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Trends and decomposition analysis of life expectancy and disparity at birth in India 1991-2018

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Keywords

Mortality, Decomposition, Inequality, Life expectancy, Life disparity

Abstract

Life expectancy and disparities in longevity are vital indicators of a population's health. This study analyzes changes in life expectancy at birth (e_0) and life disparity at birth ($e_0^\dagger$) across India and its states from 1991 to 2018. It explores age- and sex-specific contributions to improvements in longevity and reductions in disparities. Using abridged life tables and decomposition analysis, the study evaluates how different age groups have influenced trends in e_0 and $e_0^\dagger$ for both males and females. During this period, male life expectancy at birth rose from 56.7 to 70.1 years, while for females, it increased from 56.4 to 72.8 years. Life disparity declined notably, with $e_0^\dagger$ for men decreasing from 26.1 to 18.3 years, and for women from 28.2 to 18.6 years. The most significant improvement in e_0 was driven by reductions in infant (0–1 year) mortality. Declines in $e_0^\dagger$ were primarily influenced by reduced mortality among infants, middle-aged (40–59 years), and older adults (60+ years). Overall, the findings highlight significant gains in survival and reductions in inequality across India. Continued efforts to reduce under-five mortality and address non-communicable diseases are essential. Focused policies are needed to address persisting regional and socio-economic disparities in health outcomes.

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Introduction

The Life expectancy at birth (e_0) in India has increased by more than 10 years during 1991-2018 as per the estimates of the abridged life table prepared by the registrar general and census commissioner of India using age-specific death rates obtained from the Official Sample Registration System (ORGI, 2022b). This suggests that during this time, the average annual growth rate of e_0 in the country was approximately 0.35 years. When compared to men (9.6 years), women (11.7 years) had a faster growth in e_0 during 1991-2018. However, there was not a continued rise in e_0 across the country over this time. e_0 has increased by almost 4 years or by about 0.4 years per year, on average, during 1991-2001 and 2001-2011, whereas e_0 has increased by 2.5 years or about 0.3 years per year from 2011-2018. Male mortality improvement in India has been on a trajectory that is somewhere between slow and medium, while female mortality improvement is on a trajectory that is between medium and quick compared to the United Nations model life tables for mortality improvement (United Nations, 2004). The e_0 in India would have risen more than 70 years in the period 2016-20 if the growth in e_0 had been continuously increasing like the period 1991-2011. It is believed that developments in medicine and technology, growing per capita income, and concomitant rises in the standard of life, all contribute to accelerating the pace of e_0 improvement; hence, the country's deceleration in e_0 gain is contradictory to expectations. Furthermore, considering the official sample registration system (SRS) data, it does not seem that this occurred in India. Although in India, the standard of social and economic development has improved, along with the standard of living, over this time, the expansion and strengthening of the country's system of health care delivery does not appear to have hastened up the rate of e_0 growth. Furthermore, India continues to have a poor e_0 by global standards. In terms of e_0 among 201 nations around the globe for which estimates have been made, India ranks 144 according to the estimates provided by the United Nations Population Division (United Nations, 2019). Bangladesh, China, and Sri Lanka are ranked 120, 72, and 68, respectively. Therefore, there is a substantial amount of room for improvement in the country's e_0. India's low lifespan reflects the poor health of India's population. It is not known why the pace of rise in e_0 has not accelerated over time in the Indian population. Everyone acknowledges that a longer life expectancy at birth is a good sign of population health and well-being. Therefore, a slowdown in the increase in e_0 suggests a slowdown in India's overall health. India signed the Programme of Action, which was approved at the Cairo International Conference on Population and Development in 1994 (United Nations, 1994). Every country was required to make the necessary efforts to increase e_0 to more than 70 years by the year 2005 and to more than 75 years by the year 2015. Which was one of the goals of the Programme of Action. When viewed in this context, India's increase in e_0 has fallen far short of the goal taken back in 1994. One goal of India's National Health Policy 2017 is to raise the life expectancy to 70 years by 2025 (Government of India, 2017). It indicates a substantial reduction in the goal compared to what was stated more than 25 years ago. Regional variations in e_0 as well as apparent gender and residence disparities that persist within the country and have existed across time in India and across states. Until 1980, male e_0 was higher than the female e_0 ; however, following 1980, the female e_0 exceeded the male e_0; the gap continued to increase until 2009–2013 but then began to close (ORGI, 2022b). Furthermore, the urban-rural difference in e_0 fell from 6.9 years in 1991 to 5.8 years in 2001, 4.9 years in 2011, and 4.6 years in 2018, respectively (ORGI, 2022b). The Official abridged life table estimates of e_0 shows that among the 17 major states e_0 ranged from 75 years in Kerala to 66 years in Uttar Pradesh during 2013-17. In addition to Kerala, there are just twelve more states where e_0 is estimated to be greater than 70 years (ORGI, 2022b). SRS does not have estimates of e_0 for the nation's smaller states and Union Territories. In India, the epidemiological transition is characterized by a dual burden of disease and a significant differential in the dispersion of disease patterns among the various states across the country. Research on mortality in India has been conducted extensively in the context of demographic and epidemiological change, and studies have stated that the concentration of deaths nearer to the modal age-at-death, which has varied from 75 years for rural men to 81 years for urban women. A change in the disease pattern from communicable to non-communicable diseases is also evidence of increased mortality in older ages. The occurrence of non-communicable illnesses has escalated in numerous states, whereas the load of communicable diseases remains constant in certain states (Dandona et al., 2017). e_0 is the most popular summary indicator of population health (Wilmoth, 2000). An increase in e_0 can be attributed to a multitude of factors, encompassing improved lifestyles, improved living standards, quality education, and more accessibility to high-quality healthcare services (OECD, 2018). e_0 is considered a reliable indicator of the average lifespan (Aburto et al., 2020). e_0 measures the overall mortality/survival experience of the entire population. e_0 and population survival experience have a convoluted but reciprocal relationship. The age specific contributions to the changes in e_0 is different for each age groups (Pollard, 1982). $e_0^\dagger$ is a widely recognized metric for mortality, it gauges the uncertainty surrounding the timing of deaths at an individual level and the divergence in overall population health at a macro level (Aburto, Kristensen, & Sharp, 2021; Aburto & van Raalte, 2018). The disparity in lifespan emerges as a pivotal demographic indicator due to the profound implications of uncertainty regarding lifespan on various life decisions such as retirement age, financial planning and educational investments (Aburto et al., 2018; Aburto et al., 2020). Consequently, the first statistical moment of lifespan distribution e_x, alongside the second statistical moment $e_x^\dagger$, plays a crucial role in quantifying mortality in India. Assessing inequality in life expectancy or life disparity can yield vital insights into the disparities in mortality rates and overall health status. The discrepancy in life expectancy has been closely associated with socio-economic standing, underscoring the importance of addressing life expectancy disparities to ensure that the benefits of increasing life expectancy are equitably distributed across all demographic groups. Historically, there existed a strong negative correlation between e_x and $e_x^\dagger$ (Aburto et al., 2020; Smits & Monden, 2009; Vaupel et al., 2011), nevertheless, recent studies have identified a positive linkage between these two metrics in certain nations and subgroups, particularly in populations exhibiting higher mortality rates at younger ages (Brønnum-Hansen, 2017; García & Aburto, 2019; Permanyer et al., 2018). Relying solely on e_x to gauge the health status of a population risks overlooking significant disparities in health equity. For instance, two populations sharing the same life expectancy may exhibit starkly different levels and trajectories of life disparity. Enhancements in mortality rates at any age bracket lead to an increase in e_x and vice versa, with varying impacts on lifespan disparities. An escalation in e_x necessitates saving more lives at younger ages to achieve a reduction in $e_x^\dagger$. The definition of "younger" or "older" hinges on a distinct threshold age that demarcates premature and delayed mortality, usually around the level of e_x. Conversely, a decline in mortality rates among the elderly amplifies variance, while a reduction in mortality below the threshold age compresses mortality rates, consequently diminishing variation (Vaupel et al., 2011). Research of the changes in e_0 and $e_0^\dagger$ is essential because improving lifespan and decreasing lifespan variation have always been major priorities of development. The most common methods of improving health are improvements in lifespan and a decline in lifespan disparity in mortality. It is well known that changes in mortality rates at different ages cause changes in e_0 and $e_0^\dagger$, but the contributions of changes in mortality rates at different ages that are specific to each age are not equal. In comparison to the change in the probability of death at older ages, the influence of the change in the probability of death at younger ages on the change in e_0 is greater, whereas older ages has more effects on $e_0^\dagger$. The trends in e_0 and $e_0^\dagger$ can therefore be understood by decomposing the change in e_0 and $e_0^\dagger$ into the change due to a decrease or increase in the probability of death at various ages. This study intends to analyze the trends in e_0 and $e_0^\dagger$ throughout the 30 years between 1989-1993 and 2016-20 in India and major states. This study examines the changes in e_0 and $e_0^\dagger$ in India and its selected states over the period from 1991 to 2018. It also analyzes how age-specific survival probabilities and age-specific probabilities of death have contributed to these changes.

