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Age Contributions to Gender Differences in Life Expectancy Inequality in Southern States of India Using the Arriaga Approach

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Abstract

Life expectancy at birth reflects the overall mortality pattern across all age groups and represents the average number of years a newborn is expected to live. This study aimed to decompose the age inequality in life expectancy between sexes in the states Kerala, Tamil Nadu, Karnataka, Andhra Pradesh and Telangana using the Arriaga method. The required data was extracted from the SRS, 2022 for all five states in the southern region of India. The analysis of life expectancy across the southern states of India reveals distinct regional and gender patterns. The findings highlight that addressing adult and middle aged mortality could play a key role in reducing life expectancy inequality across the southern states.

Introduction

Life expectancy is one of the most important indicators of population health and overall development. However, a consistent gap in life expectancy exists between men and women across the world. On a worldwide scale, women generally have a longer life expectancy than men. Inequality in life expectancy is influenced by multiple factors such as biological, social, economic, cultural and behavioral factors. Saikia et al. (2011) decomposed changes in temporary life expectancy (0 – 60 years) across Indian states and revealed that significant regional differences in mortality decline driven by variations in child and working age survival. Singh et al. (2017) analyzed SRS data using decomposition techniques and showed that improvements in life expectancy and reductions in I equality in India were mainly driven by mortality declines at younger ages, with variations across states and sexes. Borah (2021) found that changes in the male- female life expectancy gap in India were driven by varying age-specific mortality patterns, with older ages gaining importance and younger ages reducing the female advantage in some states.

The study of age contributions to gender differences in life expectancy inequality holds significant importance in understanding the health dynamics of populations. Identifying the specific age groups that contribute most to these differences helps highlight critical periods where preventable or premature deaths are concentrated. In the context of the Southern states of India, where demographic and epidemiological transitions are rapidly unfolding, analyzing mortality patterns by age and gender becomes highly relevant as it directs attention to the stages of life where interventions could have the greatest impact in reducing mortality disparities.

Objectives

1) To examine the extent of gender differences in life expectancy across the Southern states of India.
2) To decompose the differences in life expectancy by using the Arriaga approach and identify the contribution of different age groups.

Data and Methodology

The study used the age specific death rates (ASDR) obtained from the sample registration system for constructing the abridged life table for the states Kerala, Tamil Nadu, Karnataka, Andhra Pradesh and Telangana.

Calculations of Life Expectancy

Life tables with broader age groups, such as 5 or 10 years, called abridged life tables, are found to be adequate and proper for most of the situations confronted in demographic analysis. The steps in the construction of an abridged life table are the following:

While constructing an abridged life table, there are seven columns, which are as follows:

Column 1, *x* to *x+n*: The period of life time between two exact ages between *x and x+n*.

Column 2, ${}_nq_x$: The probability that a person alive at the beginning of the indicated age interval at *x* will die before reaching the end *(x+n)* of the age interval.

$$ {}_nq_x = \frac{2 * n * {}_nm_x}{2 + n * {}_nm_x} $$

Column 3, l_x: The number alive at the beginning of the indicated age interval. Constructing a life table usually starts with an arbitrary number of newborns, such as 100,000. This starting number is called the radix of the table.

Column 4, ${}_nd_x$: The number of persons who die within the indicated age interval *x* to*x+n*.

$$ {}_nd_x = l_x * \quad {}_nq_x $$

Column 5, ${}_nL_x$: The number of years of life a person lives within the indicated age interval *x* to*x+n*.

$$ {}_nL_x = n * (\frac{l_x + l_{x+n}}{2}) $$

Column 6, T_x: The total number of years remaining for a person after surviving till the beginning of the indicated age interval *x* to*x+n*.

$$ {}_nT_x = \quad {}_nL_x + T_{x+n} $$

Column 7, e^0_x: The average number of years of life remaining for a person after reaching the beginning of the age interval indicated.

$$ e_x^0 = \frac{Tx}{lx} $$

Decomposing the Life Expectancy gap

After finding the life expectancy by sex for each state, we divided the absolute gap in Life expectancy between them into age using the Arriaga's method. Arriaga distinguishes three different effects of mortality changes on life expectancy: a direct effect (DE), an indirect effect (IE) and an interaction effect (I). The direct effect is the change in the number of person years lived within a particular age group (iLx) due to a mortality change in that group. The indirect effect is the number of years added to (or removed from) a given LE because a mortality change within a specific age group produces a difference in the number of survivors at the end of that age interval. In the presence of unchanged mortality rates at older ages than the age group under consideration, the increase (or decrease) in the number of survivors at the end of the age interval results in increased (or decrease) in the number of years lived. Both the direct and indirect effects take into account mortality change in a specific age group, independent of the changes in other ages. Since mortality changes coincide in all ages, a small part of the change in LE is because the additional (or fewer) survivors (those responsible for the indirect effect) do not experience unchanged mortality at older ages. The impact resulting from combining the changed number of survivors at the

end of the age interval and the lower (or higher) mortality rates at older ages is termed the interaction effect (I). Adding the direct, indirect and interaction effect gives the total contribution of each age group to the change in life expectancy, or in other words, the decomposition of a difference in LE by age.

