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Paper Title	SOCIO-ECONOMIC DETERMINANTS AND LIFE EXPECTANCY IN INDIA: AN ECONOMIC ANALYSIS
Similarity	5% AI - 20%
Paper ID	5290899
Total Pages	102
Submission Date	2026-02-23 10:17:05

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DECLARATION

I hereby declare that this dissertation, " **SOCIO-ECONOMIC DETERMINANTS AND LIFE EXPECTANCY IN INDIA: AN ECONOMIC ANALYSIS** ", submitted by me in partial fulfilment of the requirements for the award of an M.A. Degree in Economics, is my original work. This work has not previously formed the basis for other academic qualifications.

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AN ECONOMIC ANALYSIS OF IMPACT OF SOCIO-ECONOMIC DETERMINANTS ON LIFE EXPECTANCY IN INDIA

Dissertation submitted to

St. Teresa's College (Autonomous), Ernakulam

(Affiliated to **MAHATMA GANDHI UNIVERSITY, KOTTAYAM**)

In partial fulfilment of the requirements of the degree of

MASTERS OF ARTS IN ECONOMICS

BY

MEENAKSHI U

REGISTER NO: AM24ECO011

UNDER THE GUIDANCE OF

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MARCH 2026

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ACKNOWLEDGEMENT

I humbly bow my head before the god almighty for the constant flow of grace in every step of this research study, making it a reality. With profound respect, deepest admiration, and gratitude, I would like to express my special thanks to my guide Dr. Anupa Jacob(Head of the Department) Assistant Professor, St. Teresa's College, Ernakulam, who gave me the golden opportunity to do this project on the topic **"AN ECONOMIC ANALYSIS OF THE IMPACT OF SOCIO-ECONOMIC DETERMINANTS ON LIFE EXPECTANCY IN INDIA"**, who helped me in doing a lot of research and I came to know about so many new things. I am thankful to her.

I am indebted to every member of the faculty of the Economics Department, St. Teresa's College, Ernakulam, for their guidance and constant supervision, for providing necessary information regarding the project, and for their support in completing it.

I would also like to thank the principal and other staff members of St. Teresa's College, Ernakulam, my parents, friends and many individuals, as without their kind support, it would not be possible for me to complete this project report. At last, I express my sincere gratitude to all who helped me greatly in finalising this project within the limited timeframe.

MEENAKSHI U

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CHAPTER 1
INTRODUCTION

1.1 Introduction

Life expectancy is considered to be an important indicator of human development and social welfare (Sen, 1999). It is not just a measure of the health of the population but it holds the mirror to the larger economic, social and political systems that define the quality of life (UNDP, n.d.). Such analysis is particularly important for a country like India where rapid economic development coincides with stark inequalities and demographic diversity (Dreze & Sen, 2013). In order to provide evidence-based policy solutions that maximize economic growth and promote inclusive health outcomes, it is imperative to understand this relationship (World Health Organisation [WHO], 2008).

The world has experienced a marked gain in life expectancy during the last century, with a transformation from dominance of infectious diseases and starvation to threats caused by chronic and degenerative ailments, as expressed by the theory of epidemiologic transition (Omran 1971). High-income countries made this transition thanks to industrialization, improvements in sanitation and innovations like antibiotics. Global life expectancy at birth is about 73.3 years, although this figure hides extreme differences between high-income world regions and low- and middle-income ones where some South Asian countries or sub-Saharan Africa are under double pressure from both communicable and newly emerging non-communicable diseases (United Nations, 2024; Bloom & Canning, 2000).

The Indian economy and public health system have changed significantly over the past three decades (Bhalotra, 2007). India has become a major economic power, fuelled by strong GDP growth, increased industrial output, and advancements in technology (Panagariya, 2008). The World Bank states that life expectancy has risen from about 41 years in 1960 to nearly 70 years by 2020 (World Bank, 2022). Even though life expectancy has increased over the past years these improvements have not reached equally to every individual. Many regions and certain social groups still struggle (Subramanian et al., 2006). Health outcomes depend on various economic factors. These include per capita income, poverty rates, inflation and public spending on health and education (Bloom & Canning, 2000). In India rapid economic growth has not necessarily led to higher life expectancy for everyone. Poverty and access barriers to healthcare still limit many individuals (Government of India, n.d.).

The economic situation of India during its modern period directly affected the health conditions of its people (Gupta & Diez, n.d.). The nation experienced both low life expectancy and widespread poverty after it became independent in 1947. The Green Revolution helped to eradicate extreme hunger but the country still faced high malnutrition and child mortality rates (Pingali, 2012). This period suggested that health of the people can be improved through economic development only when it occurs alongside socially inclusive policies (Anand & Ravallion, 1993).

The 1990s brought about a major transformation through the process of liberalisation (Ahluwalia, 2002). Maternal health and vaccination coverage saw rapid growth through rising GDP and globalisation (Nayar, 2007). The gains from these initiatives did not reach to all individuals in the society. Urban areas experienced significantly better progress than rural areas (Baru et al., 2010). The Gini coefficient, a measure of inequality, is an essential determinant of whether economic growth results in extended life expectancy and improved health for all citizens (Marmot, 2005; Kawachi & Kennedy, 1999). While growth in income tends to benefit the affluent most, marginalised groups witness lower health improvements (Joe et al., 2008). Strong government investment in health is what helps turn economic progress into broader gains in life expectancy (Hall & Jones, 1999). Education empowers people to make informed health decisions and improves living conditions (Case & Deaton, 2020). Safe housing and sanitation also shield communities from infectious diseases that persist in parts of India (Spears, 2013).

The COVID-19 pandemic brutally exposed vulnerabilities in India's health infrastructure, underscoring the need for economic stability to rebuild and strengthen systems (Sumner et al., 2020). The crisis triggered a short-term dip in life expectancy, highlighting the tight links between economic health, healthcare resources and public health capacity (Heuveline & Tzen, 2021). Surging medical costs, widespread loss of job and service interruptions made it clear that economic policies must align more closely with health protection (Global Health Council, n.d.).

The Preston Curve demonstrates that people live longer when their income increases because higher per capita income results in extended life expectancy, which reaches a point of declining benefits at advanced income levels (Preston, 1975). The World Health Organization describes social determinants of health as external elements that shape human health across all stages from birth through death, which create disparities in health outcomes (World Health

Organization, 2008). In India, female literacy, access to improved sanitation, urbanization, education, employment stability, housing and nutrition play pivotal roles, with education acting as a social vaccine for healthier choices and healthcare utilization (Marmot, 2005).

The Grossman health production model treats health as a durable capital stock that individuals invest in through market goods (such as medical care), time inputs and other resources, while it depreciates over time due to factors like age and environmental conditions (Grossman, 1972). Life expectancy functions as an endogenous outcome because it derives from economic and social factors which affect the efficiency of health production in the system. The basic socio-economic factors which determine life expectancy in various regions show significant differences between rural-urban areas and different gender which makes this research essential for health equity, inclusive growth and sustainable development goals.

The research investigates how key socio-economic factors which include GDP per capita, education levels that focus on literacy, sanitation, access to drinking water affect life expectancy at birth in India. The study uses the health production function and WHO's social determinants of health framework with econometric methods which include correlation, regression analysis for key indicators and ANOVA for regional to measure how these factors affect longevity outcomes. The study examines the relationship between GDP per capita and life expectancy, assessing whether national wealth enhances population health. Key social indicators including literacy rates, access to safe drinking water and sanitation are evaluated for their impact on India's life expectancy. The study also assesses regional disparities on persistent health inequities across Indian states. The economic development of India creates a base for better health outcomes which requires both social inclusion through dedicated policies and effective health programs to reduce health disparities. The findings are expected to provide evidence-based policy strategies that promotes economic growth and health improvement across the nation.

1.2 Review of Literature

A significant amount of literature has explored the complex relationship between socio-economic determinants and life expectancy, emphasizing that economic growth alone does not leads to improved life expectancy rates of individuals. In the Indian context, research suggests that the effects of rising income levels are significantly mediated by factors such as public

expenditure on health such as access to safe drinking water and sanitation, educational attainment and broader social structures. This literature review therefore examines how key socio-economic variables collectively shape life expectancy in India highlighting the multidimensional pathways through which development influences longevity.

The relationship between socio-economic determinants and life expectancy has been widely explored across demographic, economic and public health literatures. The Preston Curve established a theoretical foundation which demonstrated a robust concave relationship between per capita income and life expectancy, highlighting that gains in income at lower levels yield substantial improvements in survival, while returns diminish at higher income levels (Preston, 1975). Preston further observed that the curve shifted upward over time which implied that the improvements in medical technology and public health knowledge enhanced life expectancy independent of income growth. This insight was later reinforced by Cutler, Deaton, and Lleras-Muney (2006), who argued that education, vaccination, sanitation, and government health policies explain a significant share of mortality decline beyond income effects. Similarly, the World Health Organization (2024), through its framework on the Social Determinants of Health, emphasizes that health inequalities are systematically structured by income, education, occupation, and access to resources, underscoring that life expectancy follows a clear social gradient across societies.

1.2.1 GDP per capita income and Life expectancy

The relation between income and longevity is prominently articulated through the Preston Curve. The curve illustrates a concave association between per capita income and life expectancy (Preston, 1975). The Preston Curve indicates that at lower income levels, the marginal increase in GDP per capita leads to substantial improvements in life expectancy. The effect diminishes at higher income levels where the marginal increase in GDP per capita leads to subtle enhancements in life expectancy. The Preston Curve also identified an upward shift over time, indicating that medical innovations and public health interventions contributes to survival rates beyond the gains from economic growth.

This view has been further developed by other researchers. Cutler et al. (2006) argued that although income is positively related to the reduction of mortality rates, a large share of the health gain has been achieved through education, sanitation, immunization and institutional changes. Deaton (2013) further develops this view by placing it in a historical context and

arguing that economic growth made possible the great escape from early mortality but at the same time created inequalities in the distribution of health gains.

The direction of causality has also been debated. Acemoglu and Johnson (2007) challenges the assumption that health gains will automatically stimulate economic growth and argue that increased life expectancy may lead to an increase in population size without proportionate gains in per capita income. Das (2023), using panel data from Indian states, finds that increased life expectancy has a significant positive effect on economic growth supporting the view that health capital enhances productivity. These findings are contradictory and reflect the complexity of the relationship between health and income.

1.2.2 Social determinants and life expectancy

The World Health Organization (2024) emphasizes that health outcomes follow a systematic social gradient, structured by income, education and access to resources. The Grossman Health Production Function conceptualizes health as both a consumption and investment good, produced through inputs such as education, healthcare and income (Grossman, 1972). This framework provides a microeconomic basis for understanding how socio-economic resources translate into survival outcomes.

Empirical studies in India substantiate these theoretical propositions. Patil and Kumar (2018), employing multiple regression analysis across Indian states identified literacy rates, per capita income and access to healthcare as significant predictors of life expectancy. Cutler et al. (2006) further highlight education as a crucial determinant which influence health behaviors and the adoption of medical technologies. Development may also generate new health risks. Rehm et al. (2024) documents how economic growth in developing countries can increase lifestyle-related risks such as alcohol consumption, thereby offsetting mortality gains. This double burden of disease illustrates that socio-economic advancement must be accompanied by appropriate public health regulation and preventive policies.

1.2.3 Regional disparities in life expectancy

Regional inequality constitutes a central theme in Indian demographic literature. The uneven distribution of economic development, healthcare infrastructure and educational attainment across states has resulted in inter-regional variations in life expectancy. Singh and Siahpush (2019) revealed subsequent socio-economic disparities in longevity across Indian populations, reflecting differential access to resources and services.

The state of Kerala provides a critical illustration of how proactive public policy can mitigate regional disparities. Krishnan (1994) attributes Kerala's superior health outcomes to sustained investments in education, decentralized healthcare, and social welfare programs. Mari Bhat and Rajan (2001) emphasize the role of female literacy and empowerment in accelerating demographic transition. Soman (2003) highlights the accessibility and affordability of Kerala's health system. These studies suggest that regional variations in life expectancy are shaped by a combination of economic capacity, governance quality and social development. Assessing disparities across India therefore provides a structured approach to understanding spatial inequality in longevity outcomes.

In the context of global scenario women tend to outlive men due to both biological and behavioral factors but socio-economic conditions significantly influence the magnitude of this gap (WHO, 2024). In India, Singh and Siahpush (2019) report that women generally exhibit higher life expectancy than men across socio-economic groups even though disparities based on wealth and residence persist. Rural–urban disparities are similarly pronounced. Urban areas often demonstrate higher life expectancy due to better healthcare access and infrastructure but urban poverty introduces internal inequalities. The Azim Premji University and NGOs (2021) document significant life expectancy gaps between the urban poor and wealthier urban populations highlighting governance and service delivery challenges. Paul (2021) further establishes that income inequality adversely affects individual health outcomes in India with poorer populations bearing disproportionate burdens. Mellor and Milyo (2002) provide supporting evidence for the income inequality hypothesis suggesting that unequal societies experience poorer aggregate health outcomes. These findings emphasize that longevity disparities in India are not merely economic but are stratified along gender, residence and socio-economic lines reflecting structural inequities in access to resources and opportunities.

The literature converges on several key propositions. First, GDP per capita is positively associated with life expectancy particularly at lower income levels and still its effect is mediated by institutional and social factors. Second, education, healthcare access, public policy and inequality play critical roles in determining survival outcomes. Third, regional disparities persist despite aggregate improvements in life expectancy. By integrating insights from the Preston hypothesis (Preston, 1975), the Grossman health production framework (Grossman, 1972), and the WHO's social determinants approach (WHO, 2024) the present study situates life expectancy within a multidimensional analytical paradigm. This framework provides the conceptual foundation for empirically examining the impact of socio-economic determinants

on life expectancy in India with particular emphasis on income effects (GDP per capita income), social determinants such as literacy, sanitation, access to safe drinking water and systematically examining the role of regional disparities in shaping variations in survival outcomes across the country.

1.2.4 Research gap

Despite the considerable literature available on the relationship between income, social determinants, inequality and life expectancy, a number of gaps exist in the Indian context. A substantial number of empirical studies have focused on the income and health relationship from a cross-country or global perspective (Preston, 1975). As a resul the contextual applicability of these studies is relatively low in the context of the Indian socio-economic structure. On the other hand numerous empirical studies conducted in the Indian context tend to focus on individual determinants such as literacy, income inequality and health access at the state level (Patil & Kumar, 2018; Paul, 2021). These studies tend to exclude the economic, social, regional, gender and rural-urban dimensions in a comprehensive framework of analysis. The existence of regional disparities in life expectancy is often presented in a qualitative manner rather than a quantitative analysis. The gender and rural-urban differentials in the context of life expectancy in India have also been highlighted in the literature but only few attempts have been made to examine the dynamic nature of these gaps particularly in the context of convergence and divergence in relation to the socio-economic changes in the country. A significant gap remains in the literature regarding a comprehensive analysis that employs secondary data to simultaneously examine GDP per capita, key socio-economic determinants, regional disparities, gender and rural–urban differentials through rigorous econometric modelling.

1.3 Statement of the Problem

The life expectancy of a country serves as the primary measure for evaluating its health status and economic development. It measures the total health status of a population together with access to healthcare and standard of living. Despite sustained economic growth and subsequent improvements in life expectancy in India over the past few decades significant disparities persist across regions. Theoretical perspectives such as the Preston Curve indicates that higher GDP per capita income is generally associated with higher life expectancy (Preston, 1975), while the Grossman Health Production Function highlights that health outcomes are shaped by multiple inputs which includes education and healthcare inputs basic such as safe drinking

water and sanitation (Grossman, 1972). The degree to which these theoretical relationships operate consistently across different regions and populations within India remains inadequately examined. Existing studies often examine regional differences, social and economic determinants in isolation without simultaneously assessing their combined impact on longevity within a unified analytical framework. Even though improvements in national averages indicate progress they may conceal substantial regional disparities across the nation as well as persistent gender and spatial (rural–urban) gaps in life expectancy (Singh & Siahpush, 2019). The central problem therefore lies in the absence of a comprehensive empirical assessment that systematically examines the association between GDP per capita income and life expectancy, evaluates the effect of major social determinants, analyzes regional, gender and spatial disparities in longevity across India. Addressing this gap is essential to determine whether socio-economic development in India has translated into equitable health outcomes. The study will examine how particular economic factors such as per capita income, access to safe water, sanitation and literacy rate contribute to different life expectancy rates across India.

1.4 Objectives

1. To examine the association between GDP per capita income of Indiaand Life expectancy of India.
2. To assess the effect of social determinants on life expectancy in India guided by WHO Social Determinants of Health framework.
3. To examine the regional disparities in life expectancy across India's administrative zonal divisions.

1.5 Theoretical Framework

The theoretical framework of this research is based upon a comprehensive model which includes macroeconomic, microeconomic, demographic and structural factors in explaining differences in life expectancy. The theories which have been applied in the study include Preston Curve (1975), Health Capital Theory and Health Production Function (Grossman, 1972), Demographic Transition Theory, Social Determinants of Health by WHO (2008, 2023) and Inequality and Health Hypothesis by Wilkinson (1996, 2010). The application of these theories would help in developing a multidisciplinary analytical tool for understanding the impact of socio-economic determinants on life expectancy in India.

1.5.1 The Preston Curve (1975)

Preston Curve offers a macroeconomic perspective on income and life expectancy. Preston (1975) highlights a positive but concave relationship between per capita income and life expectancy across countries. At low-income levels a significant increase in GDP per capita results in substantial gains in life expectancy due to better availability of safe drinking water, proper sanitation and healthcare facilities but beyond a certain level of income life expectancy increases only marginally. Preston curve also identified an upward shift of the curve over time indicating a positive impact of advancements in healthcare, public health and institutional capacity on life expectancy regardless of income level. This implies that economic growth is a necessary but not a sufficient condition for increasing life expectancy (Preston, 1975). The application of Preston Curve in the Indian context also raises a vital question of whether growth in GDP per capita would result in a subsequent improvement in life expectancy in India.

1.5.2 Health Capital Theory and Health Production Function (Grossman, 1972)

The Health Capital Theory proposed by Grossman (1972) defines health as a durable stock of capital that produces two types of benefits i.e. consumption benefits in the form of utility and investment benefits in the form of productivity. In this theory individuals are not passive recipients of health but are active producers of health. Health is accumulated and preserved through investment in various forms of medical care, education and time spent on health-enhancing activities (Grossman, 1972). The Health Production Function is a key component of this theory. The function shows how various socio-economic inputs are converted into health outcomes. Health is a function of income, education, medical care, environmental conditions and behavior. Income helps to purchase medical care and food. Education helps to enhance knowledge about health. Safe drinking water and sanitation facilities protect people from diseases and hence life expectancy is a result of both private investment decisions and government interventions (Lleras-Muney, 2005). In this study sanitation, education and safe drinking water are considered important factors in the health production function. These factors affect life expectancy as they influence exposure to diseases, utilization of medical care and preventive measures (World Health Organization, 2008). This theory as proposed by Grossman which helps to explain how socio-economic factors contribute to differences in life expectancy in India.

1.5.3 Demographic Transition Theory

Demographic Transition Theory is the theory that explains the changes in mortality rates and fertility rates that occur in the context of economic growth, industrialization, urbanization, and modernization (Notestein,1945). In the first stage, both fertility and mortality rates are very high. As food availability and health services improve, the mortality rate decreases, increasing the life expectancy (Lee & Reher, 2011). Later, the fertility rate also decreases in response to the increase in the literacy rate of the female population and the increase in income level. In the later stages, the mortality and fertility rates are very low, and the life expectancy is very high. With respect to the Indian context, the demographic transition is not uniform across all states. This has been attributed to the varying economic conditions, female literacy rates, and health services in the states (James, 2011). The Demographic Transition Theory explains the structural causes of the varying life expectancy in the Indian context (James, 2011).

1.5.4 Social Determinants of Health (WHO Framework)

The social determinants of health framework which was designed by the WHO describes health outcomes in the context of the conditions in which individuals are born, live, work and age (WHO, 2008). The conditions refer to income, education level, health services, availability of drinking water and sanitation facilities. According to the social determinants of health framework health inequalities are the consequences of structural determinants rather than individual choices (WHO, 2023). In the context of the current study the social determinants of health model consider sanitation facilities, literacy rates and availability of drinking water facilities as the social determinants of health that affect disease prevalence health awareness, and health service utilization directly. According to the social determinants of health model, the varying life expectancy in the context of gender, rural/urban areas and states is the reflection of the unequal availability of structural determinants.

1.5.5 Inequality and Health Hypothesis

According to the Inequality and Health Hypothesis not only income level but also income distribution affects population health (Pickett & Wilkinson, 2010). The Inequality and Health Hypothesis asserts that countries with higher income inequality will have a lower life expectancy even if their per capita income is similar. Income inequality is a major cause of health disparities which arise through a number of different pathways which includes unequal access to healthcare and education for poorer individuals, reduced social cohesion, and reduced

investment in healthcare infrastructure. In the Indian context, income inequality is a major issue as there is a wide disparity in income levels across states, socio-economic groups and rural-urban areas (Pickett & Wilkinson, 2010).

By integrating all the different theoretical perspectives this present study conceptualizes life expectancy as a resultant of a complex interaction of different economic, social, demographic and structural factors. The Preston Curve would explain the macro-level relationship between income and longevity, the Grossman Health Capital and Health Production Model would provide a micro-economic foundation for linking social determinants with life expectancy, Demographic Transition Theory would provide a contextual understanding of life expectancy and the WHO's SDH perspective would emphasize structural.

1.6 Methodology

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 (World Bank,2024).

