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Original Research Article

Role of various causes of death in diverging life expectancy in Kerala, India

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ABSTRACT

Background: Life expectancy at birth is an indicator of mortality conditions and health conditions. Mortality happens due to many causes. The multiple-decrement life table is used widely in human actuarial literature and provides statistical expressions for mortality in which the cause elimination is used. Cause elimination life tables address the hypothetical question of what a cohort's mortality experience would be if a particular cause of death were eliminated. The goal of this study is to estimate the potential gain in life expectancy after complete elimination of certain causes of death in Kerala, India for the year 2018.
Methods: The data for the study was taken from annual vital statistic report, Kerala, 2018. Life table method was used for estimating the potential gain in life expectancy after eliminating certain causes of deaths.
Results: The elimination of deaths due to heart diseases, cancer, respiratory diseases, accidents and suicides resulted a gain of 7.18 years, 6.90 years, 8.04 years, 6.72 years and 7.09 years respectively. The results show that in 2018, for Kerala, the highest gain in life expectancy was due to elimination of respiratory diseases, followed by other causes of death. The present study shows that heart diseases and respiratory diseases are the causes which are more affected among Keralites.
Conclusions: Effective intervention needs to be implemented in Kerala so as to reduce the risk of the diseases, which would result in the increase of life expectancy at birth.

Keywords: Life expectancy, Mortality, Elimination, Kerala

INTRODUCTION

Mortality is one of the basic components of population change. Life expectancy is an indicator of mortality conditions and health conditions and is also one of the key indicators of human development. A country's life expectancy reflects its social and economic conditions and the quality of its public health and healthcare infrastructure among other factors. Life expectancy has been increasing substantially throughout the world over the last few decades. During the mid-2000s, women are having higher life expectancy compared to men across most countries worldwide, likely attributable to social and economic transformations that have benefited women more significantly than men.[1] The investigation into the factors contributing to human mortality is a widely recognized field of study encompassing medicine, public health, biostatistics, demography, and actuarial science.[2] The examination of mortality patterns holds significance as it allows us to pinpoint the primary causes of death and understand their implications for public health. Mortality happens due to many causes. The information on causes of

death plays an important role in the analysis of mortality. Cause eliminated life tables provide a clear measure of the public health significance of a particular cause of death. Generally, health status is measured in terms of mortality indicators like death rate, infant mortality rate and expectation of life at birth among other indicators. Mortality reduction is closely linked to the shifts in disease pattern. In the first stage of mortality reduction, the shift occurs in the cause of death pattern from infectious to chronic degenerative diseases.[3] This leads to a distribution of death from younger to older age groups. However, the transition later moves from the older age groups to the oldest age group, which is also known as the age of delayed degenerative diseases.[4]

Kerala, the southernmost state of India, has been the focus of international attention in socio-economic and demographic fields because of its achievements in the improvement of people's health and standard of living without a positive change in the economic sector. The crude death rate and infant mortality rate have gone down to a very great extent. Kerala is the state with highest life expectancy and also low mortality and high morbidity in India.

The life expectancy of Kerala is the highest in the recorded history. It is mainly because of the better public health services such as improved sanitation, healthy food, safe drinking water, health promotion efforts etc.[5] Mortality indicators show that health status of Kerala is far advanced and higher than the all-India average and is even comparable with developed countries. Though Kerala has attained better health care indicators, the people are facing the problem of high morbidity both from communicable and non- communicable diseases.

According to global burden of disease-2016, the contribution of most major non-communicable disease categories to the total disease burden has increased in all states in India since 1990. These include cardiovascular diseases, diabetes, chronic respiratory diseases, mental health and neurological disorders, musculoskeletal disorders, cancers, and chronic kidney disease. The contribution of injuries to the total disease burden has also increased in most states since 1990, with the leading ones being road injuries, suicides, and falls. Kerala has made significant changes in health transition in terms of the rate of mortality and pattern of morbidity. The state has also been going through an epidemiological transition as reflected in its morbidity profile. Kerala have entered into the fourth stage of the epidemiological transition.[6]

The elimination of a specific cause of death within a population leads to an increase in life expectancy. The potential gain in life expectancy refers to the difference between the new life expectancy resulting from the complete eradication of a particular cause and the current life expectancy of that population. The elimination of causes of death will provide an estimate of the life expectancy of that population if a certain disease were eliminated. The estimation of life expectancy gained by elimination of specific causes of death using mortality analysis will suggest the future increase in life expectancy and would be helpful for future proper health services programmes. Various health programs and policies use life expectancy as an indicator to understand the needs to be addressed.

