

Decomposition of Change in Female-Male and Urban-Rural Gap in Life Expectancy at Birth in India

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Abstract

India has experienced substantial improvement in the life expectancy at birth (*LEB*) over the last five decades. However, significant female-male and urban-rural disparities persist, and age-specific factors driving these differences remain insufficiently understood. This paper, based on the data from the Sample Registration System of India examines the contribution of broad age groups to female-male, urban-rural, and temporal differences in *LEB* in India and states. The paper highlights a pronounced shift in the age pattern of mortality improvement in India. While mortality young and reproductive ages has substantially improved population health, recent gains in *LEB* contemporary disparities are increasingly determined by survival at older ages. The paper underscores the growing importance of healthy ageing, chronic disease prevention, and geriatric healthcare in sustaining future improvement in longevity and reducing inequalities across population groups.

Introduction

Life expectancy at birth is universally used as the measure of population health. Studies on life expectancy provide valuable insights into the health of the population. into the effects of healthcare, lifestyle, and socioeconomic factors on human longevity and play a crucial role in shaping public health strategies, planning healthcare infrastructure, and designing effective interventions for improving population health outcomes. Changes in life expectancy guide health policy and development initiatives. It also serves as a summary measure of mortality across all ages, allowing comparisons of longevity between regions and over time, even where demographic structures differ markedly (Aburto et al, 2021; Aburto et al, 2022). The steady rise in human life expectancy over the past two centuries stands as one of the most remarkable achievements of the modern civilisation (Oeppen and Vaupel, 2022; Riley, 2001). According to the United Nation Population Division (2024), the global life expectancy at birth was estimated at 73.2 years around the year 2023, while in India, it was 72.0 years. Monaco reports the highest life expectancy at birth (86.7 years) while *LEB* in Nigeria was the lowest (55 years) among the countries and areas for which estimates have been prepared by the United Nations Population Division (United Nation, 2024).

India has experienced a remarkable increase in *LEB* since independence. At the national level, *LEB* exhibits a distinct rural-urban divide, with urban residents living longer, on average, than their rural counterparts. This disparity stems from rural-urban differences in socioeconomic status of the population, access to healthcare facilities, sanitation, education, and occupational exposures. Urban population benefits from better health care facilities, higher literacy levels, improved maternal and child healthcare, and healthier living environments, leading to lower mortality rates across all age groups. Conversely, rural population often faces inadequate healthcare infrastructure, relatively higher prevalence of communicable diseases, poor nutrition, and unsafe working and living conditions, all of which contribute to shorter lifespan.

When examined by sex, a female advantage in life expectancy is evident in both rural and urban areas, but it tends to be more pronounced in the urban areas. Urban women benefit from greater access to reproductive healthcare, education, and lower maternal mortality. In contrast, persistent gender disparities in rural areas are driven by early marriage, limited healthcare access, and undernutrition which continue to influence female mortality patterns. Biological evidence across species suggests higher mortality among males than females (Borah, 2021). Globally, higher female *LEB* is almost universal and is reflected in most life tables, particularly in the developed countries (Lee, 2021; Gleit and Horiuchi, 2002). Omran states that females in the adolescent and reproductive years are at a higher risk of dying than males, but at lower risk of dying at older ages. His theory also suggest that Life expectancy reaches an unprecedented high of 70+ years and is about three or more years higher for women than for men (Omran, 2001).

Several socio-behavioural and environmental factors contribute to the observed male disadvantage in survival. Historically, men have exhibited higher consumption of tobacco, alcohol, and other substances, resulting in greater risks of diseases such as lung cancer, tuberculosis, and liver cirrhosis. According to the World Health Organization, ischemic heart disease remains the leading cause of death globally, with male mortality (121.5 per 10,000) exceeding female mortality (99.4 per 10,000) (WHO, 2024). Women consistently outlive men across most countries because of both biological resilience and social determinants of health. Similarly, the United Nations highlights that population ageing is increasingly feminised, with women forming the majority of older population worldwide. In the Indian context, research using data from the National Family Health Survey and the Sample Registration System have also shown that while the sex ratio may favour males at younger ages, it shifts in favour of females at older ages due to differential survival patterns. Mayer (1999) termed it as "mortality paradox" defined as a growing masculine bias in the overall population occurring alongside real but unequal gains in female life expectancy and literacy.

Evidence available from the Sample Registration System indicates that female-male gap in *LEB* in India is widening. Life tables based on the data from the Sample Registration system suggests that up to the period 1976-1980, male *LEB* in India was higher than female *LEB*. However, after 1980, female *LEB* has become higher than the male *LEB* and the gap is widening since then. During the period 2020-2024, females are estimated to have lived more than four years longer than males in the country according to the official life tables (Government of India, 2026).

The widening male-female gap in *LEB* in India and in its states is influenced by multiple interacting factors, including behavioural risks, cause-of-death patterns, age-specific mortality changes (particularly among adults). Tobacco and alcohol use are far more prevalent among Indian men and account for a substantial share of male deaths due to cancers, cardiovascular diseases, liver disease, and injuries (Dandona et al, 2020). Young and middle-aged men also face higher risks of road traffic accidents, occupational hazards, and suicide, all of which contribute to elevated male mortality (Vasan, 2025). Moreover, social norms and health-seeking behaviours often discourage men from seeking timely medical care, allowing treatable conditions to progress into fatal ones.

From the perspective of mortality, the human life can be divided into three broad age groups – young age (0-14 years), reproductive age (15-49 years) and old age (50 years and above). The main causes of death in the three age groups are essentially different. The female-male and urban-rural difference in *LEB* should, therefore, be analysed in terms of female-male and urban-rural difference in mortality in young age, reproductive age and old age. From the policy and programme perspective, it is imperative to explore how female-male and urban-rural difference in the person-years lived in the three ages of life contribute to female-male and urban-rural difference in the difference in person-years lived in all ages or the difference in *LEB* and how, this contribution has changed over time.