The present study investigates the impact of socio-economic determinants on life expectancy in India over the period 1970–2023, employing a quantitative research design based exclusively on secondary data. India represents a diverse socio-economic landscape with substantial inter-regional, gender and rural–urban variations in health outcomes. The extended time frame of 53 years was selected to capture long-term structural changes, demographic transition processes, economic reforms and public health transformations thereby enabling a comprehensive time-series assessment of the determinants of life expectancy.

Annual data were collected from reliable and authenticated sources which includes:

The World Bank's World Development Indicators (WDI) – It is an international financial institution that provides development data through its World Development Indicators database. WDI offers annual macroeconomic and health-related statistics, including GDP per capita and life expectancy across countries. It is a primary source for long-term time-series economic data.

World Health Organization (WHO) – It is a specialized agency of the United Nations responsible for international public health. It compiles standardized global health statistics through platforms such as the Global Health Observatory (GHO). WHO provides internationally comparable data on different indices.

Sample Registration System (SRS) – It is a large-scale demographic survey for providing reliable annual estimates of Infant mortality rate, birth rate, death rate, other fertility and mortality indicators at the national and sub-national levels (Office of the Registrar General & Census Commissioner India, 2025).

Reserve Bank of India (RBI) – It is India's central banking institution and publishes macroeconomic data including national income statistics, inflation indicators and economic trends (Reserve Bank of India, 2023). RBI publications are used to validate GDP per capita figures and macroeconomic indicators.

Ministry of Statistics and Programme Implementation (MOSPI) – It is the nodal agency responsible for national statistical data in India. It compiles and disseminates official statistics related to national accounts, economic growth, and social indicators (Ministry of Statistics and Programme Implementation, n.d.)

Ministry of Health and Family Welfare (MoHFW) – It oversees health policy and public health programs in India and publishes data related to sanitation initiatives, health infrastructure and public health expenditure supporting the analysis of health determinants (Ministry of Health and Family Welfare, 2021).

Census of India – It is conducted every 10 years by the Office of the Registrar General and Census Commissioner. Census provides comprehensive demographic and socio-economic data at national and state. Census data are considered the most authoritative source for population and household characteristics levels (Office of the Registrar General & Census Commissioner, India, 2011).

National Family Health Survey (NFHS) – It is a large-scale nationally representative household survey conducted under the Ministry of Health and Family Welfare. It provides detailed data on health, sanitation, education, and demographic characteristics (International Institute for Population Sciences [IIPS] & ICF, 2021).

Life expectancy data (total, male, female, rural, and urban) were primarily sourced from SRS life tables and WHO databases. GDP per capita data were obtained from the World Bank and

RBI publications. Data on selected social determinants which includes sanitation coverage, literacy rate and access to safe drinking water were compiled from Census reports, NFHS, World Bank and WHO databases. States were grouped according to administrative zonal divisions (Northern, Southern, Eastern, Western, Central, and North-Eastern zones) to facilitate regional disparity analysis.

The theoretical foundation of the study draws upon the WHO Social Determinants of Health (SDH) framework and the Health Production Function. The WHO Social Determinants of Health framework defines health outcomes as being shaped by structural and environmental conditions such as education, income, sanitation and living standards rather than solely medical care. The Health Production Function which is derived from Grossman (1972), conceptualizes health as an outcome produced through socio-economic inputs including income, education, healthcare access and environmental infrastructure. Administrative zonal divisions are used as an analytical tool to group states geographically in order to systematically examine spatial disparities in life expectancy.

In accordance with the research objectives, multiple statistical techniques were employed. The association between GDP per capita and life expectancy was examined using correlation analysis to measure the strength and direction of the income–health relationship. The impact of selected social determinants (sanitation, literacy and access to drinking water) on life expectancy was evaluated using multiple regression analysis since this method allows for the estimation of the independent contribution of each variable while controlling for others, consistent with the health production and social determinants of health framework. Regional disparities across administrative zonal divisions were assessed using Analysis of Variance (ANOVA), which is appropriate for comparing mean differences in life expectancy across multiple groups.

Secondary data were chosen due to their reliability, national representativeness and availability over a long historical period which is essential for macro-level and inter-state comparative analysis. The 1970–2023 time frame ensures adequate degrees of freedom for statistical testing and captures multiple phases of India's economic and demographic transformation. The selected methods are consistent with the study's objectives, theoretical grounding and the nature of the available data thereby providing a robust empirical framework for analyzing the socio-economic determinants of life expectancy in India.

The variables included in the study are selected based on the theoretical foundations of the Preston Curve, the Health Production Function (Grossman, 1972), and the WHO Social Determinants of Health framework. Life expectancy is treated as the outcome variable reflecting overall survival conditions, while GDP per capita and selected social determinants which includes sanitation, literacy rate and access to safe drinking water are considered explanatory variables influencing longevity.

VARIABLE	TYPE	DEFINITION / MEASUREMENT	THEORETICAL JUSTIFICATION	DATA SOURCE
Life Expectancy at Birth (LEB)	Dependent Variable	Average number of years a newborn is expected to live under prevailing mortality conditions	Core indicator of population health; reflects cumulative socio-economic and demographic conditions	SRS, WHO, World Bank
GDP per Capita Income (PCI)	Independent Variable	Total value of goods and services produced within a country during a given year divided by its mid-year population.	Preston Curve: Higher income improves nutrition, healthcare access, and living standards	World Bank (WDI), RBI
Sanitation	Independent Variable	Percentage of population with access to improved sanitation facilities	WHO SDH: Reduces disease exposure and mortality risk	Census of India, NFHS, WHO, World Bank
Access to Safe Drinking Water	Independent Variable	Percentage of population with access to improved water sources	WHO SDH & Health Production Function: Prevents waterborne diseases and child mortality	Census, NFHS, WHO, World Bank
Literacy Rate	Independent Variable	Percentage of population aged 7+ who can read and write	WHO SDH &Health Production Function: Enhances health awareness, healthcare utilization, and preventive behaviour	Census of India, NSSO, World Bank

Life Expectancy is chosen as it is a comprehensive measure of mortality and overall population health (World Health Organization, 2023). GDP per capita captures macroeconomic development and income effects as proposed in the Preston framework (Preston, 1975). Sanitation and safe drinking water are fundamental environmental determinants under the WHO SDH model, directly affecting communicable disease prevalence. Literacy rate represents human capital and influences health behavior, awareness, and adoption of medical innovations as per the Health Production Function and WHO Social determinants of health framework. These variables together enable a multidimensional assessment of how economic growth, social determinants and structural disparities collectively shape life expectancy patterns in India over time.

1.7 Limitations of the study

- Complete data about life expectancy and economic indicators which research requires for extended periods does not exist for some Indian states. The research data contain measurement errors because researchers used interpolation and estimation methods to create their results.
- National data may obscure regional disparities but state data distribution for econometric research lacks uniformity across all regions.
- The results of this study apply only to India because its economic and institutional framework governs the research findings. The research results become inapplicable to other developing nations which have different demographic characteristics and healthcare systems and policy systems.
- India's various health system developments and governance practices and social customs create difficulties which prevent researchers from applying national research findings to all regions of the country.

1.8 Scheme of Study

This thesis is divided into four comprehensive chapters to ensure conceptual clarity, analytical coherence, and logical progression of the study.

Chapter 1 outlines the foundational framework of the study. It includes the introduction, which outlines the background and significance of the study, followed by a comprehensive review of the relevant literature. This chapter also outlines the statement of the problem and the objectives of the study. The theoretical framework of the study is outlined in terms of established economic and public health theories. In addition, the research methodology adopted for the

study, the data sources, the description of the variables used for the study, the statistical techniques adopted for the study, the limitations of the study, and the scheme of the thesis are outlined in this chapter.

Chapter 2 presents national and state-wise trends in life expectancy in India over the years, highlighting regional disparities. It also examines international trends, comparing India's performance with other countries to provide a global context. Additionally, the chapter outlines key healthcare policies and schemes implemented to improve longevity in India.

Chapter 3 presents the empirical analysis of the research, comprising a comprehensive statistical examination of the collected data. In this regard, correlation analysis is used to examine the relationship between GDP per capita income and life expectancy, regression analysis to examine the impact of social determinants such as sanitation, literacy rate and access to safe drinking water on life expectancy, Analysis of Variance (ANOVA) to examine the regional differences in the data by dividing the regions into different zonal divisions. This chapter provides an in-depth statistical exploration of the data, shedding light on the research findings.

Chapter 4 integrates and interprets the empirical findings in context of the study's theoretical framework and objectives. It discusses policy implications, highlights key findings and outlines the study's contributions. The chapter concludes by suggesting future research directions, providing a comprehensive overview of the research outcomes and their significance.

The adopted structure of the study would ensure a smooth transition from the theoretical framework to the empirical investigation and policy implications, thereby providing a comprehensive study of the socio-economic determinants of life expectancy in India.

CHAPTER 2
LIFE EXPECTANCY: AN OVERVIEW

2.1 Life Expectancy

Life expectancy is a key demographic indicator and a measure of human development index (HDI). According to World Health Organisation life expectancy is defined as the average number of years a person is expected to live assuming they experience the prevailing age-specific mortality rates throughout their remaining life. It is primarily measured using period life expectancy. It applies current mortality rates hypothetically across all ages as opposed to cohort life expectancy that tracks actual survival of a birth group over time (Office for National Statistics,2023). Indicators of life expectancy include life expectancy at birth (LEB) which indicates overall mortality patterns. Life expectancy at older ages like 60 and healthy life expectancy (HALE) subtracts years lived with disability or poor health (World Health Organization,2024). Life expectancy is calculated based on life tables that estimate survival probabilities using age-specific mortality rates and calculate remaining years as total person-years lived beyond a certain age divided by survivors at that age (World Bank, n.d.). Registration systems, national censuses and surveys compiled by organizations such as the United Nations Population Division and the World Health Organization are the key sources of data for life expectancy.

According to the Office of the Registrar General of India life expectancy at birth in India has shown steady improvement reaching approximately 70.3 years for the period 2019–2023. Male life expectancy of India is at 68.5 years and female life expectancy at 72.5 years (Office of the Registrar General & Census Commissioner, India, 2025). Estimates from the United Nations and other sources indicates that life expectancy is expected to be around 72 years by 2023–2024 reflecting gains from reduced infant mortality, better healthcare access, and disease control, though significant state-level variations. Kerala has the highest life expectancy rate in India with about 75 years due the states unique developmental model which indicates higher health indicators. Bihar and Uttar Pradesh has lower life expectancy due to malnutrition, availability of safe drinking water, nourishment, healthcare facilities, infrastructure and other socioeconomic conditions (Deshpande & Ramachandran, 2022). Events of non-communicable diseases continue to be a challenge that influences future trends of life expectancy.

Life expectancy has increased significantly across the world. This increase in life expectancy is driven by medical advancements, improved sanitation and nutrition (World Health Organization, 2024). The COVID-19 pandemic caused a temporary decline in life expectancy

dropping the levels to around 71.4 years by 2021 but recovery has occurred with global life expectancy reaching 73.3 years in 2024 (United Nations, 2024). There is still evidence of persistent disparities in life expectancy. High-income countries have better life expectancy rates which exceed 80 years while low-income regions face a common health crisis of people living under 65 years (United Nations, 2024).

Registration systems along with censuses and international organization's surveys provide accurate life expectancy data. (United Nations 2024). The United Nations World Population Prospects (UN WPP) serves as a primary source because it provides standardized life estimates from national statistical data. The World Health Organization Global Health Observatory supplies both life tables and HALE metrics (World Health Organization, 2024). India's Registrar General and other national agencies provide basic mortality data and population statistics.

2.2 Measures of Life expectancy

In demography measures of life expectancy describe different ways of summarizing survival and mortality patterns in a population (Keyfitz & Caswell, 2005). The measures of life expectancy include life expectancy at birth, period life expectancy, cohort life expectancy, and health-adjusted life expectancy

Life expectancy at birth refers to the average number of years a newborn would live if current mortality conditions stayed the same throughout life (World Health organisation,2024). Period life expectancy summarizes mortality conditions at a specific point in time, while cohort life expectancy follows the actual survival experience of a real group of people born in the same year (Keyfitz & Caswell, 2005). Health-adjusted measures, such as healthy life expectancy, go a step further by accounting for years lived in poor health or with disability, linking length of life with quality of life (Robine & Ritchie, 1991).

2.2.1 Life Expectancy at birth

Life expectancy at birth is denoted as e_0. According to world health organisation it is defined as the average number of years a newborn would live if exposed throughout life to the age-specific mortality rates observed during a particular period. It provides a summary of the mortality conditions prevailing at the time the measure is calculated.

Life expectancy at birth is a period measure which is based on mortality data from a specific calendar year or short reference period. The calculation assumes that these mortality rates remain constant over the lifetime of the newborn. This assumption is rarely true in reality. This assumption allows life expectancy at birth to function as a standardized and comparable indicator across populations and time periods (Chiang, 1984).

Life expectancy at birth is particularly sensitive to deaths occurring at younger ages since it reflects mortality risks at all ages. As a result reduction in infant and child mortality can lead to large increases in life expectancy, especially in low and middle income countries (United Nations, 2022). In high income countries where early life mortality is already low, gains in life expectancy increasingly depend on improvements in adult and elderly survival (Oeppen & Vaupel, 2002).

Life expectancy at birth requires researchers to obtain exact numbers of deaths together with demographic data that specifies age and gender distribution. The data source to obatian life expectancy at birth includes civil registration and vital statistics (CRVS) systems which maintain continuous records of all births and deaths together with their age and sex and cause of death information. Countries that have developed efficient CRVS systems can generate precise life tables together with their life expectancy values (Wilmoth et al., 2007). The population census data provides age-based population counts which researchers use to calculate death risk exposure for the entire population. The United Nations reports that researchers use three data sources to assess mortality rates in areas with missing death registration data which includes sample registration systems, demographic surveillance sites and household surveys that include demographic and health surveys. International organizations such as the United Nations and the World Health Organization collect data from countries, adjust the differences in data quality and standardise methods so that life expectancy estimates can be compared with other countries. In India the Sample Registration System tracks births and deaths for accurate figures (Indian Ministry of Health and Family Welfare [MoHFW], 2021).

Life expectancy at birth is derived from a period life table, which is a structured statistical representation of age-specific mortality conditions for a hypothetical cohort (Chiang, 1984). The life table describes how a group of individuals would gradually die off as they age if they were exposed to the mortality rates observed during a given period. The life table begins with a fixed number of births, known as the radix, which is typically set at 100,000. Using observed age-specific death rates, the table tracks the number of survivors, deaths, person-years lived,

and remaining life expectancy at each age. The life table therefore serves as the technical foundation for calculating life expectancy and related survival measures (Preston et al., 2001

Significance of Life Expectancy at Birth

Life expectancy at birth is widely used because it summarizes mortality conditions across all ages in a single measure. It is especially sensitive to infant and child mortality making it a strong indicator of basic health conditions, nutrition, sanitation, and access to healthcare (United Nations, 2022).

In low-income countries increase in life expectancy at birth reflect improvements in early life survival. In high income countries where early mortality is already low further gains depend more on reductions in adult and elderly mortality particularly from chronic diseases (Oeppen & Vaupel, 2002).

Life expectancy at birth plays a central role in policy planning, informing decisions related to health systems, education, pensions, and economic development. It is also a key benchmark for international comparisons and for monitoring progress toward health and development goals (Wilmoth et al., 2007).

2.2.2 Period Life Expectancy

Period life expectancy summarizes the mortality conditions observed during a specific calendar period, most commonly a single year. It is calculated by applying the age specific mortality rates observed during that period to a hypothetical cohort that is assumed to experience those same rates throughout its lifetime (Preston et al., 2001). Period life expectancy does not describe the actual lifespan of any real group of people. It provides a glimpse of prevailing mortality conditions at a given point in time. Since it reflects current mortality risks rather than future changes period life expectancy is useful for monitoring short-term trends and making comparisons across countries and time periods. The interpretation of period life expectancy requires care, particularly during periods of rapid mortality change.

2.2.3 Cohort Life Expectancy

Cohort life expectancy refers to the average length of life of an actual birth cohort based on the mortality rates experienced by that cohort at each age over time (Keyfitz & Caswell, 2005). Unlike period life expectancy which relies on hypothetical assumptions cohort life expectancy follows a real group of individuals from birth through death.

Cohort life expectancy provides a more realistic estimate of actual lifespan because it incorporates mortality improvements over time. Its dependence on mortality projections makes it uncertain particularly for cohorts that are still young (Tuljapurkar & Caswell, 1997).

2.2.4 Healthy Life Expectancy (HALE)

Healthy life expectancy estimates the average number of years a person is expected to live in good health by adjusting total life expectancy for time spent in states of illness or disability (Robine & Ritchie, 1991). HALE explicitly incorporates morbidity making it a measure of both survival and health quality. HALE is central to global health monitoring and policy evaluation because it bridges the gap between mere survival and functional well-being, offering a more holistic indicator of population health than life expectancy alone (Mathers et al., 2004). It is widely used in burden-of-disease studies (e.g., Global Burden of Disease project), health-system performance assessments, health equity analyses, and setting priorities for resource allocation, as it reveals the years of healthy life lost due to preventable or treatable conditions (Murray et al., 2012; Salomon et al., 2012). By incorporating morbidity, HALE highlights the double burden of disease in low- and middle-income countries, where populations may live longer but spend more years in poor health due to non-communicable diseases, injuries, and inadequate long-term care (World Health Organization, 2019; GBD 2019 Demographics Collaborators, 2020).

In the Indian context, HALE is particularly relevant because rapid gains in life expectancy have not always been accompanied by equivalent improvements in healthy years, especially in regions with high rates of malnutrition, infectious diseases, and emerging non-communicable conditions (Indian Council of Medical Research et al., 2020; Yadav & Yadav, 2024). Tracking HALE alongside life expectancy allows researchers and policymakers to assess whether economic and social progress is translating into genuine improvements in quality-adjusted life years, and to identify gaps in preventive care, rehabilitation, and chronic disease management (Salomon et al., 2012).

2.3 Global Trends

Life expectancy is widely used in demographic and public health research as a broad indicator of population health because it reflects mortality risks accumulated across the entire lifespan. During the past 200 years and most notably after the mid-twentieth century average human longevity has increased at a pace unmatched in earlier history. These improvements are closely

tied to progress in controlling infectious diseases, rising nutritional standards, better housing conditions, expanded education, and the development of modern public health and medical systems (Preston et al.,2001). Despite this overall progress, improvements in life expectancy have not occurred evenly. Substantial differences remain across regions, sexes, and socioeconomic groups, and recent decades have revealed periods of stalled or reversed gains, shaped by pandemics, demographic shifts, and growing social inequalities (United Nations, 2022).

At the global level, life expectancy at birth rose from below 50 years in the early 1950s to more than 72 years by the late 2010s. This increase stands as one of the most important indicators of human development in the modern era (United Nations, 2022). Early gains were largely driven by sharp declines in deaths among infants and children, particularly in low- and middle-income countries. These changes followed the widespread adoption of relatively simple but highly effective interventions, including vaccination, antibiotic treatment, safer water supplies, improved sanitation, and expanded maternal and child health services (Cutler et al., 2006).

In wealthier countries, initial improvements in life expectancy were also concentrated at younger ages. Over time, however, the main source of longevity gains shifted toward older ages, especially from the second half of the twentieth century onward (Vaupel et al., 1998). Reductions in cardiovascular mortality, declining smoking rates, and advances in medical care and chronic disease management allowed increasing numbers of people to survive into advanced old age, accelerating population ageing (Oeppen & Vaupel, 2002).

By comparison, many poorer countries experienced later but often rapid improvements after 1950. This led to some narrowing of international gaps in life expectancy during the latter half of the twentieth century (Wilson, 2001). However, these gains proved fragile. Economic shocks, conflict, and major health crises interrupted or reversed progress in several regions, underlining the instability of longevity improvements.

Large regional inequalities in life expectancy persist. High-income regions such as Western Europe, North America, Japan, and Australia continue to record the highest levels of longevity, frequently exceeding 80 years at birth. These outcomes reflect sustained investment in healthcare systems, education, disease prevention, and long-term treatment of chronic illness (OECD, 2021). In contrast, sub-Saharan Africa continues to experience the lowest life expectancy globally, despite noticeable improvements since the early 2000s. The HIV/AIDS epidemic caused major increases in adult mortality in the late twentieth century, sharply

reducing life expectancy in many countries. Although access to antiretroviral therapy has improved survival, life expectancy in much of the region remains well below the global average (WHO, 2023).

Countries in South Asia and parts of Southeast Asia occupy a middle position, with steady but slower gains in longevity. These patterns reflect the coexistence of persistent infectious diseases, rapidly rising non-communicable diseases, and environmental risks such as air pollution and unsafe water (Bloom & Canning, 2007). India exemplifies this trajectory: life expectancy has risen substantially since independence, yet continues to lag behind global leaders due to unequal access to healthcare, gender disparities, and preventable adult mortality (Registrar General of India, 2022).

Gender differences are another consistent feature of global life expectancy trends. In almost all countries, women outlive men, typically by four to seven years at birth (Barford et al., 2006). This pattern arises from a combination of biological advantages and differences in social roles and behaviors, including lower exposure to occupational hazards and risky behaviors among women (Rogers et al., 2010). While the female advantage widened during the mid-twentieth century in many high-income countries, it has narrowed more recently as male mortality declined and female smoking rates increased (Preston & Wang, 2006).

The rise in life expectancy is closely connected to changes in the causes of death associated with the epidemiological transition. As infectious diseases declined, chronic non-communicable diseases became the dominant causes of mortality, particularly in high-income countries (Omran, 1971). Many low- and middle-income countries now face a dual burden, where infectious diseases persist alongside growing rates of chronic illness, placing additional strain on health systems (Boutayeb, 2006).

