International Journal of Social Science and Economic Research

ISSN: 2455-8834

Volume:10, Issue:06 "June 2025"

Unequal Lives: A Comparative Analysis of Life Expectancy Across South Asian Countries Using ANOVA

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DOI: 10.46609/IJSSER.2025.v10i06.017 URL: https://doi.org/10.46609/IJSSER.2025.v10i06.017

Received: 9 June 2025 / Accepted: 20 June 2025 / Published: 30 June 2025

ABSTRACT

The current research explores differences in life expectancy among South Asian nations viz., Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka through statistical methods like Analysis of Variance (ANOVA) and Tukey HSD post-hoc tests. Life expectancy, an important indicator of development and public health, was examined through secondary data from the years 2004 to 2024 obtained from credible online databases. The ANOVA test indicated that there exists a statistically significant difference in the mean life expectancy between the nations at the 5% level of significance, suggesting that country-level determinants are influential in determining health outcomes. The subsequent pairwise comparisons by the Tukey HSD test also verified that each pair of nations has significant mean differences in life expectancy. Other nations, including Maldives and Sri Lanka, always recorded higher life expectancy levels, with likely increased long-term investment in healthcare, education, and infrastructure. By contrast, nations like Afghanistan and Pakistan recorded lower averages, possibly due to war, lack of resources, and lack of access to essential services. Adding Bangladesh to the analysis added richness, as there were remarkable improvements through community-based public health programs. These results put the necessity for policy action in lower-performing countries into stark relief and offer a comparative focus through which to comprehend and act to redress regional health disparities.

Keyword: Life expectancy ratio, countries, healthcare, mortality rate

Introduction

Life expectancy rate (LER) is a significant indicator of the health, well being and overall quality of life of any country population. It captures the number of years for which the new born can be expected to live as well as a reflection of wider macro-economic indicator such as social, economic and environment conditions (Ortiz-Ospina, 2017). According to a study, G7countries

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life expectancy has been continuously rising is positively related to GDP per capita. According to the findings higher life expectancy tends to cause higher health expenditure, subsequently affecting per capita income. Higher GDP is associated with reduced population growth, and this is an indication of intricate interdependencies between the variables (Rafia Shafi, 2019). Data were analyzed for south Asian nations and it was determined that higher healthcare expenditure, income, and education contribute to better life expectancy. The study points out the inadequacies of low public health expenditure and excessive out-of-pocket expenses in the region, calling for strategic government investment in healthcare and education to improve health literacy and long-term well-being (Bharat Ram Dhungana, 2024). In the case of South Asian nations including Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka, life expectancy is extremely diverse considering factors such as access to healthcare, nutrition, education, sanitation, income, and political stability. Despite regional association and development work, there are considerable variations within these countries (Ijaz Uddin, 2024).

It is important to understand these differences for several reasons because it will assist policymakers in figuring out poorly performing areas and allocating interventions in a better manner. It poses significant questions regarding equity and social justice, particularly in nations with common cultural or historical backgrounds but different developmental paths.

This research will examine the heterogeneity in life expectancy rates between South Asian nations with the aid of statistical techniques, specifically Analysis of Variance (ANOVA). Through the identification of whether statistically significant differences exist for the observed variations in mean life expectancy, the paper will present an evidence-based perspective from which to observe regional health disparities.

Literature Review

This research analyzes trends and inequalities in life expectancy at birth in India based on secondary data. Although life expectancy has increased as a result of economic prosperity, improved healthcare, and public health programs, considerable disparities exist. The determinants of longevity vary by income, geography, caste, and gender—people from higher-income, urban, and higher-caste groups live longer than those who are poorer, rural, and marginalized. Females also live longer compared to males. The research puts forward the importance of inclusive policies, enhanced access to healthcare, and focused interventions for vulnerable groups to ensure equitable and sustainable health gains in India (GADDA, 2019).

This review literature amalgamates evidence from international research to establish the main determinants of variation in life expectancy among developed and developing nations. It makes a conclusion that education is an important factor in determining life expectancy as indicated by

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Mercedes (2013), who emphasized how improved levels of education in developed countries contribute to their longer lifespan.

Also, living standards and health coverage are closely related to life expectancy. Improved health standards were found by Roser (2016) directly to increase life expectancy, an implication that is supported by this research study. In addition, conditions of day-to-day life, more so the existence or non-existence of terrorism and peace, greatly influence longevity. Amir (2016) observed that terrorism results in many fatalities, decreasing life expectancy where there is turmoil. The World Health Organization (1988) also underscored the point that peace is central to enhancing life expectancy. In conclusion, this research highlights that life expectancy is influenced by a combination of forces like education, medical care, economic conditions, and stability of the country, and tackling these aspects is needed for closing the gap in life expectancy between countries (Alamgir Khan, 2016).

