# Mortality Variations in India

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## 1. Introduction

This paper is written with a view to find whether there is any significant mortality variations present across the country. The mortality is used in all life insurance contracts. Life insurance contracts make use of mortality rates; some of the contracts such as whole life and term assurance are more sensitive to mortality rates. Therefore, it is important to know the magnitude of mortality variations in any region. If the mortality variations are known, it will help in pricing the product according to the risk presented. For example, if one product is sold through bancassurance and another sold through sales agent, the mortality rates used for pricing both the product will be different. Similarly, at least in theory, the product priced for any particular market segment (region) known to have heavier mortality, an allowance for heavier mortality should be allowed. Otherwise there will be large cross subsidy in mortality due to regional effect.

For about four and a half decades insurance business was done by Life Insurance Corporation of India but very little studies are available to get the feel of assured lives mortality variations in India. One of such studies was conducted by Late L.S.Vaidyanathan while doing the mortality investigations in the investigation period 1925-35. The idea of this paper is to study the population mortality variations in India and to draw some conclusion about the mortality variations present in different region.

The next section deals in the country's demography.

## 2. Demography of India

According to United Nation 2004 world population data, the current Indian population stands at 1087 million people and expected to grow to 1628 million by 2050, will leave China behind by about 200 million people. The annual crude death rate is 8 per 1000 total population. The annual birth per 1000 total population is 25. About 36% of the population is less than 15 years of age and about 4% of population is greater than 65 years. This implies that only 60% of the total populations (about 652 million) are insurable and roughly 4% of the populations (about 43 million) are available for the annuity market. These figures will further be less as 36% of the population lives below the poverty line. A crude estimate of insurable population are about 417 million after taking off 36% of lives living below poverty line and population above 65 years are about 28 million available for annuity business.

The life expectancy at birth for the total population is 62 years, and life expectancy for males are 61 years and for females it is 63 years.

A progression of Indian population in 20<sup>th</sup> century is given in the table below:

| Census Year | Population | | | Figures in million |
|---|---|---|---|---|
| | Total | Urban | Rural | Urban percent |
| 1901 | 238 | 26 | 212 | 10.92% |
| 1911 | 252 | 26 | 226 | 10.32% |
| 1921 | 251 | 28 | 223 | 11.16% |
| 1931 | 278 | 33 | 245 | 11.87% |
| 1941 | 319 | 44 | 275 | 13.79% |
| 1951 | 361 | 62 | 299 | 17.17% |
| 1961 | 439 | 79 | 360 | 18.00% |
| 1971 | 548 | 109 | 439 | 19.89% |
| 1981 | 683 | 159 | 524 | 23.28% |
| 1991 | 846 | 217 | 629 | 25.65% |
| 2001 | 1027 | 285 | 742 | 27.75% |

A graphic representation is

**Indian population in 20th Century**
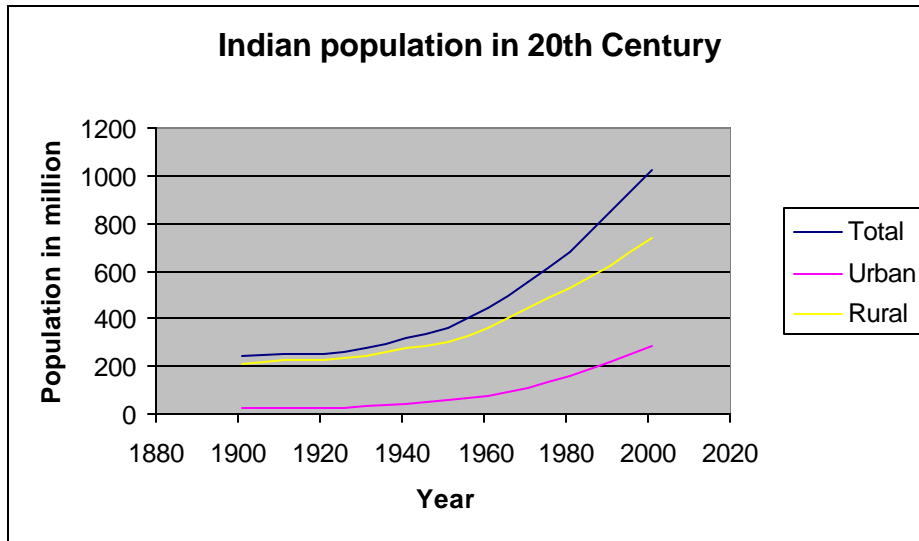


The census of 2001 indicates that close to twenty eight out of hundred people in India lives in urban area. This is two more than the number that lived in urban area in 1991 census. In the 20$^{th}$ century, Indian population grew up by 4.32 folds and during the last decade, the population growth was 1.21 folds. The Indian urban population growth at the end of last century was 10.96 times of urban population at the start of the century. For the same period rural population growth was 3.5 times. There is clear trend of urbanization of Indian population in the last century. The next section deals in the historic mortality of India from 1971 using census data.

## 3. Historic population mortality

The next three pictures explain the mortality improvement from 1971 and subsequent censuses in 1981, 1991. The comparisons are for total mortality and for males and females separately.

**Historic populationl mortality**
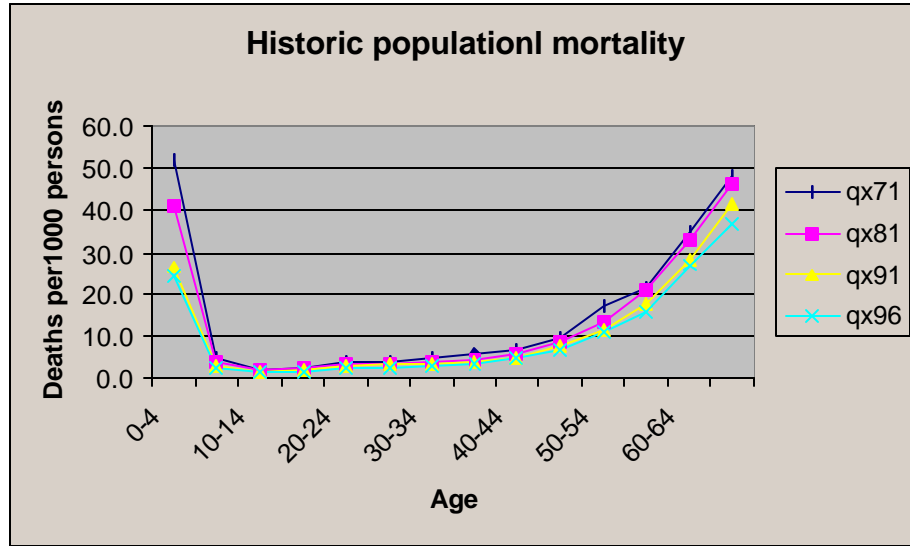
The overall mortality rates of 1971 upto the age 70 was 20.8 deaths per 1000 lives, in 1981 census the mortality rates dropped to 18.4 deaths per 1000 lives, this mortality rate dropped further to 15.8 deaths per 1000 lives in 1991 census. In 1996, the mortality rates were 14.6 deaths per 1000 lives. All the above mortality rates are upto age 70 years, meaning that the total deaths up to the age 70 years divided by total population upto age 70 years.



**Historic population mortality of males**
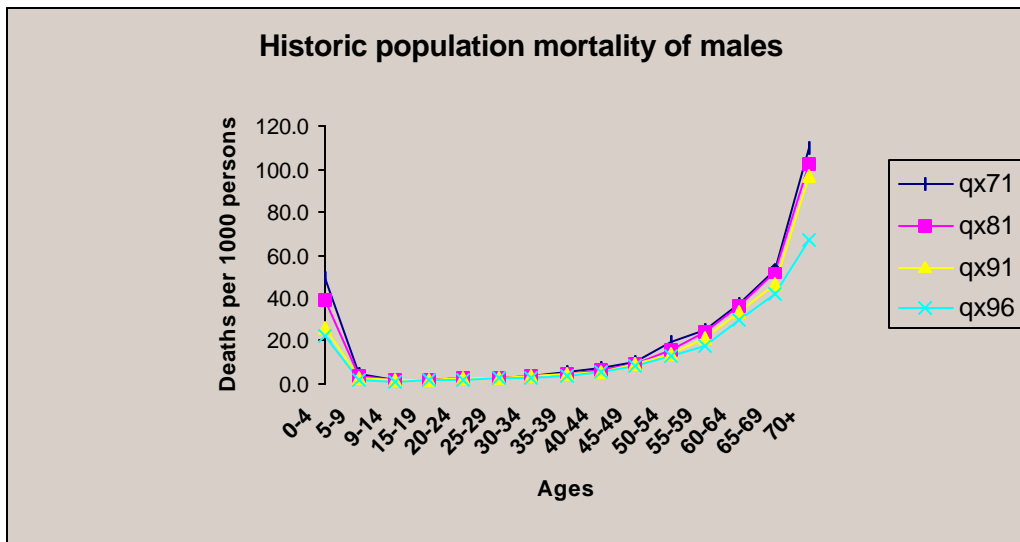
The overall mortality rates of male lives in 1971 census were 21.3 deaths per 1000 lives, heavier than overall total mortality. The mortality rates of males in 1981 dropped to 19.3 deaths per 1000 lives, which was again higher than the overall total mortality. Further, in 1991 census, the mortality of males dropped to 17 deaths per

1000 lives again higher than the overall total mortality.  In1996, the overall mortality rates of males were 14.1 deaths per 1000 lives higher than total mortality.

**Historic population mortality of females**
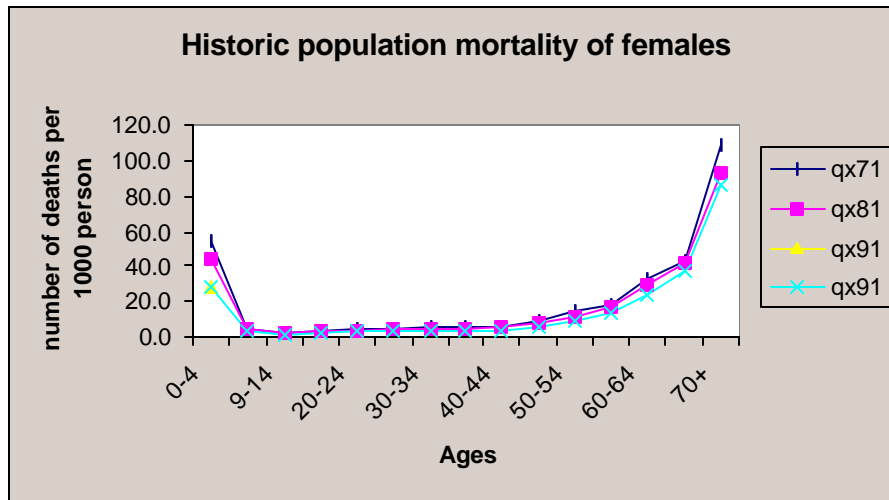


The overall mortality rates of female lives were lighter than both male mortality rates and overall total mortality rates in all three censuses.  In 1971 census, female mortality rate was 20.2 deaths per 1000 lives, in 1981 female mortality rates dropped to 17.5 deaths per 1000 lives.  The female mortality rates further dropped to 14.7 deaths per 1000 lives in 1991 census.  In 1996, female mortality rates were 12.1 deaths per 1000 lives.  All the mortality rates are upto age 70.

The historic mortality indicated that the female mortality rates were lighter than males' mortality rate at least from census 1971.  The lighter mortality of females' lives should be reflected in the assured lives mortality, if sufficient data are available to do any sex differential mortality investigations.  However, even if sufficient data are not available  to do any sex differential mortality investigations in  assured lives, an allowance of female lighter mortality should be made in pricing and valuation at least to the extent of differential available in the population as assured lives mortality are lighter than the population mortality due to the selection effect.

The next section deals in the life expectancy at birth.

## 4.  Life expectancy

According to SRS (Sample Registration System) abridged life table, the life expectancy at birth during the period 1993-97 was 61.1 years as compared to 49.7 years in 1970-75, an increase of close to 23%.  The life expectancy of male in 1993-97 was 60.4 years as compared to 50.5 years in 1970-75 and for females; the life expectancy in 1993-97 was 61.8 years as compared to 49.0 years in 19970-75.