It is in the above context that the present study investigates the contribution of the change in the proportionate share of person-years lived in young age, reproductive age and old age to the change in *LEB*. The study also analyses how female-male and urban-rural difference in the person-years lived in young age, reproductive age and old age to female-male and urban-rural difference in *LEB* in India and in its selected states for which abridged life tables have been made available by the Government of India through the official Sample Registration System.

The paper decomposes the change and the difference in *LEB* to the change or the difference in the proportionate share of person-years lived in young age, reproductive age and old age. Decomposition analysis has been widely used in demographic research to identify the age-specific contributions to the difference or the change in the life expectancy at birth. Early approaches were developed by Chandra Sekar (1949), Lopez and Ruzicka (1977), Pollard (1982), and Arriaga (1984). Arriaga method is widely used but it has some limitations. Namboodiri and Suchindran (1987) have also suggested an approach to decompose *LEB* into age-specific components. Subsequent studies have demonstrated the mathematical equivalence of different decomposition methods and highlighted their utility in understanding the change in the age pattern of mortality on the change in *LEB* (Ponampalli, 2005).

Chaurasia (2010) has proposed a decomposition framework based on survival probabilities in broad age groups and the logarithmic relationship between life expectancy and age-specific survival. Unlike conventional age-by-age decomposition methods, this approach partitions the difference or change in life expectancy into an average change component, and an age-specific deviation associated with different age groups. Later Chaurasia (2021) used this decomposition technique for the decomposition of the female-male and urban-rural gap in *LEB* in India for the time period 1998-2017.

Data Source

The present study is based on the abridged life tables based on the Sample Registration System (SRS) prepared by the Government of India for the periods 1976-1980, 1986-1990, 1996-2000, 2006-2010, 2016-20 and 2019-2023 (Government of India, 1986; 1994; 2012; 2022; 2025). These abridged life tables are the only source of information about *LEB* in India and its selected states. They are also available for female and male population and for urban and rural areas which permit estimation of female-male and urban-rural gap in the life expectancy at birth. These life tables suggest that *LEB* in India has increased from 49.7 years during the period 1970-1975 to 70.3 years during the period 2019-2023. The male life expectancy at birth increased from 50.5 years to 68.5 years during this period whereas female life expectancy at birth increased from 49 years to 72.5 years. Similarly, rural life expectancy at birth increased from 48 years to 69.1 years during this period while urban life expectancy at birth increased from 58.9 years to 73.1 years (Government of India, 2025).

Abridged life tables for all states and Union Territories of the country are not available from the official sample registration system because of sample size constraints. During the period 2019-2023, abridged life tables for 22 states were available from the system. During the period 1976-1980, however, abridged life tables were available for only 15 states of the country. State level comparison of life expectancy at birth and female-male and urban-rural difference in *LEB* is hampered by changes in the administrative boundaries of the state. Three states – Andhra Pradesh, Madhya Pradesh and Uttar Pradesh – as they existed during 1976-80 have now been divided into Andhra Pradesh and Telangana, Madhya Pradesh and Chhattisgarh, and Uttar Pradesh and Uttarakhand so that life tables for existing Andhra Pradesh, Madhya Pradesh and Uttar Pradesh are not comparable with the erstwhile states of Andhra Pradesh, Madhya Pradesh and Uttar Pradesh. The administrative boundaries of only 12 states have remained unchanged during the period 1976-2023 to analyse the change in *LEB* between 1976-1980 and 2019-2023. Abridged life tables for Union Territories and for small states of the country are not available from the Sample Registration System. The present analysis is, therefore, confined to only those states for which abridged life tables are available from the Sample Registration System. Details about the official Sample Registration System are given elsewhere (Government of India, 2026).

Methodology

LEB is the sum of person-years lived in different ages of life. If L_x is the person-years lived in the age interval $(x, x + 1)$, then.

$$LEB = \sum_{x=0}^{\omega} L_x \quad (1)$$

where *LEB* is the life expectancy at birth. Dividing the entire duration of life into young age (0-14 years), reproductive age (15-49 years) and old age (≥ 50 years), equation (1) can be written as

$$LEB = \sum_{x=0}^{\omega} L_x = \sum_{x=0}^{14} L_x + \sum_{x=15}^{49} L_x + \sum_{x=50}^{\omega} L_x$$

Where, $\sum_{x=0}^{14} L_x$, $\sum_{x=15}^{49} L_x$ and $\sum_{x=50}^{\omega} L_x$ are the person-years lived in young age, reproductive age and old age, respectively. In other words

$$LEB = LEB * \left(\frac{\sum_{x=0}^{14} L_x}{LEB} + \frac{\sum_{x=15}^{49} L_x}{LEB} + \frac{\sum_{x=50}^{\omega} L_x}{LEB} \right) = LEB * (p_1 + p_2 + p_3) \quad (2)$$

Equation (2) suggests that the change or the difference in LEB can be explained in terms of the change or the difference in p_1 , p_2 and p_3 or the proportionate distribution of total person-years lived across young age, reproductive age and old age. The change in LEB can be decomposed following the logarithmic mean division index decomposition approach (Ang, 2013). Let LEB^2 denotes the LEB at time 2 while LEB^1 denotes the LEB at time 1. Then the change in LEB may be written as

$$\nabla^{21} = LEB^2 - LEB^1 = \sum_{i=1}^3 LEB^2 * p_i^2 - \sum_{i=1}^3 LEB^1 * p_i^1 \quad (3)$$

Or

$$\nabla^{21} = \sum_{i=1}^3 LEB^2 * p_i^2 - LEB^1 * p_i^1 \quad (4)$$

We can write.

$$LEB^2 * p_i^2 - LEB^1 * p_i^1 = \frac{LEB^2 * p_i^2 - LEB^1 * p_i^1}{\ln\left(\frac{LEB^2 * p_i^2}{LEB^1 * p_i^1}\right)} * \ln\left(\frac{LEB^2 * p_i^2}{LEB^1 * p_i^1}\right) = L_i^{21} * \ln\left(\frac{LEB^2 * p_i^2}{LEB^1 * p_i^1}\right) \quad (5)$$

where

$$L_i^{21} = \frac{LEB^2 * p_i^2 - LEB^1 * p_i^1}{\ln\left(\frac{LEB^2 * p_i^2}{LEB^1 * p_i^1}\right)} \quad (6)$$

is the logarithmic mean (Carlson, 1972; Lin, 1974). In other words,

$$LEB^2 * p_i^2 - LEB^1 * p_i^1 = L_i^{21} * \ln\left(\frac{LEB^2}{LEB^1}\right) + L_i^{21} * \ln\left(\frac{p_i^2}{p_i^1}\right) \quad (7)$$