Finally, recent events have demonstrated how vulnerable life expectancy gains can be. The COVID-19 pandemic caused sharp declines in life expectancy in many countries during 2020 and 2021, with losses in some high-income countries comparable to those seen during major historical crises (Aburto et al., 2022). These declines varied widely across countries, reflecting differences in health system capacity, vaccination coverage, and social inequality (WHO, 2023). Together, these patterns show that improvements in life expectancy are not guaranteed and depend heavily on social policy, equitable access to healthcare, and effective governance.

Table 2.1 Top 10 Countries with highest life expectancy

Country Name	Monaco	San Marino	Hong Kong SAR, China	Liechtenstein	French Polynesia	Switzerland	Japan	Andorra	Spain	Italy
2000	82.121	80.504	80.87317 073	76.8268293	79	79.6804878	81.07 61	81.863	78.966	79.7780 5
2001	82.485	80.803	81.41926 829	79.2756098	79.316	80.1804878	81.41 634	82.162	79.368	80.1268 3
2002	83.055	81.061	81.45219 512	79.6365854	79.544	80.3853659	81.69 073	82.448	79.568	80.2292 7
2003	83.613	81.33	81.34341 463	79.9609756	79.71	80.5365854	81.76	82.718	79.62	79.9829 3
2004	84.151	81.592	81.79926 829	81.7707317	79.829	81.0878049	82.03 024	82.815	79.871	80.7804 9
2005	84.34	81.926	81.60902 439	80.6682927	79.951	81.2365854	81.95 512	83.086	80.171	80.7829 3
2006	84.194	82.258	82.38487 805	80.9487805	80.1	81.4902439	82.32 195	83.374	80.822	81.2829 3
2007	83.903	82.605	82.36682 927	81.295122	80.328	81.7414634	82.50 707	83.632	80.873	81.4341 5
2008	83.827	82.894	82.34048 78	82.6829268	80.587	81.9926829	82.58 756	83.855	81.176	81.4853 7
2009	84.187	83.224	82.77512 195	81.5	80.867	82.0439024	82.93 146	84.1	81.476	81.6365 9
2010	84.644	83.464	82.95756 098	81.8414634	81.141	82.2463415	82.84 268	84.197	81.627	82.0365 9
2011	85.01	83.713	83.41195 122	81.7926829	81.434	82.695122	82.59 122	84.296	82.476	82.1878
2012	85.045	83.943	83.45024 39	82.3829268	81.695	82.697561	83.09 61	84.334	82.427	82.2390 2
2013	85.056	84.175	83.83121 951	82.2609756	81.935	82.797561	83.33 195	84.406	83.078	82.6902 4
2014	85.093	84.394	83.93560 976	82.0731707	82.151	83.197561	83.58 78	84.485	83.229	83.0902 4
2015	85.323	84.596	84.25268 293	82.6560976	82.339	82.897561	83.79 39	84.532	82.832	82.5439
2016	85.63	84.775	84.21146 341	82.2585366	82.555	83.602439	83.98 488	84.489	83.329	83.2439
2017	85.878	84.933	84.69560 976	83.7463415	82.774	83.5512195	84.09 976	84.359	83.283	82.9463 4
2018	86.084	85.095	84.86975 61	83.0414634	82.985	83.7536585	84.21 098	84.242	83.432	83.3463 4
2019	86.151	85.257	85.15585 366	84.1609756	83.195	83.904878	84.35 634	84.098	83.832	83.4975 6
2020	86.089	82.65	85.49634 146	81.6585366	82.459	83	84.56	79.418	82.232	82.1951 2

2021	85.113	83.539	85.53268293	84.402439	79.571	83.7512195	84.44561	82.331	83.178	82.64634
2022	85.746	85.708	83.66097561	84.1219512	83.859	83.604878	83.99634	84.016	83.134	82.7
2023	86.372	85.706	85.24731707	84.8414634	84.07	84.0560976	84.04122	84.041	83.883	83.7

Source: World Bank Data

Monaco has always topped the list of country with highest life expectancy. The population of Monaco lives longer because of extreme wealth, the small population, availability of top healthcare services and the Mediterranean climate create optimal living conditions. The life expectancy of the Monaco population rose from 82.12 years in 2000 to 86.37 years in 2023. Hong Kong has achieved the most significant growth in life expectancy because its citizens face extreme population density which causes them to live five additional years. This achievement exists because people in the population who smoke cigarettes tend to smoke less while public healthcare systems function efficiently and people focus on active aging (The Lancet 2021). Japan has long been a model for longevity. The data shows a remarkable consistency because even the lowest values exceed the highest values of most other countries. The average life expectancy in Japan reached 84.04 years by 2023.

Table 2.2 Top Leaders

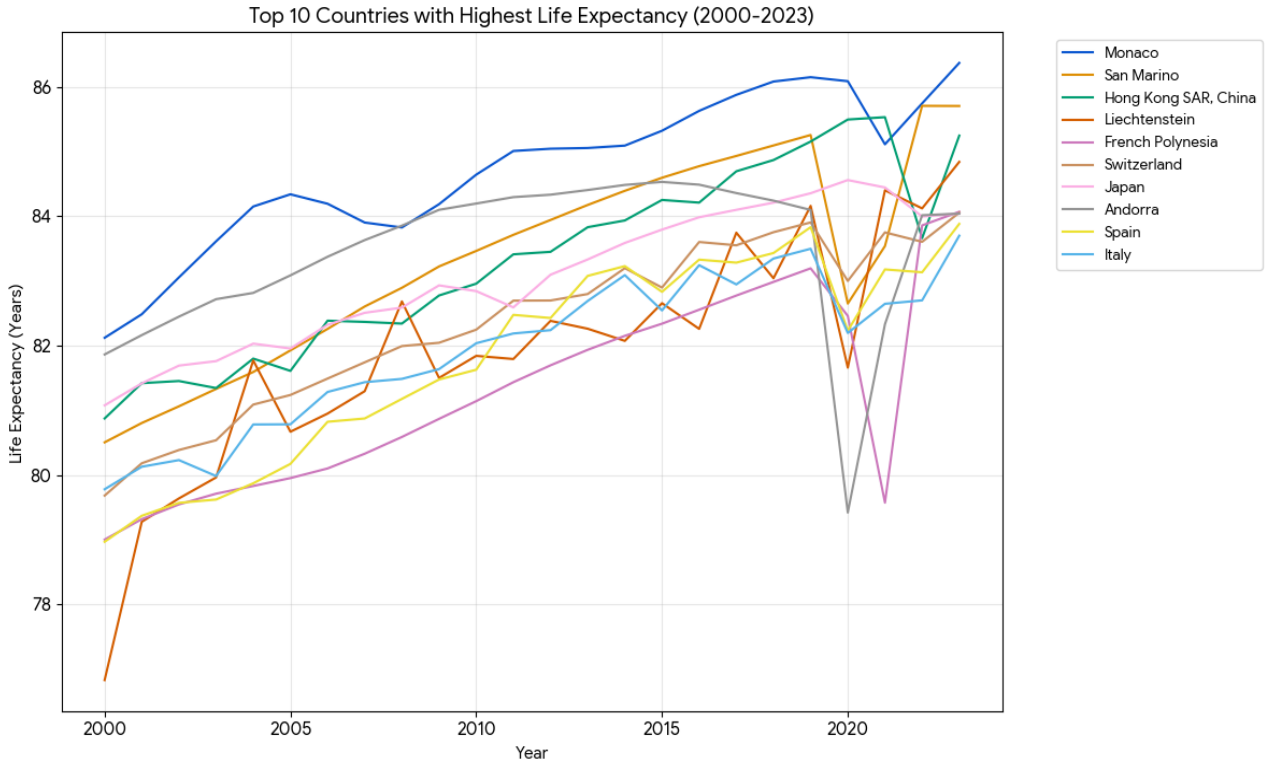
Country	2000 Life Expectancy	2023 Life Expectancy	Net Gain (Years)
Monaco	82.12	86.37	+4.25
Japan	81.08	85.06	+3.98
Hong Kong	80.88	85.83	+4.95
Switzerland	79.68	84.25	+4.57

Source: World Bank

The table 2.2 shows the data on life expectancy changes that occurred between 2000 and 2023 for Monaco, Japan, Hong Kong, and Switzerland which are the leading countries with highest life expectancy rate. The countries achieved additional life expectancy gains between 2000 and 2020 because they started with high life expectancy rates. The largest increase in life expectancy occurred in Hong Kong which was followed by Switzerland and Monaco while Japan experienced continuous improvement. The pattern reflects the idea of diminishing returns where improvements in income alone no longer lead to large increases in life

expectancy and further gains depend more on advanced healthcare systems, disease prevention, medical technology and healthy ageing policies (Preston, 1975; World Health Organization, 2023; World Bank, 2024). The table demonstrates that humanity maintains progress toward extreme longevity but current advancements occur at a reduced speed because social factors and health system development drive progress more than economic advancement.

Figure 2.1 Top 10 countries with highest life expectancy



Source: Compiled from World bank data by the researcher

The graph indicates that the world's top ten countries with the highest life expectancy which include Monaco, San Marino, Hong Kong SAR, China, Liechtenstein, French Polynesia, Switzerland, Japan, Andorra, Spain, and Italy have maintained a similar life expectancy pattern since 2000. From the initial stage itself all these countries displayed high life expectancy rates which exceeded 78 years but their life expectancy continued to increase for another 20 years. The gradual upward movement shows how older people now survive better because of medical advancements while child death rates already reached their lowest point by 2000 according to the World Health Organization 2023 report. The graph shows that progress went through an irregular pattern because most countries showed a clear decline during the 2020 to 2021 period due to the COVID-19 pandemic's excess deaths that affected older populations in Spain, Italy

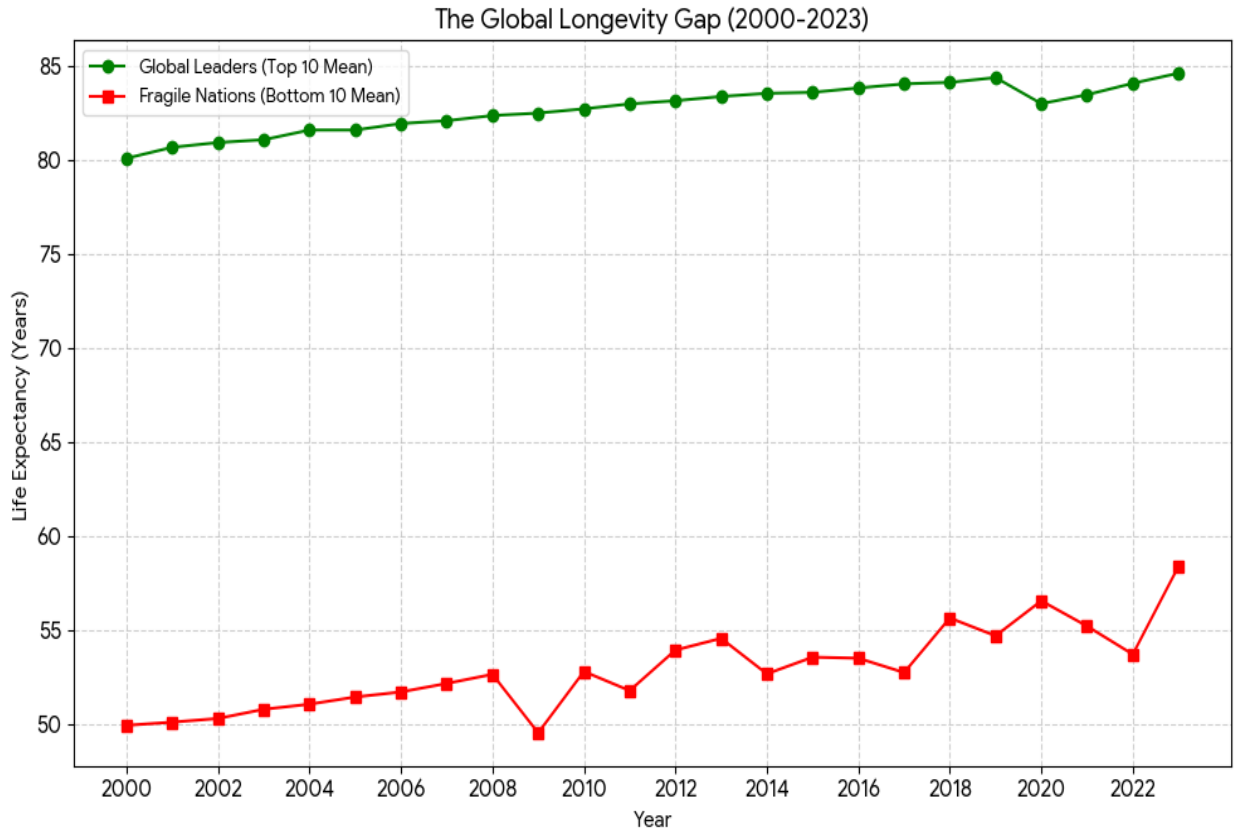
and Switzerland according to the World Health Organization 2024 report. The life expectancy rates for most countries except two nations reached pre-pandemic levels by 2022 to 2023 which demonstrated that the health system had recovered and vaccination programs had achieved success according to the World Bank 2024 report. The pattern of data shows that people in the highest longevity range of the planet can still achieve life expectancy increases but these advancements take time to develop and they face risks from worldwide health emergencies.

These countries achieved high life expectancy rates primarily because of strong health systems combined with favourable social conditions. Universal or near-universal health coverage ensures early detection and effective treatment of chronic diseases, which is especially important in ageing societies (World Health Organization, 2023). Countries such as Japan, Switzerland, and Spain have well-developed primary healthcare systems that emphasize prevention, regular screening and long-term management of non-communicable diseases such as heart disease, diabetes, and cancer (World Bank, 2024). Public health policies related to clean water, sanitation, food safety and air quality remains strong reducing mortality throughout the life course (World Health Organization, 2023). Lifestyle factors also play a major role. Diets rich in vegetables, fish and healthy fats particularly in Japan, Italy, and Spain, are associated with lower cardiovascular risk and longer healthy life expectancy (WHO, 2023). High levels of education, low poverty rates and strong social protection systems further support longevity by reducing stress, improving health literacy and ensuring access to care across income groups (World Bank, 2024). In small high-income countries like Monaco, Andorra and Liechtenstein high public spending on health and social services combined with relatively small populations allows for highly personalized and efficient healthcare delivery (World Health Organization, 2023).

The graph demonstrates that these top countries had the same success level yet they showed different patterns which proved that high life expectancy development requires multiple pathways to achieve its goals. Hong Kong SAR shows one of the strongest long-term gains reaching the highest life expectancy by 2023. This reflects rapid adoption of medical technologies, dense healthcare infrastructure and effective public health governance in an urban setting (World Bank, 2024). Japan demonstrates a stable trend which shows slower growth at present because the country has reached its maximum capacity for biological and technological development which now requires healthy aging and dementia prevention practices to achieve future progress (World Health Organization, 2023). Southern European countries such as Spain and Italy experienced sharper pandemic related declines but also strong

rebounds, highlighting both vulnerability due to older populations and resilience due to robust healthcare systems (WHO, 2024). Demographic research reveals that once countries attain very high income and health levels, their life expectancy increases depend more on social policies and healthcare quality and prevention measures and crisis protection methods for older individuals than on economic growth (World Bank, 2024). The graph therefore illustrates not only who lives the longest, but also how sustained investments in health and social systems shape long-term survival at the global frontier of life expectancy.

Figure 2.2 Global longevity gap



Source: Compiled from World bank Data and WHO by the researcher

The figure 2.2 compares the life expectancy trends between the top 10 countries with the highest life expectancy and 10 countries with the lowest life expectancy. The graph shows two distinct paths that the two groups take throughout the two decades because their living conditions create different outcomes. People born in the highest performing countries could expect to live nearly 80 years in 2000 while people born in the lowest performing countries had a life expectancy of approximately 50 years which created a three-decade gap between the two groups at the beginning of the century (World Bank, 2024). Life expectancy serves as a

health measurement which also functions as a measurement tool for determining social and economic disparities within a society. The researchers currently identify this divide as the biological manifestation of inequality because social disadvantages develop as physical health problems whose effects include increased mortality rates and shorter life spans (World Health Organization, 2023). The social determinants of health which include essential resources like proper nutrition, safe housing, clean water, education, stable governance and functioning healthcare systems remain inaccessible to various populations who therefore determine their survival outcomes through unequal access to these resources (WHO, 2024).

The graph enables us to understand how countries differ because it shows how global development has advanced toward unequal distribution because various populations experience different levels of progress towards improved living conditions. The trends among the top 10 countries demonstrate a pattern of stability and gradual improvement that reflects their advanced stage of health and social development. Life expectancy in these countries increased from about 80 years to about 85 years during the year 2000 to 2023 showing steady but decreasing gains over time. This pattern reflects diminishing returns where additional improvements become harder once basic public health problems have already been solved (World Bank, 2023). In these countries infant and child mortality had already reached very low levels by the early 2000s which indicates that further increase in life expectancy mainly depended on extending survival at older ages. As a result rise in progress came from better management of chronic diseases, advances in medical technology, improved elderly care and healthier lifestyles rather than from basic disease control (WHO, 2023). The relative smoothness of the trend line also indicates strong resilience to external shocks.

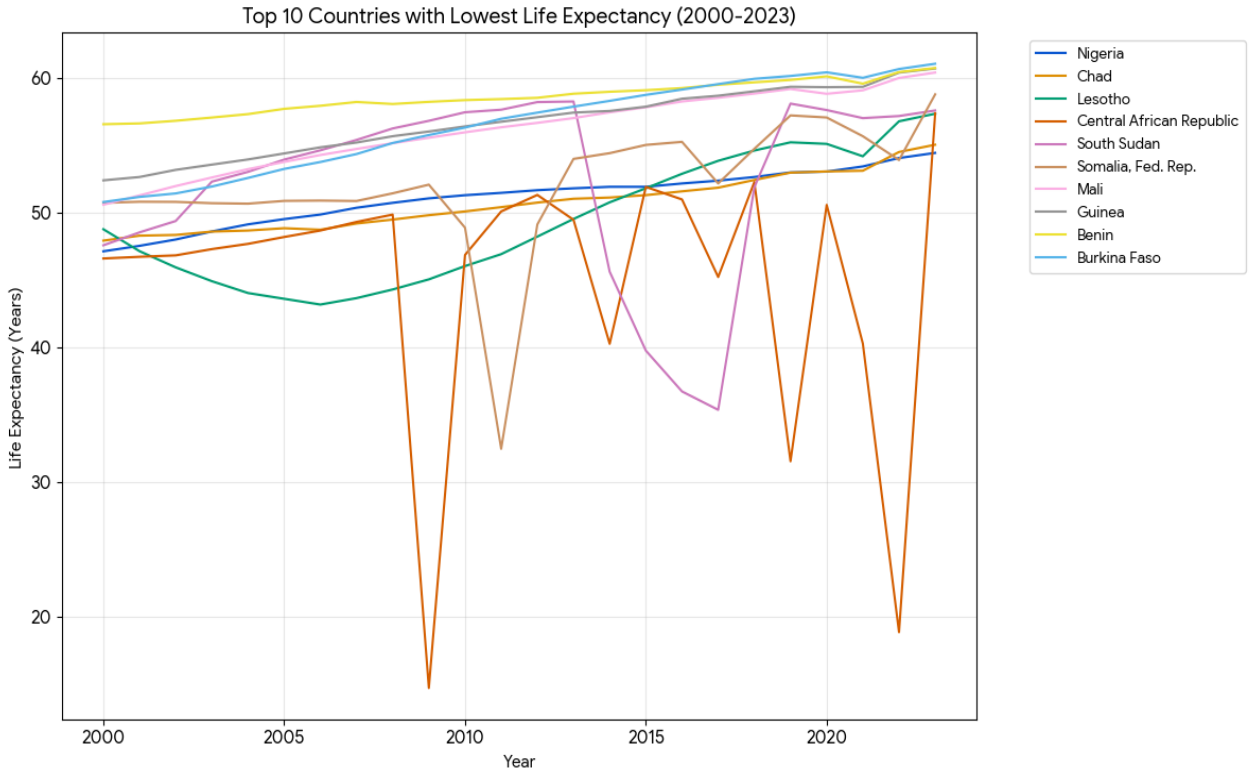
A temporary slowdown or decline is visible around 2020 due to the COVID-19 pandemic which disproportionately affected older populations even in high-income countries (World Health Organization, 2024). The rapid recovery after 2021 suggests that strong healthcare systems, widespread vaccination and effective public health responses helped restore longevity levels. The experience of these leading countries shows that while very long lives are achievable and further gains depend mainly on innovation, prevention and long-term care rather than on economic growth alone.

The life expectancy trend among the bottom 10 countries is marked by instability, vulnerability and repeated disruptions. Life expectancy in these groups increased from around 50 years in 2000 to approximately 58 years by 2023. The progress was uneven and frequently interrupted

by sharp declines. These sudden drops is due to periods of conflict, economic crises, disease outbreaks and the COVID-19 pandemic, demonstrating how fragile health systems react strongly to external shocks (World Bank, 2024). These countries remain heavily affected by preventable causes of death including infectious diseases, maternal mortality, malnutrition, and inadequate access to basic healthcare services (WHO, 2023).

The improvement after 2020 reflects a rebound effect. Despite these gains the overall gap between the two groups has narrowed only slightly from about 30 years in 2000 to roughly 26-27 years in 2023 indicating that global development efforts have not been sufficient to close the divide (World Bank, 2024). Many of the lowest performing countries remain stuck in a pre-epidemiological or early transition stage where infectious diseases and reproductive health risks dominate mortality patterns while the highest-performing countries have moved into a post-morbidity phase focused on healthy ageing and quality of life (WHO, 2024).

