PATTERN OF MORTALITY CHANGES IN KERALA: ARE THEY MOVING TO THE ADVANCED STAGE?

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Abstract

During the last century, Kerala has experienced a drastic decline in mortality level and high advancement in life expectancy even with less per capita income and low nutritional status. This achievement in health indicators was even comparable with developed countries. However, most of the developed countries achieved an advanced stage of mortality reduction among adults and early old ages to the advanced ages in the recent decades namely 'delayed degenerative stage of epidemiological transition'. This paper examines the possibility of this advanced stage of mortality reduction in Kerala by using the methodology given by Olshansky and Ault (1986) mainly from census and SRS data in a historical perspective. It was found that overall mortality drastically declined in the state in the recent decades. Younger ages have contributed the maximum for this reduction. Therefore, further mortality reduction is possible in adult and early old ages. However, the contribution of these ages to life expectancy was lower than that of youngsters until 1991-2000. It became highest in the recent decade, which indicates the beginning of the decline in the advanced stage of mortality in the state. These changes are lower in males than females because of the lower reduction in adult mortality. The paper concludes that the though healthcare policies in Kerala are sufficient to address the health issues of infants, children and mothers in the reproductive ages, the state also should make necessary policy initiatives to address the health problems of adults especially the males.

During the last century, Kerala witnessed a remarkable decline in mortality and considerable advancement in life expectancy. This change was often compared to the pattern observed in developed countries (Franke and Chasin, 2000; Parameswaran, 2000). Interestingly, Kerala has achieved low mortality despite low per capita income and higher incidence of malnourishment (CDS, 1975; Panikar and Soman, 1984). It remains as a paradox to the development theorists. The changes in Kerala were highlighted as unique and referred to as the 'Kerala Model' of development (CDS 1975; Sen 1997; Parayil, 2000). There are also conflicting arguments on the rapid decline in mortality and the reasons for such decline. On the one hand, it is argued that state intervention since 1956 has played a major role in achieving reduction in mortality. According to them, the increase in life expectancy was a result of superior medical care through primary health institutions[1] and other measures such as provision of clean water, sanitary facilities and an efficient public distribution system since the formation of the state in 1956 (Panikar and Soman, 1984; Panikar, 1999). Contrary to this, some scholars argued that the beginning of the massive reduction in mortality in Kerala could be traced to the era before the formation of the state[2] . They argued that social and cultural improvement especially through education, climate

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[1] It includes primary healthcare services such as vaccination, direct medical care for infectious diseases and perinatal, maternal and child care besides raising general awareness about health.

[2] Kerala was formed on 1 November 1956 by merging two princely states, Travancore and Cochin with Malabar (a part of erstwhile Madras presidency) on the basis of vernacular language.

conditions, the scattered pattern of settlements and the mysterious disappearance of major cause of deaths like plague were the prime factors for mortality reduction (Bhat and Rajan, 1990; Panikar, 1999; James, 2001). However, there was no detailed historical assessment of mortality reduction and increase in life expectancy in Kerala to bring in greater clarity to this debate. Moreover, the recent changes in mortality pattern were not analysed carefully.

A comprehensive assessment of mortality trends necessitates an investigation into the expected pattern of change based on the experience in developed countries. The mortality reduction is closely linked to the shifts in diseases pattern. In the first stage of mortality-reduction, the shift occurs in the cause of death pattern from infectious to chronic-degenerative diseases (Omran 1971). This leads to a distribution of death from younger to older ages (ages more than 50). However, the transition moves later from older ages to oldest ages known as the age of delayed degenerative diseases (Olshansky and Ault 1986). At this stage, there is further postponement of death in older to the oldest age groups (ages more than 80) as a result of bringing down deaths from degenerative diseases in adult ages to older ages (Olshansky and Ault 1986; Rogers and Hackenberg 1987; Frenk et al, 1990). Although it is well known that Kerala has moved from younger age mortality to older ages, the extent of transition to oldest ages (delayed degenerative disease pattern) remains unknown.

Considering the above, this paper examines the pattern of mortality changes in Kerala since the beginning of the last century. It aims to capture the dynamics of mortality reduction over the decades to explore the levels and trends in the transition process. Further, it investigates how far Kerala has moved from older age mortality to oldest age mortality as experienced in the developed countries. Specifically, the analysis attempts to establish which time-periods provided the largest gain to life expectancy and who (by age group and sex) were the beneficiaries of mortality reduction and by how much?

Data and Methodology

A major difficulty of measuring mortality transition in Kerala emerges from the unavailability of a single reliable data set in the last century. The only reliable data prior to the 1960s are the decennial census in India (Namboodiri, 1968; Bhattacharjee and Shastri, 1976; Nag, 1983, Bhat and Rajan, 1990; James, 2001). However, the inception of the Sample Registration System (SRS) in Kerala provided an alternative and more reliable data on mortality after the mid-1960s. Therefore, the study mainly uses these two data sets for the purpose of estimation., i.e., the first main set of data is from Monograph No: 7, Census of India 1961 (1931-40 to 1951-60) (Namboodiri, 1968) and rest of the data (1971-80 to 2001-08) are from the Sample Registration System (SRS). However, there was no readily available data for 1961-70 periods. Therefore, the study uses figures from the Western Model of Life Tables by Coale, Demeny and Vaughan (1983) for the decade 1961-70 as proxy considering the life expectancy of Kerala as estimated by Bhat (1987).

It is understandable that the data used for the study is limited by its quality. The census data which are used to analyse the patterns of mortality are constrained by the inaccuracy in the mortality estimations due to two factors. Firstly, to make reliable estimates of mortality from census data, a supplementary data on infant and child mortality is essential which is not always readily available.

