MORTALITY TRANSITION IN INDIA 1970-2005

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ABSTRACT

Using the life tables prepared on the basis of the Sample Registration System, this paper attempts to analyse mortality transition in India during the period 1970 through 2005. The analysis reveals that the rise in the expectation of life at birth in India has at best been slow by global standards despite the fact the mortality levels in India are still high. Improvement in the expectation of life at birth has been particularly slow in the urban areas of the country. The analysis also reveals that the rate of improvement in the probability of survival in the first five years of life has decelerated over time and, in females, this probability has decreased instead of increasing in recent years. There has also been a considerable slow down in the decline in the entropy of life table, especially female life table in recent years which indicates that the shift in the concentration of deaths towards older ages has slowed down considerably. Hastening the pace of mortality transition in India requires a pragmatic, multi-dimensional approach which is missing at present. There is a need to emphasise substantive health care rather than the formal, institution based care.

KEY WORDS
India, mortality, expectation of life at birth, survival probability, life table, entropy.

1. INTRODUCTION

This paper attempts to analyse transition in mortality in India during the 35 years between 1970 through 2005. The primary objective of the paper is to highlight salient features of changes in age patterns of mortality in India and in its constituent states that have taken place in the recent past. Transition in mortality reflects improvements in the quality of life through improvements in health and nutritional status of the people and, therefore, is a necessary requirement for improvements in the standards of living (United Nations, 1973). Analysis of mortality also contributes to the evolution of the health policy. Ideally, there should be congruence between transition in mortality and evolution of the health policy as health policy has a direct reflection on the levels and trends in mortality. On the other hand, evolution of health policy should essentially be a response to the health status of the population as reflected in terms of changes in mortality. It is well known that with the improvements in the health status of the population, the disease profile changes, there is a shift in the patterns of causes of death and a transition in the age pattern of mortality. Evolution of the health policy, therefore, should also be a response to mortality transition resulting from the improved health status of the people.

The paper is organised as follows. The next section of the paper describes the methodology used in the analysis while the third section describes the data source. Mortality levels and trends in India as reflected through the expectation of life at birth are discussed in section four. The fifth section of the paper estimates and analyses trends and differentials in the probability of survival up to age 70 and decomposes this change into the change in age-specific survival probabilities. The effect of change in the probability of survival on the change in the expectation of life at birth has been analysed in the sixth section of the paper while policy implications of the prevailing trends in mortality have been discussed in section seven.

2. METHODOLOGY

The expectation of life at birth is the most widely used indicator for analysing mortality transition. It gives the number of years a new born is expected to survive, on average, given the prevailing age schedule of mortality (Pollard, 1982). The relationship between mortality transition and improvements in expectation of life at birth is essentially reciprocal but the exact connection is not straightforward (Vaupal and Romo, 2003). Since mortality transition varies by age, any analysis of mortality transition requires examination of changes in the age-specific mortality rates and how changes in mortality at different ages contribute to the change in mortality all ages combined. Such an analysis results in numerous comparative indexes which may be grouped into two categories: aggregative index such as directly standardised mortality rates that reflect absolute difference between corresponding age-specific mortality rates; and average of relative indexes which reflect proportional difference between these rates (Schoen, 1970). Spiegelman (1966) and Kitagawa (1964) have examined a number of suggested mortality indexes and discussed there advantages and drawbacks. Kitagawa (1966) has found that use of different indexes of mortality may provide different picture of mortality transition over time. In case of aggregative indexes, there are problems of choosing appropriate standard population and various factors involved in the selection of the standard are of appreciable significance (Speigelman and Marks, 1966). On the other hand, there is no widely accepted average of relative index that is intuitively simple, easy to calculate,

expressive of underlying mortality function and independent of the choice of the 'standard' population. It therefore seems reasonable to focus attention on differences in the pattern of death rates over the whole age spectrum (Schoen, 1970).

Analysis of mortality transition, considering the whole age spectrum, can be done in different ways. The common approach is to analyse changes in the expectation of life at birth and to decompose the change in the expectation of life at birth into the change in the expectation of life at different ages (Pollard, 1982; United Nations, 1982). Such analyses have been carried out for India in the past by Chandrasekaran (1949, 1986), Gupta (1972) and Navaneetham (1993), and by the author (Alok Ranjan, 1993). The author has recently used this approach to analyse mortality transition in urban India (Alok Ranjan, 2006). Ponnapalli (2005) has reviewed different methods of decomposition and has concluded that all methods give exactly the same result.

Another approach to analysing mortality transition using the whole age spectrum is the parameterisation of the age schedule of mortality by means of a mathematical representation or fitting a mathematical model to the age schedule of mortality. The first attempt, in this direction was apparently by DeMoivre around the year 1725, who suggested that the probability of survival from birth to a given age could be expressed as a linear function of age (Keyfitz, 1982). A more realistic representation for the pattern of mortality in adult ages was offered by Gompertz (1825) but a realistic expression for mortality covering the entire life span was given by Thiele (1872). Following Thiele's decomposition approach, Heligman and Pollard (1980) suggested a mathematical representation of age schedule of mortality which has been applied widely. The Heligman- Pollard Model of mortality has been applied by McNown and Rogers (1989) and Rogers and Gard (1991) for the time series analysis of mortality decline in United States of America. Ranjan (1994) has applied the model for the analysis of mortality transition in India.

The third way of analysing mortality transition is to analyse how the rate of change in age specific mortality rates translates into the rate of improvement in the expectation of life at birth (Keyfitz, 1977) or to the rate of improvement in the probability of survival up to a given age (Shyrock and Siegel, 1976). The dynamic relationship between the probability of survival and life expectancy can be approximated by the quantity 'H' developed by Keyfitz (1977) and referred as entropy or information in the life table by Demetrius (1976). In terms of standard life table notations, 'H' is minus the mean value of *ln(a)*, weighted by *l(a)* Keyfitz (1977; 1985). In other words

$$H = \int_0^{\omega}[\ln(a)]l(a)da \,/\, \int_0^{\omega} l(a)da \qquad (1)$$

Entropy (H) is also interpreted as a measure of heterogeneity of a population with respect to mortality at different ages (Vaupel, 1986). With the decline in mortality, an increasing proportion of deaths gets concentrated in old ages and so the survival curve becomes increasingly rectangular. The change in the shape of the survival curve as the result of transition in mortality can be captured through entropy. In this way, entropy (H) measures the impact of changes in the age-specific mortality rates on the expectation of life at birth (Demetrius, 1979; Goldman and Lord, 1986; Keyfitz, 1977; 1985). In its most simple conceptualisation, entropy (H) gives the proportional change in the expectation of life at birth as the result of a 1 per cent reduction in the force of mortality at all ages. The value of H depends directly upon the concavity of the survivorship curve. If everyone dies at the same age, H=0; if the force of mortality is the same at all ages, H=1. When the

force of mortality declines linearly with age, the value of H lies halfway between the values described above, i.e., H= ½. A high level of entropy implies that the deaths are widely dispersed over the entire age range. When entropy is low, the dispersion of deaths by age is small which means that deaths are concentrated in a very narrow age range (Glei and Horiuchi, 2007; Nusselder and Makenbach, 1996; Wilmoth and Horiuchi, 1999). An important result from the formal demography is that the decline in mortality in the presence of high level of entropy is associated with a very rapid increase in the expectation of life at birth. The reason is that a high proportion of deaths averted would have occurred among infants and young children. Since the mortality risk in adolescence and in young adulthood are relative low, mortality decline in the youngest ages yields a much higher return in terms of the expectation of life at birth than mortality decline in older ages (Wilmoth, 2001).