Methodology

Data

The study used the age-specific death rates (ASDR) obtained from the official sample registration system (SRS). SRS, also known as the birth and death registration system, provides accurate and continuous data on vital rates. The SRS uses a dual record approach to gather information on vital statistics from representative sampling villages and urban blocks. The baseline survey records the usual residents of the sample population. An enumerator regularly records each birth and death in the sample area. After six months, an independent supervisor updates the vital events of households. To find unmatched cases, the data from the two sources are compared. To improve data accuracy, the unmatched cases are verified (ORGI, 2022a). The Sample Registration System (SRS) administered by the Office of the Registrar General of India (ORGI) is the primary and continuous source of data on mortality and life tables in India (ORGI, 2022a, 2022b). The SRS provides data on age-specific death rates by broad age categories and abridged life tables started in 1970. Based on SRS data, abridged life tables are published for five-year intervals from 1970 -1975. This study uses data on age-specific mortality rates from the SRS statistical report from 1989 to 2020.

Methods

This research uses the age-specific mortality rate for each year from 1989 until 2020. A five-year moving average of ASDR is obtained yearly from 1991 to 2018. The Five-year average age-specific death rates are converted into the age-specific probability of deaths using the Greville method to construct abridged life tables (Greville, 1977). Abridged life tables are constructed yearly from 1991 to

2018 for India and major states. SRS does not provide abridged life tables for smaller states or Union Territories. The abridged life tables are constructed for both sexes, separately for males and females, as well as for populations living in rural and urban areas, as well as for four groups of people who are mutually exclusive: men and women from rural and urban areas.

Construction of abridged life tables

Using the Chiang methods, we constructed abridged life tables for 1991-2018 based on the age-specific death rates by sex and residence from the SRS data (Chiang, 1972). Chiang method is based on the derivation of relation for the total number of person-years lived between exact ages x and $x+n$ (${}_nL_x$) in terms of the average number of years lived by an individual of age x who dies in the interval (x, x+n) (${}_na_x$). The columns of the life table are obtained using the following formulas:

${}_nq_x$:the probability of dying between age x and $x+n$

$$ {}_nq_x = \frac{n \cdot {}_nM_x}{1 + (n - {}_na_x) \cdot {}_nM_x} \tag{1} $$

l_x: number of people alive at the exact age x among a hypothetical birth cohort of 100000, usually called the radix of the life table.

$$ l_{x+n} = l_x \cdot (1 - {}_nq_x) \tag{2} $$

${}_nL_x$: total number of person-years lived between exact ages

$$ {}_nL_x = n \cdot (l_x - {}_nd_x + {}_na_x \cdot {}_nd_x) \tag{3} $$

${}_nd_x$: number of deaths in the age interval x to $x+n$

$$ {}_nd_x = l_x \cdot {}_nq_x \tag{4} $$

T_x: total number of person-years lived beyond age x

$$ T_x = T_{x+n} + {}_nL_x \tag{5} $$

e_x: average number of years of life remaining for a person alive at the beginning of age interval x

$$ e_x = \frac{T_x}{l_x} \tag{6} $$

Decomposition of e_0 using the discrete method

Arriaga's (Arriaga, 1984) discrete decomposition method was used for the decomposition of e_0. Consider the age group x to $x+n$ of life tables 1 and 2, where script '1' refers to the base life table population. The total effect (${}_n\Delta_x$) of a difference in mortality rates between age group x to $x+n$ on e_0 between two life tables can be calculated by using Arriaga's method as:

$$ {}_n\Delta_x = \frac{l_x^{(1)}}{l_0}\left(\frac{{}_nL_x^{(2)}}{l_x^{(2)}} - \frac{{}_nL_x^{(1)}}{l_x^{(1)}}\right) + \frac{T_{x+n}^{(2)}}{l_0}\left(\frac{l_x^{(1)}}{l_x^{(2)}} - \frac{l_{x+n}^{(1)}}{l_{x+n}^{(2)}}\right) \tag{7} $$

where, $l_x^{(1)}$= number of persons alive at exact age x in the life table '1', $l_x^{(2)}$= number of persons alive at exact age x in the life table '2', ${}_nL_x^{(1)}$= number of person-years lived between ages x and $x+n$ in the life table 1, ${}_nL_x^{(2)}$=number of person-years lived between ages x and $x+n$ in the life table 2, $T_x^{(1)}$= number of person-year lived above exact age x in the life table 1 (base life table), $T_x^{(2)}$=the number of person-years lived above exact age x in the life table 2. The first part of the right-hand side (RHS) of the above formula (7),

$\frac{l_x^{(1)}}{l_0}\left(\frac{{}_nL_x^{(2)}}{l_x^{(2)}} - \frac{{}_nL_x^{(1)}}{l_x^{(1)}}\right)$

Corresponds to the direct effect of a

change in mortality rates between ages x and $x+n$, i.e., the effect that a change in the number of years lived between x to $x+n$ produces on e_0. The second term of the above formula (7),

$$\frac{T_{x+n}^{(2)}}{l_0}\left(\frac{l_x^{(1)}}{l_x^{(2)}}-\frac{l_{x+n}^{(1)}}{l_{x+n}^{(2)}}\right)$$

Corresponds to the sum of the indirect and interaction effects, i.e., the contribution resulting from the person-years to be added because additional survivors at age $x+n$ are exposed to new mortality conditions (Preston et al., 2001). We can say that the total contributions of an age group to the life expectancy gap (in years) is the sum of two mathematical terms: the direct effect and the indirect and interaction effects.

