# Trends in geographical mortality differentials in India

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## Abstract

Present study attempts to examine the variation of mortality among different regions in India by using Sample Registration System (SRS) data. As evaluation of SRS data quality confirms good quality of data for children and adult ages, we restrict our analysis below age 60. Temporary life expectancy between the exact ages 0 and 60 years shows after a spectacular progress during the 1970s &1980s, improvements in longevity have almost halted in the 1990s and 2000s. Gini coefficient and dispersion measure of mortality confirm the convergence of mortality across the regions in India during 1971-75 to 2001-04. In addition, decomposition of temporary life expectancy by age group 0-14 & 15-59 shows improvement of temporary life expectancy is basically for the reduction of infant and child mortality. Nevertheless, contribution both young and adult age group to improve mortality condition have been reduced which needs further attention of researchers and policy makers.

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## 1. Introduction

Health inequalities between and within countries is a matter of growing concern internationally (Marmot, 2005). In 2001-05, the life expectancy at birth for a females living in urban Kerala was 76.7 year whereas the corresponding figure for females in rural Madhya Pradesh was only 56.0 years (ORG, 2006). Thus, the maximal regional life expectancy gap in India constituted about 21 years! Life expectancy differentials are even more striking in case of socio-economic status as the mortality burden falls disproportionately on economically disadvantaged and lower-caste groups (Subrmanian et al. 2006; Dyson & Moore, 1983).

What is known about regional mortality variation in India? First, many authors observe a clear north-south demographic division which is reflected by almost all demographic indicators including infant and child mortality (Dyson and Moore, 1983). Some recent studies confirm that excess female child mortality in India varies considerably across regions reaching its highest levels in north (Arokiasamy, 2004; Subramanian et al. 2006). Much less is known about principal regularities of regional differentials in all age mortality and, especially, in adult mortality. In his fundamental study on mortality trends and patterns in India, Bhat (1987) found that although southern states show significantly lower levels of child mortality, adult mortality appears to be somewhat lower in the northern states, particularly in the north-western parts of the country. The study also confirmed that regional differentiation in adult mortality is significantly smaller than that of child mortality. He also found that there is a notable variation across the states in the speed of mortality reductions: the fastest decline in mortality between 1951-1961 and 1971-1981 occurred in southern state of Karnataka, whereas the slowest progress during the same period was observed in eastern state of Orissa (Bhat, 1987).

The lack of studies on all age and adult mortality in India and many other developing countries can be explained by several specific problems related to the registration of adult mortality. In general, reliable mortality statistics require fully functioning vital registration systems. However, the registers ensuring good coverage of vital events are missing in India (Malaker, 1986; Bhat, 1987). Therefore, retrospective demographic and health surveys have been seen as a good alternative for measuring mortality. However, these surveys may provide reliable information only about infant and children mortality, whereas obtaining information about adult deaths is often problematic. First, adult deaths are relatively rare events, and a very big sample size is therefore needed to provide a precise mortality estimates. Second, information about child deaths is mainly provided by their mothers or guardians. At the same time, information about adult deaths in some cases cannot be reported due to a lack of informant or may be reported by variety of informants which increases the probability of a bias. Finally, it seems to be a lack of interest among researchers in India to explore possibilities of existing data and address the growing importance of mortality at adult or old ages.

The present study attempts to fill the research gap in studies on all age mortality variation across the regions in India in several ways. First, the study uses data from the Sample Registration System (SRS) which is unique source of information providing representative and the most complete data on mortality across all ages in India (National Population Commission, 2001). We address data quality issues by performing systematic data plausibility checks and by comparing the SRS data to the respective figures from National Family Health Survey (NFHS) and other surveys. We also assess the accuracy of old age mortality estimates by fitting a parametric (Gompertz) mortality model. Second, we examine time trends in temporary life expectancy between the exact ages 0 and 60 in 16 states of India from the early 1970s until 2001-2005. Using dispersion measure of mortality and Gini coefficients, we analyze the changes in inter-regional variability over time. Finally, we estimate the contributions of child and adult mortality to the total changes in temporary life expectancy in different states of India.

## 2. Data source

The study is based on mortality estimates calculated according to the Sample Registration System data. The system was initiated by the Office of the Registrar General, India with a goal to generate reliable and continuous data on demographic indicators. Introduced as a pilot scheme in some selected states in 1964-65, the SRS was converted into a full scale system in 1969-70.

This SRS is based on a dual record system. This system involves continuous enumeration of births and deaths in a sample of villages/urban blocks by a resident (part time) enumerator. In addition, at the end of each six months period, a retrospective survey is being conducted by a full time supervisor. The data obtained through these two sources are matched. The unmatched and partially matched events are re-verified in the field to obtain their unduplicated count. The advantage of this procedure, in addition to elimination of errors of duplication, is that it leads to a quantitative assessment of the sources of distortion in the two sets of records making it a self evaluating technique.

The sampling units of SRS are replaced periodically using the results of the latest census report. Once a sample unit is included in the system, a complete census is taken and this forms the baseline data for the sample population. In short, the sequence of the Sample Registration System is performed by completing the following steps:

- Base-line survey of the sample units to obtain usual resident population of the sample areas (population exposed to death)
- Continuous (longitudinal) enumeration of vital events pertaining to usual resident population by the enumerator
- Independent retrospective half-yearly surveys for recording births and deaths which occurred during the half-year under reference and up-dating the House list, Household schedule and the list of women in the reproductive age group along with their pregnancy status by the Supervisor
- Matching of events recorded during continuous enumeration and those listed in course of half-yearly survey
- Field verification of unmatched and partially matched events.

In order to check the quality of data from SRS, information from the Demographic and Health Survey of India, commonly known as National Family Health Survey (NFHS) is utilized in this paper (Macro Int. IIPS & ORC Macro, 1995, 2000 & 2007). NFHS is a large scale, cross sectional, multi-round survey conducted in a nationally representative sample of households throughout India. The three rounds of NFHS have been conducted during 1992-93, 1998-99 and 2005-06 (IIPS 1995; IIPS & ORC Macro, 2000; IIPS & ORC Macro, 2007). In each state, the rural sample was selected in two stages, with the selection of Primary Sampling Units (PSUs), which are villages, with the probability of selection proportional to their population sizes (PPS) at the first stage, followed by a random selection of households within each PSU at the second stage. In urban areas, a three-stage procedure was performed; first, wards were selected with PPS sampling, secondly, one census enumeration block (CEB) was randomly selected from each sample ward and lastly, households were selected randomly within each selected CEB. The NFHS sample size varies from one round to another (89,777 ever-married women of age 13-49 in NFHS I; 91,000 ever-married women of age 15-49 in NFHS II; 124,385 ever-married women of age 15-49 and 74,369 men of age 15-54 in NFHS III). NFHS I & II collected information on mortality both from women and household questionnaires. Questionnaire for women asked all women of age 15-49 to provide complete histories of given births that included for each live l birth, the sex, month and year of birth, current survival status of the child, and child's age at the time of the survey or child's age at death. This information was used to calculate the direct estimates of infant and child mortality. In addition, household questionnaire provided information about the deaths among usual residents which are taken place within two years before the survey. The household head or any other able adult member was responsible for providing information about the sex, age at death, date of death, and cause of death. The complete procedure of calculating death rates is described in the NFHS reports (IIPS, 1995; IIPS & ORC Macro, 2000). The procedure was the same in case of the NFHS III for under-five mortality but this round of NFHS does not provide information on death among other members of the household. Thus given the difference in the structure and sample designs of SRS and NFHS, it is sensible to compare the mortality data of these two sources to check the concordance between them.

The region of residence in India has particular importance in the demographic performance of the residents. Appendix 3 summarizes certain socio-economic and demographic characteristics of the regions. Although Hindu and Muslim are two main religions at the national level, some states have also considerable percentages of population of other religions. The latter include Christianity, Sikh, Buddhism, Jain, and other. There is a significant variability according to religion across the states. For example, the percentage of Hindu population varies from 95 percent in Himachal Pradesh to 56 percent in Kerala and 36 percent in Punjab. Variation in literacy rate is also very notable ranging from 47 percent in Bihar to 91 percent in Kerala. Scheduled Castes (SC) and Scheduled Tribes (ST) are Indian population groupings that are explicitly recognized as a socially distressed group of the society by the Constitution of India. This classification is based on ethnicity of the person and constitution of India has given these castes special status for upward socio-economic mobility. Scheduled Castes (SC) and Scheduled Tribes (ST) together comprise over 24 percent of India's population. The populations of Madhya Pradesh and Orissa show higher percentages of socially disadvantaged groups. Similarly, total fertility rates and infant mortality show considerably variation across the states. All southern states have reached below replacement level of fertility whereas states like Bihar and Uttar Pradesh are far from the replacement level. Infant mortality rates vary from 73 per 1000 live births in Uttar Pradesh to 15 per 1000 live births in Kerala in 2005-2006. Percentage of population living below the poverty line has also wide variation from five percent in Punjab to forty percent in Orissa.