Secondly, the census data often suffer from bias due to rampant misreporting of age by the respondents (Bhat and Rajan, 1990). Similarly, the proxy mortality rates taken from Western Model of Life Table' may have slight variations between different age intervals. At the same time, the quality of mortality data from SRS may also be restricted by its own sample size.

The paper follows the methodology forwarded by Olshansky and Ault (1986) considering the possibility of mortality reduction from adult and early old ages to oldest ages. It makes an overview on changes in death rates as well as life expectancy during the last century in Kerala in the first section. It also compares the change in absolute value of mortality level by the increase or decrease in life expectancy between different periods. However, a major lacunae of life expectancy indicator is that it measures the mortality level for an open age interval x and above. Therefore, it is often limited to the problems of data reliability at older ages and the restriction of limits of human life span (Arriaga 1984). To avoid these problems the paper analyses the relative risk of mortality transition for closed age interval (x, x+n) by using Temporary Life Expectancy (TLE) and index of Annual Relative Change (ARC) of TLE in the second section. Finally, the paper analyses changes in relative importance of death at older ages in Kerala by estimating the rate of survival to older ages, median age of death, survival curves and the exact contribution of each group (by age and sex) towards life expectancy at different time intervals.

For the purpose of the analysis, the study classifies the male and female population into three major groups as youngsters (ages 0-15), adults (ages 15-60) and old (more than 60s). However, the adults and old population are again sub-divided into young adults (ages 15-40), old adults (ages 40-60), older (ages 60-80) and oldest (ages 80+) for cross examination while considering the vulnerability of diseases (Feachem *et.al*, 1992; Murray et.al, 1992). Similarly, the historical periods are also divided into different decadal intervals.

An Overview of Changes in Death Rates and Life Expectancy in Kerala

Trends in Pattern of Mortality

The Crude Death Rate (CDR), death rates of infant and children are often used to examine the pattern of mortality change. The available information shows that the decline in CDR in Kerala began even before the 20th Century though it showed a drastic downward trend thereafter (Bhattacharjee and Shastri, 1976; Nag, 1983; Bhat and Rajan, 1990, James, 2001). However, a surge in mortality was also noticed mainly in three quinquennial periods: 1916-20, 1931-35 and 1941-45. The abnormal deaths during 1916-20 were attributed to the First World War and the attack of influenza in the country. However, the high death rates in 1931-35 and 1941-46 were considered a result of the Economic Depression and the Second World War respectively (James, 2001). However, there is no doubt that mortality in Kerala substantially declined, especially after 1930 (Namboodiri, 1961).

However, there was a possible regional disparity in death rates within Kerala as evident from the different levels of population growth across the regions in the earlier decades of the last century (UN, 1975, Panikar and Soman, 1984). The population growth was very high in Travancore and Cochin in the first four decades of the 20th Century and was higher than the Indian average. Nevertheless,

growth of population was lower in Malabar areas like in Madras Presidency (Panikar and Soman, 1984). Similarly, caste-wise difference in mortality reduction was also noticed during the period prior to 1950. It was found, from an indirect estimation from Parish data and Census records that the Syrian Catholics (A faction among Kerala Christians) benefited more in a decline in mortality (James, 2001) compared to other sections of the population.

The table 1 shows a substantial decline in mortality rates in Kerala over different decades of the last century. It indicates a drastic reduction of CDR in Kerala even before the formation of the state. Moreover, the rate of decline was very high during those periods. It declined from 38.7 at 1911-20 to 16.9 at 1951-60 and again to 6.4 at 2001-08. A similar pattern of mortality decline was also recorded in other studies (WHO, 1974; Bhattacharjee and Shastri, 1976; Nag, 1983).

Table 1 Crude Death Rates in Kerala during 1911-20 to 2001-05

Period	CDR#	Decennial Difference*	Sex-Ratio^
1911-20	38.7	_	1008
1921-30	33.8	4.9	1001
1931-40	29.1	4.7	1022
1941-50	22.3	6.8	1027
1951-60	16.9	5.4	1028
1961-70	9.2	7.7	1022
1971-80	7.9	1.3	1016
1981-90	6.6	1.3	1032
1991-00	6.2	0.4	1058
2001-05	6.4	-0.2	1055

Source : #'Fact Book on Population and Planning', Demographic Research Centre, Trivandrum (applicable for 1911-20 to 1961-70),
: #Rest of the figures are average for the period based on various SRS reports
: ^Census of India 1991, Series Paper 1 (applicable for 1921-30 to 1981-90) and Census India 2001 (applicable for 1991-00 to 2001-05)
: * indicates the difference between corresponding decade and its preceding decade

A comparison of absolute changes in decennial CDR shows that high differences in mortality change happened in the earlier decades of the last century in Kerala. Moreover, the difference persisted in the subsequent decades indicating that the reduction in CDR was a continuous phenomenon in Kerala in those periods. The rate of reduction in CDR recorded a maximum of 7.7 from 1951-60 to 1961-70 (i.e., after the formation of the state) followed by 6.8 from 1931-40 to 1941-50 (i.e., before the formation of the state). Similar results were noted by Bhattacharjee and Shastri (1976) and Bhat (1987). However, the period after 1961-70 witnessed a much smaller decennial change in CDR. Moreover, the rate of CDR was also low in both rural and urban areas where no significant difference was visible (SRS, 2009). However, the low rate of reduction in CDR could be due to the fact that Kerala has already achieved a near-maximum reduction in mortality considering its age structure.