Entropy may also be interpreted as the rate at which lives are lost relative to life expectancy (Smith, 1992). Approximately

$$H = \sum_{x} {}_{n}d_{x}e_{x+(1/2)n} / ({}_{\omega}d_{0}e_{0}) = \sum_{x} {}_{n}d_{x}e_{x+(1/2)n} / (l_{0}e_{0}) \quad (2)$$

Empirical evidence suggests that historic rise in the expectation of life at birth was accompanied by large reduction in entropy. Increase in life expectancy from 55 years in 1940 to 74 years in 1981 in United States was associated with a decrease in entropy 0.37 to 0.16 (Goldman and Lord, 1986). In Sweden, entropy decreased from 0.772 to 0.157 as male life expectancy increased from 33.7 years in 1800 to 72.7 years in 1980 (Vaupel, 1986).

Probability of survival up to a given age is another indicator widely used for analysing mortality transition. It is well known (Shyrock and Siegel, 1976) that

$${}_{a}p_{0} = \prod_{i=1}^{a} {}_{1}p_{i-1} \quad (3)$$

where p is the survival probability and i represents age. This implies that

$$\nabla {}_{a}p_{0} = \ln({}_{a}p_{0}^{2} / {}_{a}p_{0}^{1}) = \sum_{i=1}^{a} \ln({}_{1}p_{i-1}^{2} / {}_{1}p_{i-1}^{1}) \quad (4)$$

where the superscript denotes time. It is now easy to show that

$$\nabla {}_{a}p_{0} = \sum_{i=1}^{a} \nabla {}_{1}p_{i-1} \quad (5)$$

which suggests that the logarithmic change in the probability of survival up to age a is the sum of the logarithmic change in the survival probability in ages less than and equal to a. One advantage of using the logarithmic change is that there is no interaction term. This is in quite contrast to the arithmetic difference in the probability of survival which leaves a number of interaction terms. The interaction effects are more difficult to interpret. It is because of this difficulty in interpretation, the usual practice is to reallocate the interaction effects among the main effects (Dasgupta, 1993).

3. DATA SOURCE

The analysis is based on life tables constructed on the basis of the information generated through the Sample Registration System which is a large scale demographic survey that provides annual estimates of key demographic indicators at national and sub-national levels (Government of India, 2008). Initiated in 1964-65, the system is now operational throughout the country. The sample, under the system, is replaced at a period of 10 years based on the latest sample frame in a staggered manner and the information about demographic events is collected through a dual record procedure consisting of

continuous enumeration by resident part time enumerators and independent survey at an interval of six months. Data obtained from the two independent sources are matched and unmatched and partially matched events are re-verified. In the year 2004, the sample under the system consisted of 7597 (4433 rural and 3164 urban) sampling units covering a population of 1.3 million households and 6.93 million population.

Estimates of age-specific death rates are available through the sample registration system for the 30-year period from 1971-75 through 2001-05 for India and for its major states (states with a population of at least 20 million at the 2001 population census) by sex for the total population as well as separately for rural and urban areas. These estimates have been used in the present analysis.

Estimates available through the Sample Registration System are generally believed to be quite accurate, although they are known to be associated with year-to-year fluctuations because of non-sampling errors or unknown origin and some under-reporting. An investigation conducted in 1980-81 suggested an omission rate of 3.1 per cent in the system at the all India level (Government of India, 1983a). Another enquiry conducted in 1985 suggested that omission rate had decreased to 1.8 per cent, although omission rates varied from state to state (Government of India, 1988). To eliminate the random fluctuations associated with estimates available through the system, five-year moving average age specific death rates are used for the construction of life tables.

One problem in using the life tables available through the Sample Registration System is that they are based on different methodologies of converting the observed age-specific death rates to the life table function ${}_nq_x$. The life tables for the period 1971-75 through 1981-85 are based on Greville's method of converting the age specific death rates into the age specific probabilities of death (Greville, 1948). Life tables for the period 1986-90 onwards, on the other hand, are prepared by using the MortPak-Lite software package developed by the Unite Nations (United Nations, 1988). The methodology of MortPak-Lite software package uses a different approach of converting the observed age-specific death rates to the life table function ${}_nq_x$ than Greville's approach. In order to eliminate the discrepancy resulting from using different methods of converting the age-specific death rates in age-specific probabilities of death, we have recalculated the life tables for the period 1971-75 through 1981-85 by using the MortPak-Lite software package for the purpose of the analysis. The discrepancy has however been found to be small and so does not have any substantial impact on the analysis.

4. MORTALITY TRANSITION IN INDIA

1. Expectation of Life at Birth. According to the Sample Registration System, the expectation of life at birth in India increased from 49.7 years during 1970-75 (Government of India, 1984) to 63.2 years during 2001-05 (Government of India, 2008) which means that average life of an Indian increased by about 13.5 years over a period of 30 years. The increase in the average life of a male (11.8 years) was, however, slower than that of a female (14.9 years). Similarly, increase in the expectation of life at birth had been more rapid in rural (13.8 years) as compared to urban areas (9.6 years). Increase in the female expectation of life at birth has also been more rapid than the increase in the male expectation of life at birth in both rural and urban areas. In the urban areas of the country, the male expectation of life at birth increased by only about 8 years compared to

an increase of about 11 years in females during the 30 years period between 1970 and 2005.

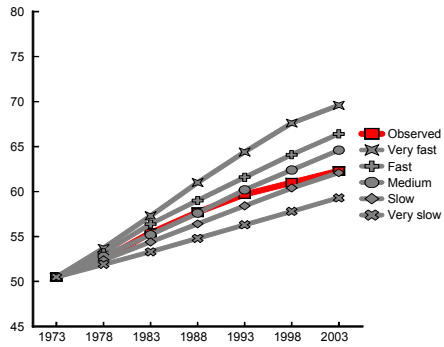
It is possible to characterise the change in the expectation of life at birth in India by comparing actual increase in the expectation of life at birth with the global model mortality improvement schedules developed by the United Nations (United Nations, 2004). The Population Division of the United Nations has developed five model mortality improvement schedules on the basis of the empirical evidence about the increase in the expectation of life at birth during the period 1950 to 2005 in countries where the expectation of life at birth ranged between 50 to 85 years. These model mortality improvement schedules represent the average experience of improvements in mortality and are grouped according to 90^{th} percentile (very fast increase), 75^{th} percentile (fast increase), the arithmetic mean (medium increase), 25^{th} percentile (slow increase), and 10^{th} percentile (very slow increase). The model schedules so obtained have then been extended to cover the expectation of life at birth ranging from 40 years to 92.5 years by fitting the Lee-Carter mortality model (United Nations, 2004a).

Figure 1 compares the trend in the expectation of life at birth in India with the model mortality schedules developed by the United Nations. The figure suggests that the improvement in the expectation of life at birth in India followed the medium trajectory of model mortality schedules till 1986-90 but after 1986-90, improvements in the expectation of life at birth slowed down so that during the period 2001-05, the male expectation of life at birth followed the slow trajectory of the model mortality schedule of the United Nations. The female expectation of life at birth, on the other hand, followed very fast and fast trajectory of model mortality schedules till 1991-95 but the pace of improvement slowed thereafter so that during the period 2001-05, it followed the medium trajectory of the model mortality schedules.