The life expectancy of a population is based on the age specific mortality patterns exhibited by that population. There are some significant causes of deaths that dominate over the other causes of deaths in numbers. So, there are some major causes and minor causes of death. Now the significant causes of death shifted from poverty related deaths to communicable and non-communicable diseases generated deaths. The increase in life expectancy has many implications such as aging, pension schemes formulation, senior care etc. The health transition in our society has also supported for the improvement of life expectancy. In such a situation it is necessary to know which diseases are leading to more loss of people in our society.

Aim and objectives

The main aim of the present study was to estimate the potential gain in life expectancy after eliminating major causes of death in Kerala by constructing abridged life table for the year 2018.

METHODS

The study is based on the data on the significant causes of death among population of Kerala. The required data on causes of death and age specific cause of deaths were taken from the annual vital statistics report of Kerala in 2018 published by vital statistics division, department of economics and statistics, Thiruvananthapuram.[7] The registered deaths by causes in Kerala published in annual vital statistics report in the year 2018 have been utilised for the study purpose. From the report the main causes of deaths in Kerala, 2018 were grouped as heart diseases, cancer, respiratory diseases, accidents and suicides for the analysis.

Life table is an essential demographic technique and can be used for improving the quality of life of human beings. When a particular cause of death is completely eliminated from a population, the life expectancy of that population will increase. The difference between the new life expectancy of the people obtained by the complete elimination of a particular cause and the current life expectancy of the same population is termed as a potential gain in life expectancy. We study the effect of causes of death in bringing variation to life expectancy by constructing abridged life tables for Kerala in 2018 and Multiple decrement life tables and cause elimination techniques are used for each cause of death to get the gain in life expectancy at each age.[8] The analysis has done for both males and females separately since there exists sex differential in the age pattern of mortality.

Abridged life table

Life tables with combined age groups (no single years) are called abridged life tables. An abridged life table is adequate and useful for most of the situations confronted in demographic analysis. The steps in the construction of abridged life table are the following. While constructing an abridged life table there are 7 columns, they are as follows: Column 1, *x* to *x+n*: The period of life time between two exact ages, that is between *x* and *x+n*. Here n is the width of the age interval. Column 2, ${}_nq_x$: The probability that a person who is alive at the beginning of the indicated age interval that is at *x*, will die before reaching the end (*x+n)* of the age interval.

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

Here ${}_nm_x$ is the age specific death rate of the population under study. Column 3, l_x: The number alive at the beginning of the indicated age interval. While constructing a life table usually start with an arbitrary number of new born as 100000. This starting number is called the radix of the table. Column 4, ${}_nd_x$: The number of persons who die within the indicated age interval *x* to *x+n*.

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

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

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

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

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

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

$$ e^0_x = \frac{Tx}{lx} $$

The life expectancy obtained from the abridged life table is used to calculate the potential gain in life expectancy.

Construction of cause eliminated life table

Cause eliminated life table is an application of the multiple decrement life table technique. Multiple decrement life tables are the life table in which the cohort can be decreased by attrition from more than one cause of death. In multiple- decrement tables, that is, two or more types of attrition operating together. The steps for constructing the cause eliminated life table are given below.

Cause of death ratio

The first step to constructing cause eliminated life table is to find the cause of death ratio.The cause of death ratio for age group *(x, x+n)* is as follows.

$$ \text{Cause of death ratio } = \frac{D_{x,\alpha}}{{}_nD_{x+}} $$

Where ${}_nD_{x,\alpha}$ is the number of deaths due to a particular cause Cα in the age group (x, x+n) and ${}_nD_{x+}$ is the total number of deaths due to all causes in the age group (x, x+n).