A major lacuna of CDR is that it does not provide sex difference in mortality levels. However, the significant increase in sex ratio (from 1008 at 1911-20 to 1055 at 2001-05) denotes comparatively better survival of females in Kerala throughout the decades, which is also given in Table 1[3]. In other words, the CDR for females has declined in more points than for males in the last century. However, the rate of change in sex ratio was different across the decades. The decades of 1921-30, 1961-70 and 1971-80 indicate low rates than their preceding decades. Nevertheless, the overall picture indicates a high rate of decline in CDR among females.

The dimension of Age Specific Death Rate (ASDR) is another important factor of CDR in Kerala. India and Kerala had about the same level of mortality and life expectancy during 1931-41, after which Kerala did remarkably well in improving the latter (Kurup, Nair and Pillai, 1974). However, it can be shown that the difference between India and Kerala is smaller in the case of life expectancy at the age of 5 years than at the age at birth (Bhat, 1987). This indicates that the achievement of Kerala in mortality reduction was mainly due to the decline of deaths of infants and children than from the ages until 1981-85 (Bhat, 1987).

To sum up, CDR in Kerala declined drastically over the decades in the last century. However, the rate of decline was relatively higher between the decades from 1951 to 1970 than the other decades. A significant decline in death of infants and children contributed to this drastic change. Moreover, a remarkable advantage for females than the males in the mortality decline is visible during these decades. However, it should be noted that CDR is calculated from the weighted mean of ASDR in an actual population, using population's age composition for weights (Namboodiri, 1996; Xinming, 1999). Therefore, CDR estimates are very much affected by the age structure of a population. Therefore, this inadequacy of estimation calls for a cross examination with highly purified indicators from the life table functions, which is our focus in the next section.

Magnitude of Absolute Change in Life Expectancy

An impressive level of life expectancy has been achieved in Kerala since 1911-20. The life expectancy at birth of males rose to 70.7 years in 2001-05 from 25.5 years in 1911-20 and similarly female life expectancy increased to 77.1 years from 27.4 years. This improvement gave an advantage of 45.2 years for males and 49.7 years for females within 88 years of time– an average annual increase of about 0.51 (male) and 0.56 (female) years (table 4). However, the average annual increase within each decade reflects disparities among the decades; i.e., the pace of increase in life expectancy was not constant but varied from decade to decade as shown in the table. Except in 1951-80 for both sex groups and 1921-40 for males and 1971-90 for females, the annual contribution of absolute years to life expectancy was below than the overall average showing a low pace in those decades.

[3] Since sex ratio was used to set up a background for the analysis, small effect from net-migration may not severely affect the key findings.

Table 4 Levels and changes of life expectancies at birth in Kerala during 1911-20 to 2001-08

Period		Absolute increase		Annual average years added	
From	To	Male	Female	Male	Female
1911-20	2001-08	45.25	49.71	0.51	0.56
1911-20	1921-30	4.05	5.29	0.41	0.53
1921-30	1931-40	5.49	5.22	0.55	0.52
1931-40	1941-50	4.58	5.06	0.46	0.51
1941-50	1951-60	4.63	5.17	0.46	0.52
1951-60	1961-70	9.90	9.41	0.99	0.94
1961-70	1971-80	7.83	7.10	0.78	0.71
1971-80	1981-90	4.53	7.64	0.45	0.76
1981-90	1991-00	2.68	2.76	0.27	0.28
1991-00	2001-08	1.56	2.07	0.19	0.26

Source: Calculated from Namboodiri, 1968; Coale, Demeny and Vaughan, 1983; Bhat, 1987; SRS various years

However, the two decades of 1951-60 and 1961-70 recorded a high pace in absolute changes of life expectancy. Perhaps, the actual value of the increment will be more in terms of relative changes considering restriction due to the limits of human life span (Arriaga 1984). We undertook this analysis of life expectancy in order to compensate for the data-problem in calculating the CDR. The CDR had registered a significant reduction in mortality after the state formation indicating an increase in life expectancy. Our analysis of life expectancy is consistent with the results of the analysis of CDR.

Another feature of change in life expectancy is the magnitude of changes at selected ages as can be seen in table 5. The early decades registered a high absolute change in life expectancy at younger ages. Nevertheless, a slowdown in gains in life expectancy in younger ages and comparatively high gains in life expectancy in the advanced ages is visible in the recent decades. For instance, the absolute change in lfe expectancy for females at birth during 1911-20 to 1941-50 was 15.6 years (56.9%) while it was 4.1 years (48.8%) at age at 60. But in the recent decades (1971-80 to 2001-08) the absolute changes in life expectancy at birth was by 12.4 years (19.2%), 4.9 year (30.6%) at age at 60 and 2.6 years (49.1%) at age at 80 in Kerala. This indicates a major shift in the relative gain at different ages towards increase in the life expectancy. There is an obvious reversal of gains in life expectancy at the younger ages has given way to a drastic increase in the life expectancy at the advanced ages. Nevertheless, this change at advanced ages was relatively lower among males than females. Between 1971-80 and 2001-08, their life expectancy increased 8.7 years at birth (14.0%), 2.4 years (16.0%) at age 60 and 1.6 years only (30.2%) at age 80 indicating delay in mortality transition among them.