Figure 2.3 Countries with lowest life expectancy



Source: Compiled from World Bank Data and WHO by the researcher

Figure 2.3 Countries with lowest life expectancy serves as a window into the health struggles faced by the world's most vulnerable populations highlighting how systemic issues such as poverty, conflict and weak institutions create lasting barriers to longevity. The graph shows that

developing nations indeed improved their life expectancy through their steady development of essential healthcare facilities and educational facilities but certain areas experience deep demographic damages which results from external shocks that eliminate all progress (World Health Organization [WHO], 2023). The countries of Benin, Guinea and Mali exhibit steady progress through their slow-burn recovery pattern while South Sudan, Somalia and the Central African Republic show data patterns which display sudden declines that happen during civil wars, food shortages and complete medical system breakdowns (United Nations Development Programme [UNDP], 2022). The graph shows that life expectancy increase do not develop in a direct upward path because external shocks such as pandemic can affect the system. The analysis of these patterns indicates that global health improvement occurs in an uneven distribution because some regions make progress through focused health programs while others remain stagnant. This shows that true equity requires fixing fundamental governance and resource distribution problems (Patel et al., 2018). The data disproves the assumption that countries will make automatic progress because the countries that belong to the lowest development tier will experience continuous development freezes when they fail to receive ongoing international assistance (Jamison et al., 2013).

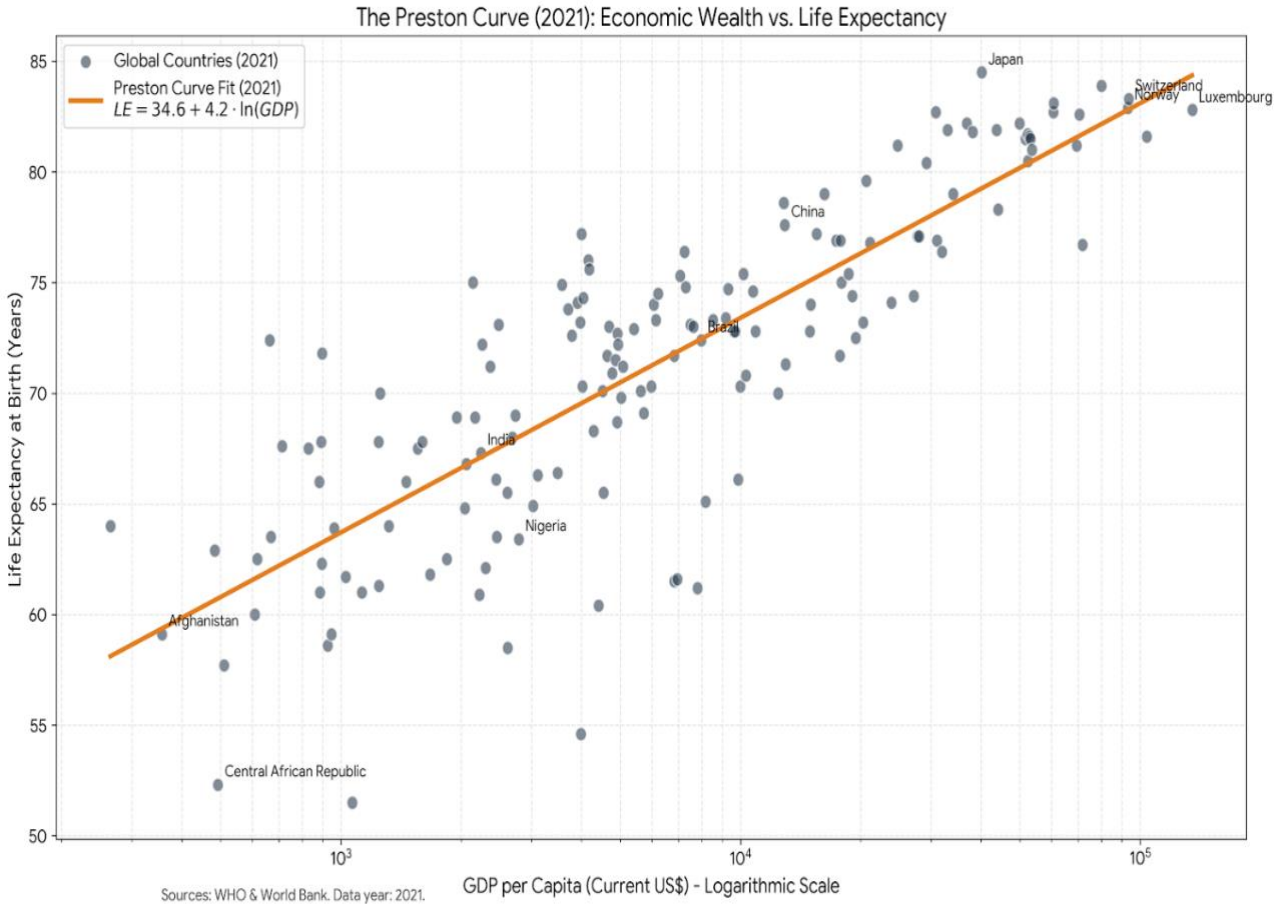
War is considered to be one of the main reason populations shrink and demographics suffer in places like Central African Republic, South Sudan and Somalia. This provides an example of what will happen when violence takeover health and society. Life expectancy in Central African Republic witnesses extreme fluctuations during the years 2009 to 2021 due to emergencies and instability which included actions by outside forces such as the Wagner group, which damaged farming and medical services by forcing people to move and violating basic rights (United Nations High Commissioner for Refugees [UNHCR], 2023). An upward trend in 2009 hints at progress masked by severe local conditions where death rates leap three to four times normal (International Rescue Committee [IRC], 2011). By 2021 the countries was caught in vicious cycles of hunger where about 82.3% of adults got only one meal every day or nothing at all according to fieldwork done just the year before (World Food Programme [WFP], 2021; IPC Global Analysis, 2022). Life expectancy takes a serious hit when wars break out. It is not only about how many die in battles. The real issue lies in what happens when entire systems fail to support people's well-being day by day. South Sudan is at the near bottom in terms of life expectancy. Fighting has never truly stopped since 2013. This created a scenario where around 383,000 lives were lost between 2013 and 2018. Researchers used careful statistical methods to show this toll existed beneath the surface (United Nations [UN], 2021). When

conflict arises death rates increases which is indicated by the graph. Shifting large numbers of families leads to growing hunger. Peace and steady politics matter most in healthcare in places like Somalia. Life expectancy climbed just 4.67 years between 2000 and 2021 despite help from abroad (UNDP, 2022). Droughts and hunger pushed people toward risks of infections. Maternal and disease-related illnesses claim far more than other causes making old health struggles still dominant (WHO, 2023). When systems fail all the past progress fades and one shock wipes out the entire progress built over decades (Goldstein & Lee, 2020).

The health landscape in developing nations is largely defined by the persistent threat of infectious diseases and malnutrition. This often prevents individuals from reaching old age where chronic conditions like heart disease become common. In Somalia these communicable and nutritional issues account for 63.8% of all deaths thus creating a massive constrain for traditional healthcare expansion (Global Burden of Disease Study, 2019). This developmental struggle is frequently worsened by environmental and social crises. In South Sudan life expectancy decrease during the period 2013 to 2018 as civil war caused the total collapse of vaccine distribution and food security (Bloom et al., 2018). In the Central African Republic widespread displacement by armed groups led to 80% of adults facing severe food insecurity. This proves that in unstable regions physical safety is a more significant determinant of survival than medical technology (WHO, 2023).These systemic failures are highlighted by the shortage of healthcare providers with the Central African Republic operating with just one doctor per 20,000 people which prevents the creation of a basic medical safety hub (WHO, 2023).While global leaders focus on refining long-term health trends the most vulnerable nations remain trapped in a cycle of instability that requires targeted international funding and new leadership to move life expectancy past the 60-year threshold (Lee & Carter, 1992). Closing these global

health gaps requires a combined effort that mixes peace with infrastructure reforms to ensure that progress is both sustainable and equitable (Patel et al., 2021).

Figure 2. 4: Global Preston curve 2021



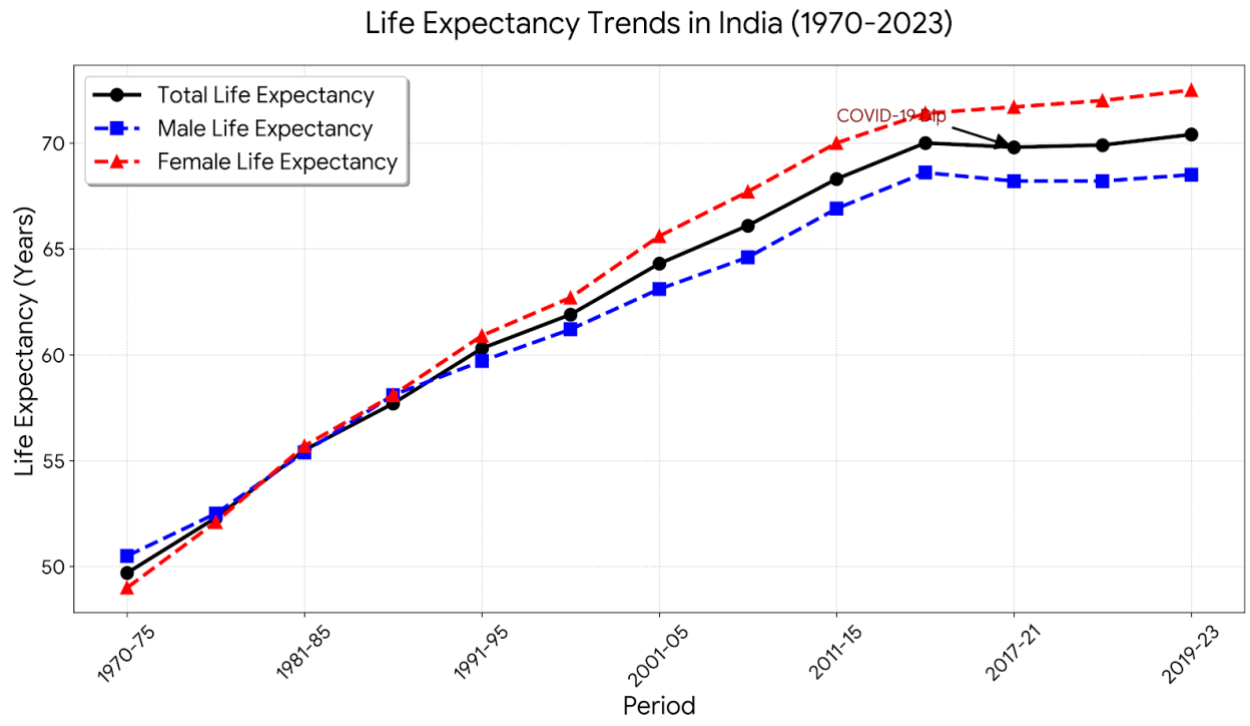
Source: Compiled from WHO and World Bank Data by the researcher

The Preston Curve developed by sociologist and demographer Samuel H. Preston in 1975 is a cross-sectional, non-linear relation of the per capita income and life-expectancy at birth for countries. The correlation establishes that wealthier is healthier but also demonstrates that income fails to provide complete protection against declining life expectancy because the curve experiences upward shift from external influences which include medical advancements and public health education (Pritchett & Summers, 1996). People from wealthier nations live longer than those from developing countries according to Preston's research findings. People in developed countries experience better health outcomes because they have access to healthcare services, educational resources, and cleaner environmental conditions, which enable them to achieve optimal health through proper nutrition and other health benefits. A poor nation experiences economic growth which leads to increased per capita income except this period creates significant life expectancy improvements because people can access better healthcare services and they gain access to more than basic nutritional needs.

2.4 Life expectancy trends in India

The people of India have achieved better life expectancy through the efforts to reduce death rates which were once extremely high in initial periods. The World Health Organization reports that the country's life expectancy has increased over time which demonstrates the worldwide evolution of health standards (WHO, 2024). The advancement of medical science has enabled people to live longer because medical practitioners now better manage infectious diseases while neonatal deaths have declined. The Sample Registration System (SRS) and Ministry of Statistics have shown that men used to have longer life spans in the early 1970s but now women achieve greater life expectancy at birth (Office of the Registrar General & Census Commissioner, 2022). People who reach advanced age do not always experience good health. The National Sample Survey Office (NSSO) reports that people have longer live expectancy but they spend most of these years dealing with persistent health problems (Ministry of Statistics and Programme Implementation, 2019). Urban areas and states such as Kerala show better life expectancy than other regions but people from different socioeconomic backgrounds still face major health differences (Borah, 2021).

Figure 2.5 Life expectancy trends in India



Source: Compiled from SRS Abridged Life tables by the researcher

The period from 1970 to 1975 saw Indian life expectancy reach about 49.7 years but during the period 2019 to 2023 it had increased to 70.3 years. The nation experienced its first demographic transition when it changed from a situation with high mortality rates to one that allowed all age groups to survive better. The early life expectancy improvements resulted from successful famine eradication and major infectious disease control. The current life expectancy improvements arise from enhanced maternal healthcare and a major decrease in infant mortality rates.

The graph also shows gender patterns in life expectancy. Life expectancy of male in the early 1970s was higher than females but by the mid-1980s female life expectancy had surpassed males. Indian women currently have a life expectancy of 72.5 year. Indian men have a life expectancy of 68.5 years. Behavioural factors also play an important role. Men are more likely to engage in risky behaviour like smoking, heavy drinking or working in hazardous occupations, which contribute to higher rates of cardiovascular disease and accidents (Borah, G,2021).

The government programs serve as a main driving force for the increased life expectancy in India. The National Health Mission (NHM) and Ayushman Bharat programs have improved primary and secondary healthcare access for rural populations through their expanded healthcare services. The National Sample Survey Office (NSSO) health experts reports that Indian people are experiencing longer lifespans but they also face extended periods of chronic non-communicable diseases. Life expectancy in India has witnessed a significant improvement for the past few decades.

2.5 Life expectancy trends in Kerala

The Kerala health data from National Health Systems Resource Centre (2021) shows the life expectancy trends for the state. It indicates that its public health achievements have established the state as India's top public health performer. The state shows higher life expectancy at birth which increased from 74.2 years during the period 2006-2010 to 75.3 years by 2014-2018. The implementation of National Health Mission (NHM) programs together with primary and secondary health services led to this health improvement. The state's exceptional success in reducing Infant Mortality Rate (IMR) from 14 in the year 2005 to 6 in 2019 accounts for most of the state's positive health results. The state of Kerala maintains 94% literacy rate which includes 92.1% female literacy and this contributes to health awareness and state demographic successes.

Women in Kerala achieve longer life expectancy than men which creates a clear disparity in longevity. Female life expectancy at birth reached at 77.9 years during the period 2014 to 2018. Male life expectancy remained at 72.5 years. Women at 60 years of age can expect to live an additional 21.9 years while men only live 17.9 years more. The difference in health-risk behaviours between men and women explains this disparity because 16.9% of men use tobacco and 19.9% of men consume alcohol while only 2.2% of women use tobacco and 0.2% consume alcohol. Elderly women in the state live longer than men yet 61.0% of women from rural areas need to rely on others for financial support which is higher than 25.0% of men who face the same situation (Health Dossier 2021 for Kerala).

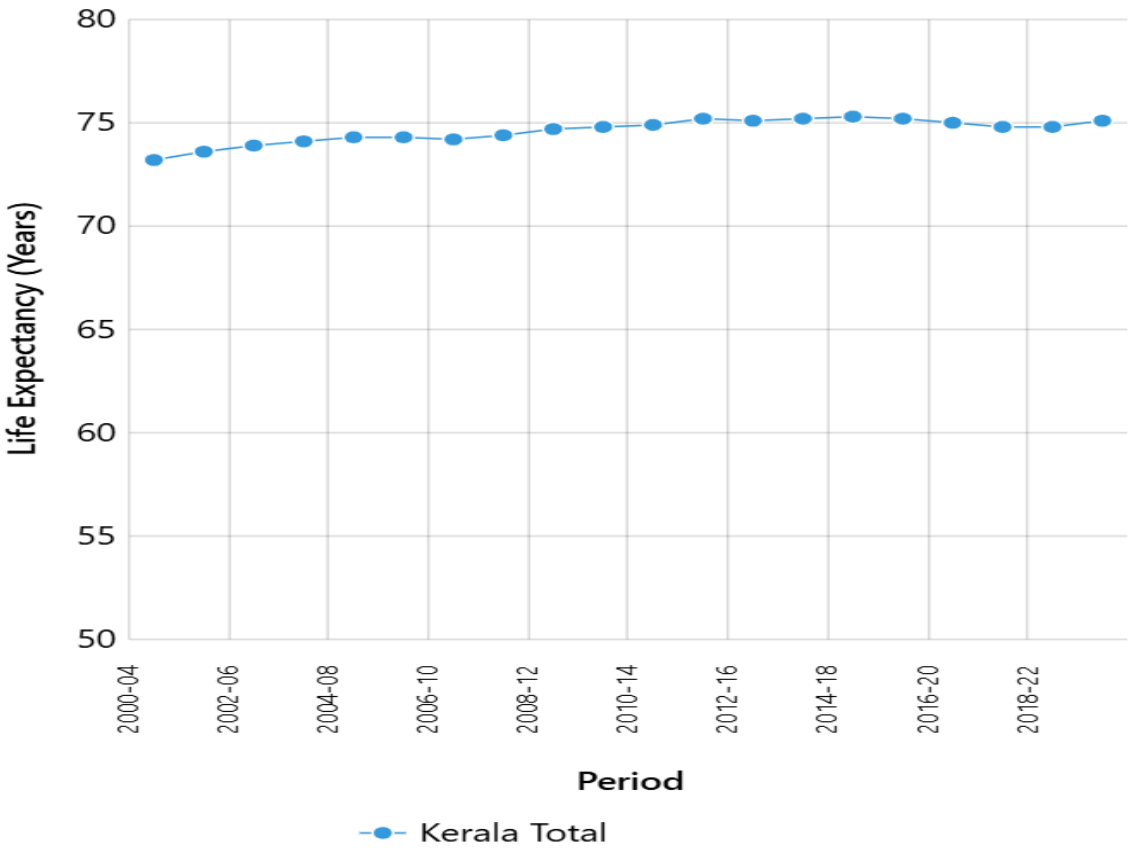
The state of Kerala controls communicable diseases successfully since these diseases now make up only 11.83% of total disease burden but the state faces increasing cases of non-communicable diseases (NCDs). NCDs now account for 76.92% of Disability-Adjusted Life Years (DALYs) within the state. The three main causes of death and disability in the United States are ischemic heart disease, chronic obstructive pulmonary disease (COPD), and type 2 diabetes. Major metabolic risk factors driving these trends include high systolic blood pressure and high fasting plasma glucose. The state shows high morbidity perception because 60% of women and 57% of men report they have an illness which is almost double the national average of 31%. The state needs to establish financial support to solve its health challenges because the government spends ₹2,272 per person on health which exceeds the national average of ₹1,753 (Health Dossier 2021 for Kerala).

The health achievements of Kerala result from its historical commitment to investment in education, access to healthcare facilities, and establishment of social welfare programs for its citizens (Drèze & Sen, 1995). The state achieved two significant public health milestones by decreasing both infant mortality rates and infectious disease occurrences (Indian Ministry of Health and Family Welfare [MOHFW], 2021). The state now faces the challenge of shifting its resources from acute paediatric care to chronic disease management for its senior population after achieving successful public health outcomes (Global Burden of Disease Study, 2019).

The greatest challenge the state is facing is the increasing lifestyle disease epidemic which affects older adults who experience longer lifespans but suffer from declining health (World Health Organization [WHO], 2023). There is an immediate requirement to develop superior pension systems and dedicated geriatric medical facilities because women tend to outlive men while they usually possess lower levels of financial self-sufficiency (United Nations

Development Programme [UNDP], 2022). Kerala maintains its commitment to these matters through substantial healthcare spending which currently emphasizes establishing dedicated clinics for heart disease, diabetes and palliative care to support dignified and comfortable living during extended life periods (MOHFW, 2021).

Figure 2.6 Life expectancy trends in Kerala



Source: Kerala Health Department Vital Statistics

Kerala's life expectancy has remained high and stable over the past decades. The graph indicates the life expectancy of Kerala from 2000 to 2022. Life expectancy of Kerala during the initial stage were high showing the state's long success in public health, education and basic healthcare. Life expectancy increased gradually in the state.

The health system shows strong performance through its current status while social development continues to progress through future improvements which will depend on more effective chronic disease management and programs that support healthy aging. (National Health Systems Resource Centre. (2021). Health Dossier 2021)

Table 2.3 Life expectancy of Kerala

Period	Life Expectancy
2000-04	73.2
2001-05	73.6
2002-06	73.9
2003-07	74.1
2004-08	74.3
2005-09	74.3
2006-10	74.2
2007-11	74.4
2008-12	74.7
2009-13	74.8
2010-14	74.9
2011-15	75.2
2012-16	75.1
2013-17	75.2
2014-18	75.3
2015-19	75.2
2016-20	75
2017-21	74.8
2018-22	74.8
2019-23	75.1

Source: Kerala Health Department Vital Statistics Dashboard

Table 2.3 represents the data on life expectancy in Kerala from 2000 to 2019. It shows a positive trend because the life expectancy increased from 73.2 years in 2000 to 75.1 years by 2019. The gradual increase in average life expectancy demonstrates substantial progress across areas like healthcare and living standards. The advancements was from improved medical service access, new medical technology developed and public health programs which worked to prevent diseases.