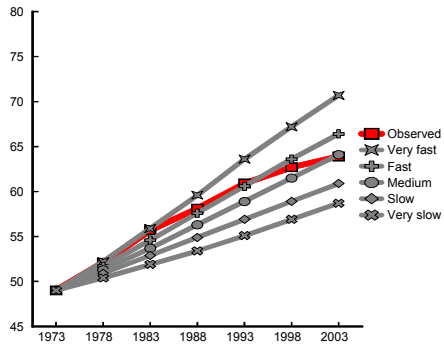
The trend in the male life expectancy has been very similar in the combined population and in rural areas but the female life expectancy in the rural areas of the country followed very fast to fast trajectory till the period 1991-95 and slowed down thereafter. In the urban areas, on the other hand, transition was very slow during 1970-75 through 1976-80, accelerated during 1976-80 through 1981-85, but decelerated again during 1981-85 through 1986-90. After 1986-90, the expectation of life at birth in the urban areas of the country followed the slow trajectory of model mortality schedules.

Figure 1
Trends in the expectation of life at birth in India, 1970-2005

Total Population

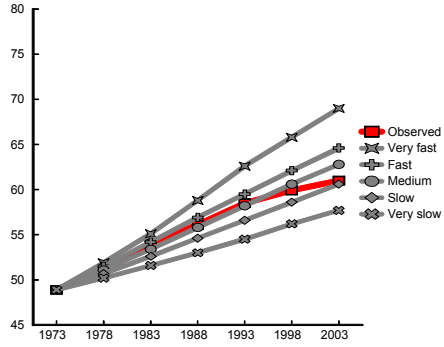


Male

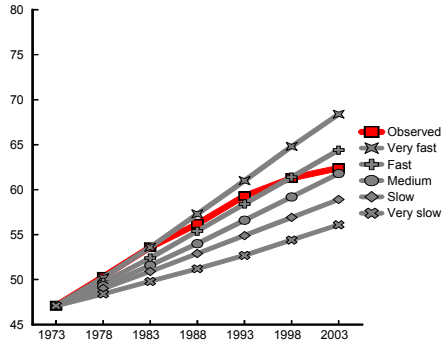


Female

Rural Population

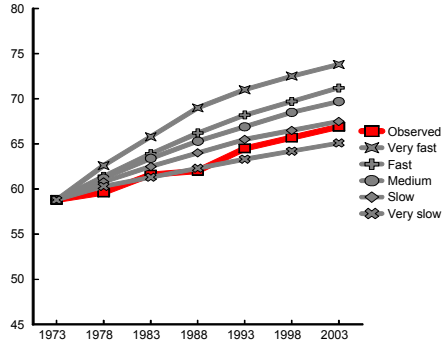


Male

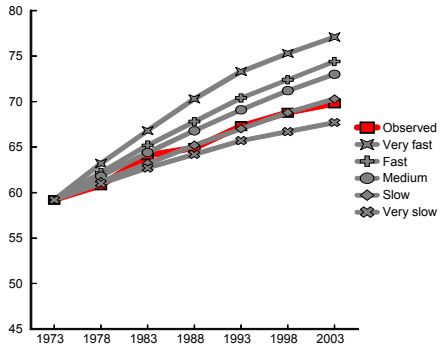


Female

Urban Population



Male



Female

Gain in the expectation of life at birth also varied widely across the states. Improvement in the male life expectancy was the highest in Tamil Nadu but slowest in Haryana during the period under reference. In case of female life expectancy, the improvement was the highest in Uttar Pradesh but lowest in West Bengal. A comparison with the model mortality improvement schedules indicates that, in case of males, only two states - Kerala and Tamil Nadu - while in case of females, only four states - Himachal Pradesh, Kerala, Tamil Nadu and Uttar Pradesh - followed the fast trajectory. In Bihar, Haryana, Karnataka, Madhya Pradesh and West Bengal, increase in both male and female expectation of life at birth followed the very slow trajectory of model mortality schedules during the period under reference.

2. Probability of Survival. The probability of survival up to age 70 in India is given in table 3. Survival probability beyond 70 years of age could not be calculated because the life tables available through the Sample Registration System are limited to 70 years only. Moreover, the expectation of life at birth in India is still well below 70 years so that the probability of survival up to age 70 covers the variability in almost entire spectrum of age specific mortality except mortality beyond 70 years for which death rates are not available through the Sample Registration System.

The probability of survival up to age 70 in India was around 32 per cent during 1970-75 and increased to around 53 per cent 2001-05. Thus the probability of survival up to age 70 in India improved by about 62 per cent during the 30 years between 1970-75 and 2001-05, at an average annual rate of 1.65 per cent per year. This improvement has been faster in rural (1.70 per cent per year on average) as compared to urban areas (1.17 per cent per year) and for females (1.783 per cent per year) as compared to males (1.474 per cent per year). Improvement in the probability of survival up to age 70 has been the slowest for urban males (1.1 per cent per year) and fastest for rural females (1.90 per cent per year) during the 30 years under reference. As the result, the female-male gap in the probability of survival up to 70 years of age has widened over time.

Improvement in the probability of survival up to age 70 was the most rapid during the period 1976-80 to 1981-85. Since then, the improvement decelerated continuously till 1991-95 to 1996-2000. It was during the period 1996-2000 through 2001-05 that the improvement accelerated again. The deceleration in the improvement in the probability of survival up to age 70 has primarily resulted from slower improvement in survival probability in the first five years of age as well as in ages 45 years and above. On the other hand, acceleration in the improvement in the survival probability up to age 70 during the period 1996-2000 through 2001-05 has been the result of improvement in survival probability in ages 45 years and above.

Table 4 decomposes the change in the probability of survival up to age 70 into changes in survival probability in different age groups. More than 80 per cent of the improvement in the probability of survival up to age 70 between 1970-75 through 2001-05 has been the result of the improvement in survival probability in ages 45 and above (58 per cent) and in the first five years (25 per cent). Improvement in the probability of survival at ages 15-45 accounted for less than 20 per cent of the improvement in the probability of survival up to age 70. Although survival probability in the age group 15-45 years is very high compared to the survival probability in younger and older ages, it is low by international standards.

A very discerning feature of mortality transition in India is that improvement in the probability of survival in the first five years of life decelerated sharply since 1976-80 and during the period 1996-2000 to 2001-05, it actually decreased instead of improving. The reason is that the probability of survival in the age group 1-5 years decreased during this period as where there has been improvement in the probability of survival in the first year of life. This decrease in the probability of survival in the age group 1-5 years has been very sharp in females so that the female probability of survival decreased during the period 1996-2000 through 2001-05. This decrease was not so sharp in males so that the male survival probability in the first five years of life continued to improve during the period 1996-2000 through 2001-05.

Among the constituent states of India, probability of survival up to age 70 was highest in Kerala and lowest in Madhya Pradesh circa 2001-05. There are only two states in India - Kerala and Punjab - where more than 60 per cent of the birth cohort was expected to survive up to 70 years when subjected to age specific mortality rates that prevailed during the period 2001-05. In Assam, Madhya Pradesh, Orissa and Uttar Pradesh, this proportion was less than 50 per cent. Improvement in the probability of survival up to age 70 during the period 1970-75 through 2001-05 also varied across the states (Figure 4). In general, is the lower the probability of survival during the period 1970-75, the higher is the improvement during the period 1970-2005. Exceptions to this pattern are Madhya Pradesh, Haryana, Punjab and Andhra Pradesh. In Madhya Pradesh, this improvement has been found to be exceptionally slow despite very low levels in this probability during the period 1970-75. In Andhra Pradesh, on the other hand, improvement in this probability has been the fastest despite the fact that the probability of survival up to age 70 was very high during the period 1970-75 in the state.