Table 5 Life expectancy at different age levels in Kerala during 1931-40 to 2001-08, by sex

	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-80	1981-90	1991-00	2001-08
Male										
0	25.5	29.5	35.0	39.6	44.2	54.1	62.0	66.5	69.2	70.7
15	29.6	33.8	35.5	38.5	41.5	49.0	53.2	55.0	55.9	57.0
40	15.1	17.0	18.4	20.6	22.7	28.6	30.4	32.0	32.7	33.7
60	6.9	8.6	9.7	10.6	11.5	14.4	15.0	16.6	16.7	17.4
80	-	-	3.8	4.0	4.3	5.1	5.3	6.6	6.9	6.9
Female										
0	27.4	32.7	37.9	43.0	48.1	57.6	64.7	72.3	75.1	77.1
15	28.9	33.7	36.8	40.3	43.6	51.6	56.3	60.6	61.6	63.4
40	16.6	17.8	22.4	24.3	26.3	31.2	33.3	37.0	37.8	39.4
60	8.4	9.0	11.5	12.5	13.4	16.0	16.3	19.2	19.9	21.2
80	-	-	4.2	4.5	4.8	5.6	5.3	6.9	7.3	7.9

Source: Calculated from Namboodiri, 1968;, Coale, Demeny and Vaughan, 1983; Bhat 1987, SRS various years

The sex difference in life expectancy at birth is also a feature of life expectancy changes in Kerala. It shows a narrow level of discrepancy during the early decades that widened towards the more recent decades. For instance, in 1911-20 the sex difference was only 1.9 years and rose to 6.4 years at 2001-08 periods. It is important to note that this sex difference in life expectancy remained at a higher level since 1981-90. This is very different from the US experience where the sex difference in life expectancy was projected to end in the fourth stage of epidemiological transition (Olshansky and Ault, 1986). In short, the analysis of absolute change in life expectancy shows that the life expectancy in Kerala has improved over the decades in absolute terms. Moreover, females are ahead in gaining greater mortality decline and improvement in life expectancy. This is consistent with the results of earlier CDR analysis.

The influence of age structure of a society on the CDR makes it difficult to compare two different regions where there are different age structures or even to compare the mortality rates of a region at different age structure at different periods (see CDR estimation). On the other hand, absolute life expectancy estimates, which can be used as a substitute, suffer from problems of relative magnitudes. In other words, the possible change in life expectancy indicators depends upon the level of already achieved life expectancy (Arriaga, 1984). Moreover, the life expectancy estimation is constrained by technical problems of unreliability of data especially about the older ages (generally more than 65 years) in developing countries (Arriaga, 1984). Besides, there is a possibility of a counteracting effect, which neutralizes the contribution of different age groups where a high mortality increase experienced by one group is offset by a reduction in the other group (Dutton, 1979). This points to a certain level of arbitrariness in results (with respect to mortality changes) in both CDR and absolute life-expectancy indicators. These lacunae in estimation call for an alternative measure to capture the changes in mortality considering its relative risks at different age structure, life expectancy levels and the quality of data at different ages. Therefore, we use Temporary Life Expectancies (TLE) and index of annual relative change of TLE for our further analysis.

Transition in Relative Risk of Mortality by Age and Sex

Temporary Life Expectancies (TLE)

Table 6 shows temporary life expectancy at select exact age intervals by sex for Kerala between 1931-40 and 2001-08. The temporary life expectancy ($_ie_x$) from age x to (x + i) can be interpreted as the average number of years that a 'group of persons' alive at exact age x will live from age x to (x+ i) years (Arriaga, 1984).

$$\text{i.e.} \qquad {}_ie_x = \left(\frac{T_x - T_{x+i}}{l_x} \right)$$

where, $_ie_x$ represents the Temporary Life Expectancy (TLE) from age x and x + n. T_x and T_{x+i} is the number of person-years lived at age l_x and older, $x+i$ and older respectively. l_x is the number of survivors at age x in a life table (as radix) of 100,000.

Table 6 Observed Temporary Life Expectancies at Selected Exact Age Intervals by Sex (1931-40 to 2001-08)

	1931-40	1941-50	1951-60	1961-70	1971-80	1981-90	1991-00	2001-08
Male								
0 - 80	34.96	39.49	44.01	53.40	60.95	64.76	67.24	68.56
0 - 15	10.85	11.48	12.06	12.94	13.79	14.34	14.69	14.77
15 -40	22.12	22.61	23.04	23.71	24.46	24.53	24.60	24.62
40 - 60	14.32	15.29	16.11	17.88	18.45	18.54	18.77	18.89
60 - 80	9.33	10.11	10.88	13.03	13.48	14.23	14.20	14.70
Female								
0 - 80	37.75	42.69	47.68	56.41	63.30	69.49	71.82	73.13
0 - 15	11.43	12.04	12.62	13.20	13.77	14.42	14.73	14.78
15 -40	21.58	22.21	22.76	23.81	24.52	24.68	24.74	24.78
40 - 60	15.88	16.47	17.11	18.34	19.06	19.38	19.44	19.57
60 - 80	10.87	11.66	12.39	14.13	14.49	15.94	16.22	16.74

Source: Calculated from Namboodiri, 1968; Coale, Demeny and Vaughan, 1983; Bhat, 1987; SRS various years

Table 6 records a substantial increase in TLE over the decades in Kerala. However, the nature and pace of this change are different across the age intervals as well as decade intervals. It can be observed that the TLE between birth and age 80 increased to 68.56 years and 73.13 years at 2001-08 periods for both males and females respectively. It means that the male babies born in Kerala during 2001-08 periods can expected to live 68.56 years and female babies can expected to live 73.13 years, provided the mortality rates in the period when they are born persists throughout their lives. Nevertheless, though the expected lifespan in Kerala has almost doubled during this period, it still leaves room of 11.44 years and 6.87 years, for both male and female groups respectively, for further improvement.

The change in TLE was also different among various age groups. It shows that younger ages benefited more from the TLE changes than the older ages over the decades. It should be noted that the subgroups (0-15, 15-40, 40-60) had already attained almost maximum TLE (difference was below 0.5 years) before 1971-80, except for males in the age group of 40 to 60. On the other hand, though the older ages (60-80) achieved improvement in TLE, there is still ample room for improvement. It also indicates that the possibility of further mortality reduction is concentrated on the older age groups (40-60, 60-80). Moreover, it should be noted that the changes in TLE showed a severe stagnation for males especially in these age groups in the last four decades in Kerala.