Distribution of life table deaths by cause of death

Distribution of life table deaths by cause of death is obtained by multiplying the total number of deaths at age interval (x, x+n) in the life table with the corresponding death ratio. The equation is as follows.

$$ {}_nd_{x,\alpha} = \left(\frac{{}_nD_{x,\alpha}}{{}_nD_{x+}}\right) * {}_nd_x $$

Cause elimination

Cause eliminated probability of death indicates that the probability of a person alive at the beginning of an age interval (x, x+n) will die before reaching the end of that interval if the risk of dying of cause C_α were eliminated in some sense. The probability of cause eliminated death is calculated as follows,

$$ {}_nq_x = \frac{{}_nd_{x,\alpha}}{(l_x - \frac{1}{2}d_x^{T-x})} $$

Where ${}_nd_x^{T-x} = {}_nd_x - {}_nd_{x,\alpha,}$ ${}_nd_x$ is the total number of deaths in the age interval (x, x+n), ${}_nd_{x,\alpha}$ is the number of deaths due to cause C_α in the age interval (x, x+n).

Construction of cause eliminated life table

Cause eliminated life table is constructed using the above cause eliminated probability of death. All other steps of constructing cause eliminated life table are the same as constructing an abridged life table.

Gain in life expectancy

Gain in life expectancy is estimation of the number of life years to be gained by elimination of specific causes of death. Gain in life expectancy at birth is calculated by subtracting the life expectancy of the abridged life table from that in the corresponding multiple-decrement table with partial or complete elimination.

$$ GLE = e^0_x - e^0_{x,-\alpha} $$

RESULTS

Life expectancy in Kerala

The (Figure 1) shows the levels in the life expectancy in the state over the past 50 years. It shows that the life expectancy at birth of males rose from 60.8 to 73.1 years from 1970-75 to 2016-20 and the corresponding increase for females is from 63.0 to 78.7 years. This improvement gave an advantage for males compared to females. From 1981-85, the gap in the life expectancy of males and females is more than five years.

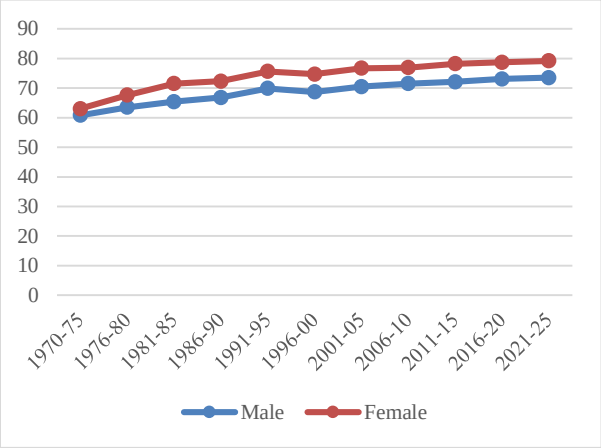

Figure 1: Life expectancy in Kerala.

The state's high life expectancy can be attributed to several factors such as high literacy rates, access to quality healthcare and a relatively low infant mortality rate. Additionally, the state has implemented several health initiatives over the years, including the establishment of a network of primary health centres, community health centres, and hospitals. However, it's important to note that life expectancy can vary depending on various factors such as socioeconomic status, lifestyle habits, and access to healthcare. So, while Kerala has a relatively high life expectancy, there may be variations within the state based on these factors.

Table 1: Life expectancy of Kerala by age and sex, 2018.

Age (years)	Life expectancy		
	Total	Male	Female
0	74.91	72.60	78.73
55	23.12	21.93	25.91
75	7.33	6.20	8.32

The (Table 1) depicts the life expectancy of Kerala in 2018. The number of years a new-born baby is expected to live, on average, in Kerala for the year 2018 is 74.9 years. The corresponding figures for males and females are 72.6 years and 78.7 years respectively. This means that females in Kerala live, on average, 6.1 years longer than males. Life expectancy at age 75 is 7.3 years and for males and females it is 6 years and 8 years respectively. There exists a sex differential in the age pattern of mortality. Kerala has a relatively low gender gap in life expectancy. Life expectancy is comparatively higher for females than males in all ages.