Disparity in lifespan or inequality in age at death

The lifespan disparity ($e_0^\dagger$), a measure of the average number of life-years lost at birth, is estimated by,

$$e_0^\dagger = \frac{\int_0^\omega e_x\, d_x\, dx}{l_0} \tag{8}$$

Where e_x is the remaining life expectancy at age x, d_x the life table deaths at age x are integrated from age 0 to ω. For an abridged life table, life disparity is presented by,

$$e_x^\dagger = \frac{1}{l_x}\sum_x^\omega \left[d_x \cdot (e_{x+1}+1-a_x)\right] + \frac{d_\omega}{l_\omega}\left(\frac{e_\omega}{2}\right) \tag{9}$$

where, a_x is the average person-years lived in an age interval by those who died in that age interval, and d_x is life table deaths at age x.

Decomposition analysis by quinquennial age groups

The difference in life disparity at birth between the two populations is shown as,

$$\Delta e_0^\dagger = \sum_{i=0}^{n-1}\left(\epsilon_{(0,x_{i+1})}-\epsilon_{(0,x_i)}\right) = \sum_{i=0}^{n}\epsilon_i \tag{10}$$

and the contributions of age groups to the difference is calculated by,

$$\epsilon_i = e_0^\dagger\left[M^{(x_i)}\right] - e_0^{\dagger\prime}\left[M^{(x_i)}\right] \tag{11}$$

where, $M^{(x_i)}$ is a vector of ASDR with elements $m_x^{\prime}$ for $x \le x_i$ and m_x for $x \ge x_i$.

Results

Improvement of life expectancy at birth (e_0) and life disparity at birth ($e_0^\dagger$) in India and States, 1991-2018

Table 1 shows the estimates of life expectancy at birth (e_0) in India and states for the years 1991 and 2018. The overall e_0 has increased nationally and across the states from 1991 to 2018. Kerala has the highest e_0 for Persons and both sexes during 1991 and 2018 respectively. The lowest e_0 was observed for Madhya Pradesh Person and both sexes in 1991, while in the year 2018, the lowest e_0 was observed for the Persons and females in Uttar Pradesh and males in Madhya Pradesh, respectively.

Table 2 shows the estimates of life disparity at birth ($e_0^\dagger$) in India and states for the years 1991 and 2018. The overall $e_0^\dagger$ has decreased at the national and across the states from 1991 to 2018.

Table 1: Life expectancy at birth (e_0) in India and States 1991 & 2018.

Year	1991			2018		
State	**Person**	**Male**	**Female**	**Person**	**Male**	**Female**
Andhra Pradesh	59.6	58.4	60.9	72.3	70.8	73.8
Assam	52.1	52.3	52.0	68.8	68.5	69.2
Bihar	54.4	56.9	52.6	71.2	71.7	70.6
Gujarat	58.4	58.0	58.8	72.3	69.8	75.1
Haryana	59.7	60.3	59.0	71.2	68.9	74.0
Himachal Pradesh	64.6	64.6	65.9	75.4	72.6	78.6
Karnataka	61.0	60.0	62.1	72.0	70.3	73.8
Kerala	73.5	70.5	76.6	78.5	75.4	81.5
Maharashtra	63.8	62.8	64.7	75.9	74.6	77.5
Madhya Pradesh	49.1	49.5	48.6	67.1	65.1	69.3
Orissa	51.2	50.8	51.6	70.6	69.4	72.0
Punjab	63.7	62.9	64.7	74.6	72.8	76.8
Rajasthan	54.4	54.7	54.0	69.9	67.9	72.1
Tamil Nadu	62.6	61.8	63.6	76.2	74.1	78.5
Uttar Pradesh	51.5	53.0	49.8	66.0	65.4	66.5
West Bengal	60.4	59.6	61.2	74.7	73.6	76.1
India	**56.5**	**56.7**	**56.4**	**71.4**	**70.1**	**72.8**

Kerala has the lowest $e_0^\dagger$ for persons of both sexes during 1991 and 2018, respectively. The highest $e_0^\dagger$ was observed for Uttar Pradesh Person and females and Bihar males in 1991, while in the year 2018, the highest $e_0^\dagger$ was observed for the Persons in Orissa, males in Andhra Pradesh, and females in Uttar Pradesh, respectively.

Table 2: Life Disparity at birth ($e_0^\dagger$) in India and States 1991 & 2018.

Year	1991			2018		
State	**Person**	**Male**	**Female**	**Person**	**Male**	**Female**
Andhra Pradesh	24.4	24.5	24.2	20.3	21.1	19.5
Assam	27.7	27.5	27.9	20.1	19.2	21.2
Bihar	28.5	29.3	30.0	15.5	15.1	16.0
Gujarat	26.8	25.3	28.2	18.7	17.7	19.2
Haryana	27.0	25.9	28.3	19.3	18.9	19.4
Himachal Pradesh	24.8	26.1	25.3	17.3	17.4	16.7
Karnataka	24.9	24.5	25.2	16.3	16.8	15.7
Kerala	16.0	16.3	15.3	12.9	12.9	12.4
Maharashtra	22.6	22.0	23.1	16.4	16.6	16.1
Madhya Pradesh	29.8	28.6	31.0	19.8	20.1	19.2
Orissa	29.1	28.8	29.4	21.0	21.0	20.9
Punjab	24.5	23.5	25.7	19.1	19.2	18.7
Rajasthan	28.9	27.1	30.7	19.1	18.0	20.0
Tamil Nadu	21.9	21.8	22.0	17.1	17.8	16.1
Uttar Pradesh	30.3	28.6	32.2	20.8	19.9	21.7
West Bengal	23.9	23.5	24.2	16.6	16.7	16.4
India	**27.1**	**26.1**	**28.2**	**18.5**	**18.3**	**18.6**

Figure 1 shows the trends of life expectancy at birth (e_0) in India and 16 states for males and females in total, rural and urban populations. The graph depicts that e_0 has improved across the states in the last 28 years. Females have higher e_0 than males, and the urban population has a higher e_0 than the rural population at the national and sub-national levels in India. In Kerala e_0 is higher than the national e_0 over the time.

Figure 2 shows the trends of life disparity at birth ($e_0^\dagger$) in India and 16 states for males and females in total, rural and urban populations. It is evident from the figure that $e_0^\dagger$ has improved over time at the national and sub-national levels in India. Females have lower $e_0^\dagger$ than males and urban populations have lower $e_0^\dagger$ than rural areas over 1991-2018 and at India's national and subnational levels.

There are state-wise variations in the trends of $e_0^\dagger$ and Kerala has the lowest $e_0^\dagger$ across the states over time and in different population groups than other states and India.

Figure 3 shows the scatterplot of e_0 and $e_0^\dagger$ at the national and sub-national level across the male-female and rural-urban populations from 1991-2018. It is evident from the figure that e_0 and $e_0^\dagger$ have a strong negative correlation with each other, and with the increase in e_0 there is a decrease in $e_0^\dagger$ for male, females in total, rural and urban populations at national and subnational levels in India.