Equation (3) can now be written as

$$\nabla^{21} = \sum_{i=1}^3 L_i^{21} * \ln\left(\frac{LEB^2}{LEB^1}\right) + \sum_{i=1}^3 L_i^{21} * \ln\left(\frac{p_i^2}{p_i^1}\right) \quad (8)$$

It may be noted that the number of person-years lived in an age interval depends upon the number of persons entering the age interval and the risk of death in the age interval. In case of person-years lived in young age, person-years lived is determined by the risk of death in young age only as persons entering young age is always the same and are equal to the radix of the life table. On the other hand, person-years lived in reproductive age depends upon the number of persons surviving to age 15 and the risk of death in reproductive age. If mortality in young age is high, number of persons entering reproductive age will be low compared to when mortality in young age is low. Similarly, person-years lived in old age depends upon both mortality in young age and mortality in reproductive age. This means that change in person-years lived in young age is solely due to the change in mortality but change in person-years lived in reproductive age depends upon both change in mortality in young age and change in mortality in reproductive age. Similarly, change in person-years lived in old age is determined by change in mortality in young age, change in

mortality in reproductive age and change in mortality in old age. In other words, the second term on the right hand side of equation 8 can be written as

$$\sum_{i=1}^3 L_i^{21} * \ln \left(\frac{p_i^2}{p_i^1} \right) = L_1^{21} * \ln \left(\frac{p_1^2}{p_1^1} \right) + L_2^{21} * \ln \left(\frac{p_2^2}{p_2^1} \right) + L_3^{21} * \ln \left(\frac{p_3^2}{p_3^1} \right) \tag{9}$$

We can write.

$$\ln \left(\frac{p_2^2}{p_2^1} \right) = \ln \left(\frac{(p_2^2/p_1^2) * p_1^2}{(p_2^1/p_1^1) * p_1^1} \right) = \ln \left(\frac{(p_2^2/p_1^2)}{(p_2^1/p_1^1)} \right) + \ln \left(\frac{p_1^2}{p_1^1} \right) \tag{10}$$

Similarly,

$$\ln \left(\frac{p_3^2}{p_3^1} \right) = \ln \left(\frac{(p_3^2/p_2^2) * (p_2^2/p_1^2) * p_1^2}{(p_3^1/p_2^1) * (p_2^1/p_1^1) * p_1^1} \right) = \ln \left(\frac{(p_3^2/p_2^2)}{(p_3^1/p_2^1)} \right) + \ln \left(\frac{(p_2^2/p_1^2)}{(p_2^1/p_1^1)} \right) + \ln \left(\frac{p_1^2}{p_1^1} \right) \tag{11}$$

Equation (8) now reduces to

$$\begin{aligned} \nabla^{21} = & \sum_{i=1}^3 L_i^{21} * \ln \left(\frac{LEB^2}{LEB^1} \right) + \sum_{i=1}^3 L_i^{21} * \ln \left(\frac{p_i^2}{p_i^1} \right) + \\ & \sum_{i=2}^3 L_i^{21} * \ln \left(\frac{(p_2^2/p_1^2)}{(p_2^1/p_1^1)} \right) + L_3^{21} * \ln \left(\frac{(p_3^2/p_2^2)}{(p_3^1/p_2^1)} \right) \end{aligned} \tag{12}$$

We are particularly interested in assessing the contribution of the change in the proportionate share of person-years lived in young age, reproductive age and old age to the change in the life expectancy at birth. Equation (12) suggests that the contribution of the change in proportionate share of person-years lived in young age (C_Y) is given by.

$$C_Y = \sum_{i=1}^3 L_i^{21} * \ln \left(\frac{p_i^2}{p_i^1} \right) \tag{13}$$

Contribution of the change in proportionate share of person-years lived in reproductive age (C_R) is given by.

$$C_R = \sum_{i=2}^3 L_i^{21} * \ln \left(\frac{(p_2^2/p_1^2)}{(p_2^1/p_1^1)} \right) \tag{14}$$

Finally, contribution of the change in proportionate share of person-years lived in old age (C_O) is given by.

$$C_O = L_3^{21} * \ln \left(\frac{(p_3^2/p_2^2)}{(p_3^1/p_2^1)} \right) \tag{15}$$

It may be noticed that the sum of the proportionate share of person-years lived in young age, reproductive age and old age is always equal to 1 irrespective of the distribution of person-years lived in young age, reproductive age and old age. This implies that the sum of the change in the proportionate share of person-years lived in three periods of life is always zero.

Following the same argument, it is also possible to explore how the female-male difference in the proportionate share of person-years lived in different periods of life contributes to the female-male difference in the life expectancy at birth. Similarly, it is also possible to analyse how urban-rural difference in the proportionate share of person-years lived in young age, reproductive age and old age contributes to the urban-rural difference in life expectancy at birth.

Results

Change in *LEB* in India, 1976-2023

Table 1 summarises the change in *LEB* in India during the period 1976-1980 through 2019-2023. *LEB* in the country increased by more than 18 years from around 52 years during 1976-1980 to more than 70 years during 2019-2023. During the period 1976-1990, the *LEB* increased in the country by more than 7 years. However, the increase slowed down in subsequent 10-years intervals and, during the period 2006-2020, the *LEB* increase by less than 4 years. During the period 2016-2023, the increase in *LEB* was marginal because of the COVID-19 pandemic which resulted in the marked increase in mortality, particularly, in the old population.