Though the data shows an improvement in TLE in almost all age groups over the decades, the changes were similar for both sexes across different age groups. Difference between the TLE at birth to age 80 can be taken as an instance where it shows a difference of 4.57 years in 2001-08. It also shows that there is miniscule sex difference in younger ages (0-15, 15-40) and high disparities in older ages (40-60 and 60-80). It denotes that the overall difference in TLE between the ages 0-80 years would be due to the disparities between male and female in the older ages. It is also worth mentioning that the reduction in difference in TLE in younger groups could be a result of effective control over the causes of death at younger ages. Perhaps, this has not have happened in the case of the older ages. A comparatively lower TLE for males than females (female almost near the maximum) in the age group 40-60 and 60-80 years means that the mortality shift was unequal and more males than females lagged in those age groups.

Index of Annual Relative Changes in TLE

The index of Annual Relative Change (ARC) in TLE during 1931-40 to 2001-08 in Kerala is recorded in Table 7. It represents the percentage change in two mortality measures in their observed reduction in deaths in relation to the total possible reduction (Arriaga, 1984). In other words, it shows the change in number of years lived between two periods considering the maximum possibility of reduction in that age group.

The ARC can be calculated as: ${}_iARC_x^n = [1-(1-{}_iRC_x^n)^{\frac{1}{n}}]\cdot 100$, where, ${}_iARC_x^n$ represents Index of Annual Relative Change in TLE; n is the number of years and ${}_iRC_x^n$ is the observed change in TLE in relation to the maximum possible change.

where ${}_iRC_x^n$ can be calculated as, ${}_iRC_x^n = \frac{{}_ie_x^{t+n} - {}_ie_x^t}{i - {}_ie_x^t}$, where, ${}_ie_x^{t+n} - {}_ie_x^t$ is the absolute change of TLE of years of life between two particular ages; and i is the maximum possible TLE between the age intervals.

Table 7: Annual Relative Change Index of TLE at Selected Age Intervals by Sex in between Different Decades (1931-40 to 2001-08)

	1931-40 | 1941-50	1941-50 | 1951 - 60	1951- 60 | 1961-70	1961-70 | 1971-80	1971-80 | 1981-90	1981-90 | 1991-00	1991-00 | 2001-08
Male							
0 - 80	1.05	1.18	2.98	3.28	2.21	1.76	1.36
0 - 15	1.62	1.78	3.52	5.14	5.89	7.30	3.68
15 -40	1.86	1.96	4.10	8.38	1.33	1.60	0.73
40 - 60	1.86	1.90	5.88	3.09	0.57	1.71	1.31
60 - 80	0.76	0.81	2.65	0.66	1.22	-0.06	1.12
Female							
0 - 80	1.24	1.43	3.10	3.40	4.52	2.47	2.16
0 - 15	1.86	2.17	2.73	3.71	7.25	7.52	2.42
15 -40	1.99	2.18	6.14	8.77	3.94	2.01	2.24
40 - 60	1.52	1.99	5.40	5.53	4.12	0.88	3.46
60 - 80	0.89	0.92	2.56	0.64	3.01	0.70	1.83

Source: Calculated from Namboodiri, 1968; Coale, Demeny and Vaughan, 1983; Bhat, 1987; SRS various years

The figures in table 7 indicate high variations in the pace of improvements in TLE across sex and time-period. By and large it can be said that significant changes happened between 1951-60 and 1981-90. It may be recalled that our analyses of CDR and absolute changes in life expectancy have pointed to a similar effect for the period after state formation. Almost all the ages and sex subgroups were at their best performance in terms of TLE in that period. It could be due to the provision of better healthcare measures that responded to the causes of death at different periods in Kerala.

However, the performance of annual relative changes in TLE indices is negligible towards the recent decades. This rapid decline in pace especially in younger ages may be due to the fact that the TLE of younger ages have rapidly approached the size of age interval and the limits of further decline. However, it is also seen in table 7 that the annual relative change in TLE at advanced ages for both sexes (40-60 and 60-80) was comparatively lower than that of the early age groups after 1971-80 in most cases. This is interesting because we expected more changes in the older age groups considering the possibility of the advanced mortality reduction indicating a shift of mortality from older to the oldest ages.

Sex difference in pace of improvement in TLE is another issue of concern. It was recorded that in all the periods except 1951-60 to 1971-80 at 0-15 and 60-80 age groups, and 1981-90 to 1991-00 at 40-60 age groups, 1991-00 to 2001-08 at 0-15 age groups the pace of change was higher for females than males. Moreover, though the difference in the pace was low in the 1931-40 to 1941-50, thereafter it stabilized at a higher level till 1981-90. Later, it dropped further for almost all age groups, then again picked-up in 2001-08 periods. This phenomenon was more intensive in younger ages than the older ages. Nevertheless, the low performance of pace indices of TLE among older age groups, especially with regard to males than females, may be an indication of a lag in moving towards the advanced mortality reduction in Kerala.

To sum up, the analysis of changes in the relative risk in mortality reflects an impressive change in TLE in Kerala during the last century. It was noted that younger ages contributed almost their maximum capacity to TLE by the reduction in mortality. However, the contribution was low from the older age groups which differed from our expectation. Moreover, there were high disparities prevailing between males and females in TLE especially in the older ages. This could be due to a low rate of increase in male TLE during those periods. Similar finding is also visible from the annual index of TLE. Notably, there was low rate of change in the indices of TLE after 1981-90 in most cases in advanced age groups.