**Life expectancy at birth**
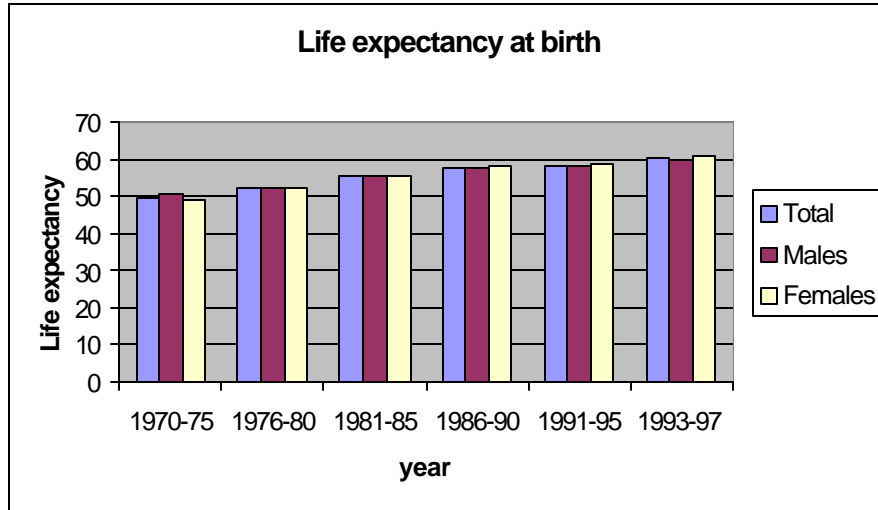
In the rural area the total life expectancy at birth was 59.9 years in 1993-97 as compared from 48 years in 1970-75. For males, the life expectancy at birth in 1993-97 was 59.3 as compared from 48.9 years in 1970-75 and for females the life expectancy in 1993-97 was 60.2 years as compared to 47.1 years in 19970-75.

**Rural life expectancy at birth**
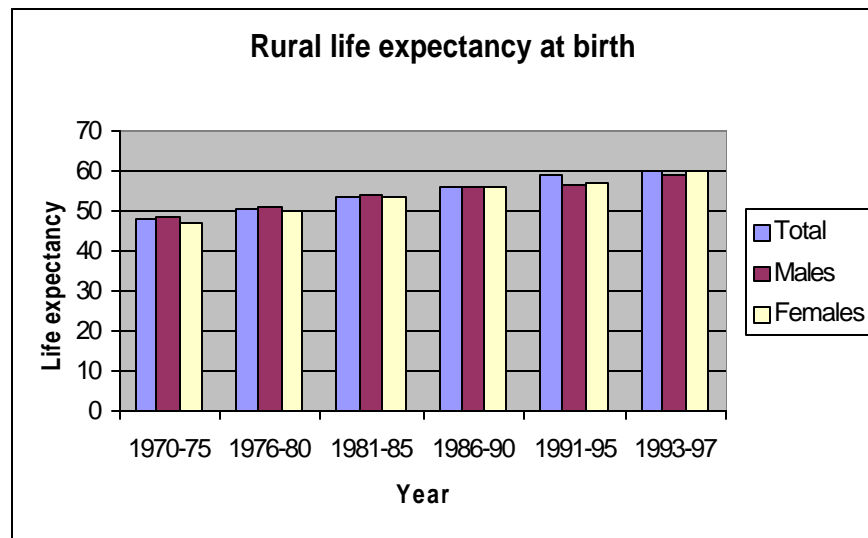
In the urban area the total life expectancy at birth was 66.6 years in 1993-97 as compared from 58.9 years in 1970-75. For males, the life expectancy at birth in 1993-97 was 65.1 as compared from 58.5 years in 1970-75 and for females the life expectancy in 1993-97 was 68.0 years as compared to 59.2 years in 1970-75.

**Urban life expectancy at birth**
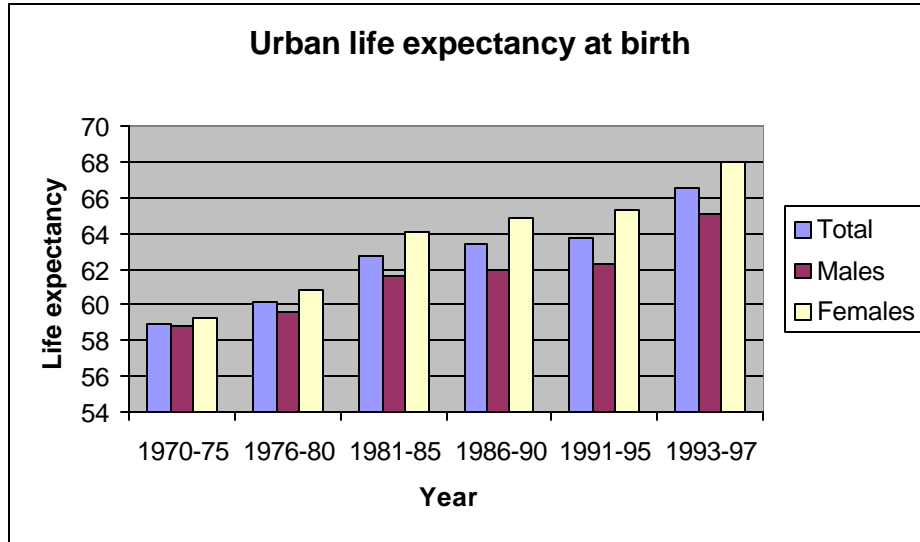


This further strengthens the argument that the female mortality is lighter than the male mortality in both rural and urban area in India. Therefore, on a broader perspective, female premium rates should be lesser than the male lives as it happens in the developed market.

The total life expectancy at age 1 of life after surviving through the initial years was 65.3 years in 1993-97 as compared from 56.2 years in 1970-75. For males, the life expectancy at age 1 in 1993-97 was 64.5 as compared from 57 years in 1970-75 and for females the life expectancy at age 1 in 1993-97 was 66.0 years as compared to 55.6years in 19970-75. This reflects that there is great impact of infant mortality on the life expectancy at birth. The chart below shows the improvement of life expectancy at age 1 during 1970 to 1997. This implies that the infant mortality pulls the life expectancy down quite substantially and therefore life expectancy at birth may not be a very good crude measure for an annuity market to explore rather it should be life expectancy at age 1.

**Life Expectancy at age 1**
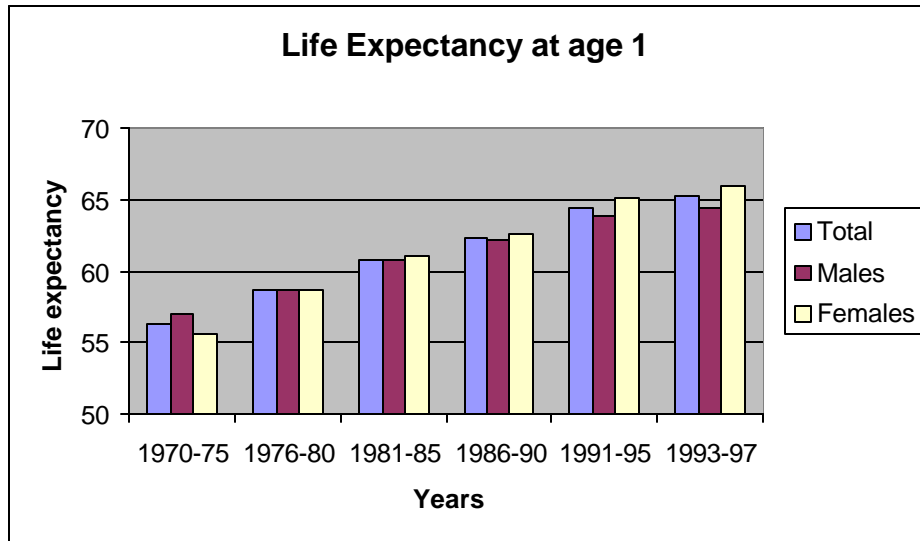


The next section deals with brief relationship between age and calendar.

## 5. Age and calendar

A life starts with the birth of a child. Age is measured through the calendar year. The common theme of calendar making is the desire to organize unit of time (day is the smallest unit of time) to satisfy the needs and preoccupation of society. In addition to serving practical purpose, the process of organization provides a sense of understanding and controlling time itself. Thus the calendar serves as a link between mankind and cosmos.

According to one estimate, about forty calendars are used in the world today. Julion calendar, introduced by Julius Caesar is currently used for everyday use in historical studies. The year in which Julion calendar was introduced is called "Year of confusion" because Julius Caesar inserted 90 days to bring the month of the Roman calendar back to their place with respects to seasons.

## 6. Assured lives and population mortality

The assured lives mortality exhibits lighter mortality than the population mortality. The assured lives mortality is lighter because of selection effect. A selection is a process of subdividing the data into more homogenous groups. A selection can also be thought of as a process of applying filter through which sub standard lives do not enter into the life insurance portfolio at normal rates.

On the other hand, population mortality contains all kinds of lives such as disabled people, people with diseases, people living below poverty line etc. According to Planning Commission estimates around 320 million populations in 1993-94 were living below poverty line. A more detailed distribution of population living below poverty line is given here as under:

**Number and percent of population living below poverty line**

| Year | Rural | | Urban | | Total | |
|---|---|---|---|---|---|---|
| | Person | Percent | Person | Percent | Person | Percent |
| **1973-74** | 261.3 | 56.4 | 60.0 | 49.0 | 321.3 | 54.9 |
| **1997-98** | 264.2 | 53.1 | 64.6 | 45.2 | 328.9 | 51.3 |
| **1983** | 252.0 | 45.7 | 70.9 | 40.8 | 322.9 | 44.5 |
| **1987-88** | 231.9 | 39.1 | 75.2 | 38.2 | 307.0 | 38.9 |
| **1993-94** | 244.0 | 37.3 | 76.3 | 32.4 | 320.4 | 36.0 |

*Figures in million*

The head count ratio declined from 56.4% in 1973-74 to 37.3% in 1993-94 in rural area and from 49% to 32.4% in urban area resulting in a significant drop of the poverty ratio from 55% in 1973 to 36% in 1993-94 for all India. The absolute number of poor had, however remained at the same level of around 320 million due to growth in the population. The decline in urban poverty ratio by about one third is very significant as it coincide with a period of rapid urbanization.

The Indian population in 1991 census was 846 millions. The number of persons living below poverty line in 1994-94 was 320.4 million. It is quite obvious that the mortality of a person living below poverty line will be heavier than those living above poverty line. The individuals living above poverty line can provide themselves and their families' better food, better sanitation, better medical facility etc., which will result in longer expected life. As population includes a big chunk of 36% population living below poverty line, it is quite obvious that the population mortality will be quite heavier than the assured lives mortality.

For the purpose of comparison of mortality of assured lives, total population and state population, SRS abridged life tables for the period of 1993-97 are used.

Estimates of age specific death rates based on SRS tables are being published from 1970s. They are of course subject to sampling error, which designed to be small at All-India level and state level, can be large at lower levels such as districts. However, the quality of data under the system has been improving and users are recognizing the data as useful for making broad comparisons.

Apart from the sampling error, 36% of lives living below poverty line need also be kept in mind while drawing the conclusions on the data of SRS tables.

A table below shows the comparison of LIC 1994-96 mortality with population mortality of 1993-97.

| AGE | LIC94-96 | Pop 93-97 | Extra mortality compared to LIC |
|---|---|---|---|
| 0-1 | 0.000713 | 0.07805 | 10847% |
| 1-5 | 0.002848951 | 0.03181 | 1017% |
| 5-10 | 0.00355992 | 0.01114 | 213% |
| 10-15 | 0.00355992 | 0.00638 | 79% |
| 15-20 | 0.004338463 | 0.00881 | 103% |
| 20-25 | 0.005286788 | 0.01223 | 131% |
| 25-30 | 0.00576068 | 0.01307 | 127% |
| 30-35 | 0.00608116 | 0.01474 | 142% |
| 35-40 | 0.008022205 | 0.01711 | 113% |
| 40-45 | 0.012093257 | 0.02368 | 96% |
| 45-50 | 0.019177983 | 0.03424 | 79% |
| 50-55 | 0.032044309 | 0.05433 | 70% |
| 55-60 | 0.050274823 | 0.07779 | 55% |
| 60-65 | 0.077957972 | 0.12488 | 60% |
| 65-70 | 0.124485117 | 0.17626 | 42% |
| 70+ | | | |

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In the table above LIC 1994-96 is compared with population 1993-97 mortality. The extra mortality figures are indicating the extra mortality exhibited by population mortality over assured lives mortality. In the age range of zero to one, population mortality is 108.47 times of assured lives mortality. This is due to higher infant mortality in population. In fact comparisons of two mortality rates are rather unfair upto age 14, as LIC 1994-96 mortality starts at age 14. The mortality rates of LIC 1994-96 below age 14 years have been calculated by dragging up to age zero.

The population mortality in the age range of 15 to 20 is 103% higher than assured lives mortality. This is the age band of *accident hump* where high percentage of deaths is due to use of motor bike, car or some kind of accidents. The over all LIC mortality up to age 70 years is around 4 deaths per 1000 lives where as overall population mortality is around 83 deaths per 1000 lives, roughly double the LIC rates.