Table 1 also shows that there has also been a change in the proportionate distribution of person-years lived in young age, reproductive age, and old age over time. During the period 1976-1980, person-years lived in young age accounted for more than 23 per cent of the total person-years lived or the life expectancy at birth. This proportion decreased to less than 21 per cent during the period 2016-2020 but increased marginally during the period 2019-2023. Similarly, the proportion of person-years lived in the reproductive age also decreased over time. The proportion of person-years lived in the olds age, on the other hand, increased from more than 27 per cent during the period 1976-1980 to almost 33 per cent during the period 2016-2020 but decreased marginally during the period 2019-2023.

Table 1: Life expectancy at birth, and person-years lived in young age, reproductive age and old age in India, 1976-2023.

Period	Life expectancy at birth	Person-years lived in			Proportionate distribution		
		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age
1976-1980	51.94	12.17	25.72	14.05	23.43	49.52	27.05
1986-1990	57.69	12.97	28.03	16.68	22.49	48.59	28.92
1996-2000	61.92	13.53	29.64	18.76	21.85	47.86	30.29
2006-2010	66.05	13.99	31.08	20.98	21.17	47.06	31.77
2016-2020	69.96	14.40	32.58	22.98	20.58	46.57	32.85
2019-2023	70.34	14.50	32.76	23.09	20.61	46.57	32.82

Source: Authors

Table 2 decomposes the change in *LEB* in India between 1976 and 2023. The change in the proportion of person-years lived in old age contributed to the increase in *LEB* during the period 1976-2020, but the change in the proportion of person-years lived in young age and in the reproductive age contributed to the decrease in *LEB*. However, during the period 2016-2023, change in the proportion of person-years lived in old age contributed to slowdown the increase in *LEB* while the change in the proportion of person-years lived in young age contributed to the increase in the *LEB*. On the other hand, there has been little change in the proportion of the person-years lived in reproductive age so that it contributed little to change *LEB* during this period.

It may be noticed that the period 2016-2023 includes the period of COVID-19 pandemic (2020-2022) in India. During the COVID-19 pandemic, there was a significant increase in mortality. It is well-known that virtually all the increase in mortality during the COVID-19 pandemic was confined to the old population and older reproductive age population while the young population, especially, population below 5 years of age had largely been unaffected from the pandemic in terms of mortality. As such, the proportionate distribution of person-years lived across young age, reproductive age and old age changed markedly. The increase in the COVID-19 associated mortality during the period 2020-2022 appears to have resulted in the decrease in the proportionate share of person-years lived in old age resulting in the increase in the proportionate share of person-years lived in young age. The decrease in the proportionate share of person-years lived in old age due to COVID-19 associated mortality contributed to the decrease, instead increase, in *LEB* whereas the increase in the proportionate share of person-years lived in young age contributed to the increase in *LEB* during the period 2016-2023. This is in contrast to earlier periods in which change in the proportionate person-years lived in young age contributed to decrease *LEB*.

Table 2: Decomposition of the change in *LEB* in India, 1976-2023.

Period	<i>LEB</i>			Average change	Change attributed to the proportionate share of person-years lived in		
	Beginning of the period	End of the period	Change		Young age	Reproductive age	Old age
1976-1990	51.94	57.69	5.75	5.75	-2.25	0.94	1.31
1986-2000	57.69	61.92	4.24	4.23	-1.71	0.62	1.09
1996-2010	61.92	66.05	4.13	4.13	-2.03	0.75	1.28
2006-2020	66.05	69.96	3.90	3.90	-1.93	0.96	0.97
2016-2023	69.96	70.34	0.39	0.39	0.10	-0.09	-0.02
1976-2023	51.94	70.34	18.40	18.38	-7.78	3.16	4.64

Source: Authors

Table 3 presents estimates of *LEB* in India and states during 1976-1980 and 2019-2023 along with estimates of person-years lived in young age, reproductive age and old age. In India, person-years lived in old age accounted for around 27 per cent of *LEB* during 1976-1980 which increased to almost 33 per cent during 2019-2023. On the other hand, the proportionate share of person-years lived in young age has decreased over time but that of person-years lived in reproductive age has increased. This pattern may also be seen in all states except Punjab where the proportionate share of person-years lived in old age decreased during 2019-2023 compared to 1976-1980 but proportionate share of person-years lived in young age and reproductive age has increased. Punjab is the only state in which the proportionate share of person-years lived in old age decreased, instead increased. *LEB* in Punjab increased from around 63 years during 1976-1980 to almost 71 years during 2019-2023. Increase in life expectancy at birth is associated with the decrease in mortality in different ages, particularly, in young age so that an increasing proportion of population survive to old age with the increase in the life expectancy at birth. In Punjab, however, it appears that mortality in old age has increased.

Table 3: Life expectancy at birth, and person-years lived in young age, reproductive age and old age in India and states, 1976-1980 and 2019-2023.

Country/State	1976-1980							2019-2023						
	<i>LEB</i>	Person-years lived in			Proportionate distribution			<i>LEB</i>	Person-years lived in			Proportionate distribution		
		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age
India	51.94	12.17	25.72	14.05	23.43	49.52	27.05	70.34	14.50	32.76	23.09	20.61	46.57	32.82
Assam	50.86	12.60	26.29	11.98	24.76	51.69	23.55	68.63	14.46	32.62	21.56	21.07	47.52	31.41
Gujarat	52.01	12.06	25.47	14.48	23.19	48.97	27.84	70.40	14.57	32.91	22.92	20.69	46.75	32.56
Haryana	54.49	12.43	26.53	15.52	22.82	48.69	28.49	68.77	14.49	32.64	21.64	21.07	47.46	31.46
Himachal Pradesh	56.17	12.85	27.70	15.61	22.88	49.32	27.80	74.36	14.67	33.45	26.24	19.73	44.98	35.29
Jammu & Kashmir	57.18	13.19	28.97	15.02	23.07	50.67	26.26	74.38	14.71	33.62	26.06	19.77	45.20	35.03
Karnataka	56.46	12.89	27.45	16.12	22.82	48.62	28.56	69.98	14.66	33.03	22.29	20.95	47.20	31.85
Kerala	65.35	13.96	31.16	20.24	21.35	47.68	30.97	75.15	14.86	33.98	26.31	19.77	45.21	35.02
Maharashtra	56.19	12.89	27.68	15.62	22.93	49.27	27.80	72.82	14.73	33.48	24.61	20.23	45.97	33.80
Odisha	48.78	12.01	24.88	11.90	24.61	51.00	24.39	70.54	14.43	32.45	23.66	20.45	46.00	33.55
Punjab	63.20	12.82	28.07	22.31	20.28	44.41	35.30	70.81	14.66	33.01	23.14	20.70	46.62	32.68
Rajasthan	51.12	12.00	25.17	13.95	23.48	49.23	27.29	70.44	14.39	32.54	23.51	20.43	46.20	33.37
Tamil Nadu	52.97	12.51	26.53	13.93	23.63	50.08	26.30	73.40	14.75	33.50	25.15	20.10	45.64	34.26

Source: Authors

Table 4: Decomposition of the change in *LEB* in India and states during the period 1976-1980 through 2019-2023.