Decomposing by Age

Let e_0^f and e_0^m be life expectancy at birth for females and males. Arriaga breaks the difference $\Delta e_0 = e_0^f - e_0^m$ into age group contributions Cx that add exactly to Δe_0.

The total contribution of an age group to the life expectancy gap (in years) is the sum of two mathematical terms, the first corresponding to a direct effect and the second to indirect and interaction effects, as follows:

For a closed age group (x, x+n), decomposition is

$$ {}_nC_x = \left[\frac{l_x^m}{l_0^m}\left(\frac{{}_nL_x^f}{l_x^f} - \frac{{}_nL_x^f}{l_x^m}\right)\right] + \left[\frac{T_{x+n}^f}{l_x^m}\left(\frac{l_x^m}{l_x^f} - \frac{l_{x+n}^m}{l_{x+n}^f}\right)\right] $$

Where ${}_nC_x$ is the total contribution between ages x and x+n, l_x is the survivors at each age x, ${}_nL_x$ is the person years lived in (x, x+n), ${}_nT_x$ is person years above age x+n. 'm' represents males and 'f' represents females with same radius $l_0 = 100000$.

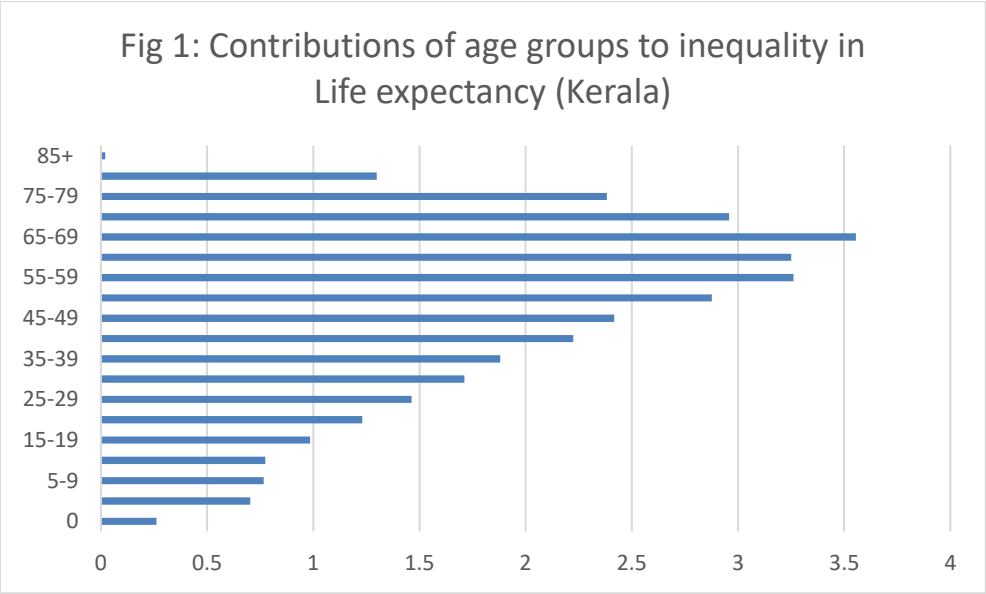
Results

Table 1 : Life Expectancies of Southern States in India by Gender, 2022

	Kerala		Tamil Nadu		Karnataka		Telangana		Andhra Pradesh	
Age	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
0	72.08	78.21	71.82	75.37	67.49	72.18	67.70	73.73	67.33	72.38
1-4	71.74	77.64	71.72	75.07	67.55	72.29	68.04	73.97	67.74	72.79
5-9	67.91	73.79	67.89	71.32	63.78	68.39	64.34	70.37	64.07	69.04
10-14	63.01	68.94	63.09	66.49	59.00	63.69	59.53	65.67	59.32	64.20