Decomposition of the change in probability of survival up to 70 years of age into changes in survival probability in different age groups for different states of the country is given in Table 6. In all states, most of the improvement has been the result of the improvement in the survival probability in very young ages (0-5 years) and very old ages (60-70 years). In Haryana and Punjab, this proportion has been more than 80 per cent but in Assam, Karnataka and Madhya Pradesh, it was less than 60 per cent. In general, the contribution of the age group 60-70 years has been higher than that of the age group 0-5 years, with the gap being widest in Orissa and Assam. However, in Gujarat, Madhya Pradesh, Punjab and Uttar Pradesh, the contribution of the age group 0-5 years has been more than that of the age group 60-70 years with the widest gap in Punjab where most of the improvement in the probability of survival up to 70 years of age during the period under reference has been the result of the improvement in the probability of survival in first five years of age.

3. Survival Probability and Life Expectancy. How has improvement in the survival probability influenced the expectation of life at birth? To answer this question, we calculated life table entropy (H) on the basis of formula (2) and the results are presented in table 7. The life table entropy, in India, decreased from 0.458 during 1970-75 to 0.291 during 2001-05. This means that one per cent reduction in the force of mortality in all ages resulted in an increase in the expectation of life at birth by about 0.46 per cent during 1970-76 but only about 0.29 per cent during 2001-05. In the rural areas, a reduction of 1 per cent in the force of mortality at all ages resulted in an increase of about 0.48 per cent in the expectation of life at birth during 1970-75, compared to only 0.31 per

cent during 2001-05. The corresponding increase in the urban areas was 0.33 per cent and 0.24 per cent respectively.

The rate of decline in entropy reflects the rate at which deaths get concentrated at the older ages as the result of transition in mortality. If the rate of decline in entropy is slow, then the rate at which deaths get concentrated at the older ages is also slow. It may be seen from table 7 that transition in mortality in India was the fastest during the period 1976-80 through 1981-85. Since then, the rate of decline in entropy has decelerated rapidly, indicating a slowing of mortality transition.

It may also be seen from table 7, that the rate of decline in entropy has been faster in rural than in urban areas. Similarly, the decrease in entropy has also been faster in females than in males till the period 1996-2000. Because of the relatively faster decline in entropy, the expectation of life at birth increased at a faster rate in the rural areas as compared to urban areas and in females as compared to males. However, the trend appears to have reversed after 1996-2000 so that the gain in the expectation of life at birth during the period 1996-2000 through 2001-05 was higher in the urban areas as compared to rural areas and in males as compared to females. The relatively faster transition in mortality in the urban areas and in males after 1996-2000 appears to have widened the rural-urban and male-female disparity in the expectation of life at birth.

Among the constituent states of the country, life table entropy varied widely currently as well as in the past (Table 8). During the period 2001-05, Kerala was the only state in the country where life table entropy was less than 0.20. A value of entropy higher than 0.20 suggests that the distribution of deaths by age has a high degree of dispersion across the life span with a substantially large proportion of deaths still occurring in young and adult ages. In Maharashtra, Tamil Nadu and Himachal Pradesh, life table entropy varied from 0.20 to 0.25. By contrast, highest life table entropy has been estimated in Madhya Pradesh. In Assam, Bihar, Orissa, Rajasthan and Uttar Pradesh, the life table entropy has been estimated to be more than 0.300, which indicates that deaths in these states are fairly spread over the life span and are not confined to old ages, thus indicating that they are not very far along in mortality transition.

The rate of change in life table entropy has also varied widely across states. The average annual rate of decline in life table entropy during the period 1970-75 through 2001-05 has been the fastest in Tamil Nadu closely followed by Uttar Pradesh and Gujarat. By contrast, this rate has been the slowest in Haryana followed by Punjab where life table entropy declined at an average annual rate of less than 1 per cent during the period under reference. A slow decline in life table entropy indicates that the pace of ractangularisation of the survival curve remains or the decrease in the dispersion of deaths across the life span remains slow. In other words, a substantial proportion of deaths continue to take place in young and adult ages.

Madhya Pradesh deserves special attention here as far as mortality transition during the period under reference is concerned. The rate of decline in life table entropy has been very slow in the state during this period. At the same time, the rate of improvement in the expectation of life at birth as well as in the probability of survival up to age 70 has also been very slow. All these trends clearly indicate that mortality transition in Madhya Pradesh has been the slowest in India during the period under review despite the fact that the expectation of life at birth in Madhya Pradesh was amongst the lowest in India during the period 1970-75. The very slow transition in

mortality in Madhya Pradesh is also reflected by the rank of the state in the expectation of life at birth vis-à-vis other states of India. During the period 1970-75, Madhya Pradesh was ranked fourth lowest in terms of the expectation of life at birth among the major states of the country - next to Uttar Pradesh, Orissa and Assam (Government of India, 1984). During the period 2001-05, Madhya Pradesh was ranked the lowest of all (Government of India, 2008).

What explains the inter-state variations in mortality transition? There is no clear explanation. Mortality transition has not only varied across states but also between sexes in many states. Transition has been fast by international standards in Kerala and Tamil Nadu for males and in Kerala, Tamil Nadu, Himachal Pradesh and Uttar Pradesh for females. Kerala, Tamil Nadu and Himachal Pradesh are comparatively developed states but mortality transition, especially female mortality transition in Uttar Pradesh appears to be most remarkable as it remains one of the least developed states of the country. Similarly, male mortality transition in Karnataka, one of the developed states, has remained very slow. In Kerala and Tamil Nadu, an advanced stage of development may be argued to be the factor behind a faster transition in mortality but the same cannot be argued in Uttar Pradesh. Similarly, the observed very slow mortality transition in Karnataka cannot be attributed to the level of development of the state. It appears that there are state specific factors and conditions that determine the pace of mortality transition in different states. There is however little exploration of these factors.

The foregoing analysis suggests that mortality transition has slowed down considerably in India in recent years and considerable inter-state disparity continue to persist. Mortality transition has been characterised as a shift from high and fluctuating mortality to low and stable mortality (Namboodiri, 1996). There are at least three stages of mortality transition based on the experience of mortality decline in the developed countries. The first stage comprises of lowering peaks of mortality. In the developed countries, this was achieved primarily through improved food supply and overall living standards and to a lesser degree through medical progress, sanitation and organised public health activities (Namboodiri, 1996).

The second stage of mortality transition is characterised by sustained decline in mortality primarily as the result of public health measures, universal availability of safe drinking water and sanitation facilities, food hygiene, etc. (McKeown, 1976). Finally, the third stage of mortality transition comprised of a shift in the primary causes of mortality from infectious and parasitic diseases to degenerative diseases and diseases of human origin (Omaran, 1977).

In India, like most of the developing countries, mortality transition has largely been the result of public health measures based on the low cost appropriate medical technology such as immunisation and oral rehydration therapy. There has been little substantial investment in health infrastructure that played a critical role in sustained decline in mortality in the developed countries. The health care system in India still lacks cohesiveness and is largely fragmented. It appears that because of the weak health care delivery system, gains in mortality that were accrued as the result of the introduction of the low cost appropriate technology could not be sustained. It is in this context that we briefly review the evolution of the health care system in India.