The life expectancy decreased from 74.3 years in 2005 to 74.2 years in 2006. This temporary decline in life expectancy was from external forces which include economic recessions, natural disasters and public health emergencies. Kerala's health systems and policy strategies have enabled their population to recover from health challenges because their life expectancy continues to rise.

The life expectancy of 2019 was at 75.1 years which indicates that although the population has experienced health progress the rate of health improvement has decreased. The current situation requires solutions which will tackle health challenges through programs that focuses on the growing elderly population and the increasing rates of chronic illnesses (United Nations 2021). Kerala must maintain its healthcare investment in medical technology, early disease detection and health education to protect or extend its life expectancy rates.

2.6 Health Schemes in India

The health programs in India have achieved their current development state through a lot of changes which aim to deliver high quality medical services to all residents. The Ayushman Bharat mission serves as the main element which delivers its two core functions through establishing Ayushman Arogya Mandirs which provide complete primary healthcare services and implementing the Pradhan Mantri Jan Arogya Yojana (PM-JAY) program. The PM-JAY program functions as the largest health security program worldwide by offering ₹5 lakh annual medical coverage to more than 12 crores impoverished and at risk families for their secondary and tertiary hospital needs. The government announced a significant expansion of Ayushman Vay Vandana in late 2024 which now provides benefits to all citizens aged 70 and older without regard to their income level (Press Information Bureau, 2025)

The National Health Mission (NHM) provides support to India's health system development through its rural and urban sub-missions while operating insurance-based models. The mission delivers assistance to various specialized programs which include Janani Suraksha Yojana

(JSY) for maternal health and the Universal Immunisation Programme and initiatives which aim to eradicate Tuberculosis and Malaria. Digital initiatives have become central to India's healthcare strategy; the Ayushman Bharat Digital Mission (ABDM) has created over 78 crore unique health accounts to link patient records across facilities, while the eSanjeevani platform has served over 36 crore patients through free remote teleconsultations (Press Information Bureau, 2025).

The combined efforts have resulted in national health improvements which include longer life expectancy and a reduction in out-of-pocket medical costs which decreased from 62% to 38% in the last few years. The PM-Ayushman Bharat Health Infrastructure Mission (PM-ABHIM) which started in 2021 helps create health infrastructure and research necessary to address public health crises. The services achieved success, yet experts identified two main problems which stopped some social groups from accessing services while the healthcare system needed to move away from hospitals toward a system which relied on trust to provide primary medical care (Press Information Bureau, 2025).

This chapter provided a comprehensive overview of life expectancy trends in India within a broader global and regional context. Globally, life expectancy has shown a sustained upward trajectory over the past decades, driven by economic growth, medical advancements, and significant improvements in public health infrastructure (Institute for Health Metrics and Evaluation, 2024). India reflects a similar long-term improvement, particularly since the 1970s, though with periods of fluctuation influenced by demographic transitions, policy shifts, and health shocks, most notably the temporary decline during the COVID-19 pandemic (World Health Organization, 2025).The analysis also highlighted Kerala’s distinctive trajectory, where sustained investments in education, primary healthcare, and social development have produced life expectancy levels comparable to developed nations (Sen, 2001; Wikipedia, 2025). This overview establishes the contextual foundation for the study’s objectives by situating India’s income–health relationship—where higher GDP per capita is strongly associated with improved survival outcomes (Kencana, 2019; Miladinov, 2020)—within the broader role of social determinants and regional disparities. It underscores the relevance of examining GDP per capita, social infrastructure, and spatial inequalities to better understand the structural drivers shaping longevity outcomes in India (Suresh, 2025; James & Syamala, 2023).

CHAPTER 3

SOCIO - ECONOMIC DETERMINANTS OF LIFE EXPECTANCY IN INDIA

3.1 Introduction

This chapter presents the empirical analysis of the trends and impact of socio-economic determinants on life expectancy in India over the period 1970–2023. The analysis is based exclusively on secondary data obtained from authoritative sources including the World Health Organization (WHO), World Bank (World Development Indicators), Sample Registration System (SRS) abridged life tables, National Sample Survey Office (NSSO), NITI Aayog, Reserve Bank of India (RBI), Census of India and National Family Health Survey (NFHS). The extended time span of 53 years allows for the examination of long-term trends that have shaped longevity patterns in India.

The analytical framework of this chapter is structured around the three core objectives of the study. First, the association between GDP per capita and life expectancy is examined using correlation analysis to assess the strength and direction of the income–health relationship, consistent with the Preston hypothesis. Second, multiple regression analysis is employed to evaluate the effect of social determinants which includes sanitation, literacy rate and access to safe drinking water on life expectancy. These variables are grounded in the WHO Social Determinants of Health (SDH) framework which conceptualizes health outcomes as being shaped by the social, economic and environmental conditions in which individuals are born, live, and work, rather than solely by medical care. Third, regional disparities in life expectancy are examined using Analysis of Variance (ANOVA) across administrative zonal divisions. Administrative zonal divisions refer to the geographical grouping of Indian states into Northern, Southern, Eastern, Western, Central and Eastern zones facilitating systematic comparison of regional inequalities.

Graphical and tabular representations are used to illustrate long-term patterns and disparities. while econometric techniques provide statistical validation of relationships among variables. By integrating descriptive trend analysis with inferential statistical methods, this chapter offers a rigorous empirical evaluation of how economic growth, social determinants, regional disparities, gender and spatial inequalities collectively influence life expectancy in India.

3.2 Life expectancy and GDP per capita income (USD)

Life expectancy at birth is defined as the average number of years a newborn is expected to live under prevailing mortality conditions and is widely regarded as a comprehensive indicator

of population health and overall socio-economic development (World Health Organization [WHO], 2024). Gross Domestic Product (GDP) per capita in current U.S. dollars represents the total economic output of a country divided by its mid-year population, serving as a standard measure of average income and economic performance (World Bank, 2024). The theoretical linkage between GDP per capita and life expectancy is grounded in the Preston Curve, which posits a positive but non-linear association between income levels and survival outcomes (Preston, 1975).

In order to examine the association between GDP per capita (in USD) and life expectancy in India, correlation analysis is employed. Correlation analysis is appropriate in this context because it measures the strength and direction of the linear relationship between two continuous variables without imposing a causal structure (Gujarati & Porter, 2009). This method enables the identification of whether increases in economic growth are systematically associated with improvements in longevity over time.

The analysis is based on secondary data obtained from the World Health Organization (WHO) and the World Bank's World Development Indicators database. These sources are selected due to their methodological standardization, international comparability, long-term time-series availability, and reliability for macro-level health and economic analysis . The use of secondary data ensures consistency in measurement across years and enhances the validity of longitudinal trend analysis.

3.2.1 Life Expectancy

Table 3.1: Life expectancy of India from 1970-2023

Period	Mid-Year	Total LE - Total
1970-75	1973	49.7
1976-80	1978	52.3
1981-85	1983	55.4
1986-90	1988	57.7
1987-91	1989	58.3
1988-92	1990	58.7
1989-93	1991	59.4
1990-94	1992	60

1991-95	1993	60.3
1992-96	1994	60.7
1993-97	1995	61.1
1994-98	1996	61.4
1995-99	1997	61.5
1996-00	1998	61.9
1997-01	1999	62.3
1998-02	2000	62.9
1999-03	2001	63.4
2000-04	2002	63.9
2001-05	2003	64.3
2002-06	2004	64.7
2003-07	2005	65
2004-08	2006	65.4
2005-09	2007	65.7
2006-10	2008	66.1
2007-11	2009	66.5
2008-12	2010	67
2009-13	2011	67.5
2010-14	2012	67.9
2011-15	2013	68.3
2012-16	2014	68.7
2013-17	2015	69
2014-18	2016	69.4
2015-19	2017	69.7
2016-20	2018	70
2017-21	2019	69.8
2018-22	2020	69.9
2019-23	2021	70.3

Source: SRS-Abridged Life Tables 2019-2023

Table 3.1 shows the that life expectancy of India has experienced a major change from 1970 – 2023. In 1973 life expectancy was about 49.7 years which marked the beginning of a period experienced with fast and significant growth during its first two decades. The basic infrastructure improvements through expanded immunization programs and improved maternal healthcare services together with successful communicable disease control measures helped the nation to achieve life expectancy of more than 60 years during the 1990s (World Bank, 2024). The period between the late 1970s and early 2000s showed continuous growth in life expectancy which demonstrated significant social transformations. Early death rates declined because people gained access to expanded immunization programs along with better nutritional practices and improved sanitation systems and basic healthcare services. Life expectancy reached 63 years in 2000 which signified a transition from basic survival to extended life spans (World Health Organization, 2024)

The highest value of life expectancy was recorded in 2018-19 which was 70 years. This indicated the decades of cumulative progress in public health and living standards. The life expectancy fell to 69.8 in 2019 to 2021 due the COVID 19 pandemic. The recovery process occurred rapidly because life expectancy reached 70.3 in 2021 which became the highest value of life expectancy that the country had experienced.

Table 3.2: Statistical Measures of Life expectancy of India

Statistic	**Value**
Number of Observations (N)	37
Mean (Average)	63.68 years
Standard Deviation	5.08 years
Variance	25.1
Minimum Value	49.70 years
Maximum Value	70.30 years
Range	20.60 years
Growth Percentage	41.45%

Source: Compiled from SRS SRS-Abridged Life Tables by the researcher

Table 3.2 presents the descriptive statistics of total life expectancy in India over the period 1973–2021. The mean life expectancy of 63.68 years indicates the average survival level

attained during the study period which reflects the cumulative impact of economic growth, improvements in public health infrastructure, expansion of primary healthcare service, and enhanced access to basic amenities (Registrar General of India, 2022; World Bank, 2023). The steady increase in life expectancy over time is further evidenced by the growth percentage of 41.45 percent which signifies a substantial long-term improvement from 49.7 years in the early 1970s to 70.3 years in 2019-2023. This magnitude of growth corresponds with India's demographic transition marked by a significant decline in infant and child mortality, the expansion of universal immunization programs, targeted improvements in sanitation and drinking water access (Gupta & Chowdhury, 2014; WHO, 2023).

The standard deviation of 5.08 years suggests moderate dispersion around the mean. Given the long time horizon of nearly five decades, this variation reflects structural progress rather than random volatility (Pritchett & Summers, 1996). The relatively lower variance (25.10) indicates that life expectancy improvements followed a consistent upward trajectory without extreme fluctuations, implying stability in mortality decline over time (Omran, 1971). The range of 20.6 years captures the profound extent of the demographic transformation experienced by the country, as it moved from a low life expectancy regime to a significantly higher survival level (Deaton, 2003).

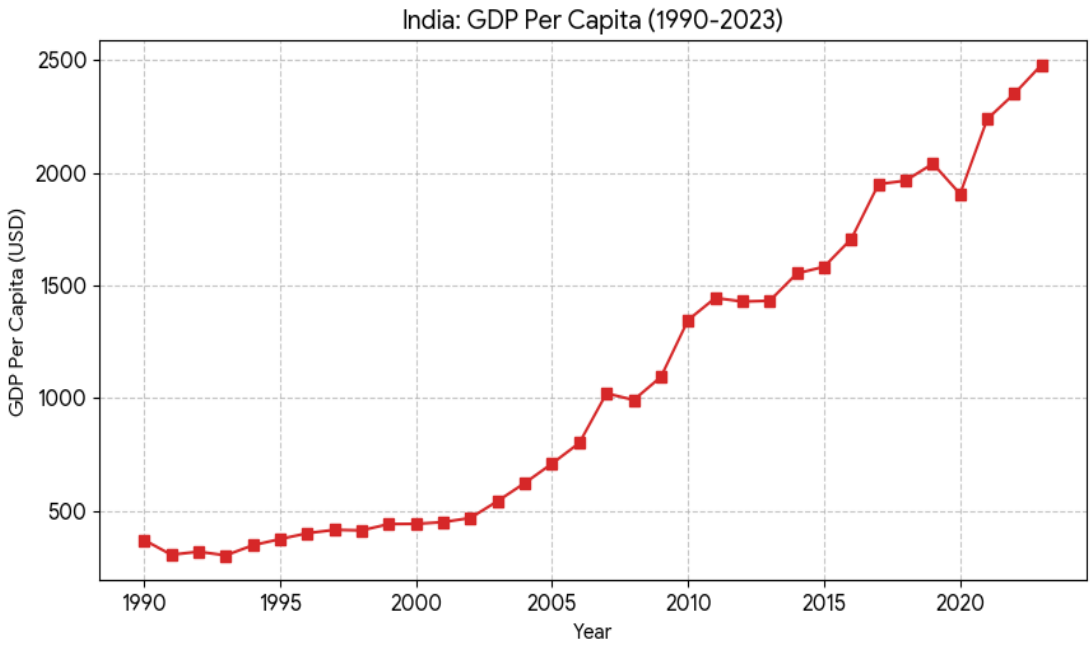
The minimum value of 49.7 years corresponds to a period characterized by higher mortality rates, limited healthcare penetration and lower socio-economic development (Sen, 1999). In contrast the maximum value of 70.3 years reflects the outcomes of sustained public investment in health, increased literacy particularly female literacy, economic liberalization and enhanced living standards (Subramanian et al., 2002). Overall the descriptive statistics confirm that India has undergone a substantial improvement in longevity, consistent with theoretical expectations from the Preston hypothesis, which links rising national income to increased survival rates (Preston, 1975). These gains appear to be gradual and structurally driven rather than abrupt or unstable, aligning with the Health Production Function theory where health stock accumulates through consistent social and economic inputs (Grossman, 1972)

3.2.2 GDP per capita income in India (in USD)

GDP per capita income in India represents the average income earned per person and is calculated by dividing the country's Gross Domestic Product (GDP) by its mid-year population. It serves as a key indicator of economic performance, standard of living, and overall development. In the Indian context, GDP per capita has increased significantly since the

economic reforms of 1991, reflecting structural transformation, expansion of the service sector, industrial growth, and greater integration into the global economy.

Figure 3.1: GDP Per Capita of India (IN USD)



Source: Compiled from World Bank Data by the researcher

Figure 3.1 shows the economic growth of India which started to accelerate in the early 2000s due to the long-term impact of the 1991 Liberalization, Privatization and Globalization reforms. This resulted in the abolishment of licensing and introduced market-oriented policies (Ahluwalia, 2002). During 1990 India experienced a slow and flat growth. From the year 2003 the curve shows an increase in slope. India's GDP per capita reached $2,480.79 in 2023 which is about seven times the value in 1990 which had GDP around $371.09. This highlights that the Indian economy experienced substantial growth during the 33-year period from 1990 to 2023 (World Bank, 2024). The economy became more efficient and competitive on two fronts industrial deregulation and lower import duties. The country also began to operate its telecom sector. The increasing demand for IT and BPO services led to a quick growth in the services sector which increased both exports and national income (Bhagwati & Panagariya, 2013). Rising FDI, major infrastructure projects like the Golden Quadrilateral and improved global integration reduced business costs and strengthened supply chains. The economy modernized through favourable demographic trends, increased literacy rates, decreasing poverty rates and

digital initiatives like India Stack and tax reforms which included GST implementation (Economic Survey, 2023–24).

Table 3.3: Statistical Measures of GDP per capita income (in USD) of India

Statistic	Value
Mean (Average)	1,267.81 USD
Median	1,221.24 USD
Minimum Value	442.75 USD
Maximum Value	2,480.79 USD
Range	2,038.04 USD
Standard Deviation	633.54 USD
Variance	4,01,372.37
Growth Percentage (2000–2023)	460.42%

Source: Compiled from World Bank Data by the researcher

Table 3.3 presents the descriptive statistics of GDP per capita (current USD) in India from with a mean of USD 1,267.81 reflecting average income levels during the post-liberalization era (World Bank, 2024). The value rose substantially from a minimum of USD 442.75 in 2000 to a maximum of USD 2,480.79 in 2023 which represents an increase of approximately 460 that were driven by structural reforms, service-sector expansion (especially IT and BPO), globalization, and macroeconomic policies following the 1991 liberalization (Panagariya, 2008; World Bank, 2024). The wide range (USD 2,038.04) and standard deviation (USD 633.54) highlight the scale of this structural upward transformation rather than short-term volatility with accelerated growth particularly evident from the mid-2000s onward (Rodrik & Subramanian, 2005). A temporary dip occurred around 2020 due to the COVID-19 pandemic which reduced GDP per capita from about USD 2,050 in 2019 to USD 1,907 in 2020 (World Bank, 2024). Rising per capita income boosts household and government capacity to invest in healthcare, sanitation, nutrition and education which is a key determinant of life expectancy (Preston, 1975) and aligns with the Preston hypothesis, which links income gains (especially at lower and middle-income levels) to improved survival through better living standards and medical access (Preston, 1975). Higher national income also enlarges fiscal space for public health and infrastructure (World Health Organization, 2023). While these statistics confirm significant income growth, the conversion of GDP increases into sustained longevity improvements depends critically on income distribution, public health spending and social

determinants such as sanitation and literacy, making economic growth necessary but insufficient on its own (Cutler et al., 2006)

TABLE 3.4: Life Expectancy and GDP Per Capita of India

Year	Life Expectancy (India)	GDP Per Capita (USD)
1990	58.62	371.09
1991	59.03	305.57
1992	59.45	319.18
1993	59.82	302.88
1994	60.24	347.73
1995	60.63	375.18
1996	61.03	401.05
1997	61.44	416.23
1998	61.85	413.63
1999	62.28	441.93
2000	62.75	442.75
2001	63.16	450.36
2002	63.65	469.15
2003	64.09	544.14
2004	64.48	624.26
2005	64.94	710.49
2006	65.37	801.67
2007	65.8	1021.89
2008	66.25	992.52
2009	66.7	1094.95
2010	67.16	1347.52

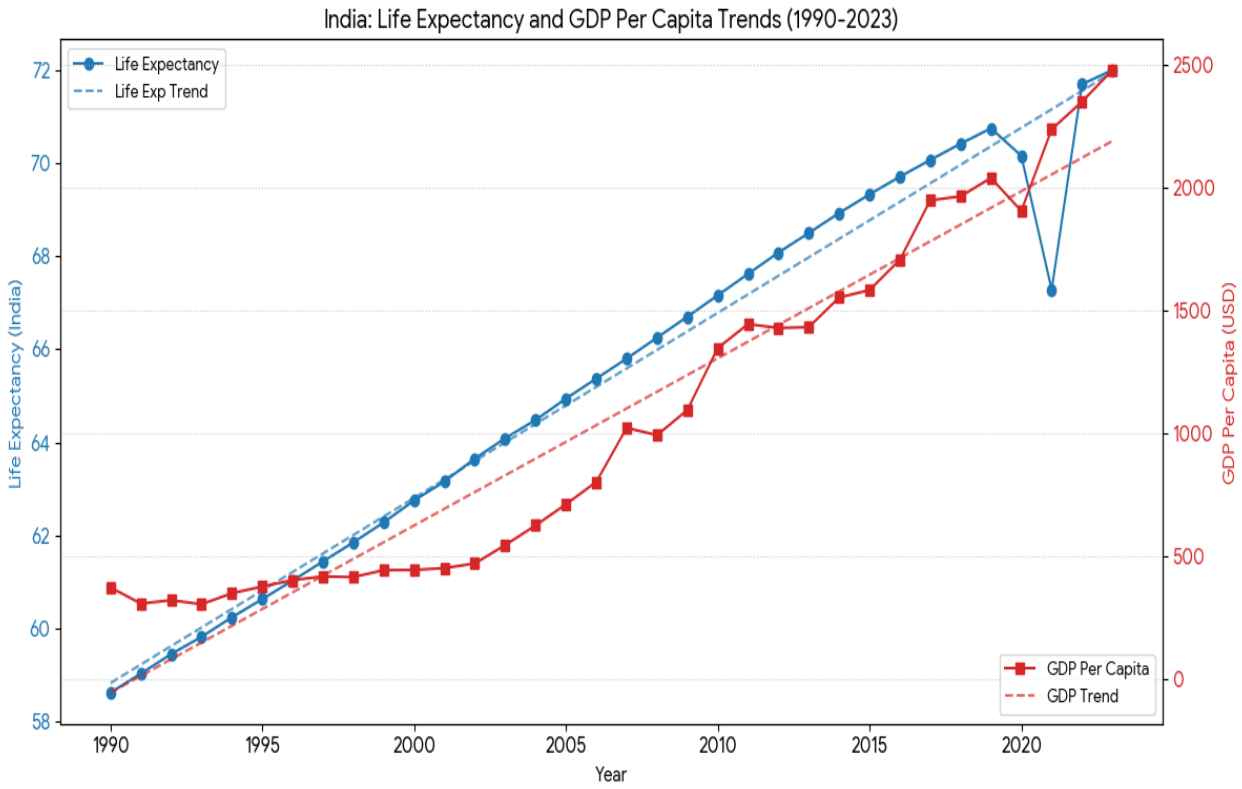
2011	67.62	1445.46
2012	68.08	1429.32
2013	68.5	1432.84
2014	68.93	1553.88
2015	69.33	1584
2016	69.71	1707.51
2017	70.07	1950.1
2018	70.42	1966.25
2019	70.75	2041.43
2020	70.16	1907.04
2021	67.28	2239.61
2022	71.7	2352.61
2023	72	2480.79

Source: World Bank Data

Table 3.4 shows the long-term changes in life expectancy and GDP per capita in India from 1990 – 2023. Life expectancy follows an upward secular trend. In 1990 life expectancy was about 58.62 years which was the lowest level in the series. This indicates high infant mortality and limited healthcare access in the early 1990s. The highest life expectancy was recorded in 2023 at 72.0 years, followed by 2022 at 71.7 years. Life expectancy dropped significantly during 2020 to 2021 period reaching 67.28 years in 2021 because of excess deaths caused by the COVID-19 pandemic. The 2022 to 2023 period shows that health systems recovered but not all health conditions returned to previous survival rates.