India/ States	<i>LEB</i>			Average change	Change attributed to the proportionate share of person-years lived in		
	1976-1980	2019-2023	Increase		Young age	Reproductive age	Old age
India	51.94	70.34	18.40	18.38	-7.78	3.16	4.64
Assam	50.86	68.63	17.77	17.73	-9.57	3.55	6.07
Gujarat	52.01	70.40	18.39	18.37	-6.93	3.22	3.73
Haryana	54.49	68.77	14.28	14.27	-4.89	2.59	2.30
Himachal Pradesh	56.17	74.36	18.19	18.15	-9.58	2.85	6.77
Jammu & Kashmir	57.18	74.38	17.21	17.15	-10.05	2.05	8.06
Karnataka	56.46	69.98	13.51	13.51	-5.38	2.74	2.64
Kerala	65.35	75.15	9.80	9.79	-5.40	1.33	4.07
Maharashtra	56.19	72.82	16.63	16.60	-8.04	2.83	5.23
Odisha	48.78	70.54	21.76	21.68	-10.90	3.75	7.22
Punjab	63.20	70.81	7.60	7.60	1.36	1.49	-2.85
Rajasthan	51.12	70.44	19.32	19.29	-8.36	3.54	4.85
Tamil Nadu	52.97	73.40	20.43	20.38	-10.10	3.36	6.79

Source: Authors

Among different states of the country for which life tables are available from the Sample Registration System, the share of the person-years lived in old age was the highest in Himachal Pradesh followed by Jammu & Kashmir and Kerala during 2019-2023. In all these states, person-years lived in old age accounted for more than 35 per cent of the total person-years lived or *LEB* and, in all these states, *LEB* during 2019-2023 was more than 74 years. On the other hand, this proportion was the lowest in Assam followed by Haryana and Karnataka. In these states, person-years lived in old age accounted for less than 32 per cent of the total person-years lived or *LEB* and, in all these states, life expectancy at birth during 2019-2023 was less than 70 years. Table 3 suggests that the higher the proportion of person-years lived in old age in a state the higher *LEB* in that state.

Table 4 decomposes the change in *LEB* during the period between 1976-1980 and 2019-2023 in different states of the country. The increase in *LEB* has been the highest in Odisha followed by Tamil Nadu during this period. These are the only two states – Odisha and Tamil Nadu – in which life expectancy at birth increased by more than 20 years during 1976-2023. On the other hand, increase in life expectancy at birth was the slowest in Punjab, followed by Kerala. Odisha had the lowest life expectancy at birth while Kerala had the highest life expectancy at birth during 1976-1980. The increase in the proportionate share of person-years lived in old age increased in all states except Punjab and was the highest in Jammu & Kashmir, followed by Odisha and Tamil Nadu but the lowest in Haryana. The proportionate share of person-years lived in young age decreased in all states except Punjab. The proportionate share of person-years lived in reproductive age, however, increased in all states. Punjab is the only state in which proportionate share of person-years lived in old age decreased during 1978-2023.

Female-Male Difference in Life Expectancy at Birth, 2019-2023

Table 5 presents the proportionate distribution of person-years lived by males and females in young age, reproductive age and old age in India and states during the period 2019-2023. The most noticeable observation of table 5 is that the proportionate share of person-years lived in old age by females is substantially higher than the proportionate share of person-years lived by males in old age in the country and in all states. In India, person-years lived by females in old age accounted for almost 35 per cent of the total person-years lived in all ages compared to around 31 by males. In Himachal Pradesh and Kerala, person-years lived by females in old age accounted for more than 37 per cent of the person-years lived in all ages while this proportion was less than 31 per cent in Chhattisgarh. On the other hand, the proportion of person-years lived by males in old age was the highest in Odisha but the lowest in Chhattisgarh.

Table 6 decomposes female-male difference in *LEB* in India and states during 2019-2023 in terms of the difference in the proportionate share of person-years lived in young age, reproductive age and old age. The female life expectancy at birth was around 4 years higher than the male life expectancy at birth in India during the period 2019-2023. The proportionate share of person-years lived by females in young age was smaller than the proportionate share of person-years lived by males in young age so that female-male difference in the proportionate share of person-years lived in young age contributed to decrease female-male difference in life expectancy at birth. However, proportionate share of person-years lived by females in reproductive age and old age was larger than the proportionate share of person-years lived by males in these ages so that female-male difference in the proportionate share of person-years lived in reproductive age and old age contributed to widen the female-male difference in the life expectancy at birth.

Table 6 also shows that in all states of the country, female-male difference in the proportionate share of person-years lived in young age contributed to decrease the female-male difference in *LEB* whereas female-male difference in reproductive age and old age contributed to increase the female-male difference in *LEB*. The magnitude of the contribution, however, has been different in different states. The female-male difference in *LEB* was the highest in Himachal Pradesh where females outlived males by more than 7 years during 2019-2023. On the other hand, female-male difference in *LEB* was the narrowest in Bihar where females outlived males by less than 1 year during the period 2019-2023. In Himachal Pradesh, female-male difference in the proportionate share of person-years lived in old age accounted for almost 6 years of the female-male difference in the life expectancy at birth. In Bihar, by contrast, female-male difference in the proportionate share of person-years lived in old age accounted for less than 0.9 years of the female-male difference in *LEB*. In Gujarat, Haryana, Kerala and Tamil Nadu also, female-male difference in the proportionate share of person-years lived in old age was more than 5 years so that female-male difference in *LEB* in these states was also very large. In Jharkhand, West Bengal, Odisha and Jammu & Kashmir, on the other hand, female-male difference in the proportionate share of person-years lived in old age was less than 2 years and, therefore, female-male difference in *LEB* in these states was less than 3 years. In Jharkhand, female-male difference in *LEB* was less than 1.8 years which is the second lowest across states, next only to Bihar as may be seen from table 6.