The analysis is, therefore, based on 16 states of India representing the five major geographical regions of the country:

1) Haryana, Himachal Pradesh, Punjab, Rajasthan (North)
2) Uttar Pradesh, Madhya Pradesh (Center)
3) Assam, Bihar and West Bengal (East)
4) Gujarat and Maharashtra (West)
5) Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu (South).

## 3. Data quality

### 3.1. Coverage by the Sample Registration System

Since the coverage by civil registration system is incomplete, sample registration system (SRS) is considered to be one of the most reliable systems for vital statistics for India (National Commission on Population, 2001). In the past, there have been some direct attempts to evaluate the completeness of vital events reported in the SRS by matching the events recorded in an intensive enquiry with those recorded in the regular phase. Results of such investigations conducted in 1980-81 suggested an omission rate for the whole India of 3.1 percent for births and 3.3 percent for deaths (RGI, India, 1983b). A similar enquiry conducted in1985 suggested that omission rates decreased to 1.8 percent for births and 2.5 percent for deaths (RGI, India, 1988). The State level estimation of under-enumeration of vital events showed that under enumeration levels are relatively higher in Assam, Karnataka, Rajasthan and Uttar Pradesh. Unfortunately, since 1985, no direct attempt has been made to evaluate the completeness of the SRS.

Applying modified version of the Bennett-Horiuchi method, Bhat (2001) found that completeness of death registration above the age of 5 years has deteriorated from 99 percent for both sexes in 1971-81 to 87 percent for males and 86 percent for females in 1990-97. However, these findings were not confirmed by independent checks using growth rates of population censuses. Another weakness of this study was a strong assumption about closed population. The application of the generalized growth balance method is more justifiable in a country like India where population is yet to be stable and open for migration. The results based on this method suggest that overall completeness of death registration for all ages during 1971-80 was 94 percent for males and 91 percent for females (Bhat, 2002). The completeness varied across the states from a low of 84 percent among females in Karnataka to 100 percent among males in Kerala and Gujarat and females in Madhya Pradesh (Bhat, 2002).

During 1971-1991, the completeness of death registration among males remained at about the same level of about 95 percent. But among females, the completeness deteriorated from about 91 percent in 1971-80 to 88 percent in 1981-91. In particular such worsening in the quality of registration was notable in Punjab, Haryana, and Uttar Pradesh in the northern part of India and in the western states of Gujarat and Maharashtra (Bhat, 2002).

### 3.2. Plausibility of mortality estimates at different ages

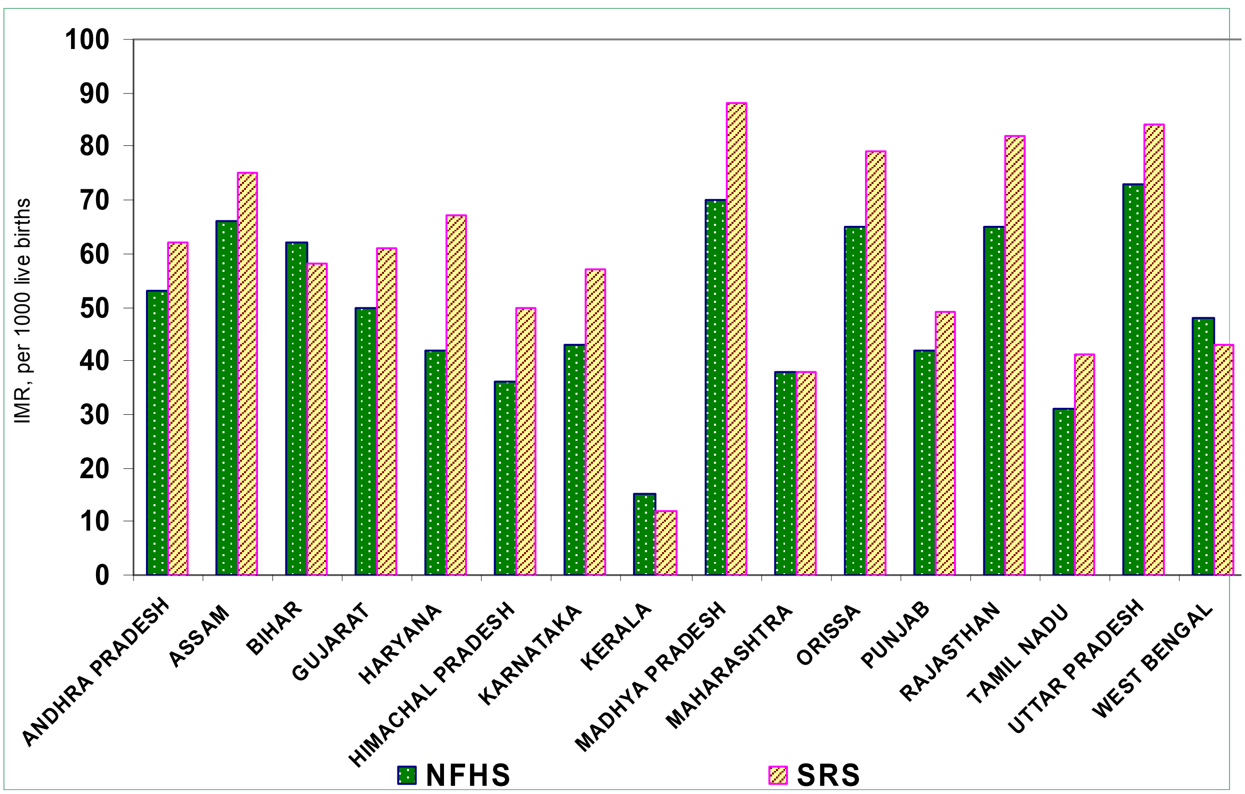
Considerable difference may exist in the degree of completeness of death registration by different age groups. As death of an adult member of a family usually cause serious consequences on the economic and psychological conditions on the remaining members of the family, the death registration at adult ages is generally sought as more reliable than in any other age group. As mentioned earlier, mortality rates for different age groups by sex and type of residence from SRS are being compared with the corresponding NFHS figures.

To evaluate the quality of data as a whole, it is very necessary to assess the completeness of infant and child death because registering a death during the early period of life is sensitive to various issues, for instance, restrictive definition of live birth, recall lapse in retrospective surveys, age misstatement, underreporting of deaths due to psychological reasons of parents etc. (Anderson & Silver, 1986). Some previous studies criticize the infant mortality from SRS during early seventies (1972-74) because of misclassification of stillbirth and early neonatal death (Bhat, 1998). Table 1 depicts infant mortality rate by type of residence from the three rounds of National Family Health Survey and SRS, India during the period 1981-2006 (IIPS, 1995; IIPS &ORC Macro, 2000; IIPS & ORC Macro, 2007). The level of agreement in infant mortality between the SRS and NFHS appears to be good. The coverage of infant deaths seems to be more complete in SRS than in NFHS for all and rural residents. The concordance level between these two sources is generally good over the period 1991-2006, with the only exception of the case of urban residents in 1996-2000. To better understand the concordance between the two sources in different geographical regions, we plotted infant mortality rates from SRS (2002-06) and NFHS

III (refers to infant mortality rate covering 0-4 year period before the survey) for fifteen major states in India (Figure 1). The NFHS III values provide infant mortality rates covering four year period before the survey.

It can be seen that for the most of the states (excluding Bihar, Kerala and West Bengal) infant mortality rates from SRS are slightly higher than the corresponding figures according to NFHS (Figure 1). This suggests that the SRS-based estimates of infant mortality are plausible. It can also be assumed that coverage of infant deaths across the states by SRS is as good or even better than NFHS.

**Fig. 1 Comparison of infant mortality rates from NFHS III[1] (for the period 2001-05) and SRS (2002-06), 16 states of India**




[1] NFHS infant mortality rates come from the ,NFHS III conducted 2005-06 and refer to infant mortality rates covering 0-4 years before the survey.