The lowest GDP per capita recorded was in 1993 with $302.88 followed by 1991 and 1992 years marked by macroeconomic stress during early liberalization. After the mid-1990s, income began to grow steadily, which accelerated after the early 2000s and crossed $1,000 in 2007 and $2,000 by 2019. The highest GDP per capita was observed in 2023 with $2,480.79. The pandemic caused a temporary economic decline in 2020. GDP per capita and life expectancy show a strong positive relationship which becomes nonlinear.

Figure 3.2: Trends of Life expectancy and GDP Per Capita (IN USD) of India



Source: Compiled from WHO and World Bank data by the researcher

Figure 3.2 illustrates a dual-axis time-series analysis evaluating the longitudinal relationship between Gross Domestic Product (GDP) per capita income in USD and life expectancy in India from 1990 to 2023. The primary Y-axis (left, blue) measures Life Expectancy in years, showing a progression from 58.6 to 72 years, while the secondary Y-axis (right, red) tracks GDP Per Capita income in USD as it moves from under $500 to nearly $2,500 over the study period. The horizontal X-axis represents the yearly timeline, and the dashed trend lines indicate the linear regression for both variables, smoothing annual fluctuations to reveal the underlying long-term trajectory. This data reveals a strong positive correlation that supports the Preston Hypothesis suggesting that rising income levels facilitate better access to nutrition, healthcare, and sanitation (Preston, 1975). Between 1990 and 2019 life expectancy grew with remarkable stability, reflecting an efficient Health Production Function where economic inputs are converted into health capital (Grossman, 1972). A notable economic acceleration phase occurred between 2004 and 2019, where the wealth-health linkage became more pronounced alongside major public health initiatives like the National Rural Health Mission (Subramanian et al., 2002). A sharp V-shaped dip is visible between 2019 and 2021 where life expectancy

plummeted to approximately 67.2 years due to the exogenous shock of the COVID-19 pandemic (WHO, 2023). Despite this a steep rebound in both GDP and life expectancy by 2022–2023 suggests that underlying structural determinants remained intact (World Bank, 2023). These trends are attributed to sustained infrastructure investment in primary healthcare and immunization, the fiscal space for health spending created by economic liberalization (Gupta & Chowdhury, 2014), and social progress in areas like female literacy and water access, which act as "social vaccines" to enhance health production efficiency (Sen, 1999).

3.3.3 Correlation Analysis between Life expectancy and GDP per capita income (In USD) of India

Correlation is a statistical tool used to measure the quantitative relation between variables. The value of correlation lies between -1(Negative correlation) and +1(Positive correlation). The degree of correlations is high (0.75 – 1), moderate (0.25 – 0.75), and low (0 – 0.25).This study uses correlation to find the relation between different variables. The relationship between life expectancy and GDP per capita has been widely examined in development economics and public health research with theoretical foundations rooted in the Preston hypothesis which posits a positive association between income levels and survival outcomes (Preston, 1975). Higher GDP per capita reflects greater economic capacity enabling improved access to nutrition, healthcare services, sanitation and education all of which contribute to reductions in mortality and improvements in longevity (World Health Organization [WHO], 2023).

In this study, correlation analysis is employed to assess the strength and direction of the relationship between GDP per capita (in USD) and life expectancy in India over the study period. Correlation is an appropriate statistical method for measuring the degree of linear association between two continuous variables without implying causality (Gujarati & Porter, 2009). By estimating the correlation coefficient the study seeks to determine whether economic growth in India has been systematically associated with improvements in life expectancy, thereby providing preliminary empirical evidence for the income–health relationship.

Variables	Life Expectancy (LE)	GDP per Capita (GDPPCI)
Life Expectancy	1.000	
GDP per Capita	0.937045607	1.000

Life expectancy is a statistical tool that measures the average number of years a person is expected to live or it reflects the overall mortality level of the population.

GDP per capita income measures the gross economic product per person in a country.

The Pearson Correlation Coefficient was used to assess how Life Expectancy at Birth correlates with GDP per capita income in India.

The analysis produced a correlation coefficient of 0.937045607 which shows that the two variables share an extremely strong positive linear connection.

The high value shows that the nation experienced continuous growth in average life span as its economic output per person increased.

The positive correlation direction indicates that GDP PCI growth leads to improvements in life expectancy. The statistical finding shows that all past public health indicators in India have maintained an ongoing connection with economic development. Higher GDP per capita enhances both private and public capacity to invest in health-promoting factors such as nutrition, sanitation, safe drinking water, healthcare infrastructure, immunization programs, and maternal and child health services (WHO, 2023). The strong magnitude of the coefficient reinforces the argument that economic development has played a central role in India's demographic transition and mortality decline.

The Coefficient of Determination, denoted as R^2, is derived by squaring the Pearson correlation coefficient. Mathematically:

$$R^2 = (r)^2$$

Where:

- r= Pearson correlation coefficient

In this case:

$$R^2 = (0.937)^2 = 0.878$$

A correlation coefficient of 0.937 indicates a very strong positive linear relationship between life expectancy and GDP per capita income of India. This indicates that as life expectancy increases, GDP per capita income of India also increases in a highly consistent and close manner.

An R^2value of 0.878 is considered exceptionally high in macro-level time-series data, suggesting that economic productivity has been a dominant factor in shaping longevity outcomes in India.

The findings strongly support the Preston Curve hypothesis which posits a positive association between per capita income and life expectancy particularly in developing economies (Preston, 1975). As a lower-middle-income country undergoing structural transformation, India appears to have translated economic growth into substantial improvements in survival conditions. Increased financial resources enable both households and the state to expand health investments, improve sanitation infrastructure, enhance educational attainment and implement large-scale public health programs.

While GDP per capita explains 87.8% of the variation, the remaining 12.2% of unexplained variance suggests the influence of non-income factors. These may include social determinants such as literacy rates, access to clean water, sanitation, governance quality, public health policy effectiveness, income inequality, environmental conditions and systemic shocks such as the COVID-19 pandemic (Cutler et.al, 2006).

The empirical results demonstrate that economic growth has been closely associated with improvements in life expectancy in India. The exceptionally strong positive correlation and high coefficient of determination indicate that GDP per capita has been a major driver of longevity gains. The presence of unexplained variation underscores that economic growth alone is not sufficient and complementary investments in social infrastructure and public health systems remain essentials for improvements in life expectancy.

3.3 Life expectancy and social determinants (Sanitation, Literacy rate and Ssafe drinking water access)

Life expectancy at birth is a comprehensive indicator of population health, reflecting the cumulative effects of mortality conditions, access to healthcare, and broader socio-economic environments (World Health Organization [WHO], 2024). Contemporary health research emphasizes that survival outcomes are not determined solely by medical care but are deeply influenced by social and environmental conditions. The WHO Social Determinants of Health (SDH) framework conceptualizes health as being shaped by the conditions in which individuals are born, grow, live, and work, including education, sanitation and access to safe drinking water (WHO, 2023). Complementing this perspective, the Health Production Function derived from Grossman (1972) explains health outcomes as the result of multiple socio-economic inputs, where income, education and environmental infrastructure are transformed into improved survival and productivity.

In this study literacy rate, sanitation coverage and access to safe drinking water are selected as key social determinants due to their direct and empirically established relationship with mortality reduction. Literacy enhances health awareness, preventive behavior and healthcare utilization. Sanitation reduces exposure to infectious diseases and safe drinking water prevents waterborne illnesses that significantly affect child and adult mortality (Cutler et.al, 2006). These variables are foundational determinants under the SDH framework and represent critical inputs in the health production process.

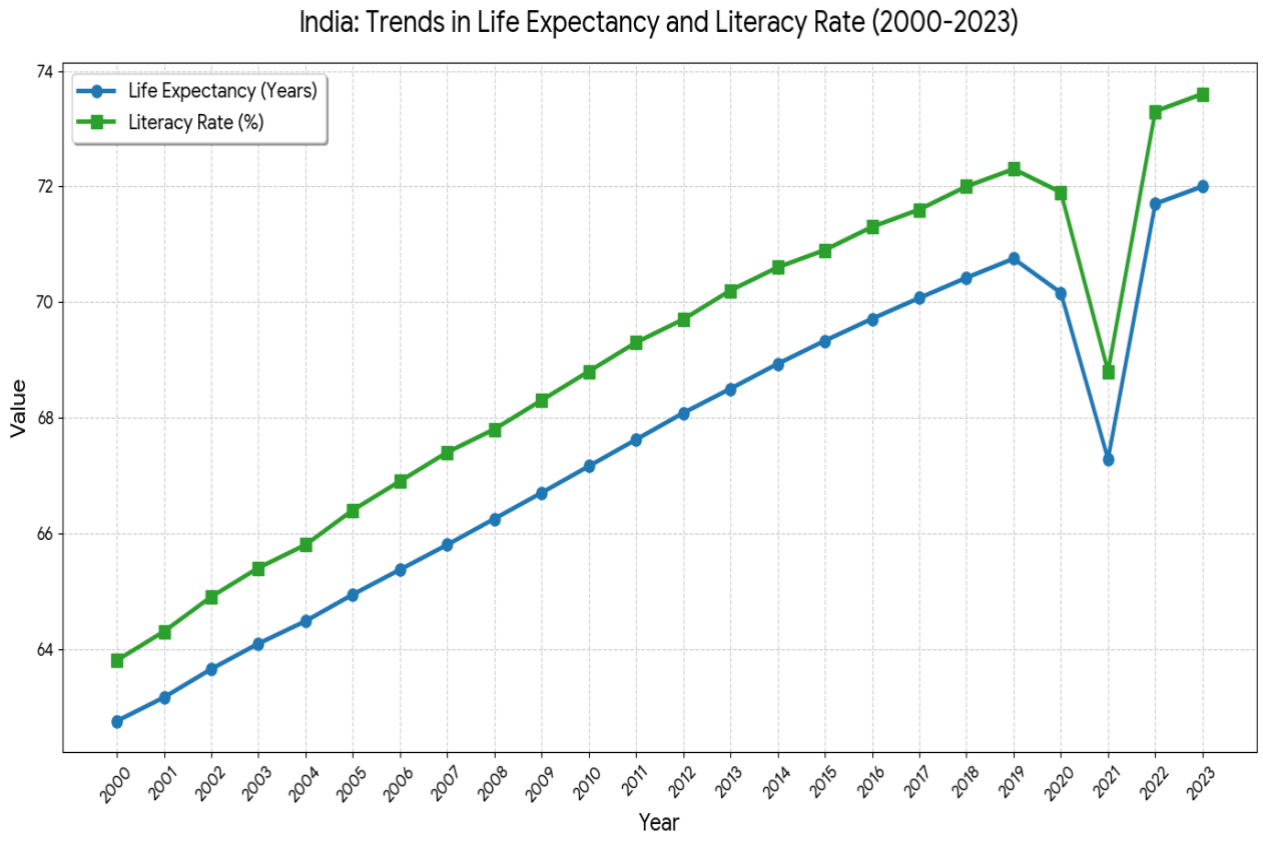
To evaluate the impact of these social determinants on life expectancy, multiple regression analysis is employed. Regression analysis is appropriate because it enables the estimation of the independent contribution of each explanatory variable while controlling for the effects of others (Gujarati & Porter, 2009). This method allows for the quantification of the magnitude and statistical significance of each determinant, thereby providing a robust empirical assessment of how social conditions influence longevity outcomes. By integrating theoretical insights from the WHO SDH model and the Health Production Function with econometric analysis, the study seeks to determine the extent to which improvements in literacy, sanitation and safe drinking water have contributed to life expectancy gains in India.

3.3.1 Literacy Rate

Literacy rate is defined as the percentage of the population aged seven years and above who can both read and write with understanding in any language (Census of India, 2011). It serves as a fundamental indicator of human capital development, educational attainment, and socio-economic progress within a country. Literacy is not merely the ability to read and write but also reflects the capacity to access information, make informed decisions, and participate effectively in economic and social activities.

In India, the literacy rate has shown a consistent upward trend over the past several decades. According to the Census of India, literacy increased from 18.3 percent in 1951 to 74.04 percent in 2011, reflecting significant progress in educational expansion and policy interventions. More recent estimates suggest further improvement, particularly due to initiatives such as the Sarva Shiksha Abhiyan and the Right to Education Act, which aimed to enhance universal access to schooling (Ministry of Education, Government of India, 2022).From a health economics perspective literacy plays a critical role in shaping health outcomes, as educated individuals are more likely to adopt preventive healthcare practices, utilize medical services effectively, and maintain better hygiene and nutritional standards (Cutler et.al, 2006). Literacy rate is considered aa a key social determinant of health and an essential input in the health production process influencing life expectancy in India.

Figure 3.3 Life expectancy and Literacy Rate of India



Source: Compiled from World Bank Data by the researcher

The graphical representation depicts a consistent upward trend in both life expectancy and literacy rate in India from 2000 to 2023, with life expectancy rising from approximately 62.7 years to 70.7 years and literacy increasing from about 63.8% to over 72%, reflecting gains in healthcare access, immunization, educational expansion and socio-economic progress (World Health Organization, 2023; Ministry of Education, 2022). This parallel movement aligns with the Health Production Function model, where education improves health knowledge, preventive behaviors, and healthcare utilization (Grossman, 1972), and the WHO Social Determinants of Health framework, which positions literacy as a structural driver of reduced mortality and better health outcomes (World Health Organization, 2008). A temporary decline in both indicators occurred around 2020–2021 due to the COVID-19 pandemic's disruption of healthcare and education systems with life expectancy showing a sharper drop from immediate mortality effects while literacy proved more resilient (World Health Organization, 2023). By 2022–2023, both recovered, signaling structural resilience, restored services, and ongoing investments in health and education, underscoring the critical role of educational attainment in sustaining long-term improvements in life expectancy in India.

Table 3.5: Statistical measures of Literacy rate of India

Statistic	Value
Mean (Average)	68.79%
Median	69.05%
Minimum Value	63.80%
Maximum Value	73.60%
Range	9.80%
Standard Deviation	2.66%
Variance	7.07
Growth Percentage (2000–2023)	15.36%

Source: Compiled from world bank data by the researcher

Table 3.5 indicates that India's literacy rate averaged 68.79 percent during the period 2000–2023, reflecting sustained progress in educational attainment. The relatively narrow range of 9.80 percent and low standard deviation of 2.66 percent suggest steady and gradual improvement rather than sharp fluctuations, indicating structural expansion of educational access over time. The overall growth of 15.36 percent between 2000 and 2023 can be attributed to policy interventions such as universal primary education initiatives, increased public expenditure on schooling, and literacy-focused programs, which enhanced enrollment and retention rates. The upward trend in literacy reflects broader human capital development and improvements in socio-economic conditions, which are closely linked to better health awareness, preventive behavior, and long-term improvements in life expectancy.

3.3.2 Correlation between Life expectancy and Literacy Rate of India

The correlation between life expectancy and literacy rate in India shows the degree to which improvements in education are associated with changes in survival outcomes over time. It indicates whether rising literacy levels have contributed to increases in life expectancy, reflecting the role of human capital in improving population health.

Variable	Life Expectancy	Literacy Rate
Life Expectancy	1	0.9992
Literacy Rate	0.9992	1

Column 1 represents life expectancy of India.

Column 2 represents Literacy rate of India.

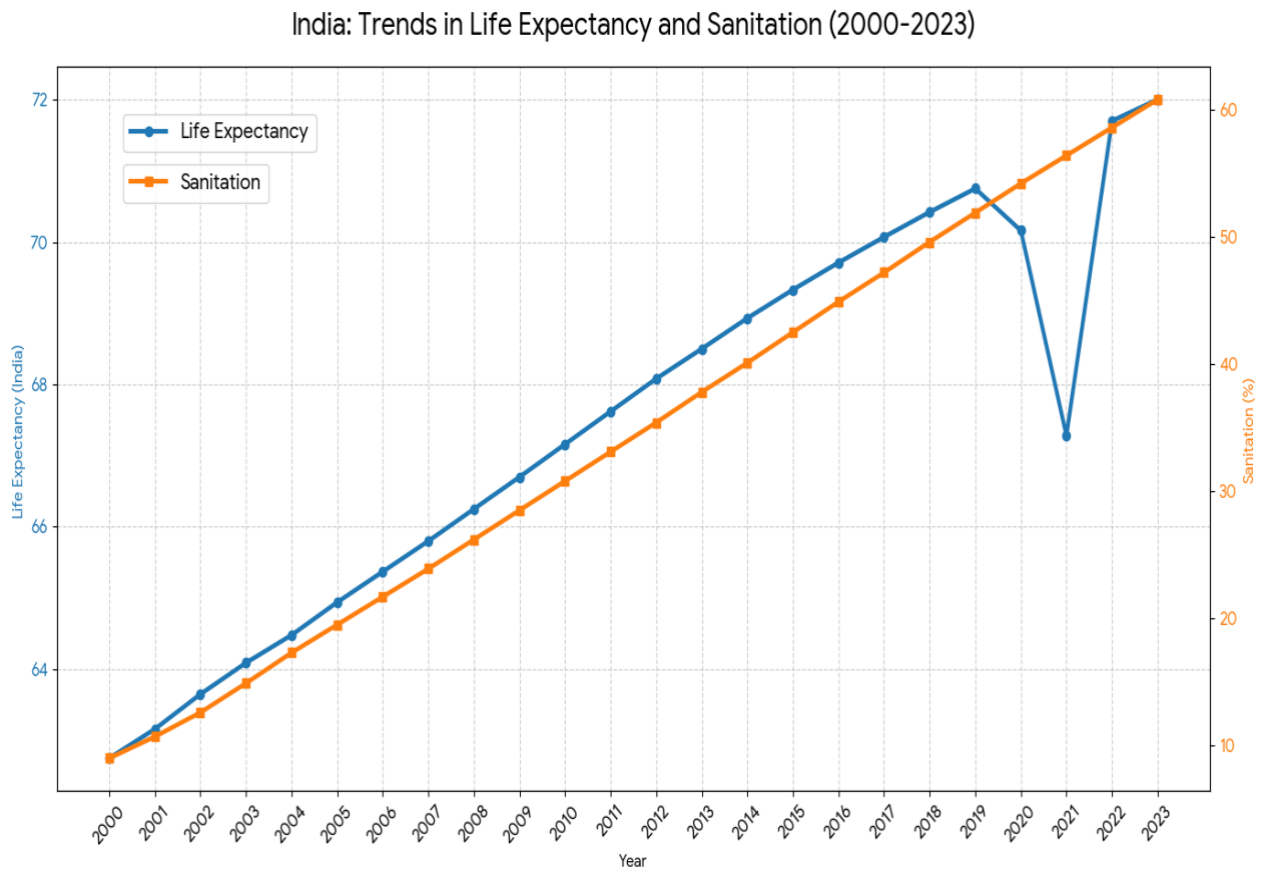
The correlation matrix reveals an exceptionally strong positive linear relationship between life expectancy and literacy rate in India, with a Pearson correlation coefficient of 0.9992. This indicates that improvements in literacy have moved almost proportionately with increases in life expectancy over the study period.

From a theoretical perspective this finding is consistent with the Health Production Function framework which states that education enhances individual's ability to produce health by improving awareness, decision-making capacity, and the efficient utilization of healthcare services (Grossman, 1972). Higher literacy levels contribute to better hygiene practices, informed health-seeking behaviour, greater adoption of preventive measures such as immunization, improved maternal and child care (Cutler et.al, 2006). The WHO Social Determinants of Health framework identifies education as a foundational structural determinant that shapes exposure to health risks and access to health-enhancing resources (World Health Organization [WHO], 2008).

3.3.3 Sanitation

Sanitation in India refers to access to improved healthcare facilities and safe waste disposal systems that prevent human contact with harmful contaminants. Over the past decade initiatives such as the Swachh Bharat Mission have significantly expanded sanitation coverage, particularly in rural areas, contributing to reductions in communicable diseases and improvements in public health outcomes. Improved sanitation is recognized as a key social determinant of health, directly influencing mortality, child survival, and overall life expectancy.

Figure 3.4 Life expectancy and Sanitation trends in India



Source: Compiled from World Bank Data and WHO by the researcher

The graph illustrates a steady and parallel upward trend in both life expectancy and sanitation coverage in India from 2000 to 2023, followed by a temporary decline in life expectancy around 2020–2021 and subsequent recovery. Sanitation coverage shows consistent improvement throughout the period, particularly accelerating after 2014, reflecting large-scale public interventions such as the Swachh Bharat Mission aimed at eliminating open defecation and expanding toilet access (Ministry of Jal Shakti, 2022). Improved sanitation reduces exposure to waterborne communicable diseases, lowers child mortality and enhances overall population health thereby contributing to increases in life expectancy (World Health Organization [WHO], 2023). The temporary dip in life expectancy during 2020–2021 is likely attributable to the COVID-19 pandemic, which increased mortality despite continued improvements in sanitation infrastructure (WHO, 2023). Overall, the co-movement of the two indicators supports the Social Determinants of Health framework, which emphasizes environmental conditions such as sanitation as fundamental drivers of longevity outcomes.

Table 3.6 Statistical measures of sanitation in India

Statistic	Sanitation (%)
Mean (Average)	34.5
Median	34.25
Minimum	9
Maximum	60.8
Range	51.8
Standard Deviation	15.69
Variance	246.16
Growth Percentage (2000–2023)	575.56%

Source: Compiled from WHO and World Bank by the researcher.