Changes in Relative Importance of Mortality at Older Ages

The epidemiological transition theory put forward by Olshansky and Ault (1986) emphasized the importance of mortality changes in the older ages. In order to analyze the importance of mortality at older ages, this section attempts to discuss the changes in survival curves, and median age of death and proportion of survival to older ages. Further, we analyze the contribution of each age group towards increments in the life expectancy to identify the recent dynamics of mortality change and thereby to understand the possibility of advanced stages of epidemiological transition.

Survival Curves

The changing relative importance of mortality in older ages can be recognized from survival curves. Theoretically, survival probability curve has three major dimensions: vertical increment[4], mortality expansion[5] and mortality compression[6]. Vertical increase in survival curves replicate corresponding decline in the probability of death in those age groups that push the mortality rates to advanced ages (called expansion of mortality). The expansion will be stopped hypothetically by biological constraints of human life and the maximum expansion from younger and adult ages will lead to phenomenal concentration of death near the biological maximum age limits (mortality compression) (Olshansky and Ault, 1986; Olshansky and Cairn, 1990). Therefore, comprehensive analytical observation of survival curves can give information about changes in mortality especially towards the older ages.

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[4] indicates the reduction in ASDR of particular age groups and a corresponding upward shift in the survival curves. See Olshansky and Ault 1986; Olshansky and Cairns ,1990

[5] Mortality expansion means the postponement of possible death towards the older ages by expanding the life span. It shows reflects in a rightward expansion (towards old ages) of survival curves in graphical presentation. See Olshansky and Ault 1986; Olshansky and Cairns, 1990.

[6] Mortality compression is a hypothetical concept mentioning the possibility of concentration of death only in the maximum biological age limits. In a graphical appearance, it gives rectangular shape to survival curves, see Fries, 1980; Olshansky and Cairn, 1990.

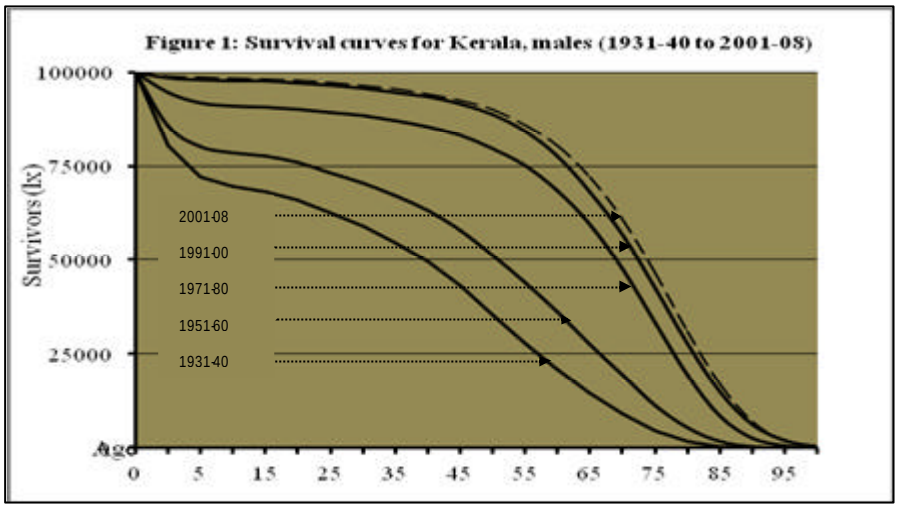
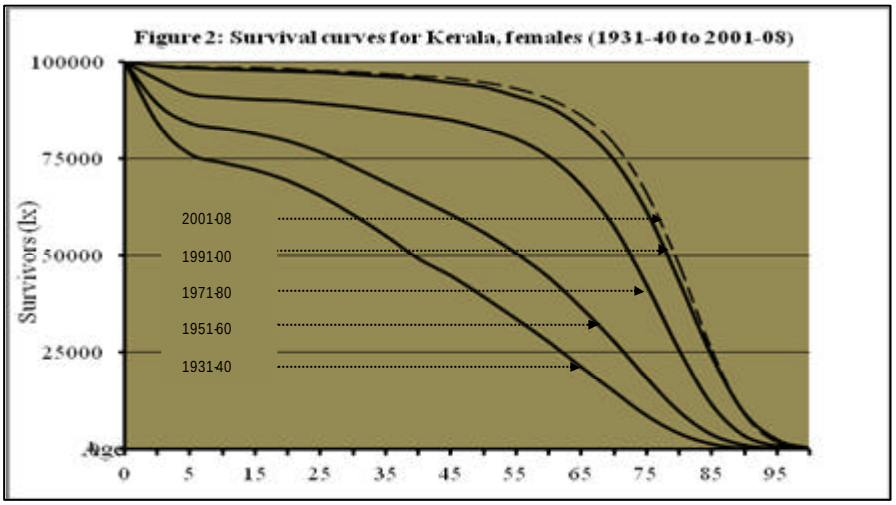


Figure 1 and Figure 2 reflect the survival pattern of people in Kerala during the last century. It is shown that there was a significant increase in survival rates especially from the younger age groups indicating high reduction of mortality in the early ages. Note that, infant and child mortality declined rapidly in the earlier decades which is shown in a vertical increment in survival curves for both sex groups. This also led to a corresponding increase in the number of survivors into middle and old ages. It is visible from the slow drop-off of the survival curves. However, in the recent decades there have been more survivors in the older age groups than that of others. In other words, the death reduction was higher in older generations by postponing more deaths to biological limits of human life span (mortality expansion). This is visible from a greater rightward shift of survival curves in older ages.



It is possible to compare the nature of the shift in the survival curves since we have taken equal interval (2 decades) between the periods. The curves indicate that there was a major shift from 1951-60 to 1971-80 for both sex groups possibly due to better healthcare measures. However, the shift in the survival curves after this period in general was small and different for male and female. It is seen in smaller vertical shift for males than females in the older ages. Even among males, this vertical shift of

the survival curves in older ages was smaller than that of the other age groups. This means that old males have a higher risk of death compared to old females and younger males.