Age-specific percent contributions to the changes in Life expectancy at birth (e_0) and Life disparity at birth ($e_0^\dagger$) in India and selected states, 1991-2018, Total Population

Figure 4 shows the age-specific percent contributions to the change in e_0 among total males in India and selected states during 1991-2018. Mortality decline in the ages 0-1 & 1-4 had made the most positive contributions to the improvement in e_0 in India and across the 16 states. Mortality has declined least in the adolescent and younger ages, so this age group has made the least positive contributions to the improvement in e_0. The adult and older ages have made positive contributions to the changes in e_0 indicating reducing mortality in these age groups in India and across 16 states.

Some age groups observed negative contributions in the states of Bihar, Himachal Pradesh, Haryana, Kerala, Punjab, Rajasthan, and Uttar Pradesh, indicating a rise in mortality in those particular ages from 1991 to 2018.

Figure 5 shows the age-specific percent contributions to the decline in life disparity at birth ($e_0^\dagger$) among total males in India and selected states from 1991 to 2018. Mortality improvement in the ages of 50 and above has made significant positive contributions to the decrease in $e_0^\dagger$ among total males in India and states. After the 50+ ages, mortality decline in the infants aged 0-1 made the most positive contributions, whereas the age groups 1-4, 5-9... till the age group 45-49 had made the least positive contributions to the decline in $e_0^\dagger$. The ages 75-79 in Bihar, ages 80-84 in Himachal Pradesh, and ages 85+ in Kerala have made negative contributions to the decline in $e_0^\dagger$ indicating increased mortality in these ages during 1991-2018.

Figure 6 shows the age-specific percent contributions to the increase in e_0 among total females in India and states from 1991 to 2018. Mortality reduction in the age group 1-4 followed by the age group 0-1 has made the most positive contributions to the increase in e_0 among the female population in India and across the states. Similarly, mortality decline in the older age group has made the subsequent highest positive contributions to the change in e_0. Mortality has not declined much among young adults and middle-aged adults and has made the least contributions to the changes in e_0.

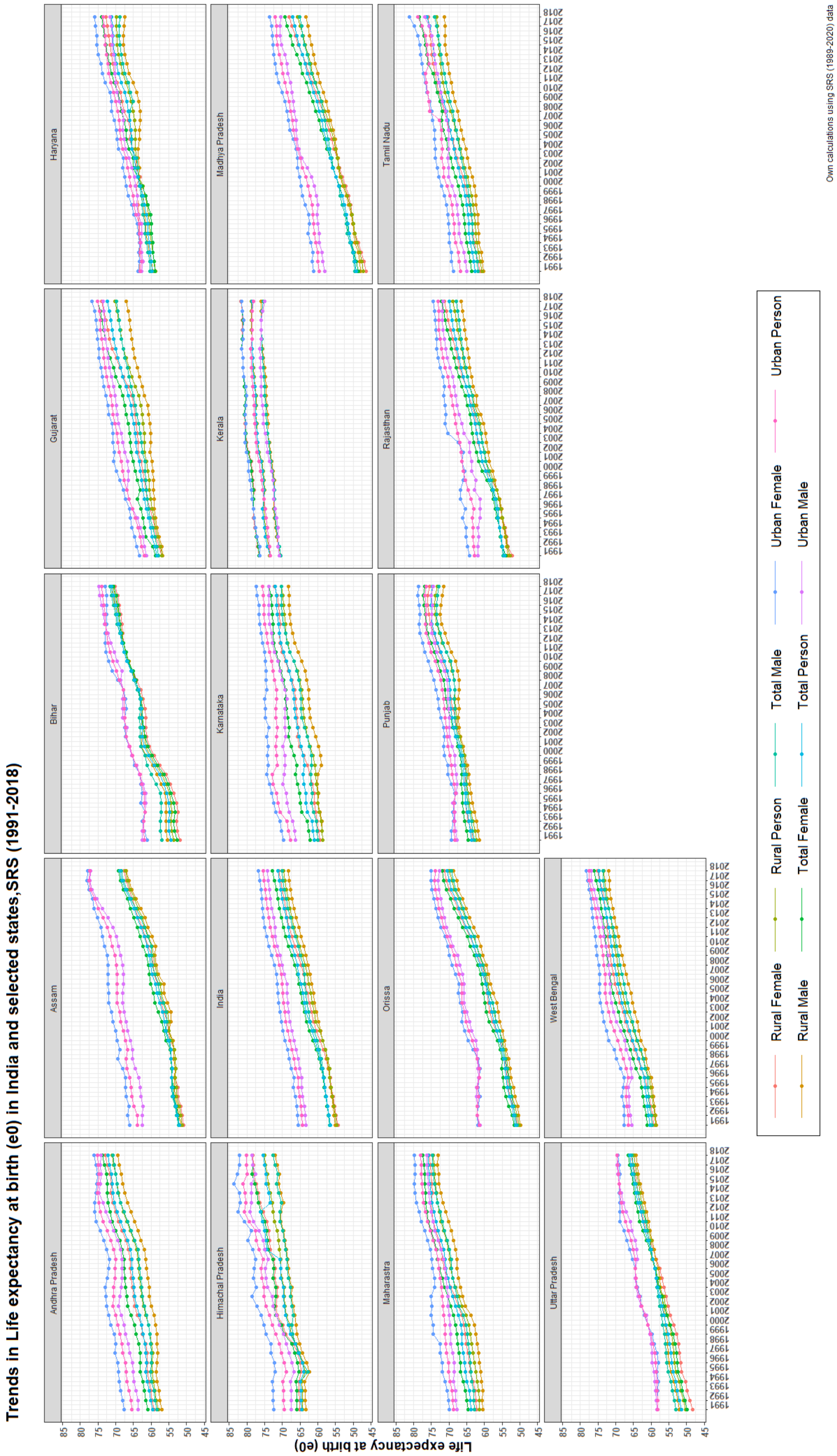

Figure 1. Trends of life expectancy at birth (e_0) in India and States, SRS (1991-2018)