Sources: IIPS & ORC Macro, 2007

## Table 1 Comparison of infant mortality rates between SRS and NFHS by type of residence (per 1000 live births)

| | NFHS | SRS |
|---|---|---|
| | **NFHS III (2005-06)** | |
| **Place/Period** | **2002-05** | **2002-06** |
| Urban | 41 | 39 |
| Rural | 62 | 69 |
| Total | 57 | 62 |
| | **1996-00** | **1996-00** |
| Urban | 55 | 45 |
| Rural | 78 | 78 |
| Total | 72 | 72 |
| | **1991-95** | **1991-95** |
| Urban | 53 | 53 |
| Rural | 86 | 86 |
| Total | 77 | 80 |
| | **NFHS II (1997-98)** | |
| | **1994-97** | **1995** |
| Urban | 47 | 48 |
| Rural | 73 | 80 |
| Total | 68 | 74 |
| | **1989-93** | **1991-93** |
| Urban | 51 | 50 |
| Rural | 86 | 85 |
| Total | 78 | 78 |
| | **1984-88** | **1986-88** |
| Urban | 65 | 61 |
| Rural | 93 | 104 |
| Total | 86 | 94 |
| | **NFHS I (1992-93)** | |
| | **1989-92** | **1991** |
| Urban | 56 | 53 |
| Rural | 85 | 87 |
| Total | 79 | 80 |
| | **1984-88** | **1985** |
| Urban | 62 | 59 |
| Rural | 103 | 107 |
| Total | 94 | 97 |
| | **1979-83** | **1981** |
| Urban | 69 | 63 |
| Rural | 111 | 119 |
| Total | 101 | 110 |

Source: Reports by the Registrar General, India & IIPS & ORC Macro, 2007 - exact data source is needed!

Comparisons of age-specific death rates between SRS and NFHS are given in Appendixes 1 & 2. Once again, there is a good concordance between the two sources. In addition, the coverage of SRS seems to be better for most of the age groups. The disagreement between the two sources becomes visible only after the age 60.

Like in other developing countries, age misreporting is quite common in India (Bhat, 1987). As far as census data are concerned, age misstatement is the most important problem for application of indirect estimation methods in India (Bhat, 1987). This is because most Indians have imprecise knowledge of their age and what gets recorded in a census is usually an educated guess of enumerator or of the respondent. Analysis of age distributions of population counts according to the census and according to the SRS shows that age exaggeration is more common among males than females. On the contrary, females are more likely to understate their age (Bhat, 1987).

Previous studies found discrepancy of age distributions between SRS and censuses, in particular, the age distributions by SRS show significantly lower proportions of population at old ages (Bhat, 1987). Bhat (1987) explains this discrepancy by several factors such as sampling and other errors. However, the qualitative difference in age reporting between the SRS baseline survey and censuses is the most probable cause leading to this discrepancy. However, numerous checks of plausibility of age distributions suggest that the SRS data are more reliable (Bhat, 1987).

### 3.3. Plausibility of old age mortality estimates: a comparison with the Gompertz model

There is much direct and indirect evidence that ages of older persons tend to be misreported in both census and death records. The ages of older people are more likely to be exaggerated rather than understated resulting in too high proportions of survivors at the oldest ages. This, in general, leads to underestimation of mortality rates at old ages and in turn, overestimation of expectation of life, unless ages at death are exaggerated considerably more than ages of living persons, and thus tend to inflate mortality (Horiuchi & Coale, 1982).

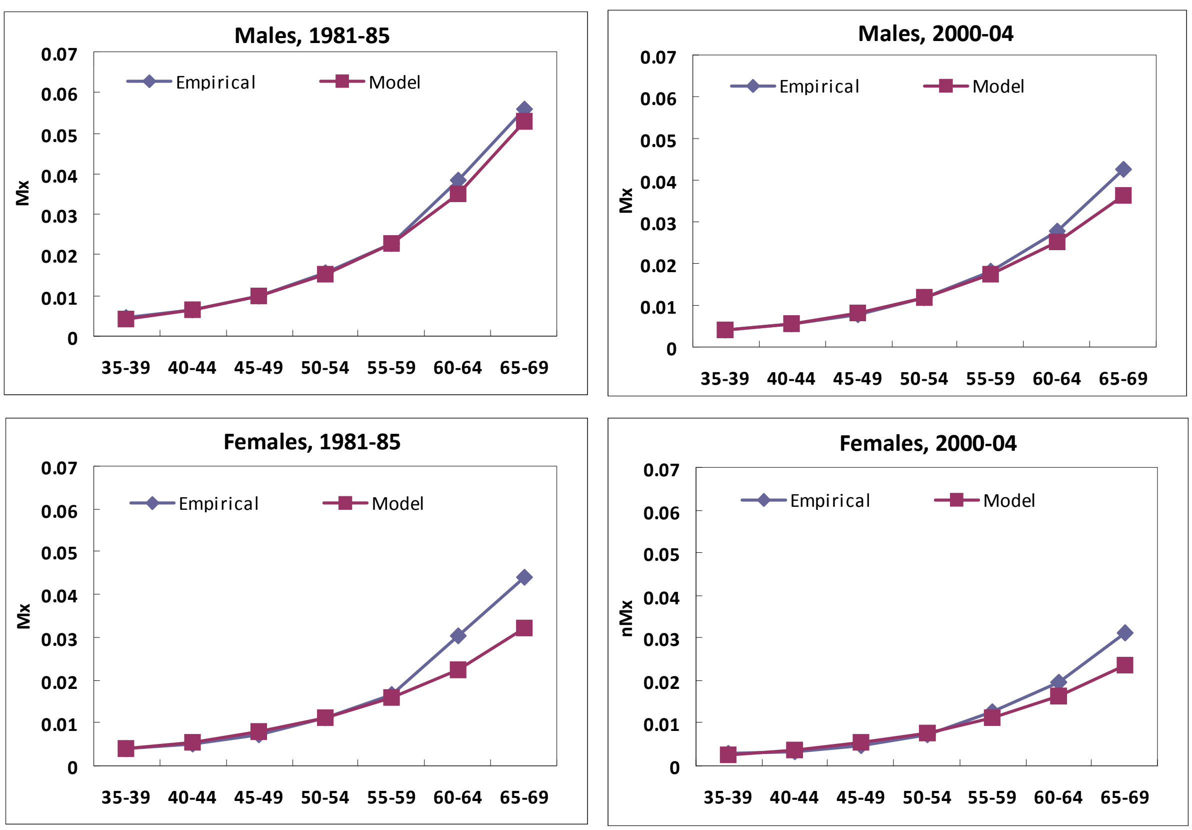
This may be true in case of SRS data as it is evident that old age mortality from SRS data is lower in comparison to NFHS old age mortality (Appendix 1 & 2). It can be seen that age specific mortality rates at young and adult ages are almost identical in both sources. However, old age mortality estimates by SRS are still lower than corresponding figures by NFHS. The study by Bhat (1995) indicated that SRS reports fewer survivors to older ages.

It is, therefore, decided to evaluate the quality of the SRS data on old age by applying a parametric model of mortality curve. One of the widely used laws of mortality is Gompertz's law which assumes that the susceptibly to death exponentially increases with age:

$$\mu = R \cdot e^{\alpha x} \qquad (1),$$

where R is a baseline level of mortality and α is the steepness of mortality increase with age. We use the range of ages 35-60[5] in the equation (1) to estimate the parameters for males and females separately for national and sub-national populations from 1971-75 to 2000-04.

**Fig. 2 Application of Gompertz Curve on SRS Data Male and Female for All India, 1981-85 and 2000-04**




Sources: own estimates based on the SRS data (???? – source for SRS data).

[5] We also experimented with other age ranges (e.g. 40-59 years, 55-69 years, or etc.) but got the same results.

Interestingly, the results of this exercise show that Gompertz model does not provide plausible mortality estimates at older ages. Figure 2 shows that original male and (especially) female mortality estimates at ages 60 years and older remain higher than Gompertz model-based estimates. One possible reason behind such pattern for females is age understatement and undercount of older females in the SRS data (Bhat, 1995). All these factors may have contributed towards overstatement of mortality at older ages. Taking into account aforementioned data problems and lower completeness of death registration at older ages, we restrict our study to the age range from 0 to 59 years.