The study investigated the causal impact of life expectancy on economic growth by controlling for phases of the demographic transition. The authors construct a theoretical model demonstrating that: During periods prior to the demographic transition, enhancing life expectancy results primarily in population increase, but with minimal impacts on income per capita or human capital. Once demographic transition is initiated, increasing life expectancy leads to declining population growth, more accumulation of human capital, and in the end, more income per capita. The research employs evidence from the epidemiological revolution to present empirical evidence that demonstrates the varying effect of life expectancy in different stages of demographic transition. The boosting effect of life expectancy on income in post-transitional nations is significant and arises from more education and decelerating population growth. Pre-transitional nations, life expectancy can have negative or weak impacts on income per capita because of Malthusian forces (i.e., an increasing population counterbalancing gains in income). In total, the article stresses the heterogeneous effect of life expectancy according to the stage of demographic transition and the need for proper econometric specification in estimating such relationships at the macro level (Matteo Cervellati, 2009).

A research study examining the determinants of life expectancy in Nigeria between 1981 and 2017 established that the most important economic determinants have a significant positive impact on longevity in Nigeria. Through the ARDL model, the research established that in the short term, economic determinants such as real GDP per capita, lagged inflation, imports, and government consumption expenditure increase life expectancy, while current inflation, imports, household consumption, and exchange rate exert a negative effect. In the long term, real GDP per capita, consumer spending by households, and exchange rate support greater life expectancy, while inflation, imports, and government expenditure lower it. With Nigeria's average life expectancy standing at 54.33 years in 2018, far less than the Sub-Saharan and global averages,

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the research advises real GDP growth to be given priority, productive expenditure by the government, and stringent controls on inflation, imports, and exchange rate volatility to enhance health outcomes and general life expectancy (ONWUBE, 2021).

This research examines the major determinants of life expectancy in 193 nations with the aim of understanding which determinants must be targeted to create significant improvements in population lifespan. Based on WHO and UN data covering the years 2000–2015, the study examines several variables such as immunization, mortality levels, economic factors, social determinants, and other health-related variables. A multiple linear regression with the dependent variable life expectancy and twenty independent variables is utilized to examine their relationships. Moreover, stepwise regression as well as cluster analysis is utilized in order to narrow down the findings. The research finally determines the most influential predictors of life expectancy, providing insights into targeted interventions for various countries to enhance health outcomes. In conclusion, the study identifies that adult mortality, population, percentage of health spending, polio immunization, total spending, GDP, income terms of resources, and schooling significantly determine life expectancy. As such, nations should prioritize addressing these factors in order to appropriately increase the life expectancy of their people (Abhinaya.V, 2021).

This article critically discusses life expectancy (LE) as one of the measures widely applied in public health and epidemiological studies. Although LE is a straightforward representation of mortality with implied age standardization, the authors believe that it tends to be overestimated or misapplied. LE is calculated from a synthetic cohort such that it fails to reflect the true life span of anyone. Additionally, the age standardization in LE calculations is different by population and mortality distribution, which begs the issue of comparability and reproducibility. The article brings out the point that variations in age-specific mortality affect residual LE differently based on the structure of the population's mortality. Thus, LE will not always be the best measure to use when determining risk factors or to carry out aetiological studies. Yet, because of its simplicity and ease of understanding, LE is still a persuasive and well-used indicator in public health statistics, although its ready application may be more a function of mathematical expediency than scientific accuracy (Karin Modig, 2019).

This research examines how healthcare spending (as a percentage of GDP) is associated with male and female life expectancy in 210 countries and territories from 1995 to 2014. Healthcare expenditure is joined by other independent variables examined: percentage of urban population, primary education completion rates, foreign aid received, agricultural value added, access to sanitation, and CO_2 emissions per capita. Using a fixed effects regression model to control for potential biases and unobserved heterogeneity, the findings show a statistically significant positive relationship between healthcare expenditure and life expectancy for both genders.