5 EVOLUTION OF HEALTH CARE SYSTEM IN INDIA

Although evolution of the concepts and principles of health care in India dates back to times immemorial, systematic evolution of health care system in India begun only during the colonial period. Before the British rule in India, the concepts and principles of health care in India were rooted in *Ayurveda* which is widely believed to have evolved during the *Vedic* period. References to diseases, herbs and herbal cures can be found in all the four *Vedas*, especially in the *Rig Veda* while *Atharva Veda* has many hymns eulogising herbs. *Ayurveda* is one of the few traditional systems of medicine that contains a sophisticated system of surgery. It deals with both preventive and curative aspects of the health in a comprehensive manner and presents a close similarity with the concept of health propounded by the World Health Organisation.

Although *Ayurvedic* practices became part and parcel of the life of every Indian during the medieval period, yet, there is little evidence of the evolution of public health care system. The practice of *Ayurveda* was largely an individual prerogative, although there were supposedly institutions for training. Meeting health needs of the people did not appear to be the state priority at that time.

During the colonial period, efforts to evolve public health care system in India followed two divergent paths. The first path, followed by the colonial powers, consisted of imposing western allopathic system of medicine over *Ayurveda* as a way of asserting their over centuries old Indian tradition. First reference, in this context, dates back to 1859 when a Royal Commission was constituted to enquire health of the army in India. This Commission recommended measures for both army and civil population which constituted the basis for establishing Commissions of Public Health in the provinces of Madras, Bombay and Bengal in 1864. Subsequently, the Plague Commission, constituted after the outbreak of Plague in 1896, recommended strengthening public health care system and establishment of laboratories for research.

Any real attempt to evolve a comprehensive public health care system in India could be made only in 1943 when the first Health Survey and Development Committee was appointed to make (a) broad survey of the present position in regard to health conditions and health organisations, and (b) recommendations for future development. The Committee recommended a long-term and a short-term plan for developing public health care system (Government of India, 1946). The short-term plan comprised of establishing a primary unit for every 40 thousand population having 30 beds with 2 medical Officers, 4 Public Health Nurses and 4 midwives besides other staff. The long-term plan, on the other hand, envisaged a primary unity for every 20 thousand population having 75 beds with 6 Medical Officers, 6 public health nurses besides 78 other staff. The primary units are to be supported by secondary and district health care units. The Committee was, however, conspicuously silent about *Ayurveda.*

The second path was followed by the nationalist forces who advocated revival of *Ayurveda.* In 1916, Members of the Imperial Legislative Councils pressed the Government to accept *Ayurveda* as the basis for the development of public health care system. Increasing pressure of nationalist forces forced the British government in 1940 to enforce the Drugs and Cosmetics Act for Ayurvedic/Siddha/Unani medicines also. In 1946, the Chopra Committee recommended that indigenous and the western systems of medicine should be combined to evolve an integrated system.

After Independence, recommendations of the first Health Survey and Development Committee became the basis for the evolution of public health care system

in the country. However, only a significantly scaled down network of primary health centres could be created. Each primary health centre, at that time, served a population of 65-75 thousand had 6 beds capacity and only 1 Medical Officer and 4 midwives besides other hospital staff. Each primary health centre was linked to 3 sub-health centres each having a midwife as the only service provider.

The inadequacy of the primary health centre in meeting health needs of the people was highlighted way back in 1959 (Government of India, 1962) but there has been little change. Even today, a primary health centre has 6 beds and is staffed by one Medical Officer and other supporting staff. The bed-population ratio at the primary health centre level is 1:5000 against a norm of 2:1000 recommended by Bhore's Committee and 5:1000 recommended by the World Health Organisation.

A population based norm is followed for establishing primary health care institutions. These norms do not take into consideration the geographical concentration of population which has implications for services delivery. For example, population density in Kerala is substantially higher than that in Madhya Pradesh. This implies that a female health worker is to travel more and cover a larger geographic area in Madhya Pradesh than in Kerala to provide services to 5000 people as provided in the norms. Obviously, other things being equal, delivery of health services in Madhya Pradesh is more constrained than that in Kerala.

The basic approach towards meeting the health needs of the people in India has been the primary health care approach (WHO, 1978). Assisted by the low cost appropriate health technology, this approach has largely succeeded in lowering peaks of mortality generally associated with episodes of infectious diseases. In order to sustain the decline in mortality, it is imperative that attention is given to continuous long term care. There is, however, little adaption of primary health care approach in this regard.

The western, allopathic system of medicine, however, is yet to become the system of medicine for Indian masses. The hospital-based health care delivery is essentially contrary to the popular Indian psyche that has strong footings in home-based care. Moreover, the western allopathic system has always been treated as an elite system for the ruling class. The situation is compounded further by limited expansion of the system. Even today, the health care delivery infrastructure in the country, especially in the rural areas is, at best, fragmentary. It has grossly overlooked *Ayurveda.* At the same time, there has been a near total neglect of urban health care needs. In the rural areas, a three tier primary health care delivery system has been evolved, at least conceptually but no such system exists in the urban areas. The neglect of the urban health care is very well reflected in the slow to very slow transition in urban mortality as reflected in the present analysis.

Some of the salient features of the evolution of public health care delivery system in India are as under:

1. There has been little integration of the indigenous system, *Ayurveda*, and the western allopathic system of medicine.
2. There has been sheer lack of the information necessary for health policy and planning and development of public health care delivery system.
3. The framework laid down by the first Health Survey and Development Committee has remained the basis for the evolution of the public health care

system. There has been little attempt to evolve an alternative system of health care delivery.

4. Evolution of the public health care system was limited to the strengthening of health infrastructure. Psycho-social and behavioural aspects of health and health care have virtually been ignored.
5. There has been little effort to evolve state specific public health care system taking into account specific health needs of the state.
6. There is little regulation of the health care delivery services either in the public or in the private sector
7. There has been little attempt to project the future health needs in the context of future population growth, projected changes in population structure and distribution of the population and transition in the health status.

The policy response to these and many other issues related to meeting the health needs of the people of India has at best been lukewarm. Although, concern about health, especially of women and children, has always been a priority agenda in the Five-year Development Plans of the country, a specific health policy could be evolved only in 1983 which did not provide any operational framework for the delivery of health care (Government of India, 1983). The 1983 policy was replaced by an updated policy in the year 2002 (Government of India, 2002). The new policy focuses on increasing access to decentralised public health system, although it is silent about the expansion of the public health care system. There is hardly any attempt to examine up to what extent, the primary health care system, conceived almost 50 years ago has been able to reach millions of Indian people living in rural and remote areas.

A major obstacle in the formulation of evidence-based health policy in India is the lack of health information, especially at the grass roots level. Government of India runs the medical certification of the cause of death scheme to get information about the causes of death but its implementation remains grossly inadequate. The scheme was supposed to be operational in 13,697 public hospitals of the country in 1998 but only 3,096 public hospitals actually submitted their reports. At the national level, less than 15 per cent of the registered deaths were medically certified in the year 1998 with wide inter-state variations (Government of India, 2004). Availability of information related to morbidity is even worse. Probably, the best source of information on morbidity may be out-patient records but no system of collecting and analysing this information has been evolved.

Current efforts towards mortality reduction in India have primarily been focussed on medical determinants of mortality. Very little attention has been paid to non-medical determinants and how they are addressed by the public health care system. After all, a certain minimum threshold of development is necessary even for the low cost appropriate health technology to be effective in addressing people's health needs.