The descriptive statistics indicate that sanitation coverage in India averaged 34.5 percent during 2000–2023 reflecting a transitional phase in public health infrastructure development. The substantial range of 51.8 percentage demonstrates a major structural shift in access to improved sanitation facilities. This dramatic expansion is largely attributable to intensified government interventions, particularly the Swachh Bharat Mission (SBM) launched in 2014 which prioritized the elimination of open defecation and large-scale construction of household toilets (Ministry of Jal Shakti, 2022). International monitoring agencies have documented that sanitation coverage in India accelerated significantly during this period due to focused policy implementation and public investment (World Bank, 2021; World Health Organization [WHO], 2023). The exceptionally high growth rate of 575.56 percent reflects the low baseline coverage in the early 2000s, when a substantial proportion of rural households lacked access to improved sanitation facilities (WHO & UNICEF, 2021). Improvements were driven by increased public expenditure, behavioral change campaigns, decentralization of sanitation programs and integration with broader rural development initiatives (Government of India, 2022). The relatively high standard deviation (15.69) indicates considerable variation over time consistent with rapid infrastructure scaling rather than gradual demographic change. Unlike life expectancy which typically evolves incrementally, sanitation coverage can experience sharp increases due to concentrated policy interventions and programmatic expansion.

From a public health perspective, improved sanitation reduces exposure to waterborne and communicable diseases such as diarrheal infections, cholera and parasitic diseases, which are major contributors to child and adult mortality in developing countries (WHO, 2023).The statistical pattern observed in the data reflects not merely infrastructural growth but a

significant shift in environmental health conditions that theoretically contributes to long-term improvements in life expectancy under the Social Determinants of Health framework (WHO, 2008)

3.3.4 Correlation between Life expectancy and Sanitation of India

Correlation is used between life expectancy and sanitation to determine whether improvements in sanitation coverage tends to move together with changes in survival outcomes over time. Pearson's correlation coefficient is an appropriate method to assess the strength and direction of their linear relationship (Gujarati & Porter, 2009).

Indicator	Life Expectancy	Sanitation
Life Expectancy	1	0.9487
Sanitation	0.9487	1

The correlation matrix indicates a strong positive linear relationship (r = 0.9487) between life expectancy and sanitation coverage in India during the period 2000–2023.

The magnitude of the coefficient reflects a high degree of co-movement between the two variables implying that expansions in access to improved sanitation facilities correspond with reductions in mortality and enhanced survival outcomes.

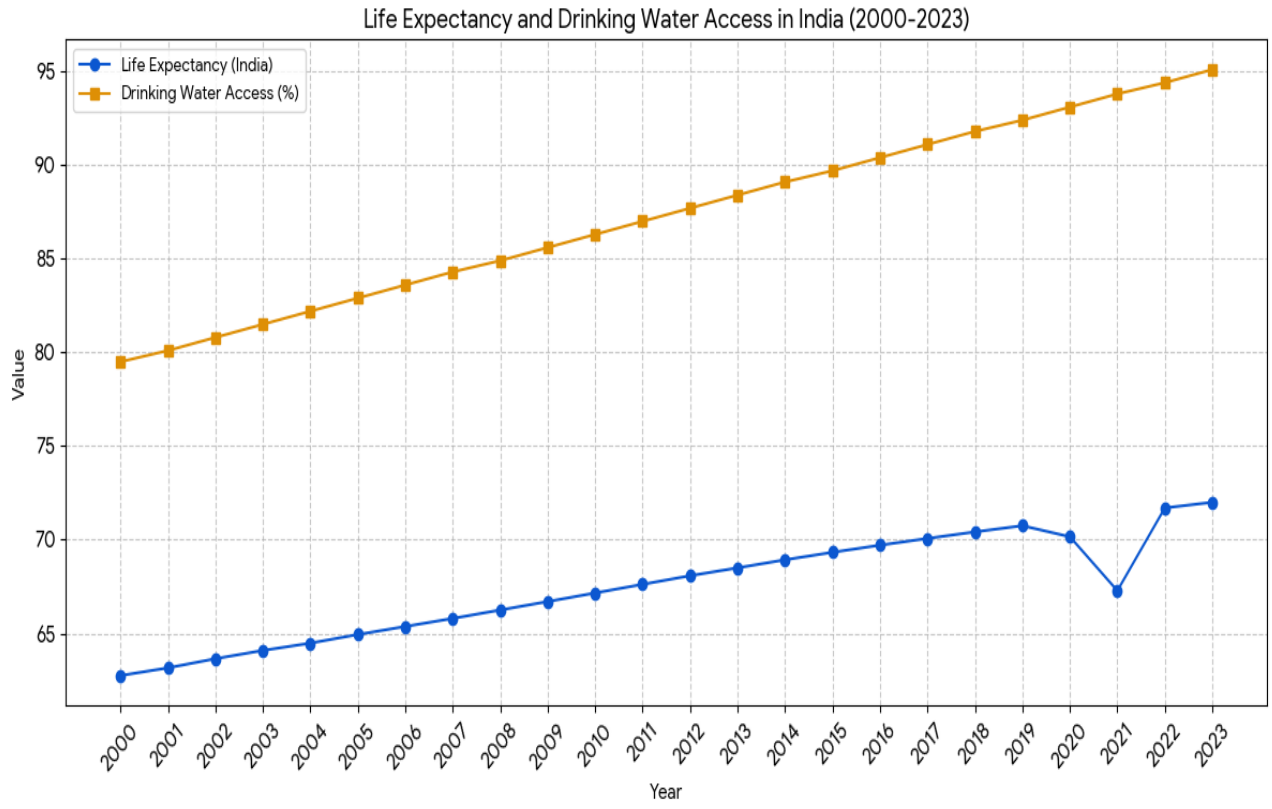
From a theoretical perspective this relationship is consistent with the WHO Social Determinants of Health framework which identifies sanitation as a foundational environmental determinant influencing exposure to infectious diseases and overall population health (World Health Organization [WHO], 2008). Improved sanitation reduces the prevalence of waterborne and communicable diseases such as diarrheal infections which are major contributors to child and adult mortality in developing countries (WHO, 2023). While the correlation is statistically strong it does not imply causation. Both sanitation and life expectancy may have improved simultaneously due to broader socio-economic development, public health investments and improvements in education and income.

3.3.5 Access to Safe drinking water

Safe drinking water refers to water that is free from harmful contaminants, meets established quality standards for human consumption and thereby posing no significant risk to health over a lifetime of use (World Health Organization [WHO], 2023). It typically includes water obtained from improved sources such as piped household connections, protected wells and treated public supply systems that are safeguarded from external contamination (WHO & UNICEF, 2021).

Access to safe drinking water is recognized as a fundamental social determinant of health because it directly reduces exposure to waterborne diseases such as diarrhea, cholera and typhoid (WHO, 2023). In the Indian context the steady increase in access to safe drinking water over the past two decades reflects improvements in public health infrastructure and rural development initiatives which are theoretically linked to enhanced survival outcomes and rising life expectancy under the Social Determinants of Health framework.

Figure 3.5 Life expectancy and Drinking water



Source: Compiled from World Bank Data and WHO by the researcher

The trend in access to safe drinking water in India from 2000 to 2023 shows a steady and continuous increase which rises from approximately 79.5 percent in 2000 to 95.1 percent in 2023. This gradual upward movement reflects sustained improvements in water supply infrastructure, rural development programs, and expansion of piped water connections across states (World Health Organization [WHO] & UNICEF, 2021). The acceleration in coverage, particularly after the mid-2010s, can be attributed to large-scale national initiatives such as the Jal Jeevan Mission, which aimed to provide functional household tap connections to rural households (Ministry of Jal Shakti, 2023).

Improved access to safe drinking water significantly reduces the incidence of waterborne diseases such as diarrhea, cholera, and typhoid which are major contributors to mortality especially among children (WHO, 2023). The consistent upward trend reflects not only infrastructural expansion but also improvements in environmental health conditions and public health outcomes. The temporary decline in life expectancy observed during 2020–2021, despite continued growth in water access, suggests that exogenous shocks such as the COVID-19 pandemic affected mortality independently of improvements in water infrastructure (WHO, 2023). The trend indicates a substantial structural improvement in water security in India, consistent with the Social Determinants of Health framework which recognizes access to safe water as a fundamental determinant of longevity (WHO, 2008).

Table 3.7: Statistical measures of safe drinking water of India

Statistic	Value
Mean (Average)	87.32%
Median	87.35%
Minimum Value	79.50%
Maximum Value	95.10%
Range	15.60%
Standard Deviation	4.71%
Variance	22.19
Growth Percentage (2000–2023)	19.62%

Source: Compiled from WHO and world bank data by the researcher

The mean access level of 87.32 percent indicates that India maintained relatively high overall coverage of safe drinking water during the study period reflecting sustained public investment

in water supply infrastructure and rural development programs. The steady increase from 79.5 percent to 95.1 percent as reflected in the moderate range of 15.6 percentage points suggests gradual and structured expansion rather than abrupt or volatile changes. This pattern is consistent with phased national initiatives such as the National Rural Drinking Water Programme and later the Jal Jeevan Mission which systematically expanded piped water connections and improved water quality monitoring across rural and urban regions (Ministry of Jal Shakti, 2023).

The standard deviation of 4.71 indicates moderate variation over time. Improvements in drinking water access typically occur through long-term capital investments, decentralized implementation mechanisms and state-level coordination resulting in progressive gains rather than sharp fluctuations (World Health Organization [WHO] ,2021). The overall growth of 19.62 percent reflects sustained efforts to improve environmental health conditions, reduce waterborne diseases and enhance public health outcomes. According to the WHO Social Determinants of Health framework access to safe drinking water is a foundational determinant of population health contributing to reductions in communicable disease burden and supporting improvements in life expectancy (WHO, 2023).

3.3.6 Correlation analysis between life expectancy and access to safe drinking water

Correlation analysis is employed to examine the relationship between life expectancy and access to safe drinking water in India in order to determine the strength and direction of their linear association. Access to safe drinking water is recognized as a key environmental determinant of health, as it reduces exposure to waterborne diseases and lowers mortality risks (World Health Organization [WHO],2023). Correlation analysis provides empirical evidence on whether expansions in safe water access have coincided with improvements in life expectancy.

Indicator	Life Expectancy	Access to Safe Drinking Water
Life Expectancy	1	0.9502
Drinking Water	0.9502	1

Column 1 represents life expectancy of India.

Column 2 represents access to safe drinking water.

The correlation coefficient of 0.9502 indicates a very strong positive linear relationship between life expectancy and access to safe drinking water in India over the period 2000–2023. This suggests that improvements in drinking water coverage have been closely associated with increases in life expectancy.

The high magnitude of the coefficient reflects strong co-movement between the two variables, implying that as access to safe water expanded, mortality levels declined and survival outcomes improved. Access to safe drinking water significantly reduces the prevalence of waterborne diseases such as diarrheal infections, cholera, and typhoid, which are major contributors to mortality in developing countries (World Health Organization [WHO], 2023). Improved water quality enhances child survival, reduces infectious disease burden and contributes to better overall health conditions. The strength of the association supports the Social Determinants of Health framework, which identifies safe drinking water as a fundamental environmental determinant of health outcomes (WHO, 2008).

3.3.7 Regression analysis between social determinants and Life expectancy of India (Sanitation, Literacy rate and Access to drinking water)

Regression analysis is used to evaluate the effect of social determinants such as sanitation, literacy rate and access to safe drinking water on life expectancy in India. This study employs a log-linear multiple regression model based on the Social Determinants of Health framework and the Health Production Function approach. The findings of the regression analysis clearly demonstrate a strong relationship between life expectancy and social variables like sanitation, access to drinking water and literacy rate.

Regression Analysis is a statistical method used to estimate the relationship between a dependent variable and one or more independent variables. While correlation tells you if two variables move together, regression tells you how much one variable changes in response to another

Null Hypothesis (H_0)

Social determinants of health such as sanitation, literacy rate and access to safe drinking water have no significant impact on life expectancy in India.

Alternative Hypothesis (H_1):

At least one of the social determinants significantly affects life expectancy.

Regression Statistics	
Multiple R	0.980847
R Square	0.962062
Adjusted R Square	0.960337
Standard Error	0.003553
Observations	24

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.007042	0.007042	557.8902	4.01E-17
Residual	22	0.000278	1.26E-05		
Total	23	0.00732			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.828658	0.000725	2521.469	1.43E-61	1.827154	1.830162	1.827154	1.830162
SDH INDEX	0.017713	0.00075	23.6197	4.01E-17	0.016158	0.019268	0.016158	0.019268

The research uses the Health Production Function and Social Determinants of Health framework to explain how different social and economic factors produce health outcomes. The research uses data on life expectancy as a health output which shows human capital. Educational achievement is represented through data on literacy rate. Environmental health infrastructure data includes access to safe drinking water and sanitation.

Health Production Function

The health production function developed by Grossman is an economic model that considers health as a capital stock produced by individuals through various inputs such as medical care,

lifestyle choices (e.g., diet and exercise), education and environmental factors to maximize utility (Grossman, 1972). It treats health as an investment where individuals allocate their time and resources to maintain or improve their health stock, balancing costs like medical expenses against benefits like increased productivity and longevity (Deaton, 2003). This framework helps explain how socio-economic determinants influence health outcomes emphasizing that health is not just a biological state but a produced good affected by choices and policies.

Social Determinants of Health

The WHO defines Social Determinants of Health as the conditions in which people are born, grow, live, work and age. It includes all social, economic, cultural and environmental factors that result in health inequities (World Health Organization [WHO], 2008). The essential social determinants of health include educational attainment or literacy rate, income and available healthcare services. Environmental factors includes access to unpolluted water and proper sanitation facilities. The WHO states that health disparities arise from systemic factors that go beyond personal choices because these determinants exist as societal structures that people cannot change (WHO, 2023).

- The WHO social determinants of health framework identify literacy as an essential component which enables people to make educated health choices and attain educational opportunities. The health production function uses literacy as a resource which develops human capital to enable healthier life choices. The Grossman model explains that educational attainment enhances health production efficiency because it enables people to spend money on activities that benefit their health (Grossman, 1972).
- Access to clean water functions as an environmental social determinant within WHO guidelines because it protects people from waterborne illness. The health production function uses this input to enhance health stock because it stops illnesses from causing health decline while the positive coefficient shows that better access increases life expectancy. The SDH framework uses environmental conditions as key elements which help to maintain human health throughout life (WHO, 2008).
- The WHO SDH framework identifies sanitation as an important element which connects to both hygiene practices and disease control. The negative coefficient suggests that poorer sanitation (higher log values indicate worse conditions) reduces health production because it increases health loss from infectious diseases which reflect the function's focus on health loss reduction inputs (t-stat: -8.09, p-value < 0.001).

According to Deaton the economic disadvantages of low sanitation access in certain groups create health disparities which impact their ability to build health capital

The study uses a log-linear multiple regression model to estimate elasticity of coefficients which show how different factors affect life expectancy through their proportional relationships. The specification uses extended Grossman Health production model and WHO Social Determinants of Health framework to assess how educational, access to drinking water and proper sanitation leads to higher life expectancy.

Dependent variable is the logarithm of life expectancy and the key explanatory variable (SDH) represents a composite social determinants of health index constructed from sanitation, literacy rate and access to safe drinking water. The use of the logarithmic transformation of life expectancy allows the coefficient to be interpreted in percentage terms and reduces potential heteroskedasticity.

The combined variable method was adopted primarily to address the issue of multicollinearity. Sanitation, literacy and access to drinking water are interrelated indicators of social development. Including them separately in a regression framework may lead to unstable coefficients, inflated standard errors and difficulty in isolating their independent marginal effects. The construction process involved first standardizing each variable to ensure comparability across different scales and units of measurement. This was followed by extracting their common variation which captured the shared development trend reflected in all three indicators. A weighted index was then constructed to summarize this shared progress into a unified measure. The resulting variable represents a consolidated measure of social determinants of health which reflects improvements in educational attainment, sanitation and access to safe water. Instead of estimating separate marginal impacts of each component, the model evaluates their collective and aggregate contribution to life expectancy thereby providing a more stable and coherent representation of structural social development.

The regression results demonstrate a very strong relationship between the composite social health determinant index and life expectancy.

The Multiple R value of 0.980847 represents the correlation between the observed values of life expectancy and the values predicted by the model (Gujarati & Porter, 2009). A correlation coefficient close to one indicates an extremely strong positive linear association, suggesting that increases in the combined social health determinant index are closely aligned with increases in life expectancy over the study period.

The R Square value of 0.962062 indicates that approximately 96.2 percent of the variation in life expectancy is explained by changes in the composite index. This implies that the predicted values from the model are very closely related to the actual observed values of life expectancy (Gujarati & Porter, 2009). It indicates a very strong positive relationship since this value is very close to 1. It suggests that most of the improvement in life expectancy during the study is closely linked to improvements in sanitation, education and access to safe drinking water (Gujarati & Porter, 2009)

The Adjusted R Square which stands at 0.960337 demonstrates a refined measure of explanatory power by adjusting for sample size and the number of independent variables included in the model. The difference between R Square and Adjusted R Square is minimal because the model includes only one explanatory variable. This small difference indicates that the model's explanatory strength is not artificially inflated. (Gujarati & Porter, 2009)

The high R Square value can be attributed to several factors. First, life expectancy and the components of the social determinants of health index exhibit strong developmental co-movement over time. This reflects steady improvements in social health conditions alongside rising life expectancy (Yadav & Yadav, 2024). Second, aggregating sanitation, literacy and drinking water into a single index efficiently captures their shared variation thereby reducing noise and enhancing model stability (Cutler et al., 2006). Third, the relationship is theoretically grounded as higher literacy improves health knowledge, preventive behaviour and healthcare utilization, better sanitation and clean water access directly lower the burden of infectious and waterborne diseases. These determinants collectively reduce mortality risk across the life course in line with both the Grossman health production function and the WHO social determinants framework. (Grossman, 1972; World Health Organization, 2008).

The time-series data display consistent secular upward trends in both life expectancy and the social determinants due to which a substantial portion of the explanatory power arises from their common long-run developmental trajectory rather than short-run fluctuations (James, 2011)

The statistical measures confirm that social health determinants play a substantial and structurally significant role in shaping life expectancy outcomes.

The coefficient of 0.017713 indicates that a one-unit increase in the composite social health determinant index is associated with an approximate 1.77 percent increase in life expectancy. Given that the dependent variable is in logarithmic form, this interpretation reflects a

proportional effect (Gujarati & Porter, 2009). This implies that if average life expectancy is around 70 years, a 1.77 percent increase corresponds to roughly 1.2 additional years. This magnitude is economically meaningful and aligns with theoretical expectations from human capital theory, demographic transition theory and social health development models. All these theories emphasize the role of education, sanitation and clean water in reducing mortality and improving survival outcomes.

The t-statistic of 23.62 and the extremely small p-value (4.01×10^{-17}) indicate that the estimated effect is highly significant and unlikely to be due to random variation. The model also demonstrates substantial explanatory power with an R^2 of 0.962. This implies that approximately 96.2 percent of the variation in life expectancy over the study period is explained by changes in social health determinants (Gujarati & Porter, 2009).

The findings suggest that life expectancy improvements in India are deeply embedded within broader transformations in social health determinants. Rather than being driven solely by income growth or medical advancements, longevity gains appear closely linked to sustained improvements in education, sanitation and access to safe drinking water. The composite index effectively captures the underlying structural process of social modernization in India encompassing progressive improvements in literacy, sanitation infrastructure and access to safe drinking water. This captures its cumulative, long term impact on population health outcomes. By integrating these interrelated indicators into a single measure, the index reflects the broader developmental trajectory reduces multicollinearity among the variables.

The findings of the combined variable regression analysis strongly support the second objective by confirming that major social determinants such as sanitation, literacy rate and access to safe drinking water significantly influence life expectancy in India. Rather than being driven primarily by income growth alone, sustained longevity gains appear deeply rooted in focused investments in education, sanitation and clean water access which are core elements of the Grossman health production function and the WHO Social Determinants of Health framework (Grossman, 1972; World Health Organization, 2008). These findings emphasis that equitable and sustained improvements in population health require prioritized, long-term public action on these foundational social determinants offering critical guidance for policy design aimed at reducing mortality disparities and achieving inclusive health progress in India.

3.4 Regional disparities in life expectancy across Indian States

Regional disparities in life expectancy reflect uneven socio-economic development, differential access to healthcare infrastructure and variations in public health investment across states. In a country as geographically and demographically diverse as India, examining inter-regional differences is essential to understanding structural inequalities in survival outcomes. Life expectancy data of different Indian states are obtained from the Office of the Registrar General of India, Ministry of Home Affairs, as they provides the most reliable and officially validated state-level life table estimates in India. To facilitate systematic comparison, states are grouped according to established administrative zonal divisions where the states are divided into Northern, Southern, Eastern, Western and Central regions which enables an organized assessment of spatial variation in longevity.

Analysis of Variance (ANOVA) is employed to examine whether statistically significant differences exist in mean life expectancy across these zonal groupings. ANOVA is appropriate in this context because it allows comparison of mean values across more than two independent groups simultaneously, while controlling for Type I error that would arise from multiple pairwise comparisons. Unlike simple t-tests, which are limited to comparing two groups at a time, ANOVA evaluates whether observed inter-regional differences are statistically significant beyond random variation. By statistically testing mean differences across administrative zones, the analysis provides empirical evidence on whether spatial inequality in life expectancy persists in India. ANOVA serves as an appropriate inferential tool to assess regional variation and to identify whether certain zones systematically outperform or lag behind others in terms of longevity outcomes

Analysis of Variance (ANOVA) is a statistical method used to determine whether there are any statistically significant differences between the means of three or more independent groups. It tests the null hypothesis that is all group means are equal against the alternative hypothesis that at least one group mean is different from the others.