## 4. Methods

### 4.1. Temporary life expectancy

One of the most widely used mortality measure in public health research is life expectancy which gives the expected number of years that a person will live after reaching certain age. As we showed, the precision of life expectancy estimates based on the SRS data can be affected by errors in the old age which makes it cumbersome to compare the life expectancies for the purpose of determining the pace of mortality change in a population (Arriaga, 1984). Such problems can be avoided, as Arriaga augmented, by the use of temporary life expectancies (or life expectancies between two specific ages) and indices based on the comparison of temporary life expectancies. As we have already seen that the quality SRS old age data is questionable, we compute temporary life expectancy between the exact ages 0 and 60:

$$e_{0/60} = \frac{T_0 - T_{60}}{l_0}$$

where $l_0$ is the radix of the life table, $T_0$ and $T_{60}$ are the numbers of person-years lived after ages 0 and 60, respectively. While life expectancy at birth depends on mortality rates over the whole age range of ages (including age over 60 years), the temporary life expectancy depends on mortality rates between the exact ages 0 and 60.

### 4.2. Inequality index of mortality: dispersion measure of mortality and Gini coefficient

Dispersion measure of mortality (DMM) is calculated as the average absolute inter-regional temporary life expectancy difference, weighted by population size, between each and every pair of regions (Moser et al, 2005). Decrease and increase in DMM show convergence and divergence of mortality across states, respectively.

Following Moser et al. (2005), we compute DMM for 16 states of India applying on $e_{0/59:}$

$$DMM = \frac{1}{2(P)^2}\left[\sum_i \sum_j p_i p_j \left(e^i_{0/60} - e^j_{0/60}\right)\right]$$

Where *i, j* are states, $1 \le i, j \le 16$ , $e^i_{0/60}$ is temporary life expectancy of state *i*,

$p_i$ is the population weight of the state $i$ and $p = \sum_i p_i = \sum_j p_j = 1$

Another measure used to assess the relative inter-regional variability in mortality in India is Gini coefficient (*G*): the lower Gini coefficient means the greater equality in mortality among different regions and vice versa (Shkolnikov et al. 2003).

$$G = \frac{DMM}{\overline{e_{0/60}}} \text{ where}$$

$$\overline{e_{0/60}} = \frac{1}{p}\left[\sum_{i=1}^{16} p_i e^i_{0/60}\right] \quad i=1,2,\ldots 16.$$

### 4.3. Method of decomposition of temporary life expectancy by age

The method for discrete decomposition of differences between two life expectancies by age was developed independently in the 1980s by the three researchers from Russia, the USA, and France (Andreev, 1983; Arriaga 1984; Pressat, 1985; Andreev et al., 2002). The decomposition of temporary life expectancy between the exact ages 0 and 60 can be expressed in the following way:

$$e^2_{x/60} - e^1_{x/60} = \frac{1}{l_0}\sum_i \delta_i \text{ where}$$

$$\delta_i = \frac{1}{2}\left[l^2_{x_i}\left(e^2_{x_i/60} - e^1_{x_i/60}\right) - l^2_{x_{i+1}}\left(e^2_{x_{i+1}/60} - e^1_{x_{i+1}/60}\right)\right] - \frac{1}{2}\left[l^1_{x_i}\left(e^1_{x_i/y} - e^2_{x_i/60}\right) - l^1_{x_{i+1}}\left(e^1_{x_{i+1}/60} - e^2_{x_{i+1}/60}\right)\right]$$

$i$=1,2,3,….,13; $x_1 = 0,\ x_2 = 1,\ x_i = (i-2)\cdot 5$ (for $i \ge 3$)

## 5. Results

Figure 3 depicts trends in temporary life expectancy for the total, urban, and rural populations. First, it is interesting to notice the fact that total females had a health disadvantage against males throughout the whole period 1971-2004 with an exception of 1986-90. Such pattern is especially pronounced and still persisting in the rural areas and may be attributed to higher level of female child and maternal mortality (R.G.I. 2006). At the same time, Indian urban females had much smaller disadvantage in the beginning and catch up with males already in the beginning of the 1980s. Since then, females in urban areas have been maintaining a small health disadvantage as compared to males.

**Fig. 3 Trends in temporary life expectancy between exact ages 0 and 60 in India, 1971-75 - 2000-04.**

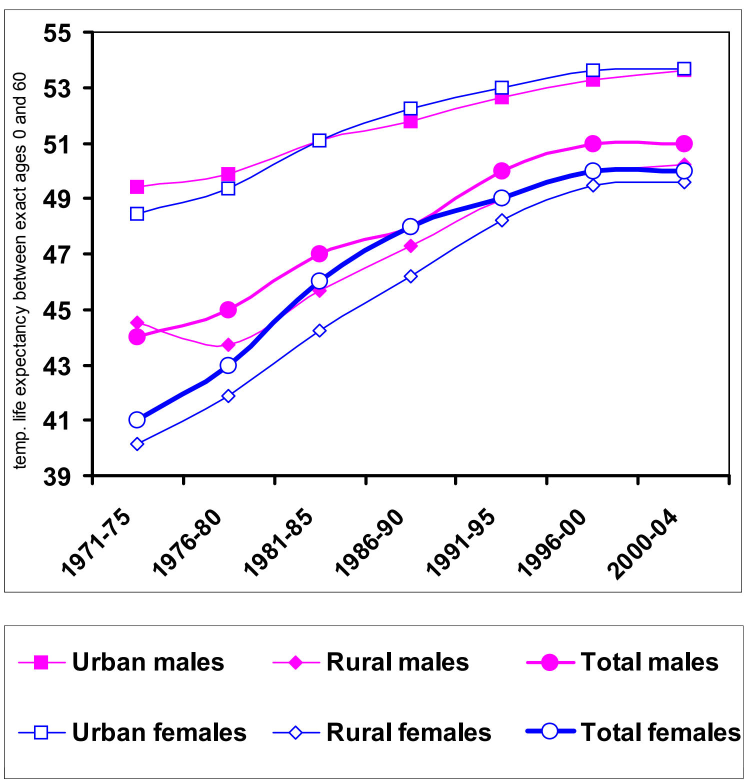
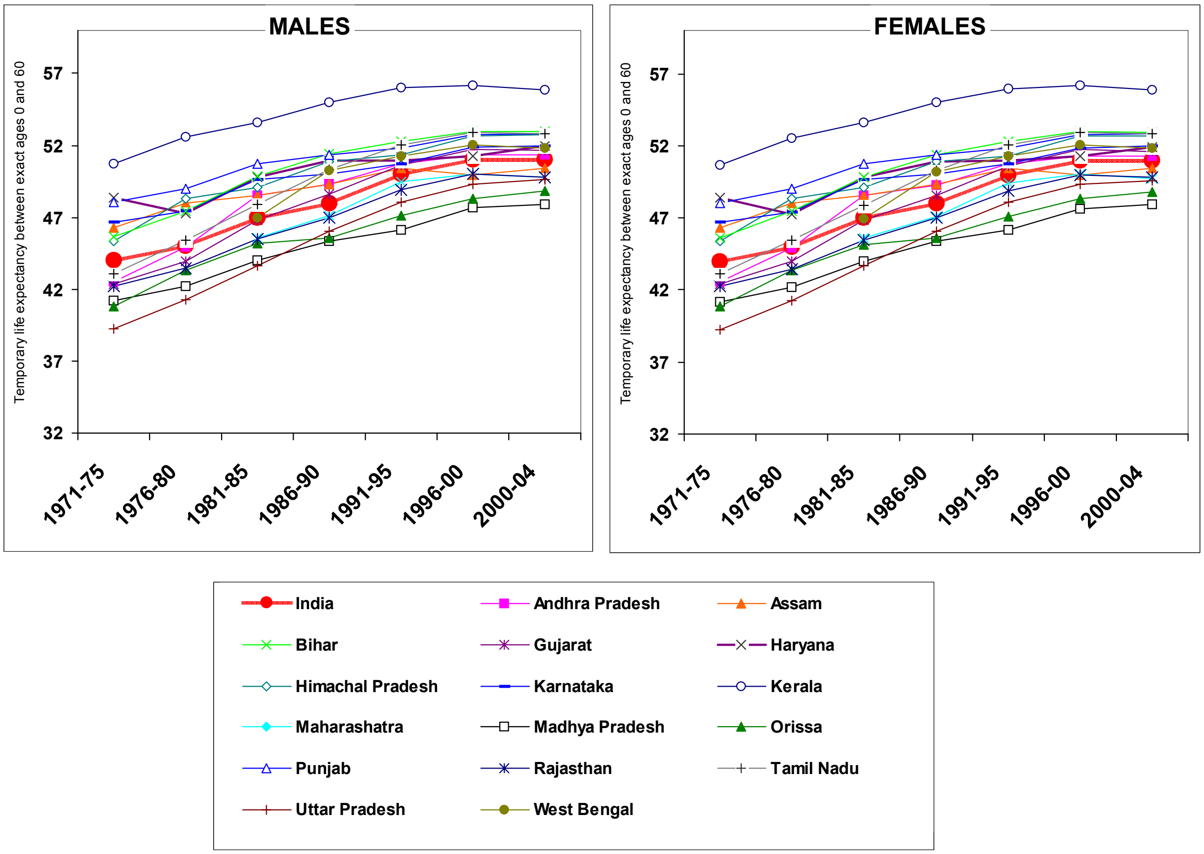



Figure 4 and Appendix 4 show trends in temporary life expectancy from 1971-75 to 2000-04. It is evident that temporary life expectancy has been increasing over the time for both sexes in all states. However, the pace of increase is different in different decades. The situation has been rapidly improving until the early 1990s. Later on in the late 1990s and the early 2000s, there was a slow down or even stagnation (Figure 4).