In order to address these and many other problems of the public health care system, Government of India launched the National Rural Health Mission in the year 2005 (Government of India, 2005). The Mission aims at transforming the public health care delivery system into an accountable, accessible and affordable system of quality health care services. One can hope that the Mission will contribute to hastening the pace of mortality transition in the country.

6. IMPLICATIONS OF MORTALITY TRANSITION FOR HEALTH POLICY

On the basis of the foregoing analysis, it is possible to summarise implications of mortality transition for the health policy in India.

- The first and foremost policy requirement is the evolution of a community-based health information system that can be the basis for evidence-based policy formulation and evolution of the public health care system. This system must be able to measure health and analyse its determinants right up to the grass roots level.
- The second requirement through a policy perspective is the decentralisation of the public health care system so that it can address the health needs of the people more effectively. Ideally, health policy should focus on promoting local level collective health action by building the capacity of the people and their organizations at the grass roots level, supporting local level collective health action by creating and sustaining community partnerships, and providing health system support in the form of affordable high quality hospital-based services through secondary and tertiary health care institutions in either the public or the private sector.
- The third policy imperative is to expand and revamp the primary health care delivery system so that it can provide continuous long term care. This is necessary as the survival curve is getting more and more rectangular leading to the concentration of deaths in older ages where main causes of death are not infectious and parasitic diseases but degenerative diseases.
- The fourth imperative for the health policy is the evolution of the primary health care delivery system in the urban areas of the country. This is important as the urban population in the country is increasing at a rapid rate and the primary health care system is unable the health needs of the majority of the urban poor who do not have the means to meet the cost of private health care.

It is also important from the policy perspective that the concept of health should be promoted in a substantive and not in a formal context as has been the tradition so far. In the formal context, the concept of health is linked to institution-based care. In the substantive context, health is linked to the interaction between the man and his environment. Formal health care has strong underpinnings in medical technology whereas substantive health care has roots in individual, family and social behaviour. There is a needs to strike a balance between the two. health needs of the people cannot be met by just focussing upon the formal health care. Moreover, the cost of formal health care may be very high simply because it is institution based. Strengthening formal health care is directly related to creating, strengthening and expanding health care institutions. However, in the absence of substantive health care, these institutions may remain unaccepted by the people at large and hence underutilised.

7. CONCLUSIONS

The analysis presented here paints a bleak picture of mortality transition in India in the recent past. Mortality levels in the country continue to be high by international standards, and the mortality transition has decelerated.

Main conclusions of the analysis presented in the foregoing pages can be summarised as follows:

- The expectation of life at birth in India was around 62 years during the period 2001-05. This shows that, by international standards, India has still to go a long way as far as transition in mortality is concerned.
- The rise in the expectation of life at birth in India during the 30 years from 1970-75 through 2001-05 has been slow. There are also indications that transition in mortality has slowed down in recent years. This has especially been the case in the urban areas.
- Most of the improvement in mortality appears to be confined to the older ages - ages 40 years and above. A more serious concern is that improvement in the probability of survival in the first five years of life has decelerated and, among females, it appears to have decreased among females, in recent years.
- The speed of transition in mortality or the pace of rectangularisation of the survival curve has slowed down over the years. This also shows that mortality transition in India has slowed down despite the fact that mortality remains high by global standards.
- In recent years, mortality transition appears to be faster in males and in urban areas whereas in the past, mortality transition has been faster in rural areas and in females.
- There has been little transition in the mortality of the adult population compared to the transition in mortality in young and old ages.
- There are significant inter-state variations. Mortality transition has been quite fast in states which are at advanced stage of transition as well as in some states where mortality is still high. At the same time there are states where mortality transition has been very slow despite high levels of mortality currently as well as in the past.
- Madhya Pradesh appears to be the deviant state of the country in terms of mortality transition. Despite very high levels of mortality during 1970-75, the transition in mortality in this state has been the second slowest in the country.
- The health care delivery system in the country remains fragmentary and unable to meet most of the health needs of the people. The approach to health care needs a reinvigoration with a focus on substantive health care rather than the formal health care. The recently launched National Rural Health Mission is directed towards architectural corrections in the public health care delivery system so that the system can address the health needs of the people in an accountable, accessible and affordable manner, although the Mission approach remains traditional, institution-based approach with little emphasis on substantive health care.

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Table 1: Expectation of life at birth in India, 1970-2005.

Period	Expectation of life at birth			Absolute increase		
	Total	Male	Female	Total	Male	Female
			Combined Population			
1970-75	49.7	50.5	49			
1976-80	52.3	52.5	52.1	2.6	2	3.1
1981-85	55.4	55.4	55.7	3.1	2.9	3.6
1986-90	57.7	57.7	58.1	2.3	2.3	2.4
1991-95	60.3	59.7	60.9	2.6	2	2.8
1996-2000	61.9	61	62.7	1.6	1.3	1.8
2001-05	63.2	62.3	63.9	1.3	1.3	1.2
Increase				13.5	11.8	14.9
Type of increase					Slow	Medium
			Rural Population			
1970-75	48	48.9	47.1			
1976-80	50.6	51	50.3	2.6	2.1	3.2
1981-85	53.7	54	53.6	3.1	3	3.3
1986-90	56.1	56.1	56.2	2.4	2.1	2.6
1991-95	58.9	58.5	59.3	2.8	2.4	3.1
1996-2000	60.7	59.9	61.3	1.8	1.4	2
2001-05	61.8	61	62.4	1.1	1.1	1.1
Increase				13.8	12.1	15.3
Type of increase					Slow	Medium
			Urban Population			
1970-75	58.9	58.8	59.2			
1976-80	60.1	59.6	60.8	1.2	0.8	1.6
1981-85	62.8	61.6	64.1	2.7	2	3.3
1986-90	63.4	62	64.9	0.6	0.4	0.8
1991-95	65.9	64.5	67.3	2.5	2.5	2.4
1996-2000	67.3	65.7	68.8	1.4	1.2	1.5
2001-05	68.5	66.9	69.8	1.2	1.2	1
Increase				9.6	8.1	10.6
Type of increase					Very slow	Very slow

Source: Government of India, 2008

Table 2: Increase in the expectation of life at birth in Indian states.

State	Expectation of life at birth (Male)			Type of increase	Expectation of life at birth (Female)			Type of increase
	1970-75	2001-05	Increase		1970-75	2001-05	Increase	
Andhra Pradesh	48.4	62.7	14.3	Medium	49.3	65.2	15.9	Medium
Assam	46.2	58.3	12.1	Slow	44.8	59.0	14.2	Medium
Bihar	54.2	62.0	7.8	Very slow	51.5	60.1	8.6	Very slow
Gujarat	48.8	62.8	14.0	Medium	48.8	65.0	16.2	Medium
Haryana	59.0	65.6	6.6	Very slow	55.6	66.0	10.4	Very slow
Himachal Pradesh	54.8	66.3	11.5	Slow	50.9	67.1	16.2	Fast
Karnataka	55.4	63.4	8.0	Very slow	55.1	66.9	11.8	Slow
Kerala	60.8	71.3	10.5	Fast	63.3	76.3	13.0	Fast
Madhya Pradesh	47.6	57.8	10.2	Very slow	46.3	57.5	11.2	Very slow
Maharashtra	53.3	65.8	12.5	Slow	54.5	68.1	13.6	Slow
Orissa	46.0	59.2	13.2	Medium	45.3	59.2	13.9	Medium
Punjab	59.0	68.1	9.1	Slow	56.8	70.1	13.3	Slow
Rajasthan	49.2	61.2	12.0	Slow	47.5	62.2	14.7	Medium
Tamil Nadu	49.6	64.8	15.2	Fast	49.6	67.1	17.5	Fast
Uttar Pradesh	45.4	60.1	14.7	Medium	40.5	59.3	18.8	Fast
West Bengal	56.8	63.9	7.1	Very slow	58.0	65.5	7.5	Very slow

Source: Government of India, 2008

Table 3: Probability of survival up to age 70 in India, 1970-2005.

