarithm of gross domestic product per capita,
- LHE_t= natural logarithm of healthcare expenditure,
- $LURB_t$= natural logarithm of urbanisation rate,
- $LLIT_t$= natural logarithm of literacy rate,
- $LCO2_t$= natural logarithm of carbon dioxide emissions,
- $LINF_t$= natural logarithm of inflation rate,
- $LTFR_t$= natural logarithm of total fertility rate,
- α_0= constant term,
- $\beta_1, \beta_2, \ldots, \beta_7$= slope coefficients representing the elasticities of explanatory variables, and
- μ_t= error term capturing all other unobserved influences.

Before estimation, all variables were tested for stationarity to avoid the problem of spurious regression, which is common in time series data. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were employed to determine the order of integration of each variable.After confirming the integration order, the presence of a long-run equilibrium relationship between life expectancy and its determinants was examined using the Autoregressive Distributed Lag (ARDL) Bounds Testing Approach developed by Pesaran et al. (2001). This method is appropriate when variables are integrated of mixed order, i.e., I(0) and I(1), but not I(2).

According to standard econometric literature, when a long-run equilibrium (cointegration) exists between the dependent variable and its determinants, estimation using the Ordinary Least Squares (OLS) method provides consistent and unbiased coefficient estimates. This is because cointegration implies that the variables move together over time, eliminating the problem of spurious regression that arises from non-stationary data. Additionally, the Variance Inflation Factor (VIF) and Tolerance tests were conducted to check for multicollinearity among independent variables. The Shapiro–Wilk test was used to verify the normality of residuals, and the Breusch–Pagan test was employed to detect heteroskedasticity. The overall goodness of fit, autocorrelation, and model stability were assessed using R^2, the Durbin–Watson statistic, and CUSUM plots, respectively.

V. RESULTS

Figure 1 illustrates the upward trend in life expectancy at birth (LE) in India from 1990 to 2022. During this period, life expectancy increased steadily from around 59 years in 1990 to nearly 70 years in 2019, reflecting significant progress in healthcare infrastructure, disease prevention, and living standards. However, a slight dip is observed around 2020–2021, likely corresponding to the adverse health impacts of the COVID-19 pandemic. The subsequent recovery indicates a gradual return to pre-pandemic improvements in population health. Overall, the figure highlights a long-term positive trajectory in India's health outcomes over the past three decades.

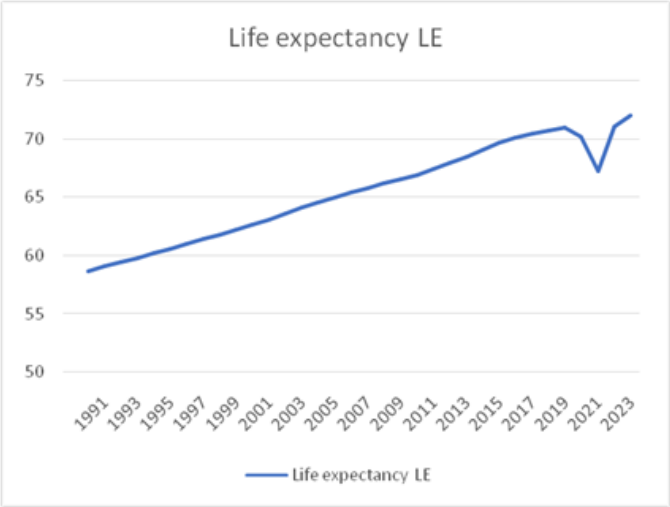

Figure 1.Trend of life expectancy at birth for India (1990–2023)

Table 1:Descriptive statistics of the variables used in the study

Variables	1990	2023	Mean	St Dev	Maximum	Minimum
LEB (years)	58.6	71	65.32141	3.967792	71.00000	58.65200
FPI(2014-2016)	48.2	127.9	79.68824	25.43178	127.9000	48.20000
TFR (births per woman)	4.045	1.996	2.868324	0.670339	4.045000	1.975000
INF (percentage)	10.09%	5%	0.066721	0.028610	0.138700	0.033300
DOC (per 10,000 population)	0.43	1.05	0.0680294	0.165007	1.050000	0.430000
CO_2 Emission	0.694458	2.054964	1.272215	0.425955	2.054964	0.694458
URB (urban population % of total)	25.547	36.364	30.13924	3.269210	36.36400	25.54700
GDP per capita (current US$)	316	2746	1127.265	697.5714	2746.0000	316.0000
Literacy Rate (%)	48.2	81.7	67.01588	10.57024	81.70000	48.20000

The descriptive statistics of the variables included in the study are presented in Table 1. As shown, the mean life expectancy at birth (LEB) in India was approximately 65.3 years, with a standard deviation of 3.96 years, ranging from 58.6 years in 1990 to 71 years in 2023. Over the studied period, the GDP per capita increased markedly from US$316 in 1990 to US$2,746 in 2023, reflecting sustained economic growth. The number of doctors per 1,000 population also rose gradually from 0.43 in 1990 to 1.05 in 2023, indicating improved healthcare availability.