Probability of death for males and females in the year 2018 are given in (Table 2-3). Gender differentials in causes of mortality in Kerala have seen while there are some similarities in the leading causes of death for both men and women. Heart Attack/ Heart diseases is the most severity and seems to be the first cause of death among people not only in older age but also working age in both sexes. It is clear that heart disease is the cause which contributes more deaths throughout the ages. Among children below 5 years the incidence of cause of death is relatively less compared to other age groups, but yet the incidence of heart disease is the most prominent of all other causes. Respiratory disease is a cause of death which is more common among those who are above the age of 65 years in both sexes. In the case of deaths due to suicides and accidents males are at higher risk than females.

The life expectancy at birth in Kerala for the year 2018 is 74.9 years. Elimination of respiratory diseases made a gain of 8.04 years in life expectancy at birth. When heart diseases were eliminated from total deaths, it made a gain of 7.18 years. Elimination of deaths due to cancer resulted in a gain of 6.90 years. If the deaths due to accidents were completely eliminated, then the life expectancy at birth increases from 74.91 years to 81.64 years, which is a gain of 6.72 years. If the deaths due to accidents were completely eliminated, then life expectancy at birth increases from 74.91 years to 81.64 years, which is a gain of 6.72 years. For the 75+ population, the elimination of deaths due to respiratory disease will significantly increase their life expectancy. Nevertheless, the potential gain in life expectancy after eliminating deaths due to cancer at age 75 is only about 135 days. The complete elimination of death due to accidents would not impact the 75+ population, which resulted in a gain of about 15 days only. Also, the complete elimination of deaths due to suicide could not affect the 75+ population. The prevalence of diseases and deaths is more among old-aged people. Among males it was found that the elimination of respiratory diseases and suicide make more gain in life expectancy at younger ages and at older age we can see elimination of heart diseases make more gain in life expectancy while among females elimination of respiratory and heart diseases make more gain in life expectancy.

DISCUSSION

The aim of cause elimination is to reduce the burden of preventable causes of death in a population, which in turn can increase life expectancy. The elimination of certain causes of death can have a greater impact on life expectancy than others. The elimination of accidents has a more significant impact in the younger ages since

accidental deaths are higher in those age groups. Since the working-age population in Kerala is more using vehicles, so the chance of accidental deaths among working-age populations is high.

Table 2: Death probabilities by causes among males, 2018.

Age group (years)	Heart attack/heart diseases	Respiratory diseases	Suicide	Cancer	Accidents
0-4	0.0197	0.0056	0.0000	0.0017	0.0033
5-14	0.0017	0.0011	0.0007	0.0017	0.0040
15-24	0.0069	0.0025	0.0122	0.0030	0.0263
25-34	0.0194	0.0056	0.0263	0.0054	0.0281
35-44	0.0613	0.0122	0.0331	0.0149	0.0286
45-54	0.2223	0.0404	0.0408	0.0578	0.0352
55-64	0.5862	0.1454	0.0481	0.1943	0.0403
65-74	0.7730	0.2622	0.0383	0.2751	0.0318
75+	4.2813	2.4428	0.1029	1.0127	0.1054

Table 3: Death probabilities by causes among females, 2018.

Age group (years)	Heart attack/heart diseases	Respiratory diseases	Suicide	Cancer	Accidents
0-4	0.0173	0.0058	0.0000	0.0022	0.0034
5-14	0.0016	0.0011	0.0008	0.0015	0.0042
15-24	0.0036	0.0025	0.0121	0.0017	0.0261
25-34	0.0074	0.0048	0.0225	0.0049	0.0241
35-44	0.0197	0.0102	0.0278	0.0176	0.0240
45-54	0.0761	0.0368	0.0371	0.0556	0.0320
55-64	0.2409	0.1397	0.0462	0.1151	0.0387
65-74	0.3474	0.2170	0.0317	0.1141	0.0263
75+	2.6197	1.5987	0.0673	0.4357	0.0690

Table 4: Life expectancy and gain in life expectancy when deaths due to a particular cause is eliminated, Kerala, 2018.