**LIC 94-96 vs Pop 93-97 mortality**
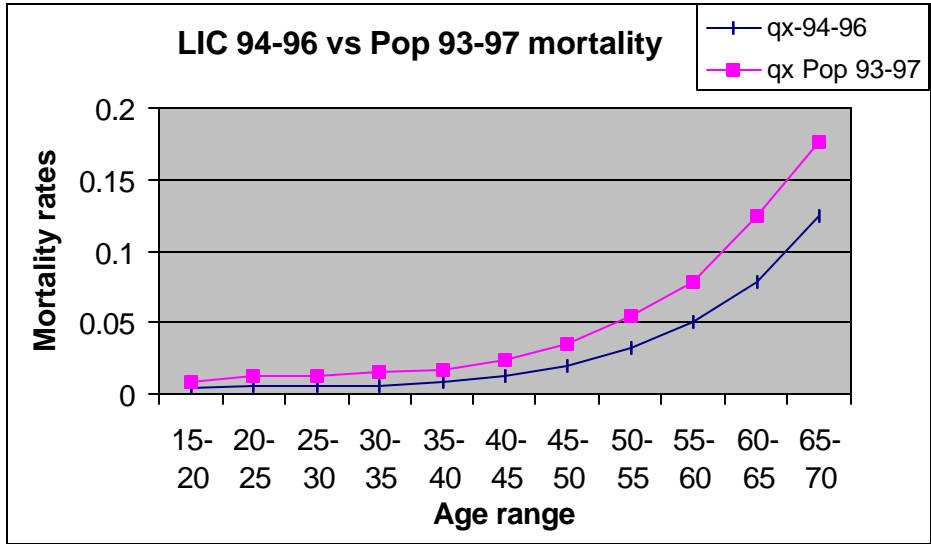
The maximum mortality rate difference is in the age range of 30-35 and is about 142% higher than the assured lives mortality. The minimum difference between the two mortality rates are in the age range of 65-70, where, population mortality is higher by 42%.

If it is possible to remove the mortality of poorest of poor (36% population), then the difference between the two rates will shrink down. However, such mortality rates of poorest of poor are not available and so we need to stick to available SRS 1993-97 abridged life tables for the purpose of comparison of mortality rates. Here for the purpose of comparison, population mortality of 1993-97 (to be around same period of LIC 1994-96) will act as benchmark rates.

**Urban mortality rates**



**Pop 93-97, Urban, LIC 93-96**
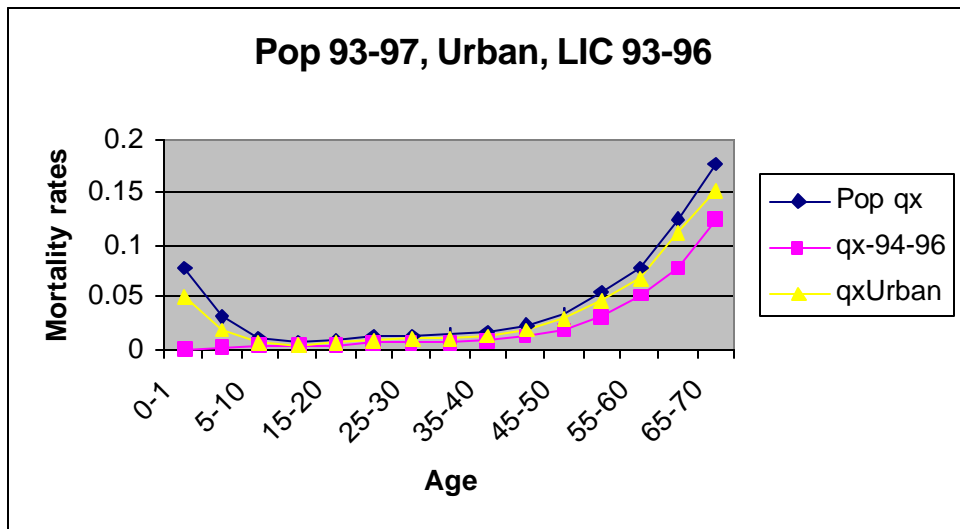
Urban mortality rates are lighter than the population mortality at all ages. The urban mortality rates upto age 70 is 6.6 deaths per 1000 lives compared from population mortality of 8.3 deaths per 1000 lives for up to age 70. Thus the urban mortality is lighter by 21% from population mortality. The mortality is lighter by 43% in the age group 1-5 years and the rate of improvement drops linearly to around 10% in the age group 60-65.

**Rural mortality**
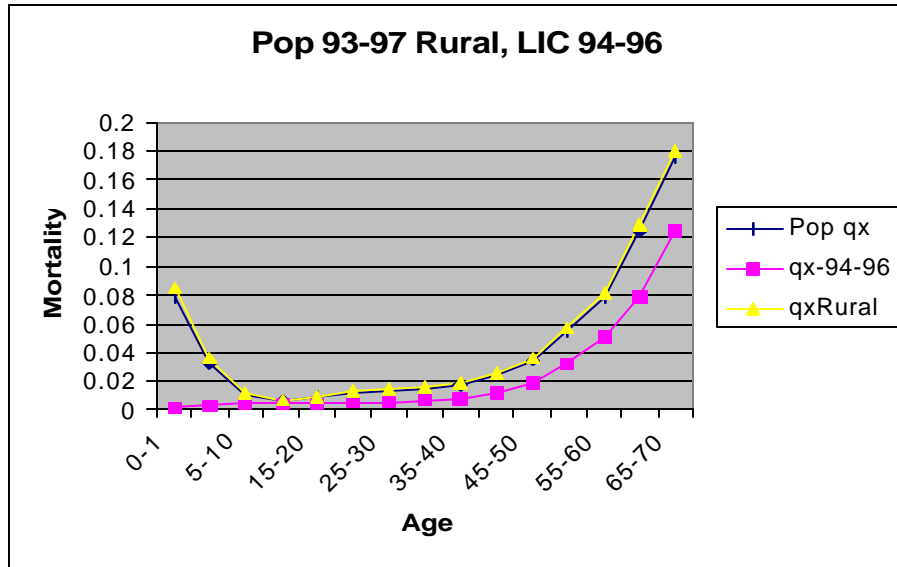


Rural mortality is heavier than population mortality at all ages. The rural mortality rates upto age 70 are 8.8 deaths per 1000 lives as compared to 8.3 deaths per 1000 lives of population mortality. Rural mortality is 6% heavier than population mortality.

**Rural / Urban comparisons of mortalities**

| Age | Pop qx | qxUrban | qxRural | Urban/Pop | Rural/Pop | Rural/Urban |
|------|--------|---------|---------|-----------|-----------|-------------|
| 0-1 | 0.07805 | 0.05062 | 0.08464 | -35.14% | 8.44% | 67.21% |
| 1-5 | 0.03181 | 0.01803 | 0.03533 | -43.32% | 11.07% | 95.95% |
| 5-10 | 0.01114 | 0.00583 | 0.01257 | -47.67% | 12.84% | 115.61% |
| 10-15 | 0.00638 | 0.00459 | 0.00693 | -28.06% | 8.62% | 50.98% |
| 15-20 | 0.00881 | 0.00613 | 0.00971 | -30.42% | 10.22% | 58.40% |
| 20-25 | 0.01223 | 0.00901 | 0.01331 | -26.33% | 8.83% | 47.72% |
| 25-30 | 0.01307 | 0.00965 | 0.0143 | -26.17% | 9.41% | 48.19% |
| 30-35 | 0.01474 | 0.01094 | 0.01617 | -25.78% | 9.70% | 47.81% |
| 35-40 | 0.01711 | 0.01331 | 0.01848 | -22.21% | 8.01% | 38.84% |
| 40-45 | 0.02368 | 0.01918 | 0.02529 | -19.00% | 6.80% | 31.86% |
| 45-50 | 0.03424 | 0.02861 | 0.03613 | -16.44% | 5.52% | 26.28% |
| 50-55 | 0.05433 | 0.04589 | 0.05698 | -15.53% | 4.88% | 24.17% |
| 55-60 | 0.07779 | 0.06652 | 0.08112 | -14.49% | 4.28% | 21.95% |
| 60-65 | 0.12488 | 0.11153 | 0.12857 | -10.69% | 2.95% | 15.28% |
| 65-70 | 0.17626 | 0.15114 | 0.18049 | -14.25% | 2.40% | 19.42% |

In the LIC 1994-96 mortality investigation, rural and urban mortality differential was carried out. It was found that rural mortality rates were heavier than urban mortality. The heavier rural mortality in the assured lives was varying from about 12% for ages 20 and below to about 38% for the age range 65-69.

A population mortality comparison shows rural mortality is heavier than urban mortality at all ages. The age band 5-10 in the rural area has about double the mortality of urban area.

**Male's mortality**
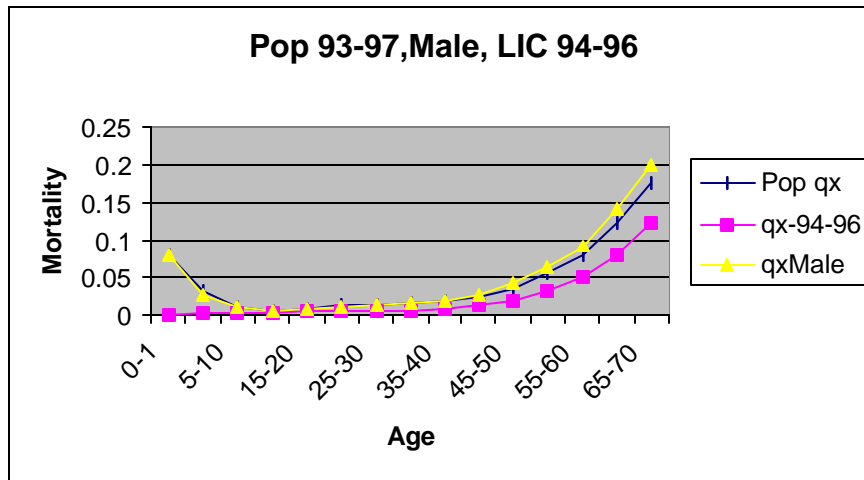


The mortality rates on male lives are 9 deaths per 1000 lives up to age 70 as compared to population mortality 8.3 deaths per 1000 lives. The mortality rates of male lives are 8% heavier than population mortality. However, the mortality rates on male lives are lighter than population mortality between ages 1-30 years and then heavier after age 30 years between 4% to 9%.

**Female's mortality**

**Pop 93-97, Female, LIC 94-96**
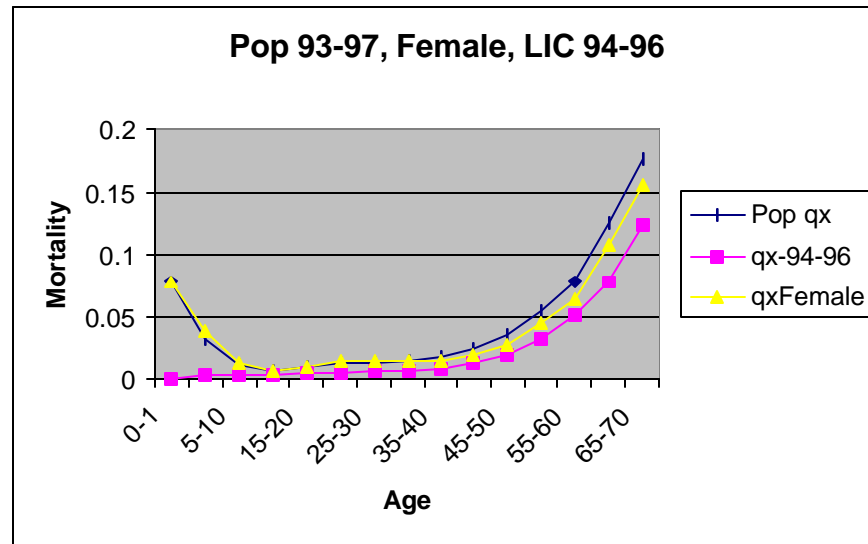


The mortality rates of female are 7.6 deaths per 1000 lives as compared to population mortality rates of 8.3 deaths per 1000 lives; female mortality lighter by around 8%. However, mortality rates of female lives are heavier than population mortality rates from age 1-30 years between 7% to 19% and then lighter from age 30 onwards to the extent of l2% to 20%. Since male mortality rate is 8% heavier than the population mortality rate, it implies that there is a difference of 16% between male and female mortality.