15-19	58.13	64.14	58.27	61.72	54.17	59.06	54.76	60.99	54.66	59.42
20-24	53.33	59.26	53.55	56.99	49.37	54.51	50.04	56.37	50.03	54.71
25-29	48.63	54.37	49.04	52.23	44.84	49.72	45.31	51.75	45.41	49.91
30-34	43.94	49.45	44.43	47.46	40.27	44.93	40.67	46.95	40.97	45.13
35-39	39.37	44.59	39.90	42.68	35.84	40.19	36.23	42.28	36.55	40.41
40-44	34.78	39.78	35.44	37.98	31.51	35.64	31.98	37.56	32.26	35.73
45-49	30.35	34.97	31.09	33.38	27.46	31.01	27.68	32.97	28.22	31.10
50-54	26.01	30.30	27.04	28.98	23.67	26.63	23.77	28.50	24.33	26.73
55-59	22.02	25.73	23.28	24.70	20.12	22.45	20.10	24.20	20.57	22.51
60-64	18.26	21.29	19.72	20.69	16.39	18.61	16.75	20.23	17.16	18.75
65-69	14.61	17.21	16.54	17.15	13.17	14.94	13.44	16.47	14.14	15.19
70-74	11.54	13.26	13.55	13.91	10.28	11.74	10.13	12.94	11.01	12.17
75-79	9.03	10.16	11.08	11.32	8.13	9.01	7.51	10.06	8.85	9.87
80-84	6.82	7.24	8.94	9.10	6.06	6.76	6.30	8.48	7.67	9.11
85+	4.81	4.91	7.74	7.98	4.55	5.31	5.19	7.19	6.93	7.67

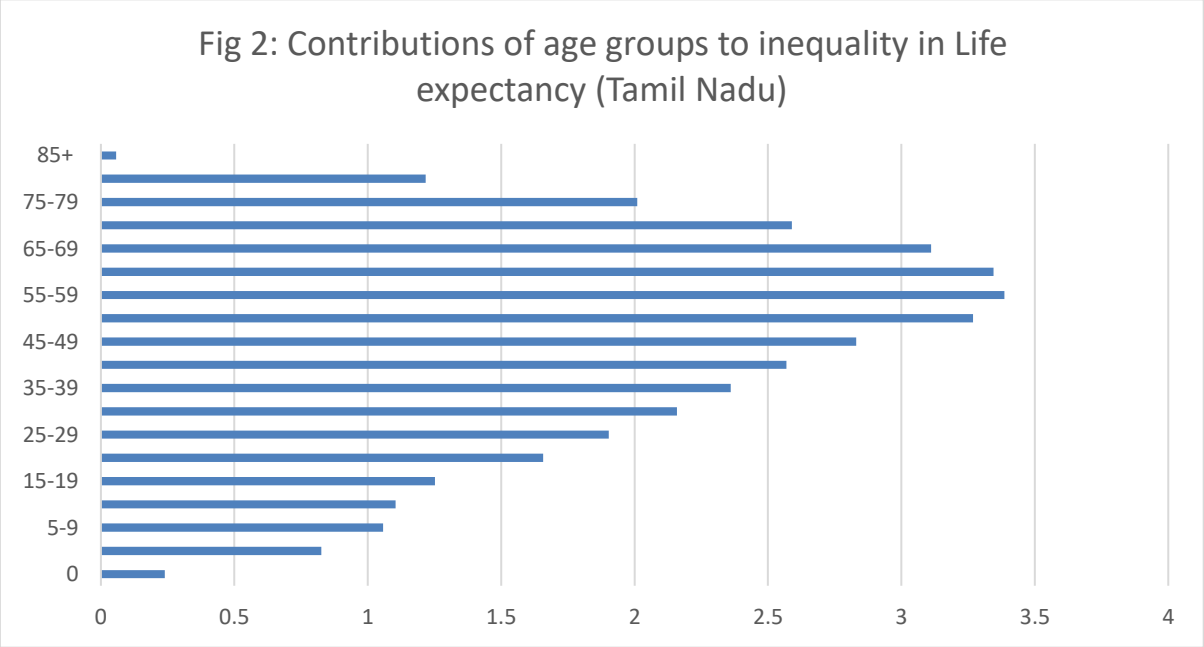
The table 1 presents life expectancy at different ages (from birth to 85+) for males and females in five southern states of India: Kerala, Tamil Nadu, Karnataka, Telangana and Andhra Pradesh. Life expectancy here means the average number of additional years a person at a given age is expected to live, assuming current mortality conditions. The table 1 highlights a clear regional and gender gap in life expectancy. Females live longer than males