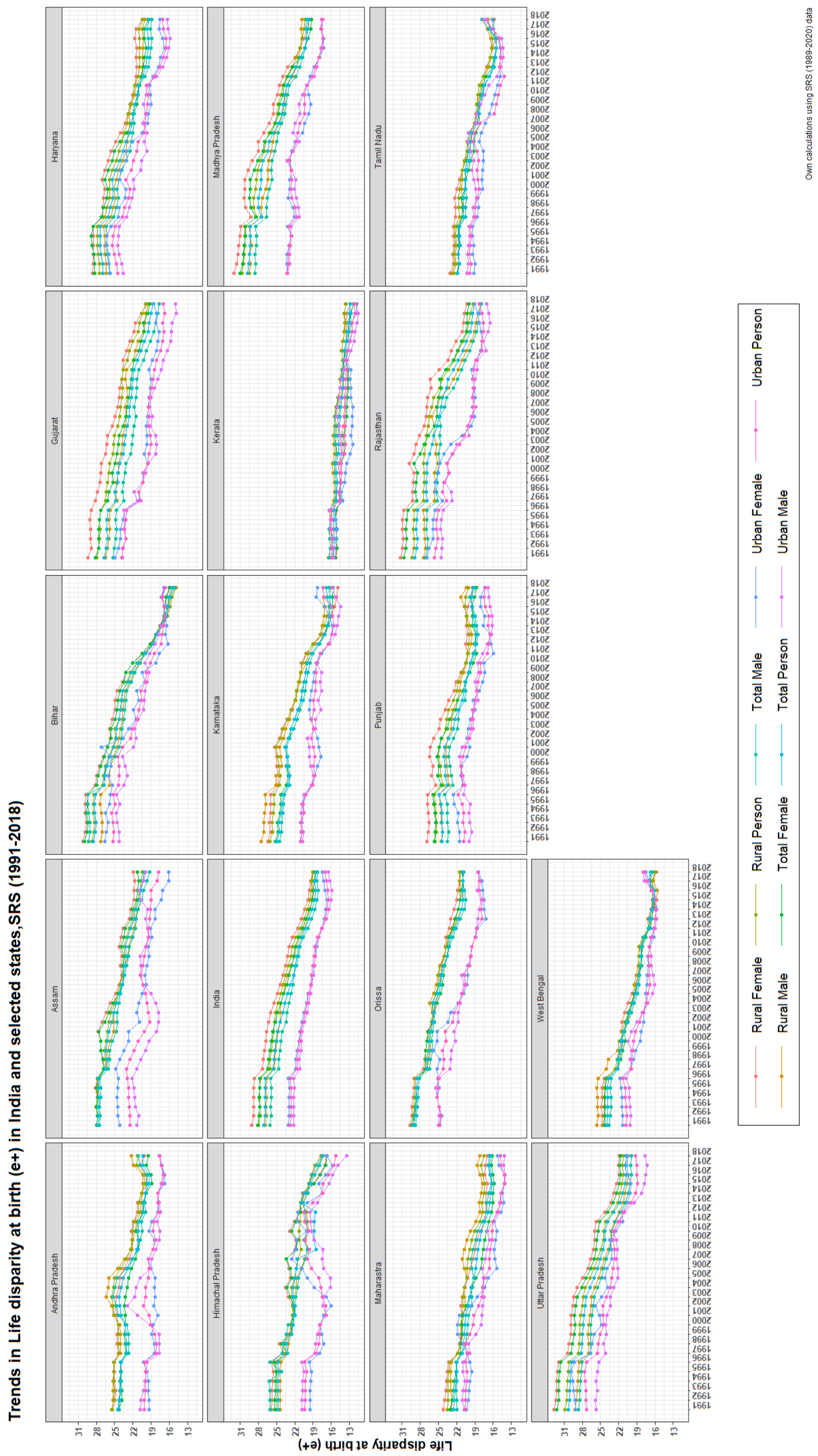

Figure 2. Trends of life disparity at birth ($e_0^\dagger$) in India and States, SRS (1991-2018)

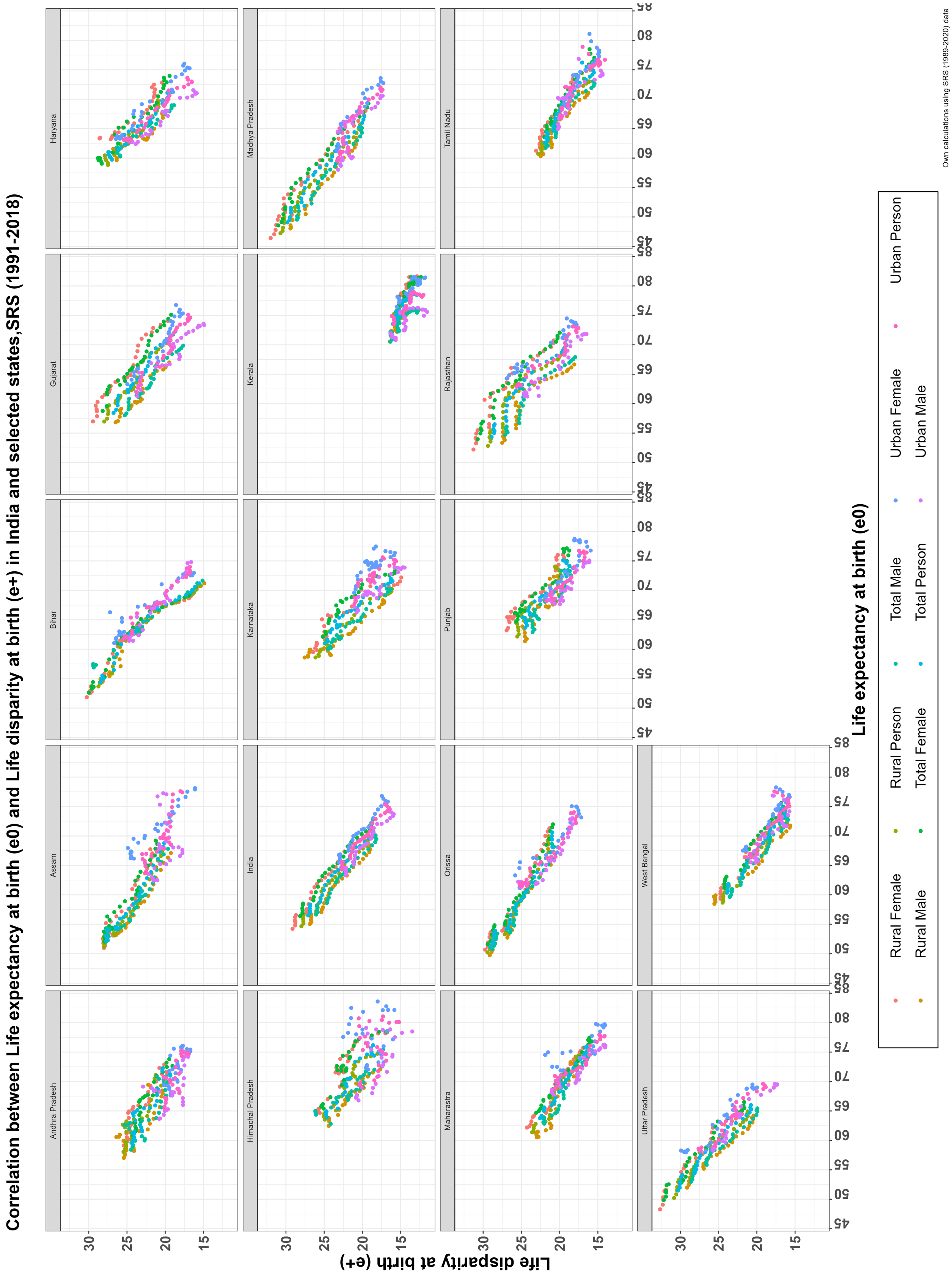

Figure 3. Correlation between Life expectancy and Life Disparity at birth in India and selected States, 1991-2018