**Comparison of Male and Female mortality**

| Age | Pop qx | qxMale | qxFemale | Male/Pop | Female/Pop | Male/Female |
|-----|--------|--------|----------|----------|------------|-------------|
| 0-1 | 0.07805 | 0.07825 | 0.07794 | 0.26% | -0.14% | 0.40% |
| 1-5 | 0.03181 | 0.026 | 0.03803 | -18.26% | 19.55% | -31.63% |
| 5-10 | 0.01114 | 0.00985 | 0.01257 | -11.58% | 12.84% | -21.64% |
| 10-15 | 0.00638 | 0.00603 | 0.00678 | -5.49% | 6.27% | -11.06% |
| 15-20 | 0.00881 | 0.00762 | 0.0102 | -13.51% | 15.78% | -25.29% |
| 20-25 | 0.01223 | 0.0104 | 0.0141 | -14.96% | 15.29% | -26.24% |
| 25-30 | 0.01307 | 0.01267 | 0.0141 | -3.06% | 7.88% | -10.14% |
| 30-35 | 0.01474 | 0.01538 | 0.01415 | 4.34% | -4.00% | 8.69% |
| 35-40 | 0.01711 | 0.01903 | 0.01499 | 11.22% | -12.39% | 26.95% |
| 40-45 | 0.02368 | 0.02749 | 0.01947 | 16.09% | -17.78% | 41.19% |
| 45-50 | 0.03424 | 0.04085 | 0.027 | 19.30% | -21.14% | 51.30% |
| 50-55 | 0.05433 | 0.06307 | 0.04474 | 16.09% | -17.65% | 40.97% |
| 55-60 | 0.07779 | 0.09124 | 0.06407 | 17.29% | -17.64% | 42.41% |
| 60-65 | 0.12488 | 0.14149 | 0.10806 | 13.30% | -13.47% | 30.94% |
| 65-70 | 0.17626 | 0.19914 | 0.15537 | 12.98% | -11.85% | 28.17% |

A comparison of male and female mortality reveals that up to age 30 years, male mortality lighter to the extent of 10% to 31% and heavier between age bands 30-70 years to the extent of 8% to 42%. A heavier mortality of female lives as compared to male lives between 15-30 years could be due to early marriage and subsequent pregnancy. The heavier mortality in the age less than 15 years could be due to childhood accidents, illnesses resulting into death. Poor upbringing of female child could be one of the reasons of heavier mortality in the ages less than 15 years.

**Annuitants**

A comparison of LIC 1994-96 assured lives mortality with LIC 1996-98 annuitants' mortality rates is shown below.
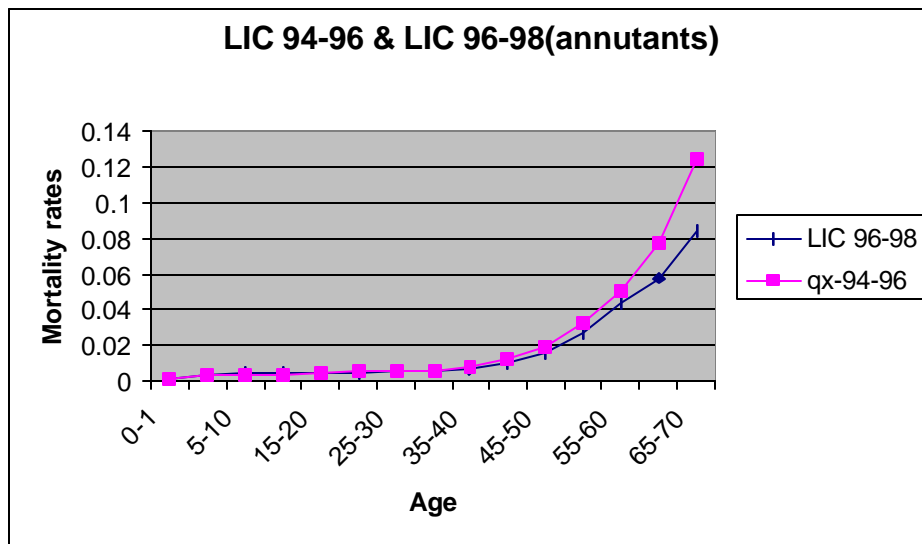


The LIC 1996-98 tables start from the age of 20 years. The LIC 1996-98 rates are 6% lighter in the age range of 20-25 than LIC 1994-96 rates. The LIC 1996-98 mortality rates are lighter by 2% to 33% in the age range of 25- 70 years.

A comparative graph of three mortality rates of LIC 1994-96, LIC 1996-98 and Pop 1993-97 are given in the graph below:

**LIC 94-96, LIC 96-98 & Pop 93-97**
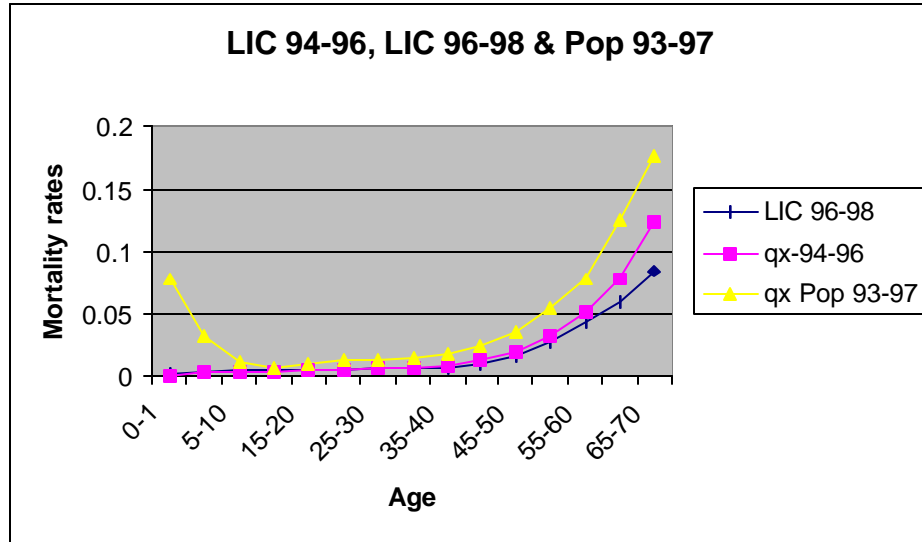
It is apparent that LIC 1996-98 are the lightest mortality rates among the three rates. In the subsequent sections comparison will be made between the LIC 1994-96, Pop 1993-97 and mortality rate of different states of India.

## 7.    State differential mortality rates

In this section, sixteen states of India are considered for the purpose of studying the state level morality with respect to total population mortality of 1993-97.  The population factors considered in the above section can be applied to have an idea about the expected assured lives mortality in the state.

When comparing the mortality of different regions it is good idea to standardize the mortality with respect to population to do away any skewness due to the mortality profile specific to age bands.

The following table gives comparative standardized mortality rates with respect to population upto age 70.  The population mortality upto age 70 is 8.3 deaths per 1000 lives.  The F-value gives the Area Comparability Factor (ACF) defined as ratio of regional mortality over population mortality.

**Standardized Mortality Rates up to age 70**

| States | SMR | F value |
|:---:|:---:|:---:|
| India | 0.0083 | 1 |
| AP | 0.0081 | 0.97 |
| *Assam* | *0.0106* | *1.28* |
| *Bihar* | *0.0093* | *1.12* |
| Gujarat | 0.0079 | 0.95 |
| Haryana | 0.0068 | 0.82 |
| Himachal | 0.0071 | 0.86 |
| Karnataka | 0.0077 | 0.93 |
| *Kerala* | ***0.0045*** | ***0.55*** |
| *MP* | *0.0106* | *1.28* |
| Maharashtra | 0.0069 | 0.83 |
| *Orissa* | *0.0102* | *1.22* |
| Punjab | 0.0064 | 0.77 |
| *Rajasthan* | *0.0083* | *1.01* |
| Tamil Nadu | 0.0075 | 0.91 |
| *UP* | *0.0094* | *1.13* |
| West Bengal | 0.0079 | 0.96 |

F value is ratio of SMR of states over country's mortality rates

The above table shows that five states namely, Assam, Bihar, Madhaya Pradesh, Orissa, Rajasthan and Uttar Pradesh have heavier mortality than the population mortality. Bihar and Madhaya Pradesh have heaviest mortality compared from population mortality of about 28% than the population mortality. On the other hand, Kerala have lightest mortality roughly 45% less than the population mortality up to age 70.

The above figures give one number to compare the overall mortality trends; however, actuaries are interested in mortality across different age bands because most of the businesses are conducted in the age band of 20-65. In the next couple of pages, mortality of sixteen states is compared against population mortality experience according to age to depict mortality profile against age.

**Andhra Pradesh (AP)**

**Pop 93-97, AP, LIC 94-96**
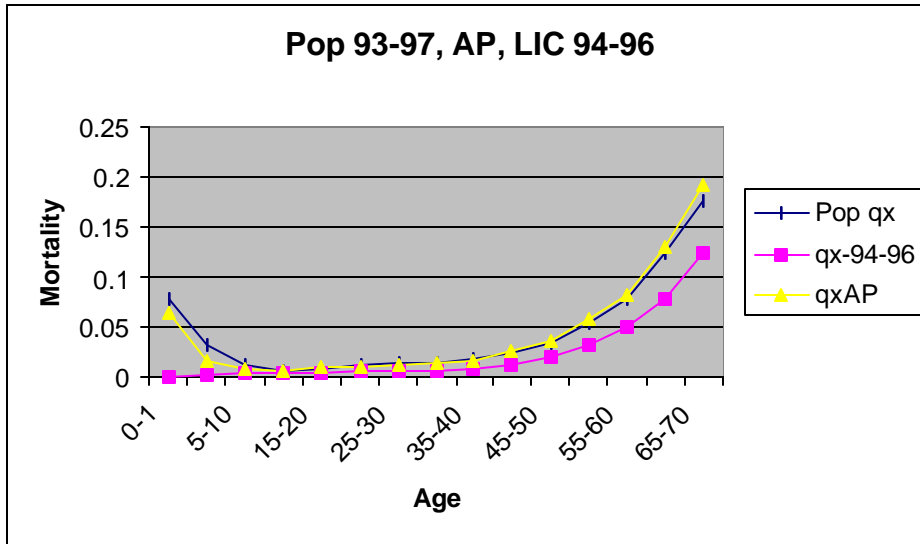


The mortality rates of Andhra Pradesh for the period 1993-97 are lower than the population mortality rates (1993-97) up to the age range of 0-40 years except in the age range of 15-20 years (accident hump) being higher by 13.5%. The lightest mortality occurs at the age 1-5 years by 47.4%. The mortality rates of Andhra Pradesh are heavier in the range of 6% to 9%, in the age range 40-70 years and heaviest mortality occurs in the age range of 65-70 by around 9%. The ACF is 0.97, means that the overall mortality is lighter than the population mortality upto age 70 by roughly 3%.

**Assam**

**Pop 93-97, Assam, Llc 94-96**
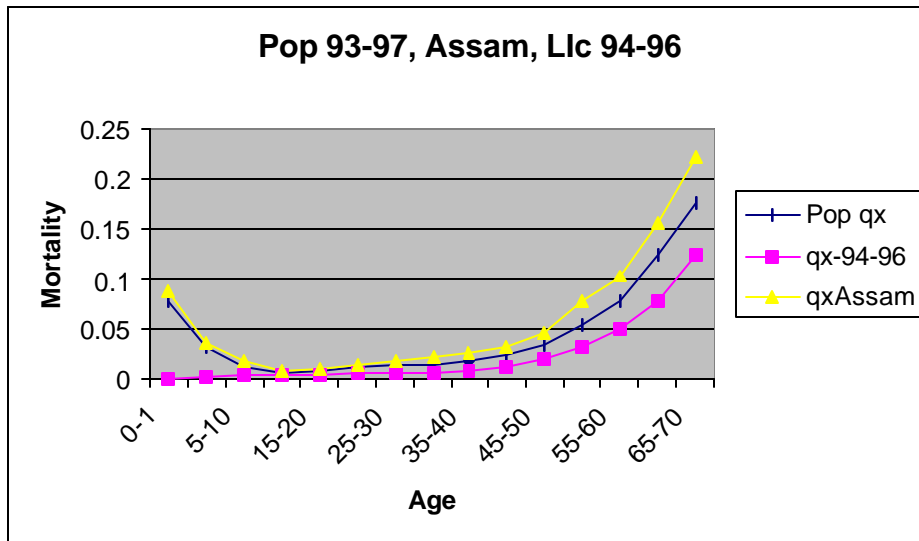
The mortality rates of Assam are heavier at all ages as compared to the population mortality in the period 1993-97. The accidental hump (age 15-20) is heavier than population mortality by around 15%. The heaviest mortality compared to population mortality is in the age range of 35-40 is around 54%. In the age range of 20-35, mortality rates are higher than the population mortality rates (of 8.3 deaths per 1000 lives) by around 16% to 48%. In the age range of 40-70, mortality varies between 25% to 42%. The ACF is 1.28 implying that the overall mortality rates are heavier than the population mortality by around 28% upto age 70.