**Fig. 4. Trends in temporary life expectancy between exact ages 0 and 60 in the 16 states of India, 1971-75 – 2000-04.**




There are important regional peculiarities in health trends. Kerala's performance in terms trends in temporary life expectancy was the most impressive throughout the period. Despite the fact that temporary life expectancy for Uttar Pradesh was the worst throughout the period 1971-90, the improvements (especially for females) were much steeper than in another poorly performing state, Madhya Pradesh.

Another important point is the convergence of temporary life expectancy among the states across time. The maximal gap between regions with the highest and lowest male temporary life expectancies has dropped from 11.4 years in 1971-75 to 7.9 years in 2000-04. However, if we exclude Kerala, we observe that the maximal gap constituted only 4.9 years in 2000-04. The same gap for females was much more pronounced than among males throughout the whole period. However, Indian females experienced much faster reductions of the geographical inequalities (from 16.8 years in 1971-75 to 11.0 years in 2000-04).

Table 2 shows two measures of absolute and relative inter-regional mortality diversity (DMM and Gini coefficient, respectively). Both measures account for differences in population size across the regions and suggest that regional mortality inequality has been higher among females than among males throughout the whole period. The two measures (also accounting for the inter-regional differences in population size) confirm the convergence of mortality across the regions in India. The progress is impressive as both DMM and Gini coefficients dropped by one half (Table 2).

**Table 2. Gini coefficient (in percent) and dispersion measure of mortality (in years) for age group 0-59 in India in 1971 – 2004.**

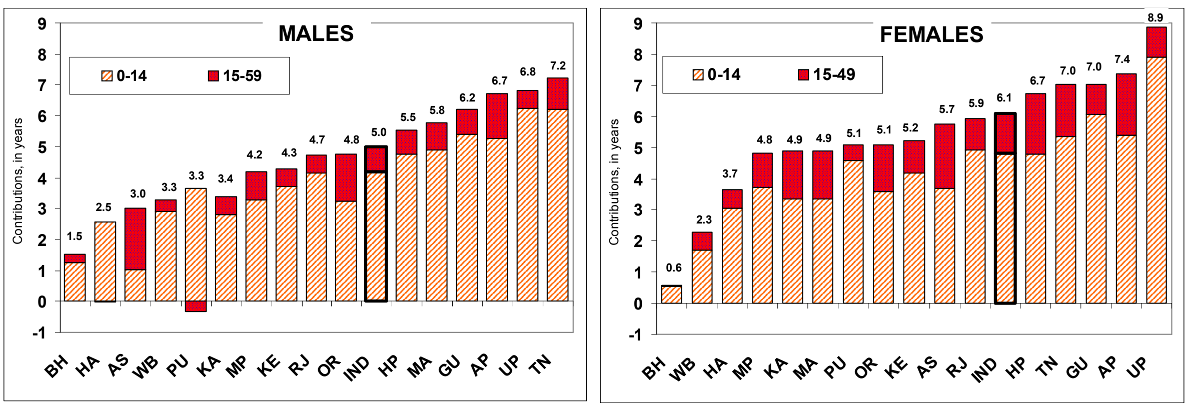
| | Male | | Female | |
|---|---|---|---|---|
| **Year** | **Gini** | **DMM** | **Gini** | **DMM** |
| 1971-75 | 4.1 | 1.75 | 6.1 | 2.51 |
| 1981-85 | 3.1 | 1.46 | 4.5 | 2.05 |
| 1991-95 | 2.4 | 1.19 | 3.4 | 1.69 |
| 2001-04 | 1.9 | 0.96 | 2.9 | 1.49 |

Results of age decomposition of changes in temporary life expectancy during the two different periods from 1971-75 to 1986-90 and from 1991-95 to 2000-04 are depicted in Figures 5 and 6. We show only contributions of mortality changes in the two broad age groups: infant and child (0-14 years) and adult (15-59 years) groups.

One immediate inference can be drawn: almost entire improvement in temporal life expectancy is attributable to reductions in infant and child mortality. With a few exceptions (males in Kerala and female in Andhra Pradesh and Haryana from 1991-95 to 2000-04), contributions of children ages are positive for all states irrespective of sex and time period. The second important point we observe is that the total gain in temporary life expectancy is much more significant during the first period. From 1971-75 to 1986-1990, the increases in temporary life expectancy were 4.9 and 6.1 years among males and females, respectively. At the same time during the period 1991-95 - 2000-04, the gains constituted only 1.2 years for both sexes. These low values tell about a slow down or even stagnation in positive health trends.

Decomposition analysis reveals that the diminishing contributions of younger ages are the main reason of such slow down in temporary life expectancy (Figures 5 and 6). The declining contribution of younger ages can be explained by the fact that infant and child mortality has reached the levels beyond which further reduction is unattainable without very substantial improvement in health care and living conditions.

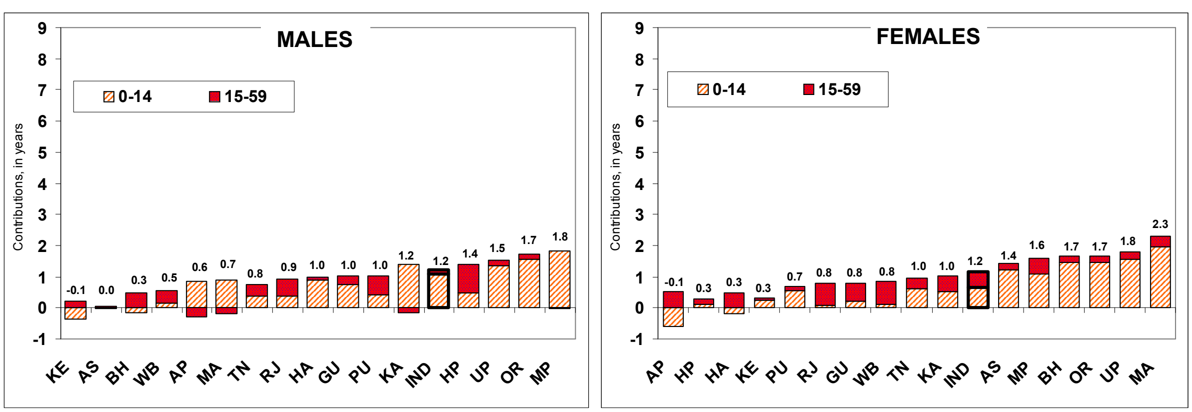
**Fig. 5. Decomposition of changes in temporary life expectancy between exact ages 0 and 60 by age groups (in years) for India and its states, 1971-75 - 1986-90**




Notes: 1. Total gains in temporary life expectancy are shown above each bar. 2. Decomposition for Bihar and West Bengal states was performed for the period from 1981-85 to 1986-90.