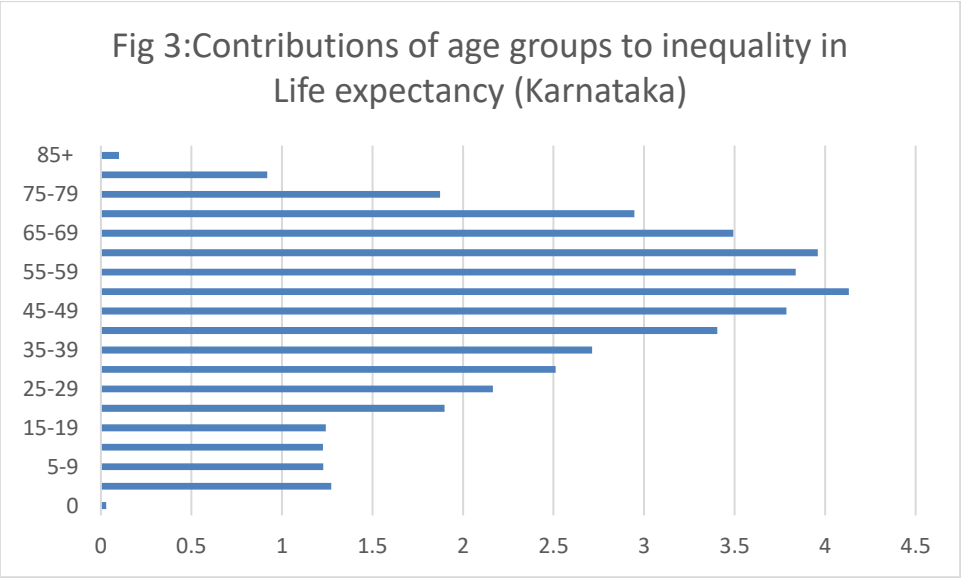
in all states and at all ages. Kerala has the highest life expectancy for both males and females across almost all age groups. Karnataka, Telangana and Andhra Pradesh show relatively lower life expectancy compared to Kerala and Tamil Nadu. Across all states, women consistently outlive men, but the advantage narrows in old age.



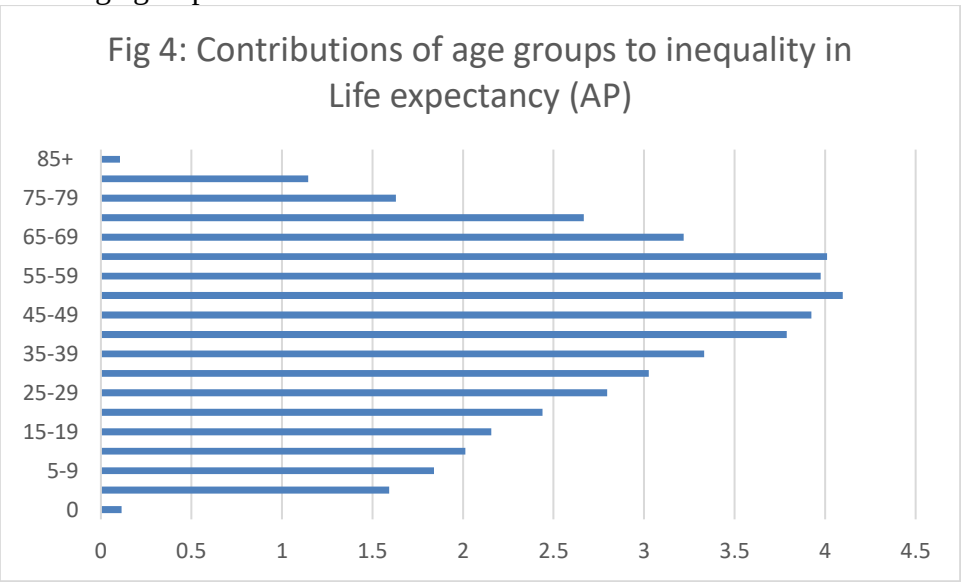
The figure 1 of Kerala shows that life expectancy inequality is not due to child deaths but is concentrated in the middle and older adult age groups. Ages (65-69) years has the largest contribution. Contributions gradually rise from younger to middle ages, peak in late adulthood, and then decline after 75+.

The figure 2 shows the contributions of age groups to inequality in life expectancy in Tamil Nadu. It indicates that mortality differences during midlife and early old age are the biggest drivers of gender inequality in life expectancy in tamil Nadu. Major contributions are by middle -aged groups(35-59 years). Child and adolescent mortality are less significant sources of gender inequality compared to adults.