**Bihar**
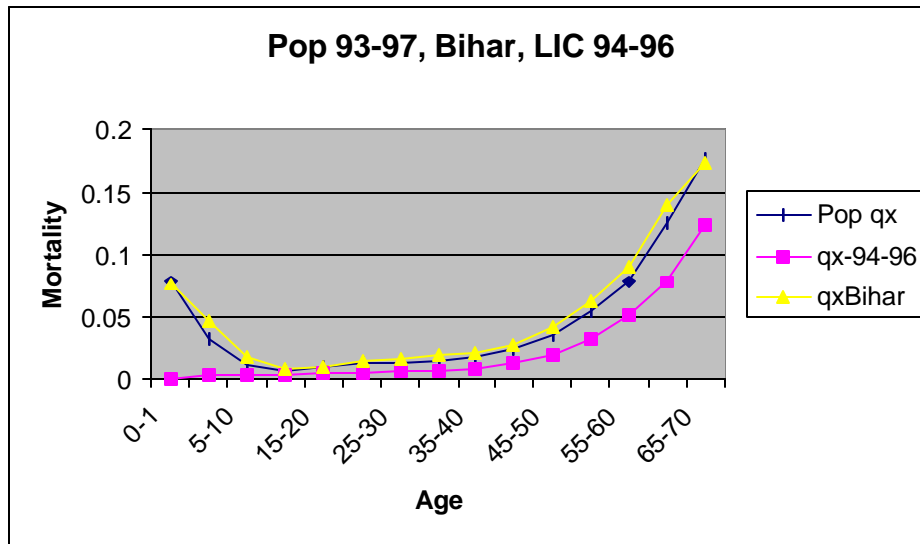


The mortality rates of Bihar are heavier at all ages compared to population mortality for the period 1993-97 except in the age range of 0-1 & 65-70 years. In the age range of 0-1, mortality is lighter by 2.2%, indicating that infant mortality is lighter than population mortality and in the age range of 65-70, mortality is lighter by 1.6%. The accidental hump age group has around 15% heavier mortality than population rates mortality in the same age group. In the age range of 20-65, mortality is heavier between 12% to 24%.The heaviest mortality occurs in the age group of 5-10 years, around 62%. The ACF is 1.12 implying that the mortality of Bihar is heavier than the population mortality by around 12% upto age 70.

**Gujarat**



**Pop 93-97, Gujrat, LIC 94-96**
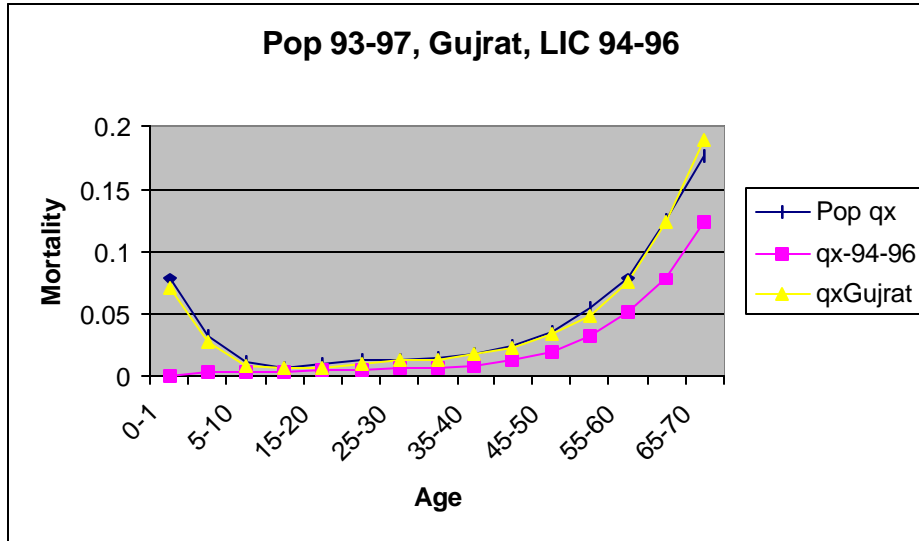
The mortality rates of Gujarat are lighter at all ages compared to population mortality except in the age groups 30-35, around 4% heavier and 65-70, around 7% heavier. The accidental hump age group (15-20) has lighter mortality by around 20%. The lightest mortality occurs in the age group of 5-10 years by around 29%. The ACF is 0.95 implying that the mortality of Gujarat is lighter than the population mortality by around 5% upto age 70 years.

**Haryana**



**Pop 92-97, Harayana, LIC 94-96**
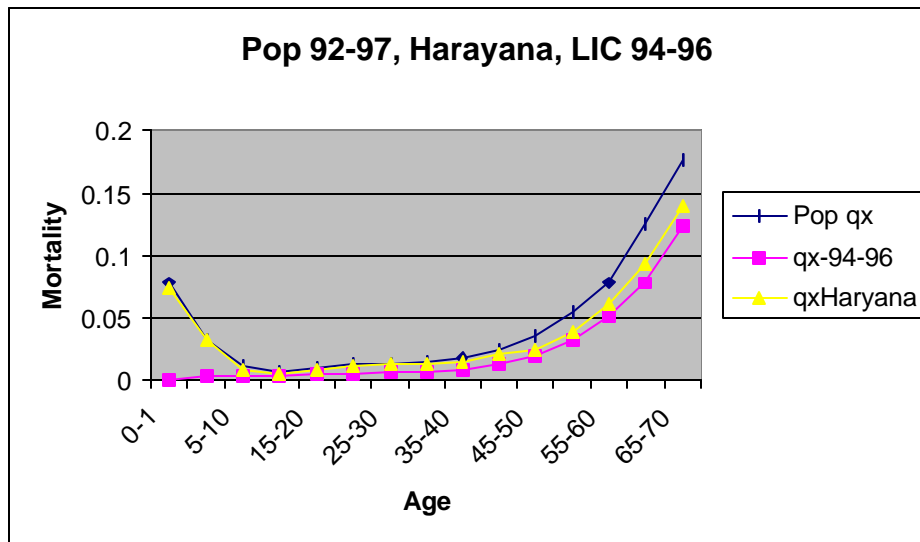
The mortality rates of Haryana are lighter than the population mortality rate at all ages for the period 1993-97. The mortality rates of Haryana are lighter than population mortality rate between 2% to 30% in the age band of 0-70 years. The accidental hump age groups are lighter by 3%. The lightest mortality is in the age group 50-55 by around 30%. The ACF is 0.82 implying that the overall mortality of Haryana is 18% lighter than the population mortality upto age 70.

**Himachal Pradesh**



Pop 93-97, Himachal, LIC 94-96
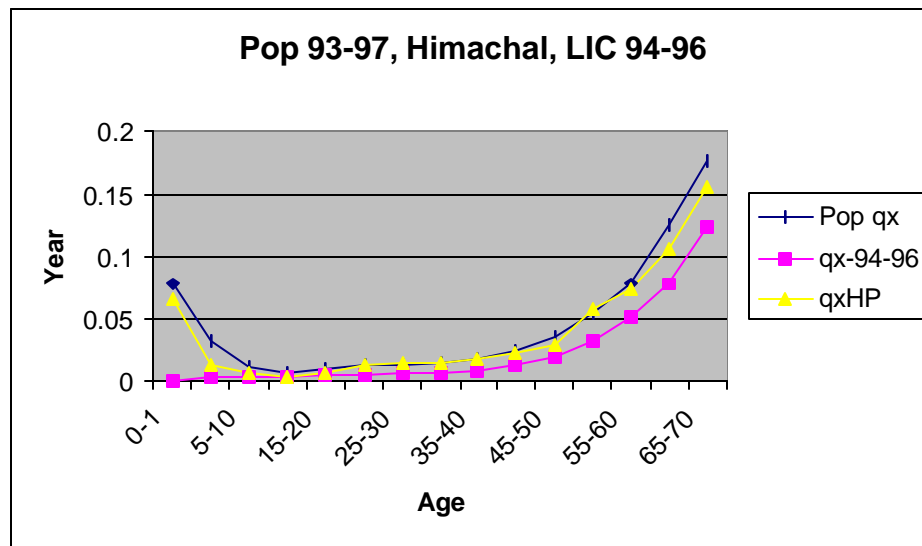
There is mixed pattern of mortality across the ages compared to population mortality. Upto age 25, mortality rates are lighter than the population mortality rate about 1% to 62%. The mortality are also lighter in the age groups of 40-50 and 60-70 by around 5% to 16%. Himachal Pradesh's mortality is heavier in the age groups of 25-35 & 50-55 by around 1% to 4%. In the age range of 35-40, mortality is same as population mortality. The accidental hump age group mortality is lighter by around 33% compared with population mortality. The lightest mortality is in the age range of 1-5 years, lighter by around 62% of population mortality. The heaviest mortality is around 6% in the age group of 50-55. The ACF is 0.86 implying that the overall mortality of Himachal Pradesh is 14% lighter than the population mortality upto age 70.

**Karnataka**



**Pop -93-97, Karnataka, LIC 94-96**
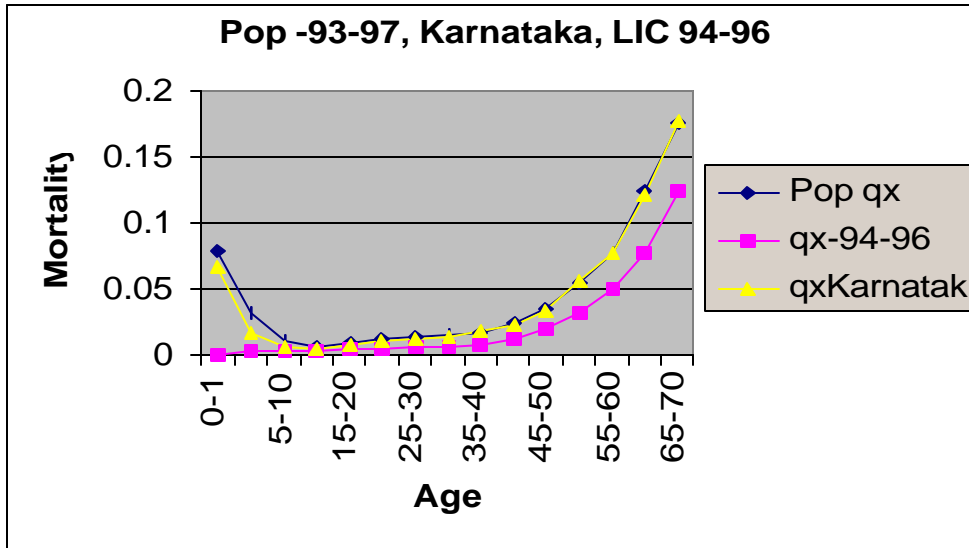
The mortality of Karnataka is lighter than population mortality at all ages, except at age groups 35-40, 50-55 and 65-70. The heavier mortality occurs at age 35-40 by 2.3%. The accidental hump age group (15-20) is lighter than the population mortality around 17%. The lightest mortality of the entire age group when comparing from population mortality is occurring at age band of 1-5 years by around 47%. The ACF is 0.93 implying that the overall mortality of karnataka is 7% lighter than the population mortality upto age 70.

**Kerala**



**Pop 93-97, Kerla, LIC 94-96**
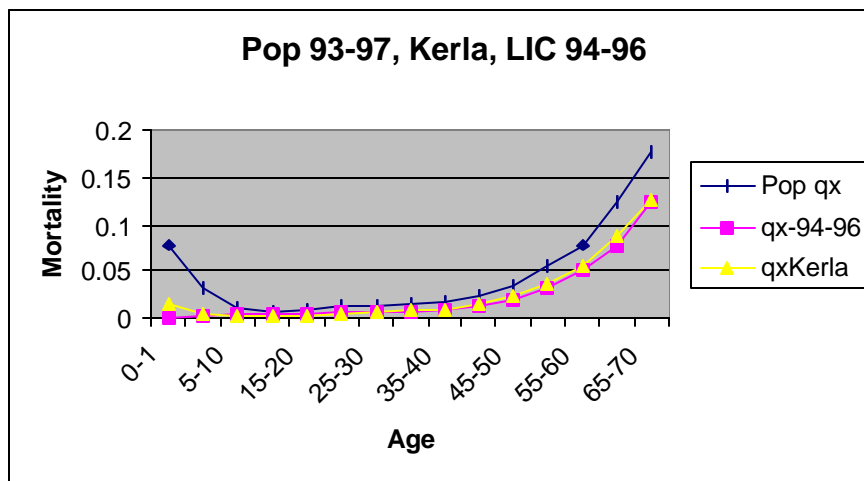
The mortality rates of Kerala are lighter than the population mortality at all ages. The Kerala's mortality is even lighter than the LIC 1994-96 mortality at age bands 15-20 (accidental hump age group) and 20-25 by around 30% and around 2% respectively. The Kerala's mortality is lighter than the population mortality at age group 1-5 years by around 87% and this improvement drops linearly to around 28% at age band 65-70. The improvements are shown in the graph below. The ACF is 0.55 implying that the overall mortality of Kerala is 45% lighter than the population mortality upto age 70.