Period	Total Population			Rural Population			Urban Population		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
1970-75	0.322	0.315	0.334	0.305	0.299	0.312	0.424	0.399	0.457
1976-80	0.356	0.335	0.378	0.337	0.318	0.357	0.448	0.417	0.485
1981-85	0.405	0.382	0.430	0.385	0.366	0.406	0.487	0.450	0.530
1986-90	0.440	0.414	0.471	0.423	0.400	0.449	0.504	0.458	0.555
1991-95	0.475	0.442	0.510	0.456	0.426	0.488	0.551	0.507	0.601
1996-2000	0.497	0.460	0.535	0.478	0.440	0.514	0.569	0.526	0.617
2001-05	0.529	0.490	0.570	0.509	0.469	0.548	0.601	0.555	0.649
	Average Annual Rate of Change								
1970-75/1976-80	1.993	1.244	2.470	1.948	1.264	2.677	1.123	0.859	1.174
1976-80/1981-85	2.567	2.631	2.579	2.713	2.802	2.590	1.642	1.516	1.796
1981-85/1986-90	1.677	1.623	1.846	1.864	1.760	2.012	0.693	0.347	0.921
1986-90/1991-95	1.532	1.316	1.593	1.482	1.249	1.629	1.783	2.059	1.565
1991-95/1996-2000	0.892	0.767	0.941	0.950	0.680	1.077	0.663	0.718	0.537
1996-2000/2001-05	1.260	1.264	1.268	1.256	1.260	1.277	1.087	1.102	1.018
1970-75/2001-05	1.654	1.474	1.783	1.702	1.502	1.877	1.165	1.100	1.169

Table 4: Decomposition of the rate of improvement in probability of survival up to 70 years of age into rate of improvement in probability of survival in different age groups.

Period	Age group															
	0-1	1-5	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	*0-70*
								Total								
1970-75/1976-80	0.193	0.225	0.080	0.025	0.027	0.037	0.035	0.073	0.094	0.042	0.169	0.238	0.153	0.201	0.400	*1.993*
1976-80/1981-85	0.448	0.337	0.044	0.017	0.024	0.049	0.036	0.038	0.062	0.099	0.082	0.156	0.323	0.367	0.486	*2.567*
1981-85/1986-90	0.308	0.249	0.064	0.023	0.014	0.008	0.019	0.051	0.042	0.057	0.066	0.134	0.133	0.305	0.203	*1.677*
1986-90/1991-95	0.224	0.315	0.059	0.012	0.020	0.015	0.013	-0.008	0.023	0.050	0.055	0.075	0.110	0.212	0.356	*1.532*
1991-95/1996-2000	0.180	0.106	0.040	0.018	0.015	0.036	0.017	0.013	0.001	-0.003	0.023	0.024	0.034	0.147	0.240	*0.892*
1996-2000/2001-05	0.136	-0.174	0.049	0.014	0.019	0.012	0.022	0.015	0.016	0.052	0.071	0.180	0.193	0.264	0.391	*1.260*
1970-75/2001-05	*0.248*	*0.176*	*0.056*	*0.018*	*0.020*	*0.026*	*0.024*	*0.030*	*0.040*	*0.050*	*0.078*	*0.135*	*0.158*	*0.249*	*0.346*	*1.654*
								Rural								
1970-75/1976-80	0.161	0.262	0.083	0.025	0.035	0.048	0.043	0.079	0.092	0.041	0.185	0.123	0.171	0.174	0.426	*1.948*
1976-80/1981-85	0.505	0.341	0.037	0.019	0.023	0.020	0.033	0.035	0.065	0.107	0.069	0.191	0.340	0.414	0.513	*2.713*
1981-85/1986-90	0.285	0.279	0.075	0.024	0.015	0.034	0.029	0.058	0.043	0.049	0.076	0.146	0.166	0.313	0.270	*1.864*
1986-90/1991-95	0.313	0.369	0.065	0.014	0.020	0.022	0.011	-0.009	0.025	0.054	0.038	0.048	0.054	0.186	0.270	*1.482*
1991-95/1996-2000	0.183	0.159	0.052	0.017	0.017	0.041	0.024	0.021	0.005	-0.009	0.021	0.019	0.042	0.114	0.244	*0.950*
1996-2000/2001-05	0.127	-0.222	0.050	0.018	0.022	0.007	0.018	0.010	0.013	0.064	0.070	0.204	0.178	0.279	0.418	*1.256*
1970-75/2001-05	*0.262*	*0.198*	*0.060*	*0.020*	*0.022*	*0.029*	*0.026*	*0.032*	*0.041*	*0.051*	*0.077*	*0.122*	*0.158*	*0.247*	*0.357*	*1.702*
								Urban								
1970-75/1976-80	0.318	-0.076	0.069	0.025	0.003	-0.003	0.001	0.029	0.090	0.011	0.078	0.035	0.068	0.286	0.189	*1.123*
1976-80/1981-85	0.229	0.205	0.033	-0.001	0.012	0.049	0.028	0.042	0.035	0.066	0.127	0.145	0.196	0.140	0.334	*1.642*
1981-85/1986-90	0.124	0.138	0.016	0.018	0.012	0.002	0.001	0.023	0.029	0.075	0.029	0.080	-0.001	0.254	-0.106	*0.693*
1986-90/1991-95	0.098	0.116	0.031	0.000	0.019	-0.005	0.004	-0.011	0.015	0.023	0.099	0.148	0.308	0.273	0.665	*1.783*
1991-95/1996-2000	0.168	0.029	0.008	0.021	0.003	0.022	-0.002	-0.005	-0.013	0.015	0.014	0.035	-0.022	0.172	0.217	*0.663*
1996-2000/2001-05	0.095	-0.146	0.035	-0.001	0.011	0.018	0.024	0.022	0.020	0.009	0.062	0.094	0.227	0.243	0.373	*1.087*
1970-75/2001-05	*0.172*	*0.044*	*0.032*	*0.010*	*0.010*	*0.014*	*0.009*	*0.017*	*0.029*	*0.033*	*0.068*	*0.090*	*0.129*	*0.228*	*0.279*	*1.165*

Source: Author's calculations

Table 5: Inter-state variations in the probability of survival up to age 70 in India, 2001-05.