It is shown that females achieved almost maximum number of survivors than the males during the decades. A steeper shape for female curves than the male survival curves denotes this difference. Nevertheless, the point of inflexion is not at the biological maximum level even in females. In other words, there is no perfect rectangular shape to survival curves[7] in Kerala. It may indicate that mortality compression has not yet started in the state.

Median Age at Death and Proportion Survival to Older Ages

Over the decades, it is observed that the proportion of survival of population from birth to the oldest ages has increased in Kerala. Table 8 records sex-wise distribution of the proportion of survival to ages 60 and 80, and median age at death in the state during the last century. It can be observed in Table 8 that the median age of death is being pushed towards older ages in Kerala. Notably, the median age of death was 20.82 for males and 26.03 for females in the early decades of the century but rose to 73.85 and 80.03 for males and females respectively in the recent decades.

Table 8: Median Age at Death and Proportion of Survival to Age at 60 and 80, by Sex in Kerala During 1911-20 to 2001-08

	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-80	1981-90	1991-00	2001-08
Median age at death										
Male	20.82	30.67	39.55	45.46	50.92	63.23	68.96	71.29	72.30	73.85
Female	26.03	35.14	39.19	47.47	55.31	67.32	72.40	77.21	78.38	80.03
Proportion surviving to age 60										
Male	9.67	15.08	20.86	28.27	36.13	55.46	68.46	73.27	77.66	80.39
Female	11.75	17.77	27.60	35.73	44.16	61.59	75.53	84.85	88.27	90.42
Proportion surviving to age 80										
Male	0.22	0.97	1.80	3.21	5.25	14.44	19.26	26.27	28.02	31.56
Female	0.73	1.36	3.95	6.41	9.65	20.44	25.49	40.75	44.61	50.26

Source: Calculated from Namboodiri, 1968; Coale, Demeny and Vaughan, 1983; Bhat, 1998; SRS various years

Similarly, the proportion of survival to the age of 60 and 80 from birth has also increased considerably over the decades in the last century. The table 8 shows that the proportion of survivors into the age of 60 was 9.67 for males and 11.75 for females in 1911-20 and increased to 80.39 and 90.42 in 2001-08 – approximately 8 times higher for both sexes. A similar increase is also seen in the proportion of people who survived to the age of 80 (oldest ages). It may be noted that the survival to oldest ages from birth cohorts in 1911-20 was less than one percent but it increased to more than 30 percent in 2001-08 for both sex groups. The proportion of population who live for more than 60 years has dramatically increased over the century thereby pushing mortality to the older ages, in the recent decades.

[7] see Fries 1980

However, the pace of change in median age of death and the survival ratios vary across decades as well as by sex group. It can be observed that the rate of increase in both the median age of death and the survival ratio were relatively lower in the recent decades than in the early decades for both sex groups. It could be due to low contribution from older ages whereas the expectations from younger and adult ages are low because they are already close to maximum reduction. However, males have recorded relatively lower median age of death, lower survivorship to old ages and it's comparatively lower rate of growth compared to the females in Kerala.

Contribution from Each Age Group to Gains in Longevity

Measurement of contribution in gains in life expectancy is one other best indicator for the relative importance of advanced ages in Kerala. According to the theory of epidemiological transition[8], we expect a higher contribution of life expectancy from older ages when the life expectancy increases to its maximum. Therefore, it is important to assess the relative contribution of age groups at different periods in order to ascertain the pattern of mortality change. The percentage contribution of each age group in gain in life expectancy at different periods is shown in Table 9.

Table 9 Contribution of mortality change at selected ages to total change in life expectancy by sex in Kerala in between different decades, 1931-40 to 2001-08 (%)

	1931-40| 1941-50	1941-50| 1951-60	1951-60| 1961-70	1961-70| 1971-80	1971-80| 1981-90	1981-90| 1991-00	1991-00| 2001-08
Male							
LE+	4.58	4.63	9.90	7.83	4.53	2.68	1.56
0-15	54.7	53.0	41.5	54.6	63.8	69.6	28.3
15-40	21.5	21.1	20.9	28.0	6.4	9.1	7.0
40-60	19.6	20.2	27.2	13.1	5.1	18.9	29.6
60-80	4.1	5.6	10.0	3.9	19.1	-0.5	35.9
80+	0.1	0.2	0.4	0.3	5.6	3.0	-0.9
All	100	100	100	100	100	100	100
Female							
LE+	5.06	5.17	9.41	7.10	7.64	2.76	2.07
0-15	50.6	50.1	30.6	43.3	49.5	64.1	16.2
15-40	31.0	27.2	35.9	33.7	9.0	8.4	9.0
40-60	13.0	15.9	21.6	20.5	12.2	7.9	20.6
60-80	5.2	6.4	11.1	3.4	24.0	14.1	39.3
80+	0.2	0.4	0.8	-0.8	5.3	5.4	14.8
All	100	100	100	100	100	100	100

Source: Calculated from Namboodiri, 1968; Coale, Demeny and Vaughan, 1983; Bhat, 1987; SRS various years using the formulae given by Preston et.al, 2001

[8] See the fourth stage of epidemiological transition (delayed degenerative stage), Olshansky and Ault, 1986.

Kerala experienced high improvement in the decades of 1951-60 to 1971-80 as shown in the table[9]. The improvement peaked in during 1951-70 gaining more than 9.5 years of life expectancy. During this period, all age groups contributed significantly. However, the contribution of younger ages (0-15) was highest. It is visible that all periods, except for the recent one, the younger age group (0-15) is the most important contributor to life expectancy improvement. This group's contribution ranges from 28.3% to 69.6% for males and 16.2% to 64.1% for females. Nevertheless, their contribution was comparatively higher in 1981-90 to 1991-00 period but declined during 1991-2000 to 2001-08.