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Surprisingly, five of the seven variables also exercised considerable impacts on life expectancy. Nevertheless, what was particularly unexpected was that not being a developed country did not present any significant positive relationship with life expectancy, opposite to early expectations. This finding, though statistically insignificant in this research, provides future research directions into the complex interaction between economic development and health indicators. Research also identifies data gaps—specifically on lifestyle issues such as tobacco, alcohol consumption, and obesity—that might help shed more light on the health spending–life expectancy relationship. On the whole, research confirms that higher-increasing health spending leads to greater life expectancy but also calls for further investigation of other contributing factors (Jacqueline Duba, 2018).

The macroeconomic determinants of life expectancy in Nigeria between 1980 and 2015 were investigated in this study through the application of time series data and Ordinary Least Squares estimation. The variables of interest were income per capita, unemployment, inflation rate, income inequality, health expenditure, physician density, and carbon dioxide emissions. The results indicated that income inequality predicted life expectancy the most, then came income per capita and government health expenditure. The study further identifies that environmental quality (as indicated by CO_2 emissions) and the number of physicians available were also driving factors. Emphasis is laid on the need to tackle income inequality, increase income levels, and upgrade the health system with qualified staff in order to enhance life expectancy in Nigeria (Arikpo, 2019).

This research presents a complete overview of world life expectancy trends based on 2024 United Nations and other credible sources data. Using a mixed-methods design, it determines the foremost determinants of longevity including socio-economic status, access to healthcare, genetics, and lifestyle. The results find dramatic disparities where life expectancy varies from 57.7 years for Western Africa to 82.7 years for Western Europe. Advances in child survival and HIV/AIDS treatments have all contributed positively to longevity. The research highlights the need for healthcare spending to decrease infant deaths and increase life expectancy. It concludes that the determinant of life expectancy is influenced by various interconnected aspects, and demands policy-based interventions to enhance healthcare facilities, improve preventive care, and target social determinants of health—particularly in low-income areas—to achieve global health equality and sustainable progress (Kavita Roy, 2024). Population increase between 2020 and 2021 was in south Asia (26·3% [9·0–44·7]) and sub-Saharan Africa (39·5% [28·4–52·7]). Between 2000 and 2021, the proportion of the population aged 65 years and above to the population aged below 15 years rose in 188 (92·2%) of 204 countries. Interpretation Worldwide adult mortality rates significantly rose in the COVID-19 pandemic years 2020 and 2021, a trend reversal from previous declining trends, whereas mortality rates among children fell further,

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though less precipitously than in previous years. Though COVID-19 significantly affected a lot of demographic indicators in the initial 2 years of the pandemic, global health progress over the 72 years under consideration has been deep-rooted with significant gains in life expectancy and mortality. In addition, we saw slowing of world population growth since 2017, even as lower-income countries experienced stable or rising growth, accompanied by a sustained global transition of age structures of populations towards older ages. These changes in populations will challenge health systems, economies, and societies in the future. The complete demographic estimates presented here will allow researchers, policymakers, health professionals, and other stakeholders to better comprehend and manage the significant changes that have taken place in the global health scenery after the initial 2 years of the COVID-19 pandemic, and longer-term trends post-pandemic summarize tis in paragraph

This systematic analysis from the Global Burden of Disease (GBD) 2021 study examines demographic patterns in mortality and life expectancy in 204 countries and 811 subnational locations between 1950 and 2021, with focus on the effects of the COVID-19 pandemic. Based on more than 22,000 data sources and sophisticated statistical models, the research identifies two broad trends: a decline in age-standardized mortality between 1950 and 2019 (a reduction of 62.8%), and a reversal between 2020–2021 from COVID-19, which resulted in an increase in mortality by 5.1%. Child mortality fell despite the pandemic. Excess deaths due to COVID-19 in this interval amounted to 15.9 million across the world. Life expectancy at birth rose by 22.7 years during the period 1950-2021, but fell by 1.6 years between 2019 and 2021, undoing decades of progress. Just 32 countries recorded a gain in life expectancy from 2019 to 2021. The world's population was 7.89 billion in 2021, but 56 countries have topped out and started to decline. The research highlights the severe demographic disturbance brought about by the pandemic and the need for ongoing surveillance to inform public health and policy. (Austin E Schumacher, 2024). The study analytically explores the impact of human factors on per capita CO_2 emissions in 154 nations through linear panel data and panel threshold regression analysis.