	Trend			Differentials					
State	2001-05	1970-75	Rate of increase (percent)	Male	Female	M-F	Rural	Urban	R-U
Andhra Pradesh	0.532	0.290	2.027	0.478	0.589	-0.111	0.513	0.594	-0.081
Assam	0.434	0.208	2.445	0.404	0.469	-0.065	0.417	0.563	-0.146
Bihar	0.512	na	na	0.514	0.507	0.007	0.502	0.590	-0.088
Gujarat	0.550	0.327	1.737	0.501	0.602	-0.101	0.532	0.585	-0.053
Haryana	0.585	0.480	0.654	0.535	0.642	-0.107	0.580	0.604	-0.024
Himachal Pradesh	0.601	na	na	0.565	0.639	-0.074	0.598	0.650	-0.052
Karnataka	0.560	0.383	1.261	0.500	0.625	-0.125	0.535	0.621	-0.086
Kerala	0.687	0.499	1.066	0.606	0.773	-0.167	0.686	0.692	-0.006
Madhya Pradesh	0.461	0.312	1.306	0.428	0.496	-0.068	0.445	0.535	-0.090
Maharashtra	0.586	0.372	1.513	0.542	0.633	-0.091	0.564	0.628	-0.064
Orissa	0.470	0.237	2.282	0.448	0.493	-0.045	0.460	0.563	-0.103
Punjab	0.613	0.501	0.669	0.577	0.651	-0.074	0.605	0.630	-0.025
Rajasthan	0.542	0.315	1.810	0.504	0.594	-0.090	0.531	0.602	-0.071
Tamil Nadu	0.561	0.292	2.183	0.525	0.600	-0.075	0.531	0.625	-0.094
Uttar Pradesh	0.486	0.265	2.019	0.467	0.503	-0.036	0.473	0.544	-0.071
West Bengal	0.556	na	na	0.522	0.596	-0.074	0.531	0.624	-0.093

Source: Author's calculations.

Table 6: Decomposition of the rate of improvement in probability of survival up to 70 years of age into rate of improvement in probability of survival in different age groups in Indian states.

Period	Age group															
	0-1	1-5	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	*0-70*
Andhra Pradesh	0.181	0.243	0.076	0.026	0.028	0.033	0.043	0.037	0.052	0.066	0.098	0.162	0.189	0.372	0.422	2.027
Assam	0.211	0.169	0.069	0.189	0.027	0.023	0.033	0.054	0.046	0.108	0.133	0.163	0.281	0.461	0.479	2.445
Bihar	Not available															
Gujarat	0.297	0.274	0.041	0.013	0.018	0.024	0.020	0.033	0.037	0.053	0.091	0.129	0.177	0.266	0.265	1.737
Haryana	0.089	0.143	0.034	0.017	0.011	0.012	0.007	0.017	0.017	0.006	-0.001	0.017	-0.009	0.177	0.118	0.654
Himachal Pradesh	Not available															
Karnataka	0.110	0.158	0.051	0.024	0.023	0.022	0.018	0.020	0.026	0.038	0.058	0.087	0.196	0.168	0.263	1.261
Kerala	0.155	0.124	0.033	0.009	0.010	0.013	0.014	0.021	0.023	0.035	0.050	0.066	0.092	0.127	0.295	1.066
Madhya Pradesh	0.196	0.229	0.044	0.022	0.017	0.028	0.026	0.022	0.030	0.040	0.082	0.108	0.130	0.171	0.162	1.306
Maharashtra	0.210	0.203	0.048	0.013	0.014	0.020	0.017	0.017	0.017	0.038	0.047	0.098	0.146	0.240	0.387	1.513
Orissa	0.216	0.173	0.070	0.028	0.030	0.033	0.024	0.054	0.065	0.068	0.101	0.156	0.247	0.392	0.624	2.282
Punjab	0.195	0.159	0.023	0.012	0.008	0.014	0.010	0.010	0.010	0.001	0.015	0.016	-0.005	0.039	0.164	0.669
Rajasthan	0.198	0.259	0.061	0.019	0.018	0.032	0.028	0.029	0.041	0.052	0.082	0.130	0.225	0.270	0.367	1.810
Tamil Nadu	0.259	0.247	0.063	0.022	0.028	0.032	0.037	0.040	0.048	0.058	0.102	0.166	0.230	0.369	0.483	2.183
Uttar Pradesh	0.353	0.431	0.083	0.016	0.022	0.019	0.021	0.016	0.026	0.033	0.079	0.144	0.165	0.294	0.316	2.019
West Bengal	Not available															

Source: Author's calculations

Table 7: Life table entropy in India 1970-2005.

State	Total			Rural			Urban		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Degree of entropy									
1970-75	0.458	0.434	0.479	0.484	0.459	0.510	0.333	0.318	0.333
1976-80	0.427	0.408	0.444	0.454	0.431	0.473	0.313	0.305	0.318
1981-85	0.379	0.366	0.392	0.404	0.386	0.421	0.286	0.286	0.281
1986-90	0.341	0.328	0.345	0.365	0.352	0.374	0.261	0.264	0.256
1991-95	0.312	0.306	0.316	0.328	0.320	0.335	0.253	0.255	0.246
1996-2000	0.296	0.291	0.299	0.309	0.303	0.312	0.246	0.246	0.237
2001-05	0.291	0.282	0.297	0.307	0.295	0.311	0.243	0.240	0.238
Average annual rate of decrease									
1970-75/1976-80	-1.405	-1.234	-1.527	-1.296	-1.261	-1.504	-1.214	-0.852	-0.938
1976-80/1981-85	-2.368	-2.197	-2.510	-2.327	-2.183	-2.330	-1.840	-1.326	-2.481
1981-85/1986-90	-2.123	-2.194	-2.510	-2.055	-1.862	-2.365	-1.760	-1.598	-1.863
1986-90/1991-95	-1.777	-1.390	-1.758	-2.114	-1.931	-2.186	-0.676	-0.668	-0.795
1991-95/1996-2000	-1.038	-0.964	-1.103	-1.203	-1.096	-1.460	-0.550	-0.717	-0.704
1996-2000/2001-05	-0.358	-0.611	-0.181	-0.108	-0.529	-0.047	-0.236	-0.515	0.055
1970-75/2001-05	-1.512	-1.432	-1.598	-1.517	-1.477	-1.649	-1.046	-0.946	-1.121

Source: Author's calculations.

Table 8: Entropy in the life table of Indian states.

State	1970-75			2001-05			Rate of change		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Andhra Pradesh	0.456	0.453	0.457	0.275	0.288	0.258	-1.690	-1.509	-1.911
Assam	0.527	0.484	0.496	0.330	0.325	0.335	-1.564	-1.333	-1.308
Bihar	na	na	na	0.320	0.311	0.340	na	na	na
Gujarat	0.482	0.462	0.501	0.261	0.263	0.256	-2.044	-1.880	-2.232
Haryana	0.370	0.342	0.403	0.284	0.277	0.287	-0.888	-0.693	-1.126
Himachal Pradesh	na	na	na	0.244	0.255	0.233	na	na	na
Karnataka	0.383	0.371	0.394	0.258	0.262	0.248	-1.318	-1.159	-1.548
Kerala	0.267	0.278	0.254	0.172	0.203	0.146	-1.455	-1.042	-1.834
Madhya Pradesh	0.521	0.509	0.534	0.346	0.342	0.350	-1.371	-1.330	-1.408
Maharashtra	0.382	0.381	0.380	0.236	0.246	0.223	-1.612	-1.461	-1.781
Orissa	0.487	0.477	0.498	0.326	0.326	0.326	-1.337	-1.265	-1.411
Punjab	0.347	0.325	0.372	0.258	0.266	0.251	-0.991	-0.672	-1.305
Rajasthan	0.492	0.457	0.528	0.302	0.298	0.304	-1.625	-1.424	-1.837
Tamil Nadu	0.438	0.435	0.441	0.233	0.246	0.219	-2.096	-1.903	-2.325
Uttar Pradesh	0.599	0.532	0.675	0.320	0.306	0.334	-2.090	-1.841	-2.345
West Bengal	na	na	na	0.262	0.266	0.255	na	na	na

Source: Author's calculations.