**Rate of improvement of Mortality across ages**

**Madhya Pradesh (MP)**

**Pop 93-97, MP, LIC 94-96**
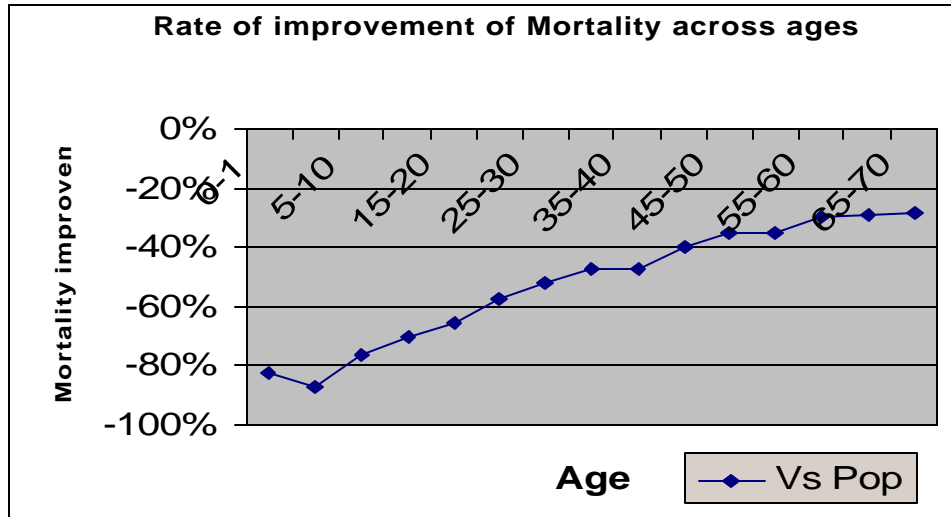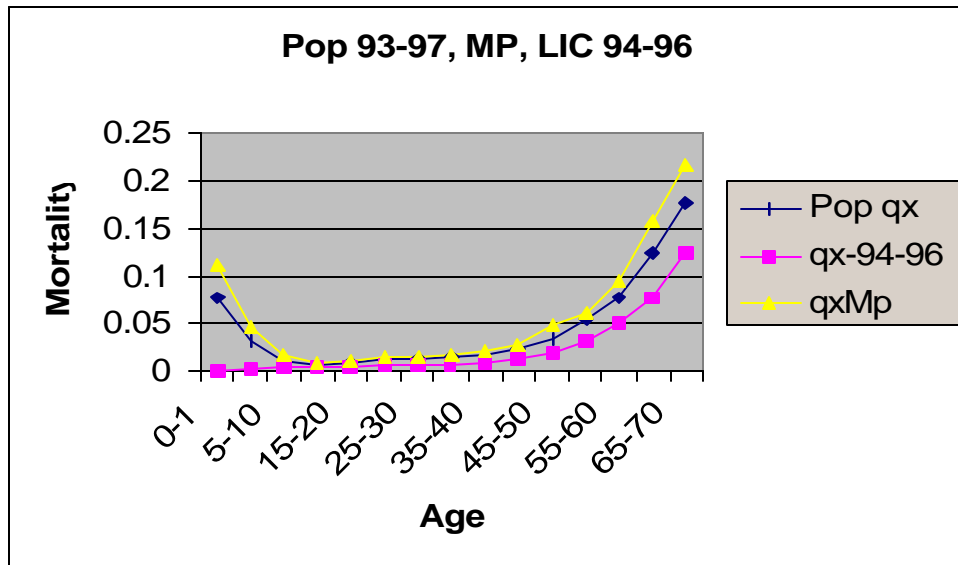
The mortality of Madhya Pradesh is heavier than the population mortality at all ages. The heavier mortality in the age range of 0-70 years varies from 11% to 46%. The heaviest mortality is at age band 1-5 years by 46%. The mortality in the age group 15-20 (accidental hump age band) is up by 28% than population mortality. The ACF is 1.28 implying that the overall mortality of MP is 28% heavier than the population mortality upto age 70.
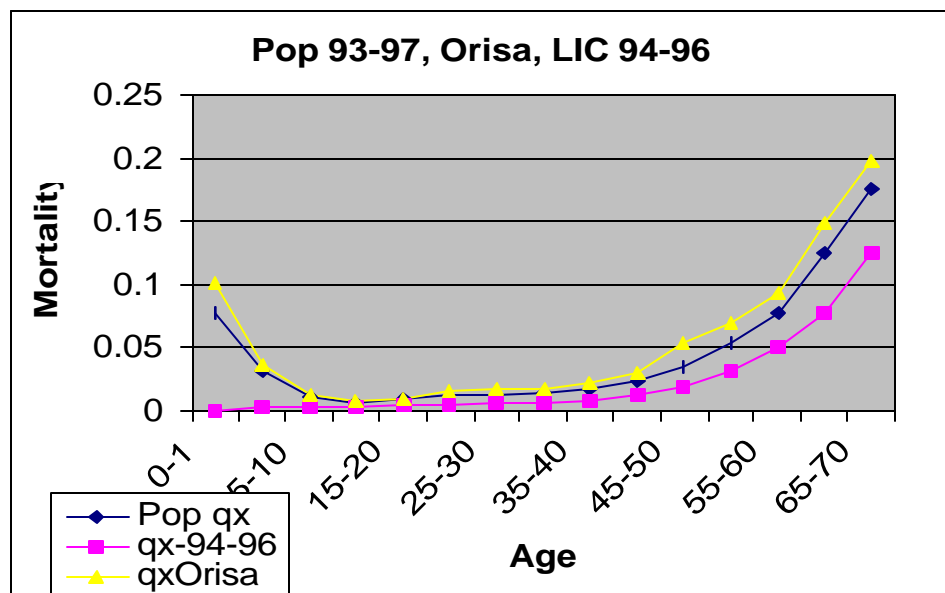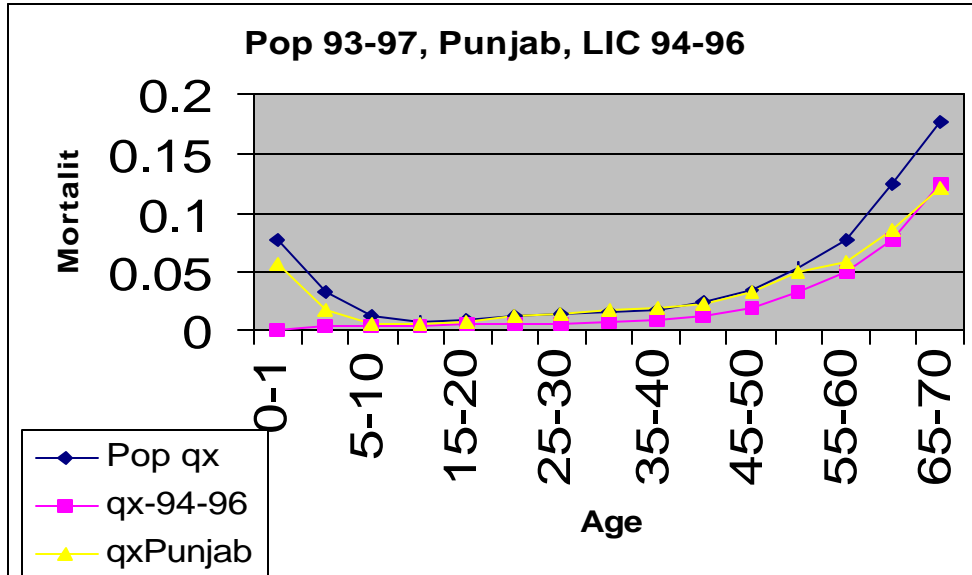
**Maharashtra**
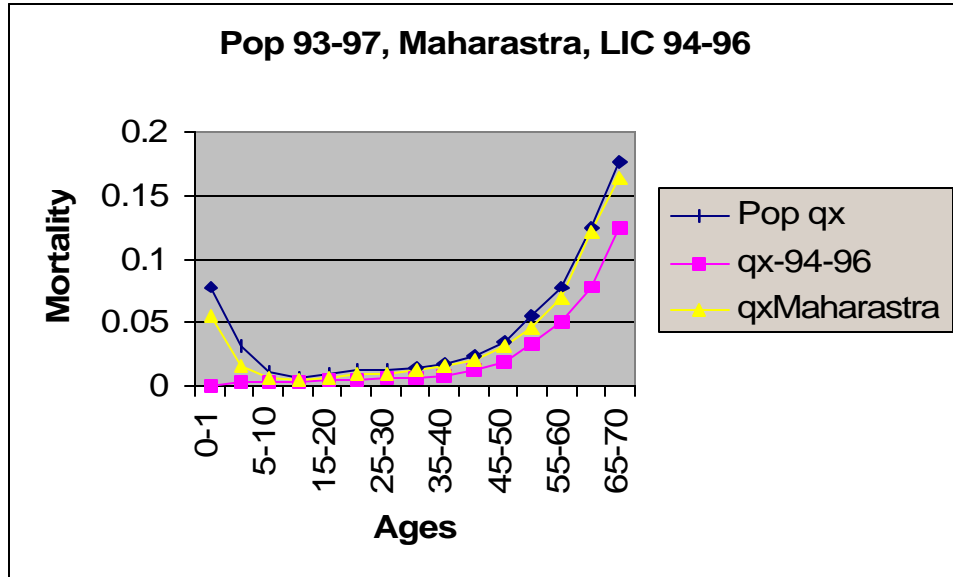


The mortality rates of Maharashtra are lighter than the population mortality rates but heavier than the LIC 1994-96 mortality rates. The lightest mortality is in the age group of 1-5 years by around 54%. The better mortality over population is shown in the graph below. The improvement variation is between 3% to 53% in the age range 0-70 years. The ACF is 0.83 implying that the overall mortality of Maharashtra is 17% lighter than the population mortality upto age 70.

**Mortality improvemnt over National Mortality**

**Orisa**



**Pop 93-97, Orisa, LIC 94-96**
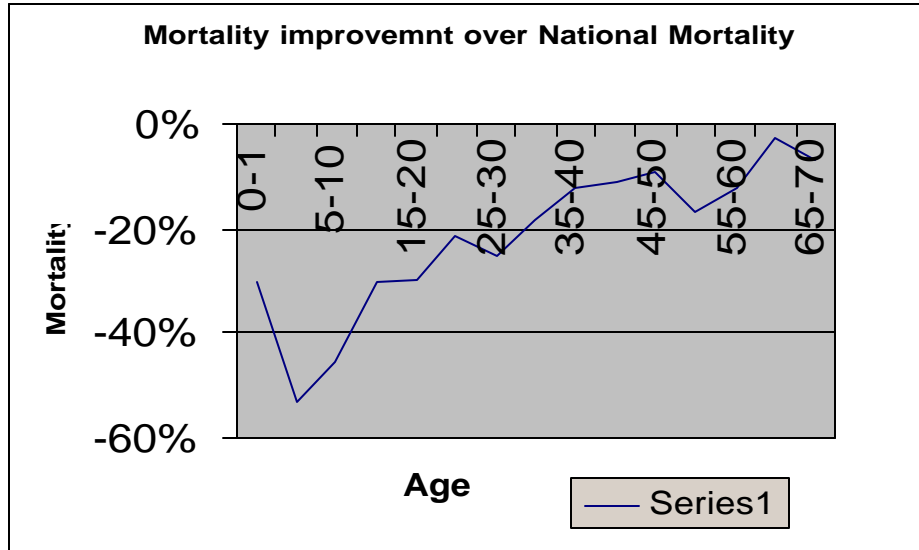
 The mortality rates of Orisa are heavier than the population mortality at all ages. The Orissa mortality rates are higher over population mortality rates are in the age band 45-50 by around 58%. The accidental hump age group (15-20) has heavier mortality by around 15%. The percentage range between the minimum and maximum heavier mortality is 12% to 57%. The ACF is 1.22 implying that the overall mortality of Orisa is 22% heavier than the population mortality upto age 70.

**Punjab**



**Pop 93-97, Punjab, LIC 94-96**

The mortality rates of Punjab are lighter than population mortality rate except at age bands 20-40 years (heavier by 5% to 10%). The lightest mortality is in the age band of 5-10 years by around 56%. The mortality rates between the age bands 55-70 are lighter in the range of 25% to 32%. The accidental age hump age group (15-20) is lighter by around 20%. The ACF is 0.77 implying that the overall mortality of Punjab is 23% lighter than the population mortality upto age 70.