Table 5: Life expectancy at birth, and person-years lived in young age, reproductive age and old age in male population India and states, 2019-2023.

Country/State	Male						Female							
	LEB	Person-years lived in			Proportionate distribution			LEB	Person-years lived in			Proportionate distribution		
		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age
India	68.46	14.50	32.57	21.39	21.18	47.58	31.24	72.46	14.49	32.95	25.02	20.00	45.47	34.53
Andhra Pradesh	68.52	14.60	32.72	21.21	21.30	47.75	30.95	73.27	14.64	33.47	25.15	19.99	45.68	34.33
Assam	66.94	14.48	32.52	19.95	21.63	48.58	29.80	70.72	14.44	32.71	23.57	20.41	46.26	33.33
Bihar	68.95	14.58	32.89	21.48	21.14	47.70	31.15	69.75	14.52	32.87	22.36	20.82	47.13	32.06
Chhattisgarh	62.41	14.35	31.39	16.67	23.00	50.29	26.71	67.06	14.30	32.21	20.54	21.32	48.04	30.64
Delhi	72.28	14.78	33.67	23.84	20.44	46.58	32.98	76.79	14.78	33.93	28.07	19.25	44.19	36.56
Gujarat	67.57	14.55	32.62	20.40	21.53	48.27	30.19	73.86	14.58	33.24	26.04	19.75	45.00	35.25
Haryana	65.95	14.49	32.31	19.15	21.97	48.99	29.04	72.18	14.49	33.01	24.67	20.08	45.73	34.19
Himachal Pradesh	70.97	14.62	33.07	23.28	20.61	46.59	32.80	78.10	14.72	33.82	29.55	18.85	43.31	37.84
Jammu & Kashmir	73.39	14.71	33.55	25.13	20.04	45.71	34.25	75.48	14.71	33.69	27.08	19.49	44.64	35.87
Jharkhand	68.70	14.55	32.58	21.56	21.18	47.43	31.39	70.47	14.52	32.87	23.08	20.61	46.64	32.75
Karnataka	67.80	14.67	32.80	20.33	21.63	48.38	29.99	72.37	14.66	33.27	24.45	20.25	45.96	33.78
Kerala	71.95	14.83	33.64	23.48	20.61	46.75	32.64	78.36	14.89	34.29	29.18	19.00	43.76	37.24
Madhya Pradesh	65.39	14.21	31.59	19.59	21.73	48.31	29.96	70.28	14.23	32.19	23.85	20.25	45.81	33.94
Maharashtra	70.73	14.73	33.24	22.76	20.83	46.99	32.18	75.19	14.73	33.74	26.73	19.59	44.87	35.54
Odisha	69.35	14.40	32.22	22.73	20.77	46.46	32.77	71.85	14.45	32.69	24.71	20.11	45.50	34.39
Punjab	68.83	14.67	32.75	21.41	21.31	47.58	31.11	73.09	14.65	33.29	25.16	20.04	45.54	34.42
Rajasthan	67.84	14.44	32.47	20.94	21.28	47.86	30.86	73.28	14.34	32.61	26.33	19.57	44.50	35.94
Tamil Nadu	71.40	14.75	33.24	23.41	20.66	46.56	32.78	75.55	14.76	33.76	27.03	19.53	44.68	35.78
Telangana	68.61	14.61	32.81	21.19	21.30	47.82	30.88	73.23	14.64	33.33	25.26	19.99	45.52	34.49
Uttar Pradesh	66.47	14.27	31.98	20.22	21.47	48.11	30.42	69.79	14.24	32.16	23.38	20.41	46.08	33.50
Uttarakhand	68.12	14.64	32.78	20.70	21.49	48.13	30.39	74.84	14.63	33.31	26.89	19.55	44.51	35.93
West Bengal	71.14	14.65	33.23	23.26	20.60	46.71	32.69	74.05	14.68	33.51	25.86	19.82	45.25	34.93

Source: Author

Table 6: Decomposition of female-male difference in *LEB* in India and selected states during the period 2019-2023.

India/ States	<i>LEB</i>			Average change	Change attributed to the proportionate share of person-years lived in		
	Female	Male	Difference		Young age	Reproductive age	Old age
India	72.46	68.46	4.00	4.00	-4.04	0.68	3.37
Andhra Pradesh	73.27	68.52	4.75	4.74	-4.51	1.10	3.42
Assam	70.72	66.94	3.77	3.77	-3.98	0.48	3.50
Bihar	69.75	68.95	0.80	0.80	-1.08	0.19	0.89
Chhattisgarh	67.06	62.41	4.65	4.65	-4.89	1.50	3.40
Delhi	76.79	72.28	4.50	4.50	-4.46	0.44	4.03
Gujarat	73.86	67.57	6.28	6.28	-6.11	0.91	5.20
Haryana	72.18	65.95	6.23	6.22	-6.20	1.15	5.05
Himachal Pradesh	78.10	70.97	7.13	7.13	-6.62	0.95	5.68
Jammu & Kashmir	75.48	73.39	2.09	2.09	-2.09	0.26	1.83
Jharkhand	70.47	68.70	1.77	1.77	-1.90	0.58	1.32
Karnataka	72.37	67.80	4.57	4.57	-4.61	0.81	3.80
Kerala	78.36	71.95	6.41	6.41	-6.09	0.91	5.19
Madhya Pradesh	70.28	65.39	4.89	4.88	-4.78	0.93	3.85
Maharashtra	75.19	70.73	4.46	4.46	-4.47	0.88	3.60
Odisha	71.85	69.35	2.50	2.50	-2.27	0.63	1.64
Punjab	73.09	68.83	4.26	4.25	-4.36	0.99	3.36
Rajasthan	73.28	67.84	5.44	5.43	-5.91	0.61	5.30
Tamil Nadu	75.55	71.40	4.15	4.15	-4.11	0.87	3.24
Telangana	73.23	68.61	4.62	4.62	-4.50	0.80	3.70
Uttar Pradesh	69.79	66.47	3.33	3.33	-0.72	-1.38	2.10
Uttarakhand	74.84	68.12	6.72	6.72	-1.38	-2.58	3.97
West Bengal	74.05	71.14	2.90	2.90	-0.57	-1.06	1.62