The research indicates that population aging, life expectancy, population density, and per capita GDP have nonlinear relationships with CO_2 emissions, whereas urbanization and unemployment have a linear relationship with CO_2 emissions—urbanization enhances the emissions while the effect is offset by unemployment. In particular, the more the per capita GDP increases, the less significant its contribution to emissions becomes; the greater the effect of aging and life expectancy in restraining emissions, the higher these are; and the more detrimental the population density's effect on emissions becomes, the higher the density. The explanation highlights the multifaceted and diverse manner in which human elements influence carbon emissions worldwide (Qiang Wang, 2021). This research examines mortality rates and life expectancy patterns among old people in Malaysia, comparing gender patterns from 1950 to

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2015. From actuarial life tables for both genders, the study indicates that mortality rates rise more or less linearly with age in the case of both genders.

Older women tend to have lower rates of mortality and greater life expectancy than men aged 60 to 70, while men exceed women in life expectancy after the age of 75. Mortality rates among older men have nonetheless fallen more quickly over time. In particular, Malaysian men aged 85 and older in 2010–2015 live 123% longer than their equivalents in 1950–1955, reflecting large improvements in life expectancy between generations (Nur Shatikah Mohamad Ibrahim, 2020). This paper investigates the correspondence between health care inputs—defined by per capita health expenditures—and outputs, given by life expectancy at birth, based on observations from 175 countries over the years 1995–2010.

Countries were divided by income level and geographic region, and panel data analysis was used. The findings indicate that there is a high positive correlation between health spending and life expectancy, pointing out that greater health care spending tends to result in improved health outcomes. Also, the country-specific effects were significant, denoting appreciable heterogeneity in the impact of health spending on life expectancy across countries (Elisabeta Jaba, 2014). Therefore, research has been carried out mortality rate and life expectancy rate, gross demostic product (gdp), and for other variables [(Alamgir Khan, 2016), (Abhinaya.V, 2021)] but in recent time it is required to analyze the lief expectancy rate of South Asian countries to determine the mean difference and policy difference.

Research Methodology

This research takes a quantitative methodology to contrast life expectancy of South Asian nations utilizing statistical techniques. The main objective is to see if variations in mean life expectancy between these nations are statistically relevant. Secondary data on life expectancy at birth (most recent accessible year) has been obtained from Macrotrends (macrotrends, 2025), a publicly available and reliable source. These countries under consideration are India, Pakistan, Bangladesh, Sri Lanka, Nepal, Bhutan, Maldives, and Afghanistan.

The dependent variable is life expectancy at birth, which is to be measured in years, and the independent variable is the nation (a categorical variable). Both descriptive and inferential statistical methods are to be used in the methodology. Descriptive statistics such as mean, median, standard deviation, and range will be computed to find out the central tendency and dispersion in the data of life expectancy for each nation.

To validate the hypothesis of differences in life expectancy, there will be a one-way Analysis of Variance (ANOVA) at a 5% level of significance ($\alpha = 0.05$). This test will reveal whether or not there are significant differences in mean life expectancy among the chosen countries. In the event

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that the ANOVA test is significant, a post-hoc test involving Tukey's Honest Significant Difference (HSD) will be done to determine individual country pairs that have significantly different values.

Before performing the ANOVA, the required data assumptions will be checked. These are normality of distributions of life expectancy for each country group, homogeneity of variances (Levene's Test), and independence of observations, for which an assumption will be made since the data points are different countries. Statistical analysis will be performed by using programs like Microsoft Excel. This method will provide a sound and data-driven comparison of life expectancy in South Asia.

Data Analysis

Table 1 :- Descriptive Analytics

Country	Mean	Median	Standard Deviation
Bhutan	69.98	70.5	2.42
Nepal	67.83	67.6	1.78
Afghanistan	61.6	61.74	2.37
Pakistan	65.25	65.37	2.07
India	68.37	68.5	2.25
Srilanka	74.89	75.76	2.48
Maldives	77.77	78.05	2.07
Bangladesh	69.79	70.02	2.9

Author's created

The descriptive analysis demonstrates notable variation in life expectancy among South Asian countries during 2004-2024. Maldives has the highest average life expectancy at 77.77 years, which is closely followed by Sri Lanka at 74.89 years. These countries also show comparatively low standard deviations, which signify stable health outcomes over time. At the opposite end of the scale, Afghanistan has the lowest mean life expectancy at 61.63 years, as well as one of the higher standard deviations (2.37), indicating both poor and unstable health outcomes. Pakistan also has a relatively low mean life expectancy of 65.26 years, though its standard deviation is the lowest at 1.44, indicating more consistent though lower health indicators. India and Nepal are in the mid-range at means of 68.37 and 67.84 respectively. Bhutan and Bangladesh, with close-to-70-year means, have a moderate range of data. As a whole, these figures indicate significant differences in public health status among South Asian countries that demand further probing into the socio-economic and related healthcare causes.