Abbreviations: HA- Haryana, HP - Himachal Pradesh, PU - Punjab, RJ - Rajasthan, UP - Uttar Pradesh, MP - Madhya Pradesh, AS - Assam, BH – Bihar, OR – Orissa, WB - West Bengal, GU – Gujarat, MA – Maharashtra, AP - Andhra Pradesh, KA – Karnataka, KE – Kerala, TN - Tamil Nadu

**Fig. 6. Decomposition of changes in temporary life expectancy between exact ages 0 and 60 by age groups (in years) for India and its states, from 1991-95 to 2000-04**



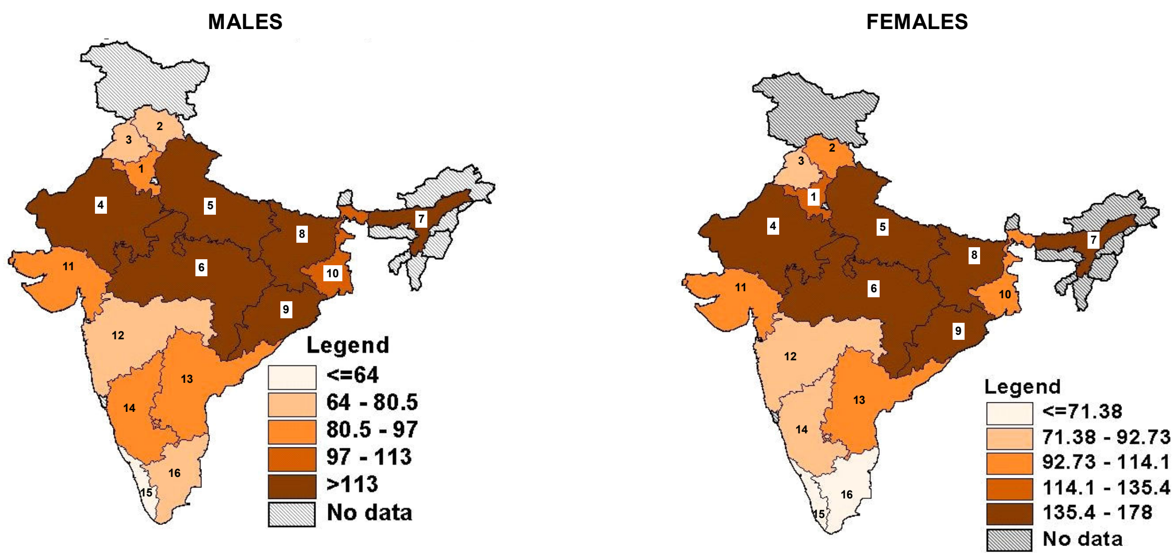

Notes: 1. Total gains in temporary life expectancy are shown above each bar. 2. Decomposition for Bihar and West Bengal states was performed for the period from 1981-85 to 1986-90.

Abbreviations: HA- Haryana, HP - Himachal Pradesh, PU - Punjab, RJ - Rajasthan, UP - Uttar Pradesh, MP - Madhya Pradesh, AS - Assam, BH – Bihar, OR – Orissa, WB - West Bengal, GU – Gujarat, MA – Maharashtra, AP - Andhra Pradesh, KA – Karnataka, KE – Kerala, TN - Tamil Nadu

Similarly to the young age group, the positive contributions of adult age group have also declined in the second period. It is interesting to note that although the contribution of ages 15 to the increase in female temporary life expectancy is positive during 1991-95 to 2000-04 for all states (which may be the result of improvements in maternal mortality), the corresponding figures for males appeared to be negative in some states such as Andhra Pradesh, Karnataka & Maharashtra. This fact could be indicating a possible negative effect of growing prevalence of HIV-AIDS among male adults since these states experienced the highest HIV prevalence in the antenatal care population in 2005. (NACO, 2006; IIPS & Macro, 2007). According to the NFHS III report, the HIV prevalence rate among male adults of age 15-49 is much higher than that among their female counterparts (IIPS & ORC Macro, 2007).

**Fig. 7. Probabilities of dying for the ranges of ages 0-15 and 15-59 for Indian states in 2002-2006.**

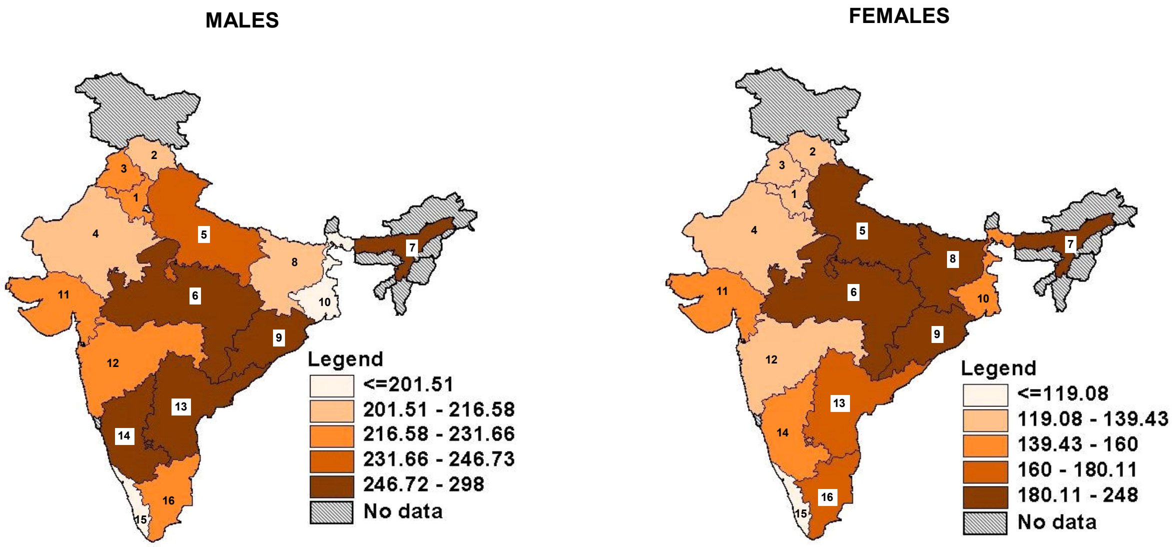
*A) Probabilities of dying for the range of ages 0-15*




Note: Probabilities of dying are multiplied by 1000.
Abbreviations: 1- Haryana, 2- Himachal Pradesh, 3- Punjab, 4 - Rajasthan, 5 - Uttar Pradesh, 6 - Madhya Pradesh, 7 - Assam, 8 – Bihar, 9 – Orissa, 10 - West Bengal, 11 – Gujarat, 12 – Maharashtra, 13 - Andhra Pradesh, 14 – Karnataka, 15 – Kerala, 16 - Tamil Nadu.

**Fig. 7 (continued). Probabilities of dying for the ranges of ages 0-15 and 15-59 for Indian states in 2002-2006.**

*B) Probabilities of dying for the range of ages 15-59*




Note: Probabilities of dying are multiplied by 1000.
Abbreviations: 1- Haryana, 2- Himachal Pradesh, 3- Punjab, 4 - Rajasthan, 5 - Uttar Pradesh, 6 - Madhya Pradesh, 7 - Assam, 8 – Bihar, 9 – Orissa, 10 - West Bengal, 11 – Gujarat, 12 – Maharashtra, 13 - Andhra Pradesh, 14 – Karnataka, 15 – Kerala, 16 - Tamil Nadu.

## 6. Conclusions

This study examines trends in temporary life expectancy and mortality in regions in India. This is a challenging task due to the absence of fully functioning vital registration system in the country. Therefore, we used data from the Sample Registration System which provides the most complete and representative data on mortality in India (National Commission on Population, 2001). However, we showed that even these data may be suffering from some deficiencies such as significant age misreporting and possible undercount of females at older ages. Unfortunately, our experiments fitting parametric model to the SRS mortality estimates did not provide a plausible solution for assessment of old age mortality. At the same time, the comparisons between the SRS and alternative sources (NFHS) suggested that the SRS estimates are likely to be accurate for children and adult ages. Thus, we assumed that restricting our analyses to the age range from 0 to 59 would allow us avoid the majority of the data quality problems. Although some studies based on indirect methods suggest that there is some variation in completeness of the SRS coverage, the completeness of the SRS is generally high. Therefore, we believe that our analyses describe the major regularities of variation in health correctly. However, it is still worth to undertake more in-depth and systematic studies and checks for assessing the quality of the SRS data across the regions of India.

Temporary life expectancy between the exact ages 0 and 60 years was used to examine trends in life expectancy and mortality in India and its states. We observed an increase in temporary life expectancy for all states. However, there were also important differences in the pace of improvement between the states and across time periods. It is worrying that after a spectacular progress during the 1970s and 1980s, improvements in longevity have slowed down or almost halted in the 1990s and 2000s. Our study revealed that temporary life expectancy has been converging across the states with time. This is mostly attributable to slower improvements in the states having initially higher longevity levels. The increases in temporary life expectancy in all states were mostly determined by contributions of mortality among infants and children. The contributions of mortality reductions at adult ages were generally smaller. Both contributions of the young and adult ages have declined since the 1990s. This worrying fact requires further attention of researchers and policy makers as a matter of priority. Another important issue is persisting female health disadvantage which is particularly notable in rural areas and in some states.