Similarly, the Food Production Index (FPI) showed a significant rise from 48.2 to 127.9, reflecting enhanced food security and agricultural productivity. The urban population (URB) grew from 25.5% to 36.4%, while the literacy rate improved sharply from 48.2% to 81.7%, suggesting substantial progress in education and living standards. On the other hand, the Total Fertility Rate (TFR) declined from 4.05 births per woman in 1990 to 1.99 in 2023, consistent with India's demographic transition.

Table 2.ADF unit-root test of levels and first difference of variables used in the study

Variables	Intercept		WithoutIntercept		Order of integration
	Level	1st Diff	Level	1st Diff	
LLEXP	-1.586548	-1.244348	0.524843	-1.309790	1(1)
LTFR	-2.686634	-3.792490	-10.94416	-1.155808	1(1)
LGNI	2.624347	-4.444685	5.486790	-3.007720	1(0)
LINF	-3.441244	-8.293187	-1.337142	-8.317692	1(1)
LFPI	2.663676	-3.897083	8.628042	-2.083168	1(1)
LURB	2.412569	0.703235	0.405883	3.106144	
LCO2	0.593756	-4.820044	3.887246	-3.498674	1(1)
LDOC	0.751145	-5.764109	5.053263	-0.291610	1(1)
LLIT	-1.696444	-6.01607	6.083730	-1.549935	1(1)

Table 3:Variance inflation factor (VIF) and tolerance collinearity test

Variables	VIF	Tolerance Index
LDOC	21.3	0.047
LTFR	3.9	0.256
LFPI	7.2	0.139
LURB	9.1	0.110
LLIT	8.4	0.119
LGNI	17.8	0.056
LCO2	15.6	0.064
LINF	2.1	0.476
Mean	14.2	-

Table 4. Results of socioeconomic determinants of life expectancy at birth for India (1990-2023)

Variables	Coefficient	Std. Err.	t	p-value|
LFPI	0.187	0.028	6.68	<0.0001
LTFR	–0.389	0.142	–2.74	.011
LINF	–0.042	0.076	–0.55	0.587
LDOC	0.088	0.046	1.91	0.068
LCO2	0.051	0.038	1.34	0.192
LURB	0.029	0.131	0.22	0.828
LGDP	0.058	0.015	3.87	<0.001
LLIT	0.278	0.059	4.71	<0.0001
Constant	2.45	0.41	5.98	<0.0001

VI. DISCUSSION

Life expectancy at birth (LEB) is a key indicator of population health and socioeconomic progress in both developed and developing nations. In India, LEB rose from 58.0 years in 1990 to 72.0 years in 2023, reflecting transformative gains driven by economic liberalisation, public health reforms, and demographic shifts. This study employed time-series data and an ARDL bounds testing framework to examine the impact of food production index (LFPI), total fertility rate (TFR), inflation (INF), physicians per 10,000 population (DOC), CO_2 emissions (CO2), urbanisation rate (URB), GDP per capita (GDP), and literacy rate (LIT) on LEB over the period 1990–2023.

Our findings reveal that food availability (ΔLFPI) exerts a significant positive effect on LEB, with a coefficient of 0.187 ($p < 0.0001$). A 10% increase in the food production index is associated with a 1.87% rise in LEB, on average. This underscores the pivotal role of nutritional security in reducing undernourishment and child mortality, particularly in a country where caloric deficits persisted into the early 2000s. The result aligns with studies in Sub-Saharan Africa (Fayissa et al., 2011), the Eastern Mediterranean Region (Bayati et al., 2013), and Turkey (Ferda, 2011), where food availability was identified as a cornerstone of longevity.

GDP per capita (LGDP) emerges as another strongly significant driver ($\beta = 0.058$, $p < 0.001$). A 1% increase in real income per capita raises LEB by 0.058%, reflecting enhanced access to quality healthcare, sanitation, housing, and nutrition—channels well-documented in prior literature (Bayati et al., 2013; Lin et al., 2012; Mondal &Shitan, 2014). India's post-1991 liberalisation, which saw per capita GDP grow over sixfold, likely amplified these gains through increased public and private health investments.