Age (years)	LE	Heart Diseases		Cancer		Respiratory		Accidents		Suicide	
	e^0_x	$e^0_{x,\alpha}$	Gain	$e^0_{x,\alpha}$	Gain	$e^0_{x,\alpha}$	Gain	$e^0_{x,\alpha}$	Gain	$e^0_{x,\alpha}$	Gain
Total											
0	74.91	82.09	7.18	81.81	6.90	82.95	8.04	81.64	6.72	82.01	7.09
55	23.12	27.91	4.79	27.12	4.00	28.15	5.03	27.20	4.08	27.27	4.15
75+	7.33	9.64	2.32	7.70	0.37	8.66	1.33	7.36	0.04	7.36	0.03
Male											
0	72.60	80.00	7.40	80.59	7.98	81.42	8.81	80.55	7.94	80.62	8.01
55	21.93	26.16	4.23	25.89	3.96	26.67	4.74	26.12	4.19	26.09	4.16
75+	6.20	8.44	2.24	6.61	0.42	7.30	1.11	6.24	0.04	6.24	0.04
Female											
0	78.73	84.01	5.29	82.89	4.17	84.34	5.61	83.20	4.47	83.17	4.45
55	25.91	29.51	3.59	28.21	2.30	29.49	3.58	28.31	2.40	28.31	2.40
75+	8.32	10.64	2.32	8.63	0.31	9.85	1.53	8.35	0.03	8.33	0.02

e^0_x is Life expectancy at age x, $e^0_{x,\alpha}$ is Life expectancy at age x after eliminating cause α.

The results was similar to an analysis using National Crime Records Bureau data, it has been found that individuals between the ages of 30-59, especially males, have a higher likelihood of succumbing to road traffic accidents. The fatality rate differs among cities and states and tends to increase during severe weather conditions.[9] The present study also shows a gain in life expectancy after eliminating suicides in the Middle Ages showed a noticeable gain.

When a significant cause of death is eliminated, it will make gains in life expectancy. Elimination of respiratory diseases from all other causes makes more gain in life expectancy at birth. Heart diseases are followed by respiratory diseases. Elimination of heart diseases from all other causes also makes more gain in life expectancy. Therefore, efforts to eliminate or reduce the burden of preventable causes of death can have a significant impact on life expectancy. This requires a multi-sectoral approach, including efforts to promote healthy lifestyle habits, improve access to health care services, and address social determinants of health such as poverty and inequality. Similar patterns of gain in life expectancy were

also seen among males and females. From the study it was found that gain in life expectancy by the elimination of various causes is benefited by males than females. From the complete elimination of specific causes of deaths, deaths due to respiratory diseases showed more gain in life expectancy at birth with respect to other causes. Kulkarni et al. conducted a study in Goa to estimate the potential gain in life expectancy when mortality due to cardiovascular diseases was eliminated. It was found that net gain in life expectancy at birth was more for females than males.[10] Jayachandran et al discovered that the improvements in life expectancy varied by sex and cause at different ages.[11] The greater male vulnerability to cardiovascular conditions emerged with the reduction in infectious mortality and changes in health-related behaviors.[12]

The state Kerala has already reached the last stage of demographic transition. The study shows that Kerala has high life expectancy for both males and females. The sex difference in life expectancy, especially at birth, is also a notable feature of life expectancy changes in Kerala. It is seen that females have been enjoying advantages in life expectancy than males over several decades. The high life expectancy at birth in Kerala indicates that aged population is increasing. Though Kerala population is enjoying a high life expectancy at birth, the people are facing the problem of high morbidity both from communicable and non- communicable diseases. The reduction of specific causes of death will lead to not only an increase in life expectancy but also provide healthy life expectancy. The present study shows that respiratory diseases and heart diseases are the causes that are more affected among Keralites. The result of the cause elimination of diseases indicates that the causes that will give highest potential gain in life expectancy at birth is respiratory diseases followed by heart diseases which is an attributable factor for the sex difference in life expectancy.

CONCLUSION

Increasing life expectancy is a significant factor that contributes to population aging. Although the longevity of the population increases, the quality of life does not increase along with this. It is clear that the causes of death have shifted from communicable diseases to non-communicable diseases in Kerala. This indicates that the policies and programs implied in Kerala succeeded up to a certain extent to control non- communicable diseases. Effective intervention needs to be implemented in Kerala to reduce the risk of certain diseases. It is essential to study the sex differential in the age pattern of mortality because it is essential for analysing several other demographic phenomena. The high morbidity conditions can be reduced by providing community level educational programs on lifestyle management and disease prevention. Setting up health goals, allocating resources for health policies, and monitoring and evaluating health programs, the findings based on eliminating different causes of deaths are of greater relevance.

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