**Rajasthan**



**Pop 93-97, Rajashtan, LIC 94-96**
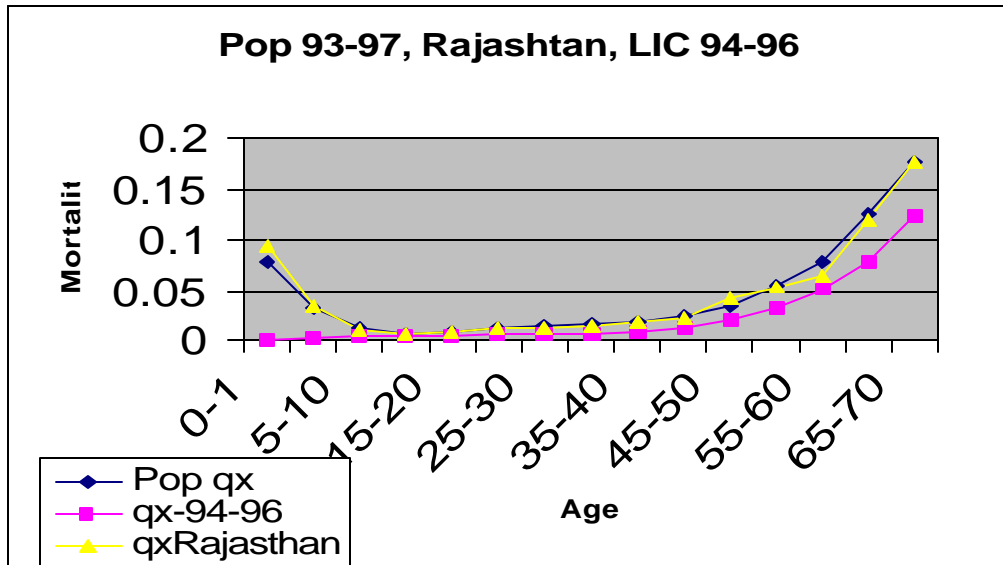
The mortality rates of Rajasthan are lighter than the population mortality rates in the age band 5-45 years in the range of around 2% to 21%. The rates are also light between age bands 50 to 65 years in the range of around 2% to16%. The accidental hump age band is
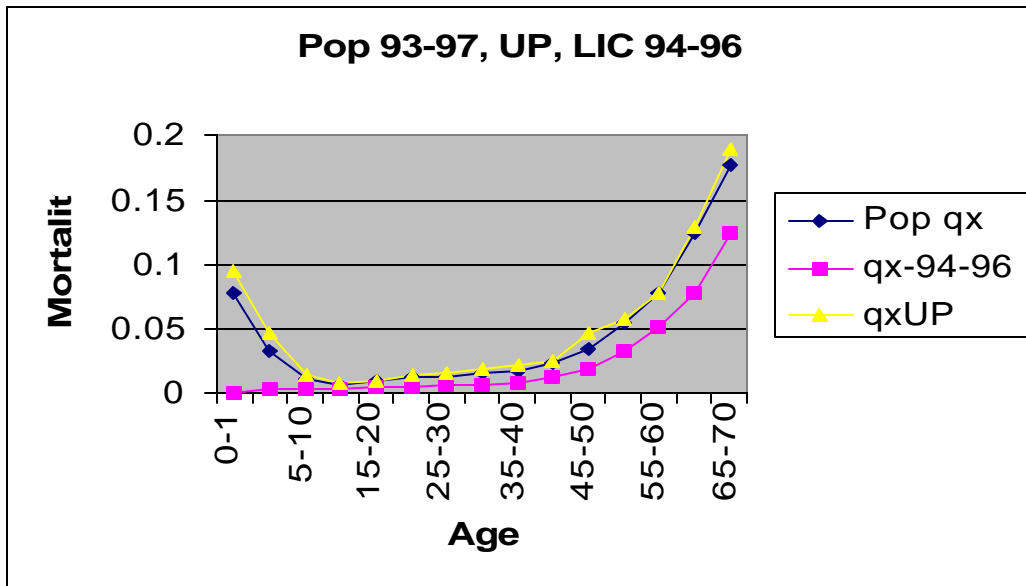
lighter than the population mortality rates by 4%. The ACF is 1.01 implying that the overall mortality of Rajasthan is 1% heavier than the population mortality upto age 70.

**Tamil Nadu (TN)**



**Pop 1993-97, TN, LIC 1994-96**
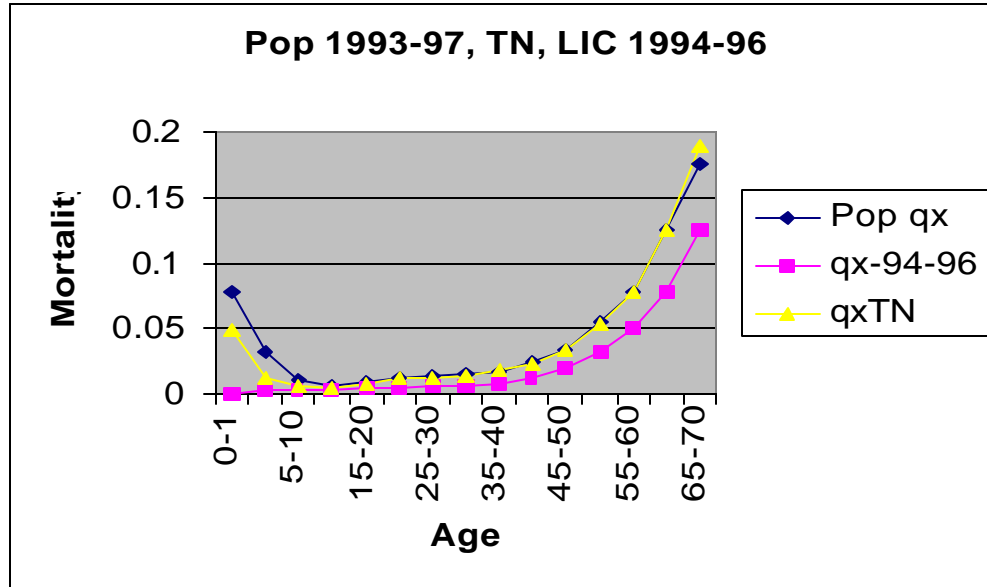
The mortality rates of Tamil Nadu are lighter than the population mortality rates at all ages except at age range of 20-25 (heavier by 1.6%), 35-40 (heavier by around 7%) and 65-70 (heavier by around 7%). The lighter mortality varies to the extent of 1% to 61%. The mortality in the age range of 15-20 years is lighter by around 6%. The ACF is 0.91 implying that the overall mortality of TN is 9% lighter than the population mortality upto age 70.

**Uttar Pradesh (UP)**

**Pop 93-97, UP, LIC 94-96**



The mortality rates of Uttar Pradesh are heavier than the population mortality rate at all ages. The heaviest mortality is in the age band 1-5 years by around 43%. The variations in mortality are between 2% to 43%. The accidental hump age group 15-20 is heavier by around 12%. In the middle ages the Uttar Pradesh mortality over population mortality in the age range of 45-50 is more by around 33%. The ACF is 1.13 implying that the overall mortality of UP is 13% heavier than the population mortality upto age 70.

**West Bengal (WB)**

**Pop 93-97, WB, LIC 94-96**
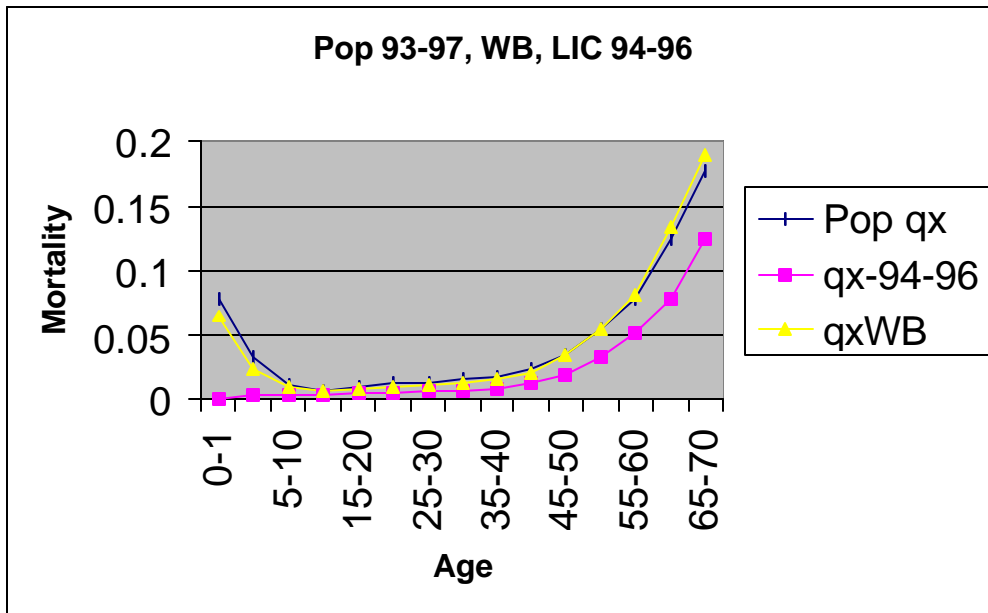
The mortality rates of West Bangal are lighter at all ages than the population mortality rate except at age band 55-70 (heavier in the range of 5% to 8%). The mortality in the age bands of 1-5 years and 20-25 years is lighter about by 29%. The mortality in accidental hump age group is lighter than population mortality by around 15%. The heaviest mortality age bands are 60-70 years where mortality is more by 8%. The ACF is 0.96 implying that the overall mortality of WB is 4% lighter than the population mortality upto age 70.

## 8. Mortality spread across age group

In this section mortality is considered for all are group in different states. On the x-axis all the sixteen states are taken and on the y-axis, mortality rates are taken. The mortality rates for different states in all age bands are shown in the Appendix-1.

## 9. Differential premium rates

In order to demonstrate the effect of mortality rates of different states, a simple term assurance plan is considered. The premiums are calculated using cash flow approach, for LIC 1994-96 mortality, population mortality and mortalities of sixteen states of India. The assumptions taken for the pricing purpose are:

## Model point:

Age = 35 years, Term = 20 years, Death benefit = Rs.100, 000,

## Realistic basis:

Expenses = Nil, Commission = 40%/ 7.5%/5%, in $1^{st}$ year, $2^{nd}$ & $3^{rd}$ year, $4^{th}$ years plus. Surrenders = Nil, Interest rates = 5%, Mortality = 100% of the table taken for pricing, Solvency margin = 6% of reserve & 0.45% of Sum At Risk (150% taken), Risk discount rate =12% and profit margin = 5%.

## Reserving basis:

10% MAD applied on Mortality and 125 basis points down on interest rates. Following table shows the different premium rates on the above basis

| States | Premium rates |
|---|---|
| **LIC** | 383 |
| **Population** | 682 |
| **AP** | 708 |
| **Assam** | 940 |
| **Bihar** | 793 |
| **Gujarat** | 648 |
| **Haryana** | 530 |
| **Himachal** | 661 |
| **Karnataka** | 687 |
| **Kerala** | 428 |
| **MP** | 816 |
| **Maharashtra** | 599 |
| **Orissa** | 911 |
| **Punjab** | 656 |
| **Rajasthan** | 704 |
| **Tamil Nadu** | 680 |
| **UP** | 789 |
| **West Bengal** | 643 |
| **Urban** | 565 |
| **Rural** | 722 |
| **Male** | 786 |
| **Female** | 568 |

There is large gap between the term assurance premium rates calculated using LIC 1994-96 mortality and mortalities using population mortality of 1993-97.

The premium rates of term assurance are around 78% higher than the premium rates using LIC 1994-96 mortality. These results are not surprising. It is known through the preceding sections that there is around 36% of population living below poverty line contributing towards higher mortality in the population and hence leading to substantial higher term assurance premium rates compared from premium rates calculated using LIC 94-96. Some allowances for heavier mortality of the population also need to be allowed for sampling error while preparing the SRS abridged life table. Also the mortality rates of the population as well as states are not graduated.

A graphical representation of premium rates is



**Premium Rates for Term Assurance**
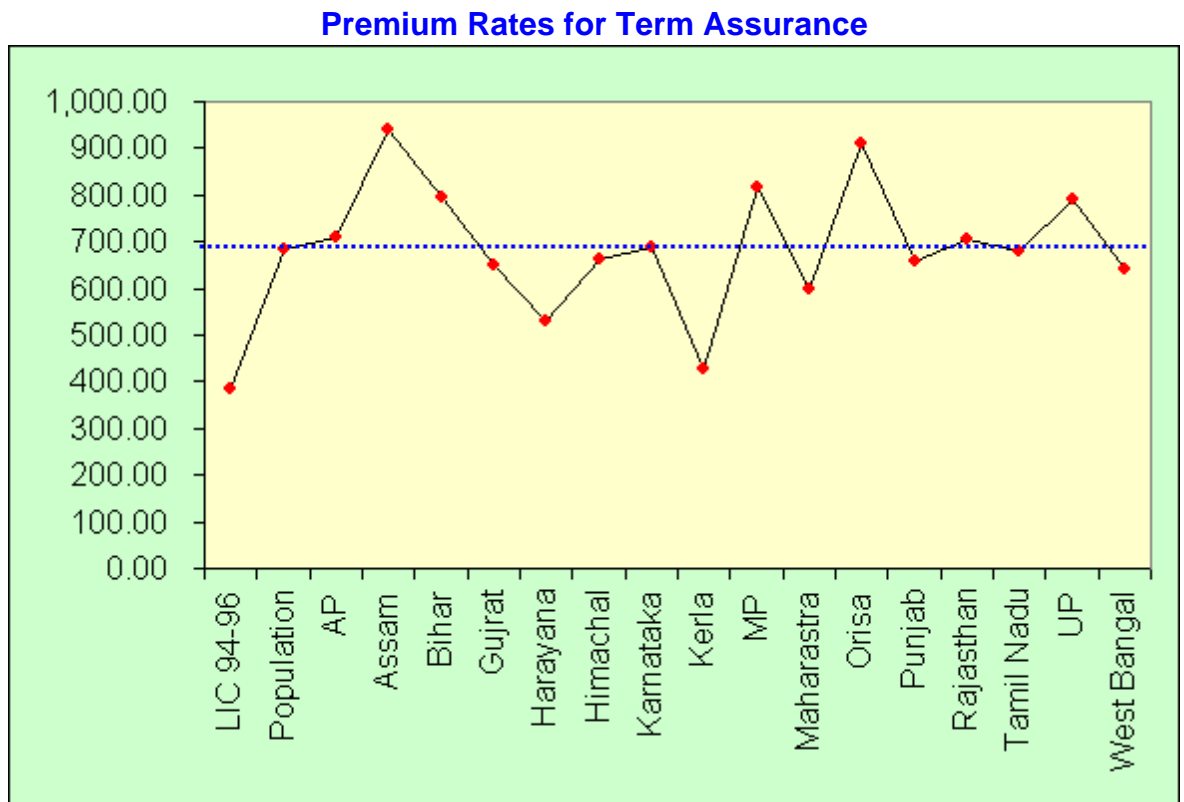
This clearly indicates that which states are above or below population premium rates of Rs.682.