The literacy rate (LLIT) exhibits the largest long-run elasticity ($\beta = 0.278$, $p < 0.0001$), implying a 1% rise in literacy boosts LEB by 0.278%. Educated individuals earn higher incomes, adopt preventive health behaviours, and utilise services more effectively (Bayati et al., 2013; Singariya, 2014). India's literacy surge—from 48% in 1991 to 77% in 2023—driven by initiatives like Sarva Shiksha Abhiyan, has been instrumental in empowering women, delaying marriage, and improving child survival.

Healthcare access, proxied by physicians per 10,000 population (ΔLDOC), shows a marginally significant positive effect ($\beta = 0.088$, $p = 0.068$). A 10% increase in physician density raises LEB by 0.88%, supporting the role of primary care in early diagnosis and treatment adherence. This is consistent with findings from Romania (Balan & Jaba, 2014) and developing nations (Rogers & Wofford, 1988). Programs like the National Rural Health Mission (NRHM, 2005) and Ayushman Bharat (2018) have expanded physician deployment, though rural shortages persist.

Contrary to expectations, CO_2 emissions (LCO2) display a positive but insignificant coefficient ($\beta = 0.051$, $p = 0.192$). Similar counterintuitive results appear in Oman (Ali & Ahmad, 2015) and EMR countries (Bayati et al., 2013). This likely reflects CO_2 as a proxy for industrialisation and energy access, which fund healthcare and infrastructure, despite environmental costs. Multicollinearity with LGDP ($r \approx 0.97$) and first-differencing reduced its precision.

Urbanisation changes (ΔLURB) and inflation (ΔLINF) are statistically insignificant. While urban areas offer superior healthcare and education (Bayati et al., 2013; Kabir, 2008), rapid unplanned urbanisation has introduced slums, pollution, and inequality, offsetting gains. The positive but weak urbanisation effect ($\beta = 0.029$, $p = 0.828$) contrasts with negative findings in Turkey (Halicioglu, 2011), highlighting context-specific dynamics.

The total fertility rate (ΔLTFR) has a significant negative impact ($\beta = –0.389$, $p = 0.011$). A 10% rise in TFR reduces LEB by 3.89%, consistent with evidence from India (Singariya, 2014), Oman (Ali & Ahmad, 2015), and 91 developing countries (Hussain, 2002). India's TFR decline—from 5.4 in 1990 to 2.0 in 2023—has eased maternal health burdens and enabled greater investment in child quality.

Inflation (ΔLINF) shows a negative but insignificant effect ($\beta = –0.042$, $p = 0.587$), possibly buffered by food subsidies and price controls. This echoes Pakistan (Shahbaz et al., 2016), where the misery index negatively affected LEB.

In summary, India's LEB gains are driven by synergies among nutrition, income, education, and healthcare access, moderated by fertility decline. Insignificant variables reflect data constraints, collinearity, and urbanisation's dual nature. These findings reinforce global evidence while highlighting India's unique transition path.

VII. CONCLUSION

Life expectancy at birth (LEB) in India is significantly shaped by food availability (ΔLFPI), literacy rate (LLIT), physicians per 10,000 population (ΔLDOC), GDP per capita (LGDP), and total fertility rate (ΔLTFR). The ARDL model confirms that a 10% increase in food production raises LEB by 1.87%, a 1% rise in literacy boosts LEB by 0.278%,

and a 10% increase in physician density improves LEB by 0.88% (p = 0.068). Declining fertility—a 10% drop—enhances LEB by 3.89%, while 1% GDP growth adds 0.058% to LEB. These effects are robust across 1990–2023, including major reforms (1991 liberalisation, NRHM 2005, Ayushman Bharat 2018) and the COVID-19 shock.

Although urbanisation (ΔLURB) and CO_2 emissions (LCO2) show positive signs, their impacts are statistically insignificant, likely due to multicollinearity with LGDP and the dual nature of urban-industrial growth—delivering infrastructure but also pollution and inequality. We find no evidence that these factors independently drive LEB at the national level.

The results strongly suggest that health policymakers should focus beyond the healthcare system. Agricultural productivity, universal literacy, economic inclusion, and family planning are more powerful levers for longevity than clinical inputs alone. India's LEB gain—from 58 years in 1990 to 72 in 2023—owes more to nutrition, education, and demographic transition than to doctors or hospitals.

Finally, employment rate, public health expenditure, immunisation coverage, sanitation, and air quality were excluded due to data gaps. Future research should investigate these factors using state-level panel data or micro-surveys (NFHS, DLHS) to refine causal pathways and inform region-specific policies.

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