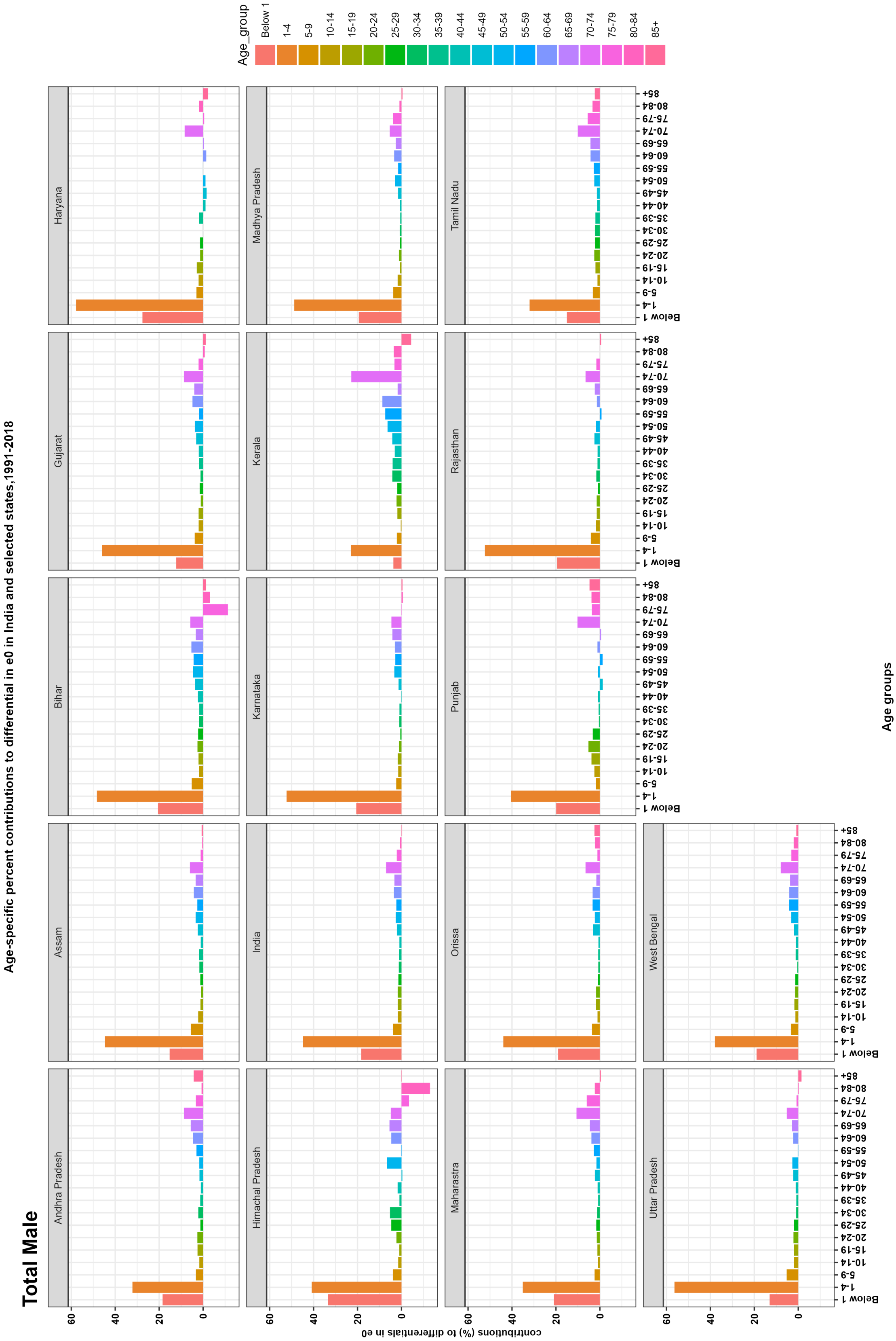

Figure 4. Age-specific percent contributions to the change in e_0 in India and selected states, 1991-2018, Total Male

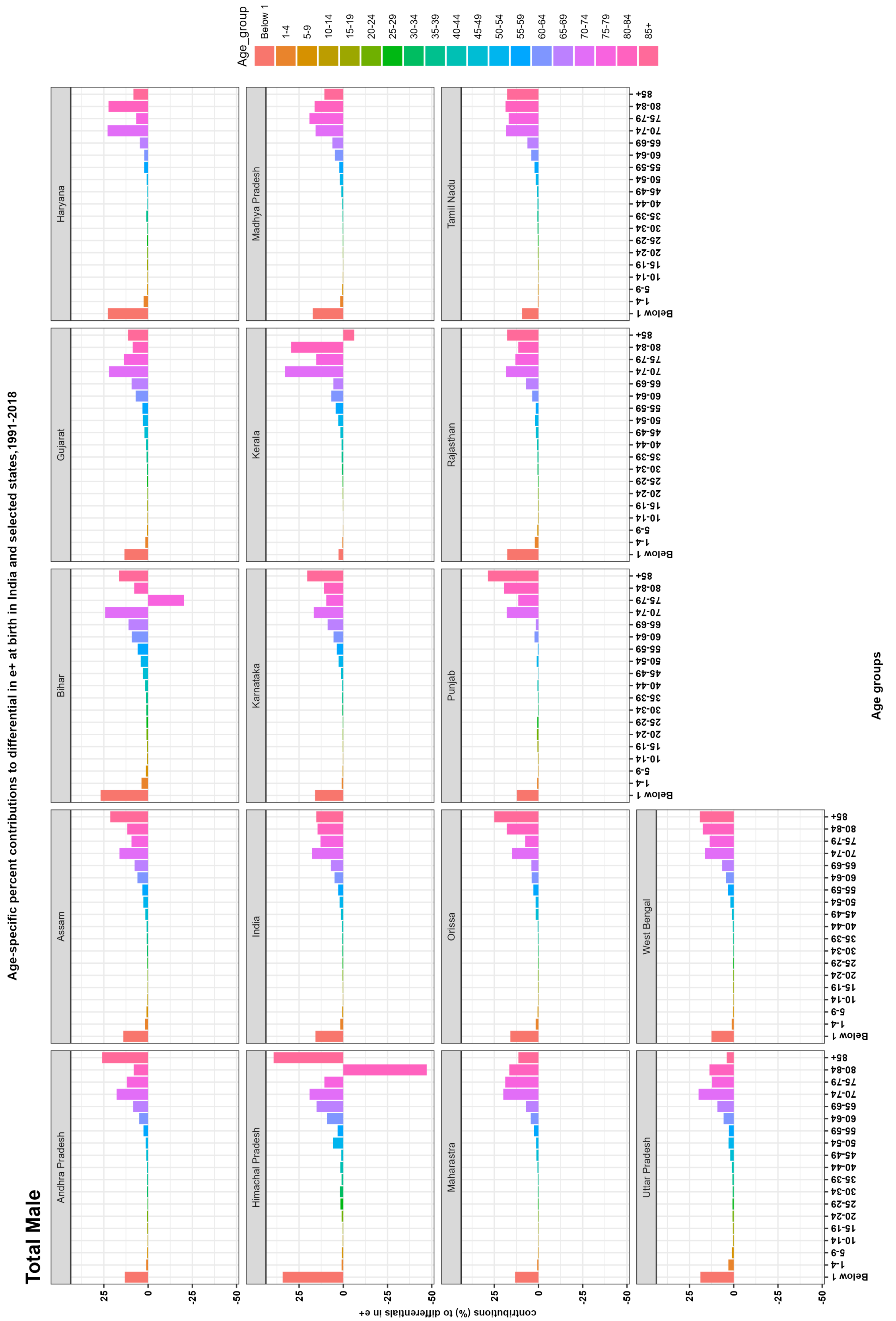

Figure 5. Age-specific percent contributions to the change in $e_0^\dagger$ in India and selected states, 1991-2018, Total Male