The trends in temporary life expectancy for India and its states, and, especially, the recent slow down in improvements, leads to some general and more specific questions. First, where is India going in terms of the stages of epidemiologic transition? It is also important to learn more about the scale of some newly emerging health threats such as AIDS, returning infectious diseases, and growing burden of chronic diseases. In order to answer these questions, data and additional further research on causes of death are needed.

## Acknowledgements

IMPRSD, other people who help you with data???

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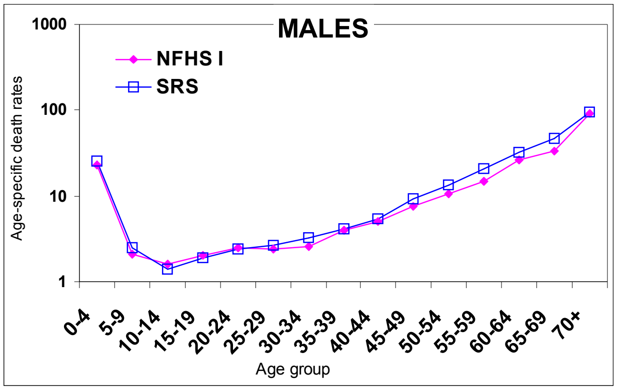
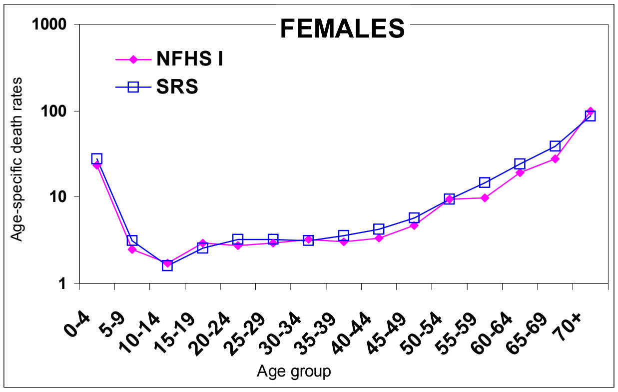
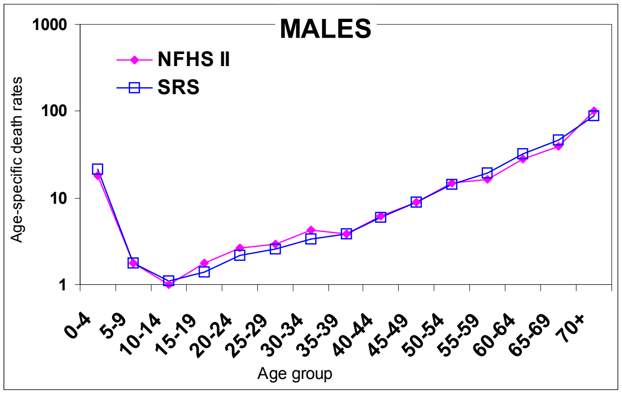
**Appendix 1. Comparison of age specific death rates between NFHS I (1991-92) and SRS (1991-92) for India**

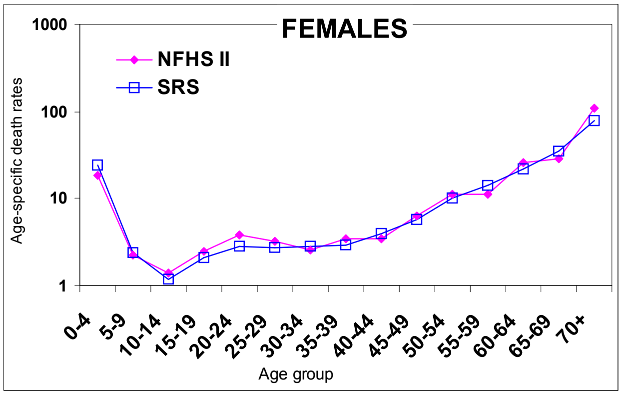



Sources : IIPS & ORC Macro, 1995,

**Appendix 2. Comparison of age specific death rates between NFHS II (1997-1998) and SRS (1997) for India**




Sources: IIPS & ORC Macro, 2000

## Appendix 3. Socio-demographic indicators of India and its states

| | Population (in millions) | Religion (%) | | Caste (%) | | | Literacy (%) | TFR[1] 2003–2005 | IMR[1] 2001-2005 | % below the poverty line[2] (2004-2005) |
|---|---|---|---|---|---|---|---|---|---|---|
| **North** | | Hindu | Muslim | SC | ST | Other | | | | |
| Haryana | 21.1 | 88.2 | 5.8 | 19.3 | 0 | 80.7 | 67.9 | 2.7 | 42 | 9.9 |
| Himachal Pradesh | 60.7 | 95.4 | 2 | 24.7 | 4 | 71.3 | 76.5 | 1.9 | 36 | 6.7 |
| Punjab | 24.3 | 36.9 | 1.6 | 28.9 | 0 | 71.1 | 69.7 | 2.0 | 42 | **5.2** |
| Rajasthan | 56.5 | 88.8 | 8.5 | 17.2 | 12.6 | 70.2 | 60.4 | 3.2 | 65 | 17.5 |
| **Central** | | | | | | | | | | |
| Uttar Pradesh | 166.2 | 80.6 | 18.5 | 21.1 | 0.1 | 78.8 | 56.3 | **3.8** | **73** | 25.5 |
| Madhya Pradesh | 60.3 | 91.2 | 6.4 | 15.2 | 20.3 | 64.5 | 63.7 | 3.1 | 70 | 32.4 |
| **East** | | | | | | | | | | |
| Assam | 26.7 | 64.9 | 30.9 | 6.9 | 12.4 | 80.7 | 63.3 | 2.4 | 66 | 15.0 |
| Bihar | 82.9 | 83.2 | 16.5 | 15.7 | 0.9 | 83.4 | **47.0** | 4.0 | 62 | 32.5 |
| Orissa | 36.8 | 94.4 | 2.1 | 16.5 | 22.1 | 61.4 | 63.1 | 2.4 | 65 | **40.0** |
| West Bengal | 80.2 | 72.5 | 25.3 | 23 | 5.5 | 71.5 | 68.6 | 2.3 | 48 | 20.6 |
| **West** | | | | | | | | | | |
| Gujarat | 50.7 | 89.1 | 9.1 | 7.1 | 14.8 | 78.1 | 69.1 | 2.4 | 50 | 12.5 |
| Maharashtra | 96.9 | 80.4 | 10.6 | 10.2 | 8.9 | 80.9 | 76.9 | 2.1 | 38 | 25.2 |
| **South** | | | | | | | | | | |
| Andhra Pradesh | 76.2 | 89 | 9.2 | 16.2 | 6.6 | 77.2 | 60.5 | 1.8 | 53 | 11.1 |
| Karnataka | 52.9 | 83.9 | 12.2 | 16.2 | 6.6 | 77.2 | 66.6 | 2.1 | 43 | 17.4 |
| Kerala | 31.8 | 56.2 | 24.7 | 9.8 | 1.1 | 89.1 | **90.9** | 1.9 | **15** | 11.4 |
| Tamil Nadu | 62.4 | 88.1 | 5.6 | 19.0 | 1.0 | 80 | 73.5 | 1.9 | 31 | 17.8 |
| **India** | **1029** | **80.5** | **13.4** | **16.2** | **8.1** | **72.6** | **64.84** | **2.7** | **57** | **21.8** |

Notes: 1. Data on population size, religion, caste, and literacy come from the 2001 census (office of RGI & Census Commissioner, 2001)

[1] TFR and IMR is collected from NFHS III, 2005-2006. [2] The data on poverty comes from Press Information Bureau, Government of India, downloaded from http://www.indiastat.com.

2.As we provide information for 16 major states out of 28 states, the total sum of the population of these 16 states is not equal to that of India.