As population premium rates are around 78% higher than the LIC 1994-94 premium rates, thus, if premium rates of different states are scaled down by 78%, we get a very rough comparable premium rate of term assurance products across the country in terms of assured lives, given in the following table:

**Comparative premium rates from LIC 94-96 Mortality**

| States | Premium rates | c/f LIC |
|---|---|---|
| LIC | 383 | 100% |
| Population | 383 | 100% |
| AP | 398 | 104% |
| Assam | 528 | 138% |
| Bihar | 446 | 116% |
| Gujarat | 364 | 95% |
| Haryana | 298 | 78% |
| Himachal | 371 | 97% |
| Karnataka | 386 | 101% |
| Kerala | 240 | 63% |
| MP | 458 | 120% |
| Maharashtra | 337 | 88% |
| Orissa | 512 | 134% |
| Punjab | 369 | 96% |
| Rajasthan | 396 | 103% |
| Tamil Nadu | 382 | 100% |
| UP | 443 | 116% |
| West Bengal | 361 | 94% |
| Urban | 317 | 83% |
| Rural | 406 | 106% |
| Male | 442 | 115% |
| Female | 319 | 83% |

These premium rates are consistent with mortality rates in the age range of 35-55 (term of the product). It may be noted that the overall mortality of Andhra Pradesh is lighter than the population mortality upto age 70 by 3%, however, the premium rates of term assurance is heavier by 4% compared from LIC because the mortality rates of AP in the age range of 40-55 are heavier than the population mortality and hence heavier than LIC.

Similarly, in Karnataka the overall regional mortality is lighter than the population mortality by 7%, the premium rates of term assurance are 1% more than the LIC rates as the mortality of Karnataka is heavier than the population mortality in the age range of 35-40 & 50-55, covering 10 years terms out of 20 with heavier mortality.

In TN, overall mortality rates are lighter than the population mortality rates by 9%, however the premium rates are same as LIC rates because mortality in the age range of 35-40 are heavier than the population rates by 7%. These were the three states which deviated from the SMR covered in the section 6.

The urban premium rates are 17% less than the LIC rates where as urban mortality are 21% lighter than the population mortality.  Rural and female's premium rates are consistent with the mortality considered in section 6. The premium rates of males are 15% higher than the LIC premium rates as the mortality between ages 30-55 are about 14% heavier than the population mortality.

The mortality investigation conducted by Late Shri L.S. Vaidyanathan in the mortality investigation of The Oriental Government Security Life Insurance Company Ltd. during the period 1925-35 found that the mortality of assured lives was heavier in Bengal, the entire North East area by 10%-15%. The mortality of Andhra Pradesh, Rajasthan and entire South of India was heavier by 0%-5%.  The mortality of Madhya Pradesh was heavier by 5%-10%. The mortality of Punjab, Haryana, Delhi and entire Jammu and Kashmire was heavier by over 15%. The mortality of Maharasthra and Kerala was lighter by 5%-10%.  The mortality of, now Pakistan was lighter by over 20%, and now Burma was lighter by 10%-15%.

## 10. Cross subsidy

It is apparent that there is difference in mortality across the length and breadth of the country. The states like Kerala, Punjab with substantial lighter mortality by 45% and 23% respectively over the population mortality contribution towards the reduction in average mortality rate against the states such as Assam, Orissa with 28% and 22% heavier mortality.

## Conclusion

**Female mortality is lighter than male mortality as well as total population mortalities. There is greater need to reflect this phenomenon in the pricing and valuations basis.**

**Life expectancy at age 1 is better measure to get a view about insurance and annuity business in the country than life expectancy at birth as infant mortality distort the total mortality .**
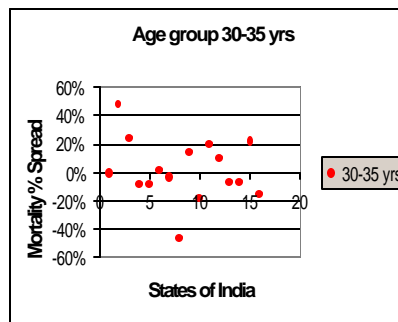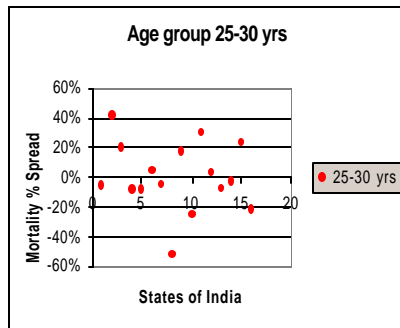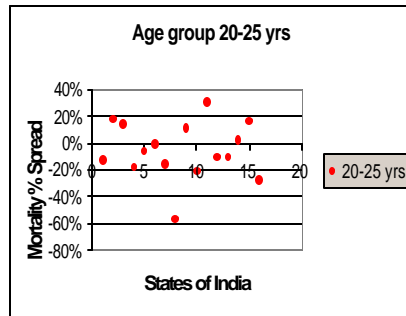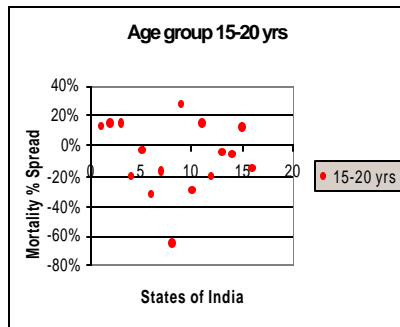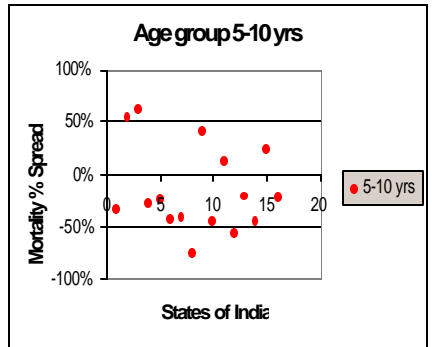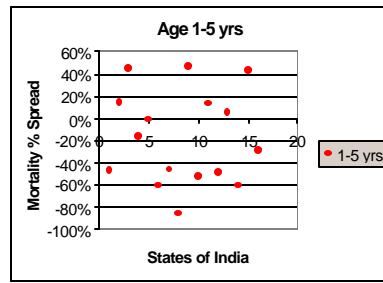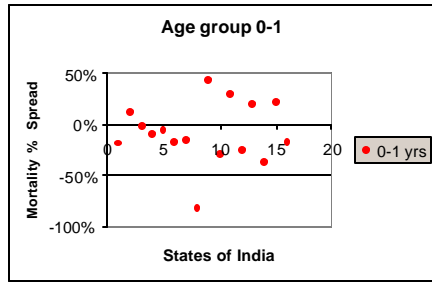
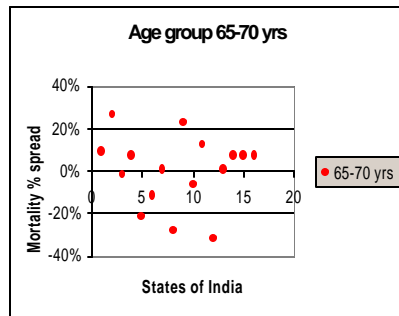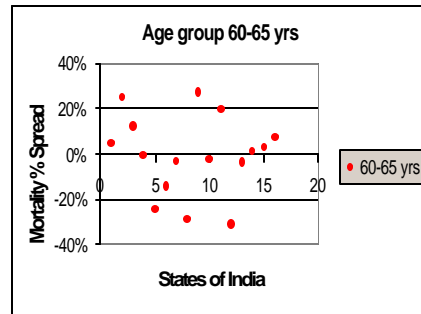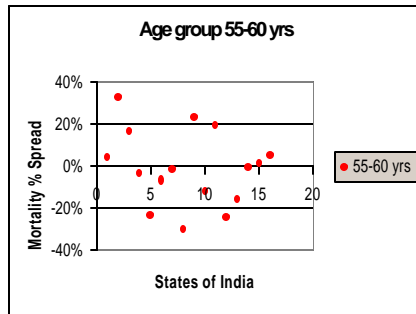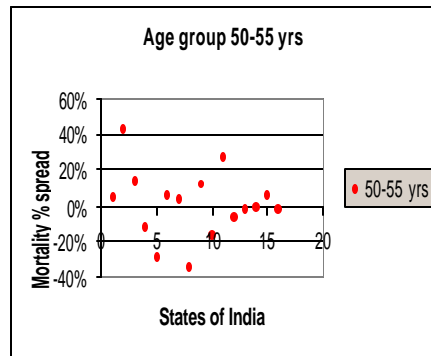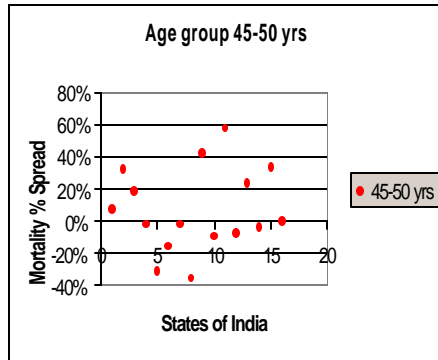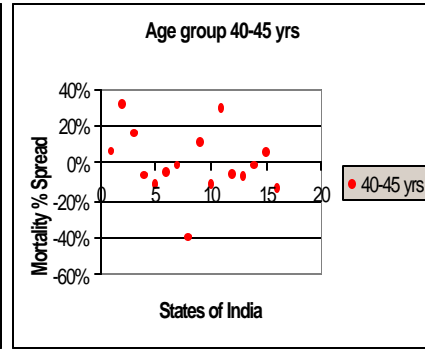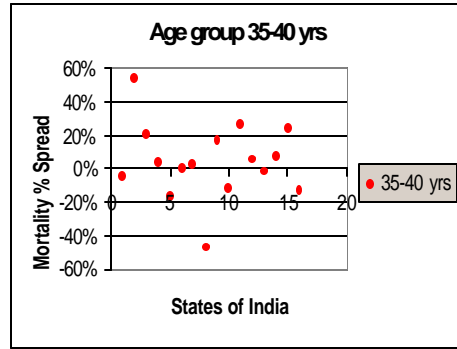**Urban mortality is lighter than rural as well as population mortality.**

**There is difference in mortality rate in the different states and allowance should be made after discussing with the actuarial community.**

## Author

Sonjai is working with Sahara India Life Insurance Company as Deputy Manager (Actuarial). He has done MA in Mathematics from University of Delhi and Post Graduate Diploma in Actuarial Management from City University, London. He is a student member of Actuarial Society of India and writing actuarial examinations.

## Mortality Variations by age for sixteen states

Age group 35-40 yrs



Age group 40-45 yrs



Age group 45-50 yrs



Age group 50-55 yrs



Age group 55-60 yrs



Age group 60-65 yrs



Age group 65-70 yrs

List of states used in the above graphs in the same order.

| S.No. | States |
|---|---|
| 1 | qxAP |
| 2 | qxAssam |
| 3 | qxBihar |
| 4 | qxGujarat |
| 5 | qxHaryana |
| 6 | qxHP |
| 7 | qxKarnatak |
| 8 | qxKerala |
| 9 | qxMp |
| 10 | qxMaharashtra |
| 11 | qxOrissa |
| 12 | qxPunjab |
| 13 | qxRajasthan |
| 14 | qxTN |
| 15 | qxUP |
| 16 | qxWB |