Source: Authors

Urban-Rural Difference in Life Expectancy at Birth, 2019-2023

Table 7 gives the distribution of person-years lived in young age, reproductive age and old age in rural and urban areas of the country and the states for which data are available through the sample registration system. In India and in all states except Kerala and Uttarakhand, people living in urban areas lived longer than the people living in the rural areas. Kerala and Uttarakhand are the only states where people living in the rural areas lived longer than the people living in the urban areas during the period 2019-2023. The urban-rural difference in *LEB* was the widest in Tamil Nadu followed by Assam. In these states, people living in urban areas lived more than 5 years longer than the people living in the rural areas. On the other hand, Odisha and Himachal Pradesh are the only states in the country in which urban-rural difference in *LEB* is narrow. The urban *LEB* in these states exceeds rural *LEB* by less than 2 years.

Table 7: Life expectancy at birth, and person-years lived in young age, reproductive age and old age in male population India and states, 2019-2023.

Country/State	Rural						Urban							
	LEB	Person-years lived in			Proportionate distribution			LEB	Person-years lived in			Proportionate distribution		
		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age		Young age	Reproductive age	Old age	Young age	Reproductive age	Old age
India	69.10	14.44	32.52	22.14	20.90	47.06	32.05	73.10	14.65	33.32	25.12	20.05	45.59	34.37
Andhra Pradesh	69.75	14.58	32.86	22.31	20.90	47.11	31.98	72.82	14.71	33.57	24.55	20.19	46.10	33.71
Assam	67.75	14.41	32.47	20.87	21.27	47.93	30.80	73.54	14.78	33.54	25.22	20.09	45.61	34.30
Bihar	68.98	14.55	32.86	21.58	21.09	47.63	31.28	71.48	14.57	33.08	23.83	20.39	46.28	33.33
Chhattisgarh	64.07	14.30	31.64	18.13	22.32	49.39	28.30	66.40	14.46	32.38	19.56	21.77	48.76	29.46
Delhi	72.11	14.80	33.49	23.82	20.53	46.45	33.03	74.29	14.78	33.80	25.72	19.89	45.49	34.61
Gujarat	68.65	14.48	32.54	21.62	21.10	47.40	31.50	72.72	14.68	33.39	24.65	20.19	45.91	33.90
Haryana	67.93	14.44	32.43	21.06	21.25	47.74	31.01	70.13	14.60	33.01	22.52	20.81	47.07	32.12
Himachal Pradesh	74.19	14.66	33.41	26.11	19.77	45.04	35.19	76.11	14.77	33.84	27.50	19.40	44.47	36.13
Jammu & Kashmir	73.41	14.69	33.57	25.15	20.02	45.73	34.26	76.67	14.76	33.75	28.16	19.25	44.02	36.73
Jharkhand	68.82	14.52	32.58	21.72	21.10	47.33	31.57	71.54	14.61	33.21	23.73	20.42	46.42	33.16
Karnataka	68.46	14.63	32.86	20.98	21.37	47.99	30.64	72.64	14.72	33.29	24.63	20.26	45.83	33.91
Kerala	75.71	14.88	34.05	26.78	19.66	44.97	35.37	74.59	14.83	33.90	25.85	19.89	45.45	34.66
Madhya Pradesh	66.76	14.16	31.65	20.95	21.21	47.41	31.38	70.45	14.46	32.68	23.31	20.52	46.39	33.09
Maharashtra	71.27	14.66	33.15	23.46	20.57	46.51	32.92	75.05	14.82	33.85	26.38	19.74	45.10	35.15
Odisha	70.22	14.39	32.34	23.49	20.50	46.05	33.45	72.05	14.60	33.04	24.42	20.26	45.85	33.89
Punjab	69.23	14.64	32.78	21.81	21.14	47.35	31.51	73.16	14.69	33.29	25.19	20.07	45.50	34.42
Rajasthan	69.74	14.36	32.41	22.98	20.59	46.47	32.95	72.74	14.51	32.99	25.23	19.95	45.36	34.69
Tamil Nadu	70.33	14.72	33.26	22.35	20.93	47.30	31.78	76.29	14.79	33.71	27.80	19.38	44.18	36.44
Telangana	69.80	14.56	32.68	22.56	20.86	46.82	32.32	71.95	14.71	33.57	23.66	20.44	46.67	32.89
Uttar Pradesh	67.42	14.21	31.90	21.31	21.08	47.31	31.61	70.10	14.43	32.68	22.99	20.59	46.61	32.80
Uttarakhand	71.35	14.62	32.94	23.79	20.50	46.17	33.34	70.96	14.66	33.30	23.00	20.66	46.93	32.41
West Bengal	71.45	14.65	33.34	23.45	20.51	46.67	32.83	74.82	14.71	33.44	26.67	19.66	44.70	35.64

Source: Authors

Table 8: Decomposition of urban-rural difference in life expectancy at birth in India and states, 2019-2023.