Table 3.8: Administrative Zonal Divisions of Indian States

NORTH	LIFE EXPECTANCY
Delhi	76.5
Haryana	72.8
Himachal Pradesh	74.5
Jammu and Kashmir	74.5
Punjab	74.5
Rajasthan	71.5

CENTRAL	
Chhattisgarh	69.5
Madhya Pradesh	69.8
Uttar Pradesh	69.77
Uttarakhand	72

EASTERN	
Arunachal Pradesh	72
Assam	70
Bihar	70
Jharkhand	71
Manipur	72
Meghalaya	72
Mizoram	72
Nagaland	72
Odisha	70.5

Sikkim	72
Tripura	74.2
West Bengal	74

WESTERN	
Goa	73.5
Gujarat	72.8
Maharashtra	73.2

SOUTHERN	
Andhra Pradesh	72.8
Karnataka	73.2
Kerala	78.26
Tamil Nadu	74.8
Telangana	73.2

Source: Compiled from Office of the Registrar General of India, Ministry of Home Affairs and Economic Survey 2025

The data comprising of life expectancy of various Indian states has been stratified into five distinct administrative clusters such as Northern, Central, Eastern, Western, and Southern based on the administrative zone. The administrative zoning of India is an organized legal system which the government uses to promote cooperation between states while handling the specific development requirements of different regions. The divisions of India functions under two primary laws which are the States Reorganisation Act of 1956 and the North Eastern Council Act of 1971.The creation of administrative zones aimed to establish a workspace environment which promotes cooperation between different states. All zones have an Advisory Council which handles their management.

Composition of Administrative Zones

The country is divided into several councils which represent specific states and Union Territories:

- **Northern Zonal Council**: The zone comprises Haryana, Himachal Pradesh, Punjab, Rajasthan, the Union Territories of Chandigarh, Delhi, Ladakh and Jammu and Kashmir.
- **Central Zonal Council**: The area contains Chhattisgarh, Madhya Pradesh, Uttarakhand and Uttar Pradesh.
- **Eastern Zonal Council**: The council includes the eastern states which are Bihar, Jharkhand, Odisha and West Bengal.
- **Western Zonal Council**: The western region of the country controls Goa, Gujarat, Maharashtra, the Union Territory of Dadra, Nagar Haveli and Daman and Diu.
- **Southern Zonal Council:** The council consists of the states Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Telangana and the Union Territory of Puducherry.
- **Eastern Council**: This organization solves the particular issues which effect Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. The council received Sikkim as a member through an amendment that occurred in 2002.

3.4.1 Analysis of Variance for regional disparity in Life expectancy across India states (based on Administrative Zonal Divisions)

Analysis of Variance (ANOVA) is employed to determine whether there is statistically significant differences in mean life expectancy among the administrative zonal groupings in India. This method enables simultaneous comparison of mean value of life expectancy across more than two independent groups while effectively controlling the overall Type I error rate. This avoids the inflated risk of false positives that would occur with multiple pairwise t-tests (Gujarati & Porter, 2009).

To examine whether regional disparities in life expectancy exist across India's administrative zonal divisions the following hypotheses are formulated:

Null Hypothesis (H_0):
There is no statistically significant difference in the mean life expectancy across the five administrative zonal divisions of India.

The null hypothesis assumes uniformity in survival outcomes across regions, implying that regional socio-economic and healthcare differences do not significantly affect life expectancy.

Alternative Hypothesis (H_1):

There exists a statistically significant difference in mean life expectancy among at least two of the administrative zonal divisions.

$$H_1: \text{At least one } \mu_i \neq \mu_j$$

The alternative hypothesis suggests the presence of regional disparity in longevity reflecting differences in development, healthcare infrastructure, education and public health conditions.

ANOVA: Single Factor

SUMMARY				
Groups	*Count*	*Sum*	*Average*	*Variance*
NORTH	6	444.3	74.05	2.935
CENTRAL	4	281.07	70.2675	1.352225
EASTERN	12	861.7	71.8083333	1.78628788
WESTERN	3	219.5	73.1666667	0.12333333
SOUTHERN	5	372.26	74.452	5.12152

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	59.9879483	4	14.9969871	6.3424449	0.001149	2.75871
Within Groups	59.1135883	25	2.36454353			
Total	119.101537	29				

The third objective of the study is to assess regional disparities in life expectancy across India based on administrative zonal divisions. The descriptive statistics reveal clear differences in average life expectancy across regions.

- The Southern region shows the highest mean life expectancy at approximately 74.45 years which is followed by the Northern region with an average of 74.05 years.
- The Western region records a slightly lower average of 73.17 years.
- The Eastern region has an average life expectancy of about 71.81 years, while the Central region records the lowest mean value at approximately 70.27 years. The variation in average values indicates differences in life expectancy across regions.
- The variance values also differ across regions with the Southern region showing the highest variance and the Western region showing the lowest variance, indicating differences in the spread of life expectancy values within regions.
- The Southern region records the highest average life expectancy due to its strong public health system, higher levels of literacy and education. Higher literacy in women and early investments in primary healthcare also contributes to it. The Northern region shows a high average life expectancy because of improved healthcare infrastructure, its growing urban healthcare facilities and better medical service access.
- The one-way ANOVA results statistically test whether these regional differences in mean life expectancy are significant.
- The between-group sum of squares is 59.99, while the within-group sum of squares is 59.11, indicating that a substantial portion of total variation is attributable to differences between regions.
- The calculated F-statistic is 6.34, which exceeds the critical F-value of 2.76. This suggests that the null hypothesis of equal mean life expectancy across regions can be rejected.
- The p-value of 0.00115 is well below the 0.05 level of significance, further confirming that the differences in mean life expectancy across regions are statistically significant.

The ANOVA results confirm the existence of statistically significant regional disparities in life expectancy across India. The observed variation in mean life expectancy across the Northern, Central, Eastern, Western and Southern regions is not due to random sampling variation. The

statistical evidence demonstrates that life expectancy differs across administrative divisions thereby fulfilling the third objective of the study. The results indicate that regional classification is an important factor in explaining variations in life expectancy, as supported by both the descriptive statistics and the ANOVA test outcomes.

The between-group sum of squares (SSB = 59.99) compared to the within-group sum of squares (SSW = 59.11) indicates that a considerable proportion of total variation in life expectancy is explained by differences between regions rather than purely intra-regional dispersion. In the ANOVA framework, the between-group variation captures systematic differences in regional means, while the within-group variation reflects random or state-level deviations around those regional means (Gujarati & Porter, 2009). The near-comparable magnitude of SSB and SSW suggests that spatial location is an important structural determinant of longevity outcomes.

The calculated F-statistic with value 6.34 exceeds the critical F-value of 2.76 at the 5 percent level of significance. This indicates that the observed variation between regional means is unlikely to have occurred by chance. The F-ratio measures the extent to which between-group variance exceeds within-group variance; a higher F-value implies stronger evidence against the null hypothesis of equal means (Wooldridge, 2016). Since the computed F-statistic is substantially greater than the critical threshold, the null hypothesis that all regional means are equal is rejected.

The p-value (0.00115) is well below the significance level of 0.05. A p-value below 0.05 implies statistical significance while a value below 0.01 indicates strong statistical significance (Gujarati & Porter, 2009). The results demonstrate that regional disparities in life expectancy across India are statistically significant.

The observed regional disparities in life expectancy across India can be attributed to differences in levels of socio-economic development among regions (Yadav & Yadav, 2024). Variations in income levels, employment opportunities and poverty incidence influence access to nutrition, housing and healthcare services which in turn affect longevity (Deshpande & Ramachandran, 2022). Regions with higher average life expectancy generally show better outcomes in education, public health indicators and standard of living (Drèze & Sen, 2013). Regions with lower life expectancy often face challenges related to economic constraints and limited access to essential services (Saikia & Shabnam, 2024). These socio-economic differences across administrative divisions contribute to uneven health outcomes and result in significant variation in life expectancy.

Another important reason for regional differences in life expectancy is the unequal distribution of healthcare infrastructure and public health services across India (Balarajan et al., 2011). Availability of hospitals, trained medical personnel, preventive health programs, maternal and child healthcare facilities also vary across different regions (Asaria et al., 2019). Differences in sanitation, access to clean drinking water and disease prevalence also influence survival rates and overall population health (World Health Organization, 2008). Demographic factors such as population density, urbanization levels, and age structure vary across regions and may further contribute to differences in life expectancy (Yadav & Yadav, 2024). These factors together create distinct regional health profiles, leading to the statistically significant disparities observed in the analysis (Deshpande & Ramachandran, 2022).

The empirical results demonstrate a strong positive long-term association between GDP per capita income and life expectancy in India. Regression analysis demonstrates that social determinants particularly literacy rate followed by access to safe drinking water and sanitation also explains the variation in life expectancy emphasizing their critical role in health production. Regional analysis reveals statistically significant disparities across zonal divisions with Southern and Northern zones consistently outperforming Central and Eastern zones. This is due to differences in education, healthcare infrastructure, sanitation and socio-economic development. These findings highlight that persistent regional and social disparities limit equitable health gains even though there is substantial improvement in economic growth. Sustained improvements in life expectancy require targeted policies for specific zones that prioritize investments in education, clean water, sanitation and primary healthcare in lagging regions. This ensures that economic advancement translates into inclusive and lasting longevity for all Indians.

CHAPTER 4

FINDINGS, RECOMMENDATIONS, AND CONCLUSIONS

4.1 Introduction

Life expectancy is considered to be an important indicator of human development and social welfare (Sen, 1999). It is not just a measure of the health of the population but it holds the mirror to the larger economic, social and political systems that define the quality of life (UNDP, n.d.). Such analysis is particularly important for a country like India where rapid economic development coincides with stark inequalities and demographic diversity (Dreze & Sen, 2013).

This chapter evaluates the empirical findings from the three core objectives of the study. Objective 1 examines the long-term association between GDP per capita and life expectancy in India. It revealed a strong positive correlation driven by economic growth and improved living standards. Objective 2 evaluates the impact of key social determinants which include literacy rate, sanitation coverage and access to safe drinking water on life expectancy, using regression analysis. The variables were aligned with the WHO Social Determinants of Health framework. Objective 3 assesses regional disparities in life expectancy across India's administrative zonal divisions (North, Central, Eastern, Western and Southern) through ANOVA which highlights significant spatial differences. These analyses provide a multidimensional view of how factors collectively shape life expectancy patterns in India

4.2 Background of the study

The study focuses on India which is 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 (World Bank,2024).

The present study investigates the impact of socio-economic determinants on life expectancy in India over the period 1970–2023 by employing a quantitative research design based exclusively on secondary data. India represents a diverse socio-economic landscape with inter-regional variations in health outcomes. The extended time frame of 53 years enables us to observe long-term structural changes, demographic transition processes and economic reforms together with public health transformations enabling a comprehensive time-series assessment of the determinants of life expectancy.

The research investigates how key socio-economic factors which include GDP per capita, education levels that focus on literacy, sanitation, access to drinking water affect life expectancy at birth in India. The study uses the health production function and WHO's social determinants of health framework with econometric methods which include correlation, regression analysis for key indicators and ANOVA for regional to measure how these factors affect longevity outcomes. The study examines the relationship between GDP per capita and life expectancy, assessing whether national wealth enhances population health. Key social indicators including literacy rates, access to safe drinking water and sanitation are evaluated for their impact on India's life expectancy. This aligns to the WHO Social Determinants of health and Health production framework The study also assesses regional disparities on persistent health inequities across Indian states based on administrative zonal divisions. The economic development of India creates a base for better health outcomes which requires both social inclusion through dedicated policies and effective health programs to reduce health disparities. The findings are expected to provide evidence-based policy strategies that promotes economic growth and health improvement across the nation.

4.3 Findings

Objective 1: To examine the association between Life expectancy and GDP per capita income of India

- The correlation coefficient of 0.94 shows a very strong positive relationship between GDP per capita and life expectancy in India.
- As GDP per capita increased over time life expectancy also increased steadily, indicating a strong co-movement between economic growth and improvements in health outcomes.
- In the early years, low income levels were associated with lower life expectancy, reflecting limited access to healthcare, nutrition, sanitation, and basic services.
- With rising income, life expectancy improved, suggesting better living standards, healthcare access, and disease control.
- India's GDP Per Capita rose from $371.09 in 1990 to $2,480.79 in 2023. This represents a roughly 6.7-fold increase in the average economic output per person, providing the fiscal space for the government to invest in public health infrastructure and nutrition programs.

- Short-term fluctuations in GDP per capita did not cause sharp declines in life expectancy, indicating that health improvements are supported by long-term investments rather than year-to-year income changes.
- Life expectancy decreased from 70.75 years to 70.16 years and then increased to 67.28 years before recovering to 72.0 years in 2023. This decline captures the severe impact of the COVID-19 pandemic on mortality rates while the subsequent rise back to 72.0 highlights the resilience of the health system and the successful resumption of routine health services
- The steady rise in life expectancy shows the impact of sustained economic development and public health programs over time.

Objective 2: To assess the effect of social determinants on life expectancy in India guided by WHO Social Determinants of Health framework.

- The log-linear model is used for the regression analysis with the natural logarithm of life expectancy as the dependent variable and a composite social determinants of health index (SDH INDEX) as the key explanatory variable which includes determinants such as sanitation, literacy rate and access to safe drinking water. This allows the coefficients to be interpreted as approximate percentage changes in life expectancy (Gujarati & Porter, 2009).
- The composite index was constructed to address multicollinearity among the 3 interrelated variables namely literacy rate, sanitation and access to safe drinking water. Variables were standardised and aggregated to create a stable, unified measure of social determinant of health.
- The coefficient (0.017713) indicates that one unit increase in the social determinant of health index leads to approximately 1.77 percent increase in life expectancy.
- The relationship is highly statistically significant with a t – statistic of 23.62 and a p-value of 4.01×10^{-17}. This confirms that the effect is not due to random variation.
- The model explains approximately 96.2 percent of the variation in life expectancy with $R^2 = 0.962$ indicating very high explanatory power.
- The Adjusted R^2 with value 0.960337 is very close to R^2 which confirms that the model is stable and not inflated due to overfitting.

- The high explanatory power reflects strong long term developmental co-movement between life expectancy and improvements in sanitation, literacy and access to drinking water.
- The findings are consistent with the Grossman's health production function and WHO Social determinants of health framework.
- Life expectancy and literacy rate show an extremely strong positive correlation (r = 0.9992), indicating almost proportional movement over time.
- Life expectancy and sanitation exhibit a strong positive correlation (r = 0.9487), suggesting that improvements in sanitation are closely associated with rising longevity.
- Life expectancy and access to safe drinking water show a very strong positive correlation (r = 0.9502), indicating substantial co-movement between water access expansion and survival outcomes.
- All correlations are positive and very high (above 0.94), demonstrating strong association between social determinants of health and life expectancy
- Improvements in literacy enhance health awareness, preventive behaviour and healthcare utilization.
- Improved sanitation and access to safe water directly reduce infectious and water-borne diseases lowering mortality risk.
- The strong upward trend in both life expectancy and social determinants over time contributes to the high explanatory power, reflecting their shared long-run development trajectory.
- The results demonstrate that longevity improvements in India are structurally linked to sustained investments in social health determinants rather than being driven solely by income growth.
- The study confirms that focused, long-term public investment in education, sanitation and clean water is critical for reducing mortality disparities and achieving inclusive health progress.

Objective 3: To examine the regional disparities in life expectancy across India's administrative zonal divisions

- The analysis compares average life expectancy across five regions of India which includes North, Central, Eastern, Western and Southern.

- The Southern region has the highest average life expectancy with 74.45 years followed closely by the Northern region with life expectancy of 74.05 years. The Southern region records the highest average life expectancy due to its strong public health system, higher levels of literacy and education. Higher literacy in women and early investments in primary healthcare also contributes to it. The Northern region shows a high average life expectancy because of improved healthcare infrastructure, its growing urban healthcare facilities and better medical service access. The Western region also shows a relatively high average life expectancy of 73.17 years.
- The Central region records the lowest average life expectancy with 70.27 years, indicating relatively poorer health outcomes compared to other regions.
- The Eastern region shows a moderate average life expectancy of 71.81 years lying between the Central and Western regions.
- The Central region experiences resource depletion from its fast population growth and urban development. These factors worsen the existing problems of maternal health and child mortality while environmental pollution and climate change risks in the Eastern region leading to increased cases of infectious diseases which reduce life expectancy.
- The Central region records the lowest life expectancy because its population face problems like reduced literacy rates and increased poverty levels and inadequate healthcare facilities and insufficient access to safe drinking water and sanitation services. The region experiences decreased survival rates because of its higher rates of infant and maternal deaths and infectious diseases which demonstrate the existence of ongoing health and development problems.
- The Eastern region shows a moderate life expectancy because its socio-economic development level falls between the Central region and Western region. The region has achieved increased life expectancy through public health program improvements and disease control measures yet continues to experience poverty, undernutrition and healthcare access problems which restrains it from reaching Southern and Northern regional life expectancy levels.
- The variance is highest in the Southern region, suggesting greater differences in life expectancy among states within this region.

- The Western region has the lowest variance indicating more uniform life expectancy values across the states included.
- The ANOVA results show that the F-value (6.34) is greater than the critical F-value (2.76).
- The p-value (0.0011) is less than 0.05, which indicates that the differences in mean life expectancy across regions are statistically significant.
- This means that life expectancy varies significantly across different regions of India, and the observed differences are not due to random chance.
- The study concludes that regional differences in life expectancy in India are significant.
- The Southern and Northern regions perform better in terms of life expectancy due to stronger health systems, better education levels and improved access to healthcare services.
- The Central region's lower life expectancy highlights the need for greater policy attention toward healthcare infrastructure, sanitation, nutrition, and education.
- Variations within regions especially in the South suggest that intra-regional inequalities also need to be addressed.
- The findings emphasize that geographical location plays an important role in shaping health outcomes in India.
- The results support the need for region-specific health and development policies rather than a one-size-fits-all approach.
- Improving life expectancy in lagging regions requires targeted investments in socio-economic development and public health services.

4.4 Recommendations

- State and central governments should increase their investment in adult and female literacy programs specifically focusing on health seeking behaviours
- Education increases awareness of nutrition, sanitation and the utilization of available healthcare services which will help to increase the standard of living.
- Provision of safe drinking water and modernized sanitation systems particularly in rural and lagging regions. The positive and significant impact of drinking water access on life expectancy highlights the need to expand clean and safe drinking water coverage, especially in rural and economically weaker regions, to reduce water-borne diseases.

- Ensure that rising GDP per capita is consistently channelled into public health infrastructure and nutrition programs.
- Life expectancy shows a strong positive relation with GDP per capita. Policies should focus on sustaining inclusive and stable economic growth so that rising incomes continue to translate into better nutrition, housing and healthcare access for the population.
- The strong link between income growth and life expectancy suggests that higher national income should be systematically channelled into strengthening hospitals, primary health centres, and rural healthcare facilities, especially in underserved areas.
- Sanitation remains a crucial determinant of health. Policies should focus on improving sanitation quality, usage and maintenance, along with hygiene awareness campaigns, rather than access alone.
- Develop pandemic preparedness protocols and surge capacity within the public health system. The temporary decline in life expectancy during the COVID-19 period shows the importance of pandemic preparedness, emergency healthcare capacity, and resilient health systems that can protect long-term health outcomes during crises.
- Adopt long-term health planning rather than short-term responses Since short-term income fluctuations did not significantly affect life expectancy, governments should focus on long-term investments in health, nutrition, and social welfare, ensuring continuity of programs across economic cycles.
- The benefits of economic growth and social development should be more evenly distributed across regions and socio-economic groups to ensure that improvements in life expectancy are broad-based and inclusive.

4.5 Conclusion

The research established that life expectancy in India depends on socio-economic indicators because people in India experience longer lives through social and infrastructural elements which improve their living conditions beyond income growth. The analysis shows a strong positive association between GDP per capita income and life expectancy of India with correlation coefficient $r = 0.94$ which confirms that sustained economic growth has contributed to better health outcomes. The regression results reveal that social determinants especially literacy, access to safe drinking water and sanitation have equal importance in determining life

span. The highly significant coefficient of 0.017713 indicates that a one unit improvement in the social determinant of health index is associated with an approximate 1.77 percent increase in life expectancy (roughly 1.2 additional years at a baseline of 70 years), underscoring that education enhances health knowledge and preventive behaviour, while sanitation and clean water directly reduce infectious disease mortality. Significant regional variations in life expectancy across India highlight disparities in development and healthcare access. The Southern and Northern zones record the highest averages at around 74 years, followed by the Western zone at 73.17 years. In contrast the Eastern zone averages 71.81 years, while the Central zone reports the lowest at 70.27 years. These differences indicate that variations in economic development, health infrastructure and social conditions significantly influence survival outcomes across regions. The regions that possess advanced health systems and educational resources achieve higher life expectancy while the regions that lag behind face ongoing issues with poverty, limited-service availability and environmental dangers. The study demonstrates that life expectancy improvements in India are not driven by economic growth alone but require an integrated development approach that simultaneously strengthens social determinants and addresses regional inequalities. Equitable and sustainable longevity gains depend on focused, long-term public investments in education, sanitation, clean water and healthcare infrastructure particularly in underperforming central and eastern zones. These findings offer critical evidence based guidance for policymakers to design targeted inclusive strategies that ensure economic progress translates into healthier, longer, and more equitable lives for all Indians. The study identifies an integrated development approach as the essential factor for achieving long term life expectancy improvements in India.

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