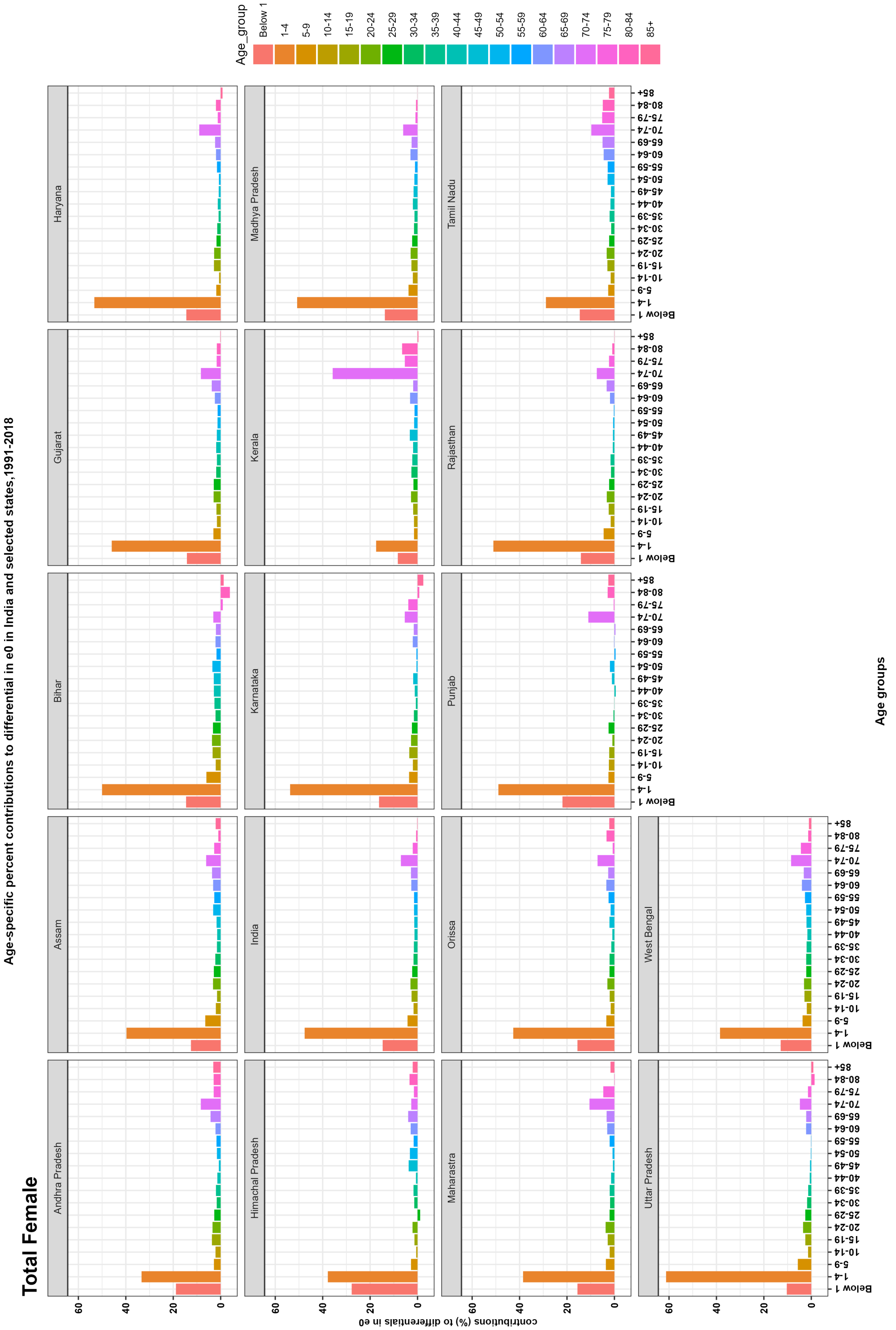

Figure 6. Age-specific percent contributions to the change in e_0 in India and selected states, 1991-2018, Total Female