India/ States	LEB			Average change	Change attributed to the proportionate share of person-years lived in		
	Urban	Rural	Difference		Young age	Reproductive age	Old age
India	73.10	69.10	3.99	3.99	-2.95	0.55	2.40
Andhra Pradesh	72.82	69.75	3.07	3.06	-2.46	0.72	1.74
Assam	73.54	67.75	5.79	5.79	-4.02	0.41	3.61
Bihar	71.48	68.98	2.50	2.50	-2.38	0.28	2.09
Chhattisgarh	66.40	64.07	2.33	2.33	-1.60	0.60	1.00
Delhi	74.29	72.11	2.18	2.18	-2.30	0.63	1.68
Gujarat	72.72	68.65	4.08	4.07	-3.13	0.69	2.44
Haryana	70.13	67.93	2.20	2.20	-1.44	0.36	1.08
Himachal Pradesh	76.11	74.19	1.92	1.92	-1.39	0.35	1.04
J&K	76.67	73.41	3.27	3.27	-2.94	0.07	2.87
Jharkhand	71.54	68.82	2.72	2.72	-2.30	0.74	1.56
Karnataka	72.64	68.46	4.18	4.18	-3.74	0.38	3.36
Kerala	74.59	75.71	-1.12	-1.12	0.85	-0.05	-0.81
Madhya Pradesh	70.45	66.76	3.70	3.70	-2.28	0.63	1.65
Maharashtra	75.05	71.27	3.78	3.78	-3.00	0.60	2.40
Odisha	72.05	70.22	1.83	1.83	-0.83	0.42	0.41
Punjab	73.16	69.23	3.93	3.93	-3.70	0.69	3.01
Rajasthan	72.74	69.74	2.99	2.99	-2.24	0.42	1.82
Tamil Nadu	76.29	70.33	5.97	5.96	-5.60	0.49	5.12
Telangana	71.95	69.80	2.15	2.15	-1.44	0.96	0.48
Uttar Pradesh	70.10	67.42	2.68	2.68	-0.34	-0.48	0.82
Uttarakhand	70.96	71.35	-0.39	-0.39	0.12	0.54	-0.66
West Bengal	74.82	71.45	3.37	3.37	-0.62	-1.44	2.06

Source: Authors

Table 8 decomposes urban-rural difference in *LEB* in India and selected states. Urban-rural difference in the proportionate share of person-years lived in young age contributed to narrow down urban-rural difference in *LEB* in India and in all states except Kerala and Uttarakhand while urban-rural difference in the proportionate share of person-years lived in old age contributed to widen urban-rural difference in *LEB* in the country and in all states except Kerala and Uttarakhand. Urban-rural difference in the proportionate share of person-years lived in reproductive age also contributed to widen urban-rural difference in *LEB* in India and in states other than Kerala, Uttar Pradesh and West Bengal. Table 8 also shows that the urban-rural difference in *LEB* is different in different states of the country. Kerala is the only state where urban-rural difference in the proportionate share of person-years lived in reproductive age and in old age contributed to narrow down the urban-rural difference in *LEB* or urban-rural difference in person-years lived in all ages. In other states, urban-rural difference in proportionate share of person-years lived in reproductive age and old age contributed to widen urban-rural difference in *LEB*.

Discussion and Conclusions

In this paper, we have analysed how person-years lived in young age (0-14 years), reproductive age (15-49 year) and old age (50 years and older) have contributed to the change in *LEB* in India during the period 1976-2023. The analysis has also explored how female-male and urban rural difference in person-years lived in young age, reproductive age and old age has contributed to the female-male and urban-rural difference in *LEB* in India and in its states during the period 2019-2023. The analysis reveals that, the increase in *LEB* in India from around 52 years in 1976-1980 to more than 70 years in 2019-2023 has been associated with the decrease in the proportionate share of person-years lived in young age and reproductive age in the person-years lived in all ages while the proportionate share of the person-years lived in old age has increased. Although, in absolute terms person-years lived in young age, reproductive age and old age increased with the increase in the life expectancy at birth, yet, in proportionate terms, the contribution of young age has decreased but that of reproductive age and old age has increased. It is only during the period 2016-2023 that the contribution of the change in the proportionate share of person-years lived in young age contributed to increase *LEB* while change on the proportionate share of person-years lived in old age contributed to the decrease in *LEB* because of the typical age pattern of mortality associated with COVID-19 pandemic. Findings reveal that, although females experience high life expectancy in younger ages still the male proportions are more in younger ages as the sex ratio favours males over females in younger ages and as males progress to higher age, they experience high mortality as they are engaged in risky jobs and they are more likely to involve in smoking, tobacco and alcohol consumption.

The decomposition analysis has revealed significant variations in the age-specific contributions to life expectancy, highlighting the changing dynamics of mortality and survival across the life course. The analysis of the female-male differential showed that the overall female advantage in life expectancy was primarily attributable to survival advantages at older ages. While the young (0-14 years) and reproductive (15-49 years) age groups contributed less than the average female-male differential, the old-age group (50 years and above) contributed substantially more than the average, indicating that lower mortality among older women is the principal source of the observed female-male gap in longevity which may be because men are more prone to engaging in risky behaviours, whereas women generally exhibit lower participation in such activities. These behavioural differences substantially contribute to the higher life expectancy observed among females compared to males.

Similarly, the urban-rural decomposition demonstrated that differences in life expectancy are increasingly concentrated at older ages. Negative contributions from the young and reproductive age groups suggest that disparities in survival during these ages have narrowed considerably, reflecting improvement in healthcare access, maternal and child health services, and socioeconomic conditions in rural areas. However, the positive contribution of the old-age group indicates that mortality differentials among old population continue to sustain the urban advantage in life expectancy.

The temporal decomposition of life expectancy gains between 1976 and 2023 further highlights a shift in the age pattern of mortality improvement. Although substantial

reduction in mortality occurred in younger ages, their contributions have been below the average increase in life expectancy. In contrast, mortality decline among individuals aged 50 years and above exceeded the average contribution and emerged as the dominant driver of longevity gains. This finding reflects the progression of demographic and epidemiological transition in India, whereby further improvement in life expectancy will increasingly depend upon survival in old ages rather than reductions in mortality in young ages.

Overall, the study underscores the growing importance of mortality in old age in shaping both life expectancy differentials and longevity improvement in India. While remarkable progress has been achieved in reducing mortality during childhood and adulthood, future gains in life expectancy and reduction in population disparities will depend increasingly upon effective strategies to improve health and survival of the old population. Strengthening geriatric healthcare services, expanding access to chronic disease prevention and management, and promoting healthy ageing should therefore constitute key priorities for public health policy in India.

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