However, the contribution of the age group 15-40 varies from period to period. It is seen that the contribution was high (between 20.9% and 35.9%) until 1971-80 but significantly came down (between 6.0% and 9.1%) after this period for both the sex groups. The drastic change could be due to the fact that this age group has attained near to the maximum possible reduction during those decades. However, the age group of 40-60 years shows an increasing pattern in the contribution to life expectancy over the decades for both sex groups. Their relative contribution was below 20 percent at 1931-40 to 1941-50 but significantly increased during 1991-00 to 2001-08. On the other hand, the contribution from oldest ages (60-80) shot up to more than 35 percentages from a nominal share (below 5%) during the same period.

It must be noted that the data of 2001-08 presents a different picture. Though the values are small and the period does not represent a decade, the figures show a reversal from the previous trend. It indicates a high contribution of improvement in life expectancy from oldest ages than from the youngsters as a result of greater reduction in mortality from adult and older ages than the youngsters. Therefore, the emerging trends may indicate the beginning of fourth stage of mortality reduction in Kerala as it has happened in developed countries. Moreover, the new trend is more evident in females than in males, where the females are in advanced momentum of changes in life expectancy and where as males are slow in decline in mortality at their old adult and older ages.

Concluding Remarks

A major focus of the paper is to identify period during which the mortality transition significantly happened in Kerala. Our analysis found that, though Kerala has experienced a drastic decline in mortality and a resultant impressive growth in life expectancy throughout the last century, the major reduction was occurred between1951 and 1970. Decline in child and infant mortality rates has played an important role during the period for the drastic reduction in mortality. Perhaps, the higher reduction of mortality achieved through a reduction in infant and child mortality was the result of healthcare intervention by the State through effective primary healthcare program like building awareness, vaccination etc. This makes Kerala's experience close to the experience of other developing countries where the primary healthcare has been the dominant factor than the socio-economic improvements in the early stages of mortality reduction.

[9] The positive values indicate the percentage gains in life expectancy due to mortality decline. Similarly, the negative values indicate reduction in life expectancy due to increase in mortality. However, we have ignored the negative figures from the mainstream interpretation because they are very few, of small magnitude, and refers to the oldest ages where misreporting of age at death is relatively high.

The second aim of the analysis was to understand the changes in the mortality decline and improvement in life expectancy in different age and sex groups to figure out the possibility of mortality transition reaching to an advanced stage in the state. Our speculation was that the mortality reduction would be higher in older ages denoting the onset of advanced stages in the state. The analysis of temporary life expectancy reveals that the age groups below 60 (except males at 40-60) have already reached their limit of mortality reduction in contributing to life expectancy. Thus, the possibility of a further mortality decline that can contribute to an improvement in life expectancy is confined to older ages. However, the analysis of Index of annual relative change in TLE found that the pace of TLE in the older age groups (40-60 and 60-80) are relatively lower than the youngsters implying low mortality decline in the older ages.

The survival curves, median age at death and survival proportion to age 60 and 80 reflect the relative importance of reduction in old age mortality in further increasing the life expectancy in the state. However, the contribution of different age groups to life expectancy until 1991-00 shows that reduction in mortality from adults and older ages contributed less than 50 percent to increments in life expectancy. It indicates that the state did not enter into the advanced stage of mortality transition yet. Nevertheless, there is a recent overall tendency of increasing contribution from older ages to life expectancy. This could point to an emergence of this advanced stage particularly among females.

The slow reduction in the mortality rates among adults and elders may be associated with the ongoing epidemiological transition and mismatches in health policies in Kerala. In epidemiological perspective, the decline in overall mortality is related to changes in causes of deaths. Notably, the state is experiencing more deaths due to non-communicable diseases such as cardio-vascular diseases, neoplasm, accidents and injuries by shifting the dominance of deaths from infectious diseases and maternal and child deaths in the recent decades as a part of ongoing epidemiological transition. These causes affected the adults and elders to a large extent. The shift in the causes of death necessitates a different level of healthcare mechanism. In other words, the post-1971 epidemiological stage in Kerala requires promotive and curative intervention in addition to maintaining the existing primary healthcare facilities. In view of this, any delay in the onset of the advanced stage of mortality transition is caused by lower mortality decline of adults and elders and raises concerns over the efficiency of the existing healthcare system in tackling the additional challenges.

The emerging pattern of morbidity along with the mortality transition is another issue of concern in Kerala. On the one hand, data shows high morbidity with low mortality in the case of acute infectious diseases (DHS - Various Years). On the other hand, it suffers from the enhanced morbidity from the chronic/degenerative diseases mainly in the adult and old ages (NSSO – Various Rounds). In essence, the mortality transition in Kerala is accompanied by the expansion of morbidity. The mortality transition with higher morbidity rates in Kerala intensified the healthcare burden.

At this juncture, the experience of developed countries such as USA and Western European countries can shed some light. The basic feature of advanced mortality reduction in these countries was the reduction in morbidity mainly as a result of a combination of preventive and health-promotive measures. Moreover, supplementing their successful primary healthcare model with a supportive intervention by providing accessible healthcare facilities and financial support through health insurance

also contributed to their success. However, such focused strategies are not yet widely implemented in Kerala. Since Kerala already has a good network of primary healthcare services, the focus should shift to the health problems of adults and address concerns related to their morbidity and mortality. The current trends in disease pattern suggest that different strategies than the typical primary healthcare intervention followed are necessary for addressing the emerging changes in the disease pattern in the State.

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