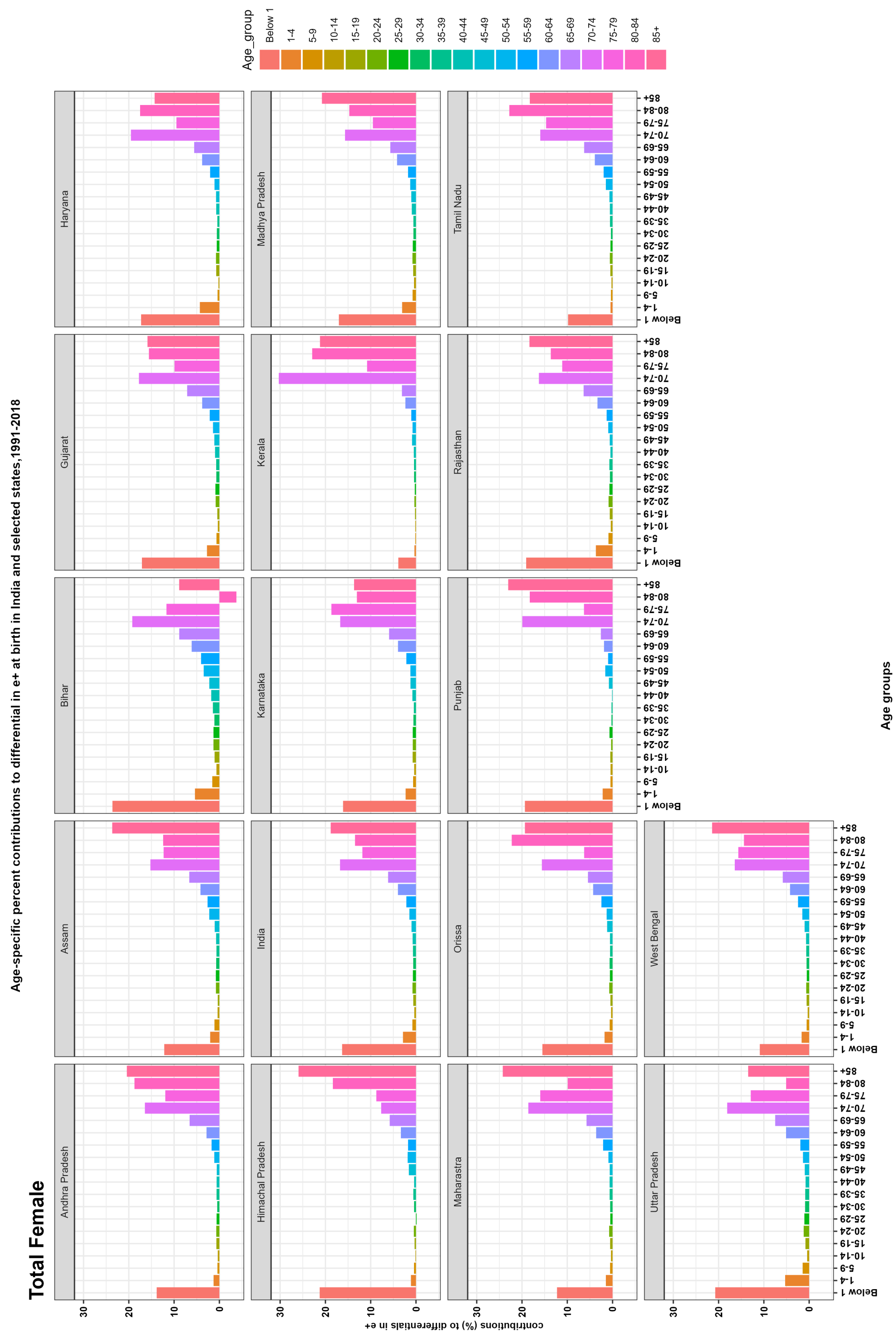

Figure 7. Age-specific percent contributions to the change in $e_0^\dagger$ in India and selected states, 1991-2018, Total Female

In a few age groups, there are negative age-specific contributions in the states of Bihar, Haryana, Karnataka, Himachal Pradesh, and Uttar Pradesh, and there was a slight increase in mortality from 1991 to 2018.

Figure 7 shows the age-specific percent contributions to the changes in $e_0^\dagger$ among females in India and states from 1991-2018. Mortality decline in infant ages, middle-aged adults (Aged 40-59), and older adults (Aged 60 and above) have contributed the most to the decrease in $e_0^\dagger$ among females in India and other states.

Mortality has not declined much for the young adult population; therefore, these ages have made the least positive contributions to the decline in $e_0^\dagger$ among the female population in India and other states. The changes in $e_0^\dagger$ observed the negative percent contributions among the females in Bihar in the age group 80-84 and showed increased mortality during 1991-2018.

Discussion

This study examines the trends in life expectancy and life disparity at birth across national and sub-national levels in India from 1991 to 2018. Additionally, a decomposition analysis was conducted to evaluate the age-specific percentage contributions to changes in both life expectancy at birth (e_0) and life disparity at birth ($e_0^\dagger$) at the national and sub-national levels. In essence, life disparity reflects the variation in the ages at which deaths occur, while life expectancy represents the average lifespan. A key factor behind the rise in life expectancy in India is the reduction in infant and child mortality (Singh and Ladusingh, 2016). Life table analyses and demographic models are widely used to estimate the impact of age-specific mortality on population health metrics (Preston et al., 2001). Studies frequently use decomposition methods to attribute changes in life expectancy and life disparity to specific age groups (Canudas-Romo, 2010). Results observed the mortality reductions in infant, Child, adult, and Older ages have made significant positive contributions to the increase in life expectancy at birth (e_0) in India and states. Declines in under-five mortality, driven by immunization, nutrition, and sanitation improvements, have significantly contributed to rising life expectancy at birth (Rajpal et al., 2020). Advances in healthcare have reduced elderly mortality, contributing to incremental gains in life expectancy at birth (Bhat & Navaneetham, 1991). Decomposition analysis results for the changes in life disparity at birth ($e_0^\dagger$) observed the most significant contributions from middle-aged adults (40-59 years), older adults (60 years and above), and the infant age group (0-1). Therefore decreases in $e_0^\dagger$ are observed due to decreased mortality in middle-aged adults, older adults, and infant age groups. High under-five mortality has historically been a major contributor to $e_0^\dagger$. Recent reductions in these rates have narrowed life disparity, reflecting more equitable survival outcomes (Alkema & New, 2014). The decline in mortality in the age group 0–1 year contributed the maximum to the decrease in inequality in length of life (G_0) between 1990 and 2010 (Singh et al., 2017). Premature deaths among working-age adults have a moderate impact on life expectancy but can exacerbate life disparity by creating unequal survival outcomes. Studies highlight the rising burden of NCDs, such as cardiovascular diseases and diabetes, which disproportionately affect working-age adults and contribute to premature mortality (Gupta et al., 2017). Mortality rates among women in this age group are influenced by maternal health complications and gender-based inequalities, including limited access to healthcare

(Patel et al., 2019).Trends analysis of e_0 and $e_0^\dagger$ observed the increase in e_0 and decline in $e_0^\dagger$ over 28 years from 1991 to 2018. The phenomenon of high e_0 and low $e_0^\dagger$ holds at the national and subnational levels in India. Southern states with better healthcare infrastructure have lower mortality rates and higher life expectancy, whereas northern states continue to struggle with higher mortality across all age groups (Drèze & Sen, 2013). The decomposition analysis results observed the contributions of infant, child, adult, and older age mortality declines to the increase in e_0 and decrease in $e_0^\dagger$ at the national and sub-national level in India.

Conclusion

Life expectancy and life disparity at birth are essential indicators of population health, reflecting average longevity and inequality in survival outcomes, respectively. Research on age-specific mortality contributions to these measures provides critical insights into demographic trends and public health challenges. In India, the interplay between socio-economic, regional, and healthcare factors has shaped mortality patterns and their implications for life expectancy and disparity at birth. Age-specific mortality is critical in shaping life expectancy and disparity in India. While reductions in infant and child mortality have driven improvements in life expectancy, challenges such as NCDs, socio-economic inequalities, and regional disparities must be addressed to ensure equitable health outcomes. By aligning public health strategies with these demographic realities, India can achieve sustainable progress in population health.

Limitations of the Study

Due to limitations in available data, the analysis was confined to age, sex, and place of residence, excluding an examination of causes of death. However, the decomposition analysis results could be further explored to assess the relative contributions of various diseases to the changes in life expectancy and disparities, contingent upon the availability of more detailed micro-level death registration data. Investigating the relationship between age and specific causes of death may yield valuable insights for developing future public health interventions. Our research has predominantly focused on the disparities in life expectancy rather than analyzing trends associated with different socio-economic variables.

Policy Implications

Continued investment in maternal and child health is essential to sustain declines in under-five mortality. Preventive and curative measures for NCDs are needed to reduce premature mortality among working-age adults. Tailored strategies are required to address regional and socio-economic disparities in mortality rates.

Abbreviations

SRS: Sample Registration System; e_x: Life expectancy at age x; e_0: Life expectancy at birth; $e_x^\dagger$: Life disparity at age x; $e_0^\dagger$: Life disparity at birth; NCDs: Non-Communicable Diseases; ORGI: Office of the Registrar General of India

Declarations

Ethical Approval

The study is based on a secondary dataset; hence, no ethical approval from any institutional board was required.

Consent for publication

It is ensured that the confidentiality of the participants was conserved and informed consent was sought from the respondents during the survey of SRS.

Competing interests

The author declares no competing interests.

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Authors' contributions

Both authors contributed equally to each section of the study and have read and approved the final manuscript.

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Availability of data and materials

The datasets used in the current study are available on the Office of the Registrar General & Census Commissioner, India (ORGI) at https://censusindia.gov.in/census.website/

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