**Appendix 4. Temporary life expectancy ($e_{0/60}$) by sex in India and its states, 1971-2004**

| Name | 1971-75 | | 1976-80 | | 1981-85 | | 1986-90 | | 1991-95 | | 1996-00 | | 2000-04 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| Andhra Pradesh | 42.6 | 42.5 | 44.9 | 45.2 | 48.5 | 49.0 | 49.3 | 49.8 | 50.7 | 51.9 | 51.3 | 52.1 | 51.3 | 51.8 |
| Assam | 46.3 | 40.1 | 48.0 | 43.8 | 48.6 | 44.5 | 49.3 | 45.9 | 50.4 | 46.8 | 50.0 | 48.1 | 50.4 | 48.3 |
| Bihar | NA | NA | NA | NA | 45.6 | 44.6 | 47.1 | 45.2 | 49.4 | 46.5 | 50.0 | 48.2 | 49.8 | 48.2 |
| Gujarat | 42.4 | 41.0 | 43.9 | 43.2 | 46.8 | 47.9 | 48.6 | 48.0 | 50.6 | 50.7 | 51.7 | 51.6 | 51.6 | 51.5 |
| Haryana | 48.4 | 45.4 | 47.3 | 43.5 | 49.8 | 47.6 | 50.9 | 49.1 | 50.9 | 50.4 | 51.3 | 50.6 | 51.9 | 50.7 |
| Himachal | 45.4 | 43.7 | 48.3 | 45.9 | 49.1 | 50.2 | 50.9 | 50.5 | 51.3 | 52.7 | 52.7 | 52.9 | 52.7 | 53.0 |
| Karnataka | 46.7 | 45.6 | 47.4 | 46.5 | 49.7 | 49.6 | 50.0 | 50.4 | 50.7 | 51.4 | 51.9 | 52.6 | 52.0 | 52.4 |
| Kerala | 50.7 | 51.2 | 52.6 | 53.5 | 53.6 | 55.3 | 55.0 | 56.4 | 56.0 | 57.5 | 56.2 | 57.8 | 55.8 | 57.8 |
| Maharashtra | 45.6 | 45.6 | 47.4 | 46.5 | 49.8 | 49.6 | 51.4 | 50.4 | 52.3 | 51.4 | 53.0 | 52.6 | 53.0 | 53.7 |
| Madhya Pradesh | 41.2 | 39.0 | 42.2 | 40.7 | 44.0 | 43.0 | 45.3 | 43.8 | 46.1 | 45.2 | 47.6 | 46.8 | 47.9 | 46.8 |
| Orissa | 40.8 | 40.1 | 43.3 | 41.7 | 45.2 | 44.6 | 45.6 | 45.2 | 47.1 | 46.5 | 48.3 | 48.2 | 48.8 | 48.2 |
| Punjab | 48.0 | 46.1 | 49.0 | 47.0 | 50.7 | 49.9 | 51.4 | 51.2 | 51.8 | 52.4 | 52.8 | 53.0 | 52.8 | 53.1 |
| Rajasthan | 42.2 | 39.6 | 43.5 | 42.8 | 45.5 | 43.8 | 47.0 | 45.5 | 48.9 | 48.3 | 50.0 | 48.9 | 49.8 | 49.1 |
| Tamil Nadu | 43.1 | 43.0 | 45.4 | 45.2 | 47.9 | 46.8 | 50.3 | 50.1 | 52.1 | 52.7 | 52.9 | 53.6 | 52.8 | 53.7 |
| Uttar Pradesh | 39.3 | 34.4 | 41.3 | 36.4 | 43.6 | 40.4 | 46.1 | 43.3 | 48.1 | 46.2 | 49.3 | 47.3 | 49.6 | 48.0 |
| West Bengal | NA | NA | NA | NA | 47.0 | 47.7 | 50.2 | 50.0 | 51.3 | 51.1 | 52.0 | 52.1 | 51.8 | 51.9 |
| India Rural | 44.5 | 40.2 | 43.7 | 41.9 | 45.7 | 44.3 | 47.3 | 46.2 | 49.0 | 48.2 | 49.9 | 49.5 | 50.2 | 49.6 |
| India Urban | 49.4 | 48.4 | 49.9 | 49.4 | 51.1 | 51.1 | 51.8 | 52.2 | 52.6 | 53.0 | 53.3 | 53.6 | 53.6 | 53.7 |
| **India** | **44.0** | **41.0** | **45.0** | **43.0** | **47.0** | **46.0** | **48.0** | **48.0** | **50.0** | **49.0** | **51.0** | **50.0** | **51.0** | **50.0** |

Note: M – males, F – females, NA – data are not available.

**Appendix 5. Age standardized death rates ($ASDR_{15-59}$) (per 1000 of population) for India and its states, 1971-2004**

| Name | 1971-75 | | 1976-80 | | 1981-85 | | 1986-90 | | 1991-95 | | 1996-00 | | 2000-04 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| Andhra Pradesh | 4.83 | 4.37 | 3.78 | 3.26 | 3.23 | 2.72 | 3.16 | 2.43 | 2.94 | 2.27 | 3.14 | 2.21 | 3.20 | 1.81 |
| Assam | 5.23 | 6.06 | 4.63 | 5.08 | 4.15 | 4.31 | 3.74 | 3.69 | 3.39 | 3.39 | 3.58 | 3.54 | 3.48 | 3.13 |
| Bihar | NA | NA | NA | NA | 3.86 | 3.82 | 3.08 | 3.33 | 2.82 | 3.11 | 2.70 | 2.87 | 2.28 | 2.08 |
| Gujarat | 4.02 | 3.34 | 3.88 | 3.03 | 3.45 | 2.83 | 3.08 | 2.43 | 2.86 | 2.07 | 2.67 | 1.85 | 2.50 | 1.58 |
| Haryana | 2.22 | 2.55 | 2.65 | 3.01 | 2.42 | 2.38 | 2.28 | 2.10 | 2.69 | 1.84 | 2.67 | 1.76 | 2.71 | 1.49 |
| Himachal | 3.30 | 3.83 | 2.97 | 3.21 | 3.26 | 2.28 | 2.64 | 2.12 | 2.77 | 1.83 | 2.20 | 1.77 | 2.05 | 1.59 |
| Karnataka | 3.42 | 3.56 | 3.30 | 3.10 | 2.92 | 2.36 | 2.77 | 2.09 | 2.81 | 2.02 | 2.95 | 1.98 | 2.86 | 1.63 |
| Kerala | 2.70 | 1.85 | 2.34 | 1.46 | 2.45 | 1.27 | 2.22 | 1.06 | 2.07 | 0.97 | 1.97 | 0.94 | 1.83 | 0.94 |
| Maharashtra | 2.51 | 1.77 | 3.35 | 2.74 | 2.85 | 2.27 | 2.60 | 1.93 | 2.50 | 2.04 | 2.62 | 1.75 | 1.63 | 1.06 |
| Madhya Pradesh | 4.01 | 4.06 | 3.53 | 3.65 | 3.22 | 2.80 | 4.91 | 2.88 | 3.07 | 2.88 | 3.23 | 2.79 | 3.03 | 2.45 |
| Orissa | 5.07 | 5.01 | 4.36 | 4.35 | 3.51 | 3.38 | 3.23 | 3.24 | 3.30 | 2.73 | 3.30 | 2.94 | 3.07 | 2.53 |
| Punjab | 2.48 | 2.11 | 2.18 | 1.79 | 2.48 | 2.00 | 2.68 | 1.80 | 2.94 | 1.62 | 2.74 | 1.74 | 2.48 | 1.53 |
| Rajasthan | 3.85 | 3.48 | 3.45 | 3.30 | 3.29 | 2.92 | 3.04 | 2.30 | 2.82 | 2.14 | 2.61 | 1.72 | 2.27 | 1.61 |
| Tamil Nadu | 4.20 | 4.35 | 3.59 | 3.49 | 3.47 | 3.35 | 3.12 | 2.48 | 2.92 | 2.15 | 2.89 | 2.01 | 2.56 | 1.89 |
| Uttar Pradesh | 3.99 | 4.30 | 3.72 | 3.83 | 3.50 | 3.52 | 3.21 | 3.03 | 3.01 | 2.83 | 2.83 | 2.63 | 2.80 | 2.62 |
| West Bengal | NA | NA | NA | NA | 3.01 | 2.94 | 2.65 | 2.48 | 2.46 | 2.18 | 2.36 | 2.01 | 2.08 | 1.59 |
| **India** | **3.86** | **3.82** | **3.59** | **3.28** | **3.17** | **2.86** | **2.95** | **2.56** | **2.81** | **2.38** | **2.81** | **2.18** | **2.63** | **1.97** |

Note: M – males, F – females, NA – data are not available.