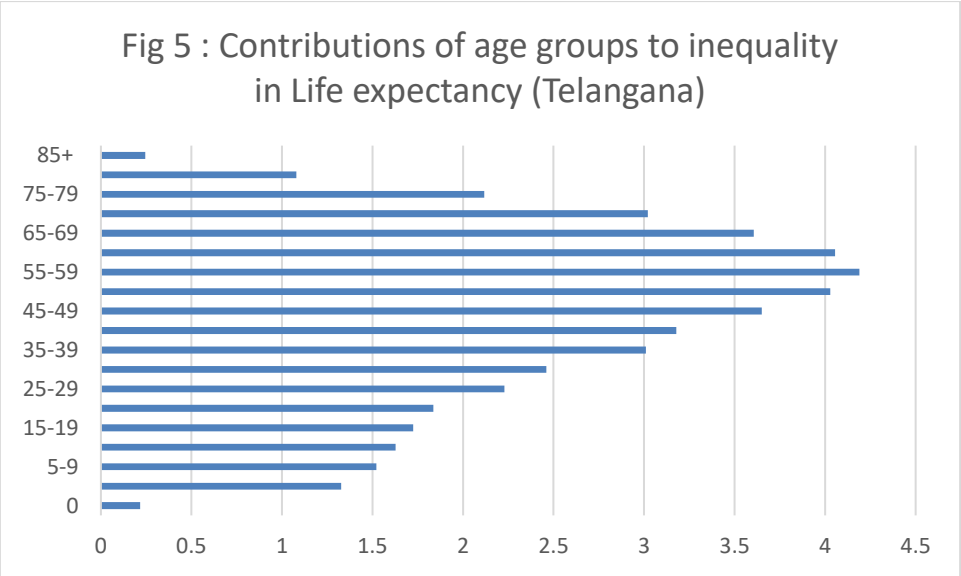




In Karnataka, the middle age groups contribute the most to inequality in life expectancy especially 45-49 age group (figure 3). The results indicates that mortality differences in middle adulthood are the main drivers of life expectancy inequality in Karnataka. Improvements in child and adolescent survival have reduced their inequality contribution. Older age groups show a moderate contribution.



The figure 4 shows that overall, the pattern suggests that in Andhra Pradesh, inequality in life expectancy is largely driven by differences in mortality during middle adulthood (35-59 years), rather than at very young or very old ages. The younger age groups (0-9 and 15-19) contribute moderately, reflecting improvements in child and adolescent survival.



The figure 5 suggests that in Telangana, middle age groups (45-59) years make the largest contribution to life expectancy inequality, reaching 4 years. This indicates that mortality differences within these age ranges have a strong impact on overall inequality in life expectancy. Older age groups (65-79) years also contribute substantially, though slightly less than the 45-59 group. Younger age groups (below 20 years) have smaller contributions, suggesting that mortality differences among children and adolescents are relatively low.

Discussions

This study is especially meaningful for Southern India, where relatively higher life expectancy coexists with persistent social, economic and health inequalities. The inequality in life expectancy in Kerala is mainly driven by mortality differences at older working ages and early old age rather than infant or child mortality. This reflects Kerala's advanced health transition: most people survive childhood, and disparities emerge mainly in adult and old age due to chronic diseases, lifestyle differences, and health system access. In Tamil Nadu, the life expectancy inequality between men and women is largely shaped by adult and middle-aged mortality rather than infant or child mortality. Inequality in life expectancy in Karnataka is not driven by child mortality anymore, but rather by premature deaths in adulthood and early old age. Improvement in child and adolescent survival have reduced their inequality contribution. Reducing avoidable deaths in middle aged adults could significantly reduce inequality in life expectancy. In Andhra Pradesh, the pattern indicates that disparities in life expectancy are primarily influenced by mortality differences during middle adulthood rather than at younger or older ages. In Telangana, inequality in life expectancy arises mainly due to mortality differences in middle and older adult ages (35-69 years). Understanding the age-specific drivers of gender differences in survival can guide evidence-based strategies for reducing inequality, improving population health, and achieving broader goals of gender equality in health outcomes.

Conclusion

The analysis of life expectancy across the southern states of India reveals distinct regional and gender patterns. Kerala consistently demonstrates the highest life expectancy for both males and females, reflecting its advanced healthcare and social development, while Karnataka, Telangana and Andhra Pradesh show relatively lower values. Across all states, females outlive males at every age, although the gender gap narrows in older ages. The decomposition figures indicate that inequality in life expectancy is primarily driven by mortality differences during middle adulthood, particularly in states like Tamil Nadu,

Karnataka, Andhra Pradesh and Telangana. In contrast, younger age groups contribute minimally, suggesting significant improvements in child and adolescent survival. Overall. The findings highlight that addressing adult and middle aged mortality could play a key role in reducing life expectancy inequality across the southern states.

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