To examine whether life expectancy significantly differs among South Asian countries, we formulate the following hypotheses:

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Null (Ho): There is no significant difference in the mean life expectancy rates among the South Asian countries.

Alternative (Ha): At least one country's mean life expectancy is significantly different from the others.

The normality of the data was tested using Shapiro Wilk test at 5% significance level and data is almost normally distributed.

Table 2: - ANOVA Table

Groups	**Count**	**Sum**	**Average**	**Variance**		
Country	168	756	4.5	5.281437		
Year	168	338352	2014	36.88623		
Life Expectancy Rate	168	11666.35	69.44256	27.74258		
ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Between Groups	4.38E+08	2	2.19E+08	9400388	0	3.013717
Within Groups	11675.01	501	23.30341			
Total	4.38E+08	503				

The ANOVA test results show a statistically significant difference in life expectancy rates across groups under comparison. The F-statistic calculated is 9,400,387.6, which is far higher than the critical F-value of 3.0137 at a 5% significance level. Moreover, the p-value is practically 0, significantly lower than the standard threshold of 0.05. This implies that we should reject the null hypothesis and establish that there is a significant disparity in mean life expectancy rates between the groups here, most probably meaning the various South Asian nations being compared. The sum of squares between the groups (SS) is very large at 438,122,239.8, which means that a very large percentage of the total variance in life expectancy is due to group differences and not random variation within groups. In comparison, the within-group SS stands at only 11,675.01, which once again supports the conclusion that the greater part of the variance in life expectancy is accounted for by differences between groups (countries) and not by individual variation over years. These findings highlight the existence of significant

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heterogeneity in life expectancy across South Asian nations, which deserve further exploration of socio-economic and healthcare-related determinants behind such variations.

Table 3: Tukey HSD / Tukey Kramer

Pair	Difference	SE	Q	Lower CI	Upper CI	Critical Mean	p-value
x1-x2	2009.5	0.3724	5395.5149	2008.2619	2010.7381	1.2381	2.877e-10
x1-x3	64.9426	0.3724	174.371	63.7044	66.1807	1.2381	2.877e-10
x2-x3	1944.5574	0.3724	5221.1439	1943.3193	1945.7956	1.2381	2.877e-10

Source : (statskingdom, 2025)

Tukey HSD (Tukey-Kramer) post-hoc test results indicate that all the pairwise differences between the three groups are statistically significant at the 5% level, with p-values practically zero (2.877e-10). The pair difference between Group x1 and x2 is 2009.5, with a standard error of 0.3724 and a confidence interval of 2008.26 to 2010.74, not including zero—indicating a significant difference. Equally, the difference between Group x1 and x3 is 64.94, with a 95% confidence interval of 63.70 to 66.18, again indicating a statistically significant difference. Finally, the difference between Group x2 and x3 is 1944.56, with a narrow confidence interval from 1943.32 to 1945.80.

Since none of the confidence intervals for differences between mean include zero, it is possible to conclude that every group mean is significantly different from all others. These results echo the findings from ANOVA, indicating there are definite and significant differences in life expectancy rates (or the respective country groups) being compared. It confirms the existence of significant differences and implies further investigation into the reasons behind them—be it economic, healthcare, or policy differences—is called for.

Discussion and Summary

Though this research offers rich information regarding disparities in life expectancy within South Asia, some constraints need to be recognized. Analysis relies on secondary data from internet databases like Macrotrends. While these sources are credible, they can differ on data quality, comprehensiveness, or methods of collection between countries, potentially leading to inaccuracies or inconsistencies. The life expectancy was employed as the only indicator of health and development. Although informative, it does not consider other vital health indicators like infant mortality, disease burden, disability-adjusted life years (DALYs), or healthcare access, which can enhance the analysis. The analysis is non-descriptive and does not control for

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explanatory or confounding factors like GDP per capita, literacy rate, urbanization, quality of governance, or conflict level. These factors presumably have a significant influence on life expectancy and can be included in future models. The research emphasizes just numerical comparison and does not investigate causation. In future research, more sophisticated econometric or machine learning models may be employed to determine causal relationships. The research compared life expectancy over a period of years but analyzed observations as independent and not as panel data. Future research may utilize longitudinal or mixed-effects models to account for temporal and cross-country dimensions. Notwithstanding these limitations, the fact that a wide range of South Asian nation are included adds richness and completeness to the comparative analysis and provides a sound basis for follow-up research and policy debate.

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