Has Child Mortality in India Really Increased in the Last Two Decades?

NANDITA SAIKIA, ABHISHEK SINGH, FAUJDAR RAM

The trend in mortality from the Sample Registration System data shows a slowdown in improvements, particularly since the mid-1990s. According to official life tables constructed by the Registrar General, there is a stagnating trend in infant mortality and an increasing trend in female child mortality for India. The ratio of child mortality rates to infant mortality rates obtained from the official life tables for the recent period does not follow any of the model life table patterns, which raises questions about the reliability of these rates. Using age-specific death rates from the SRS, new life tables constructed for the most recent period show lower levels of child mortality rates compared to those provided by the SRS.

A levelling off in mortality rates at a rather high level in India has drawn the attention of researchers in the recent period. Studies examining the mortality trend in India from the Sample Registration System (SRS) based official life tables show that mortality level for India and its major states has stagnated since the late 1990s (Saikia et al 2009; Claeson et al 2000). The SRS data shows that the rate of decline in infant mortality stagnated for a brief period during 1981-97 and was then followed by a subsequent rapid decline. However, during the most recent period (1999-2006), the reduction in infant and child mortality rates slowed down considerably. This result leads to some general and more specific questions. First, is the recent slowdown in mortality decline real or it has something to do with the quality of data or the construction of life tables? Second, if the current trends are true, then what is the rationale behind the recent slowdown in improvements despite increasing coverage of child immunisation, institutional delivery and development programmes in India (IIPS and ORC Macro 1995, 2000, 2007)? This study attempts to answer these questions in the following sections.

Trends in Infant and Child Mortality

In the absence of a complete vital registration system, SRS is the only reliable source providing data on vital rates in India. It is the only source which facilitates a detailed analysis of the levels and trends in mortality in the country and no investigation of the mortality situation is complete without a reference to the SRS data (Roy and Lahiri 1988; Anand et al 2000; Mathers et al 2005).

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 of 3.1% for births and 3.3% for deaths at the all-India level (Registrar General India 1983). A similar enquiry conducted in 1985 suggested that omission rates decreased to 1.8% for births and 2.5% for deaths (Registrar General India 1988). The state level estimation of under-enumeration of vital events showed that under-enumeration levels were 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. The application of the generalised growth balance method to assess the completeness of death registration by Bhat (2002) suggests that overall completeness of death registration for all ages during 1971-80

The authors acknowledge P M Kulkarni for his thoughtful suggestions and comments on the paper and thank him for allowing us to borrow one figure (Figure 8 in the text) from his presentation. We are also grateful to the anonymous referee for useful suggestions and comments.

Nandita Saikia *(nanditasts@gmail.com)*, Abhishek Singh *(abhi_iips@yahoo.co.in)* and Faujdar Ram *(fram@iips.net)* are at the International Institute for Population Sciences, Mumbai.

was 94% for males and 91% for females (Bhat 2002). The completeness varied across states from a low of 84% among females in Karnataka to 100% among males in Kerala and Gujarat and females in Madhya Pradesh. During 1971-91, the completeness of death registration among males remained stable, at about the same level of 95%. But among females, the completeness declined marginally from about 91% in 1971-80 to 88% in 1981-91 (Bhat 2002). Thus, there is no doubt that SRS is a reliable source of data for fertility and mortality indicators in India. So the stagnation in the decline in infant and child mortality in India during the recent period cannot possibly be attributed to the quality of SRS data.

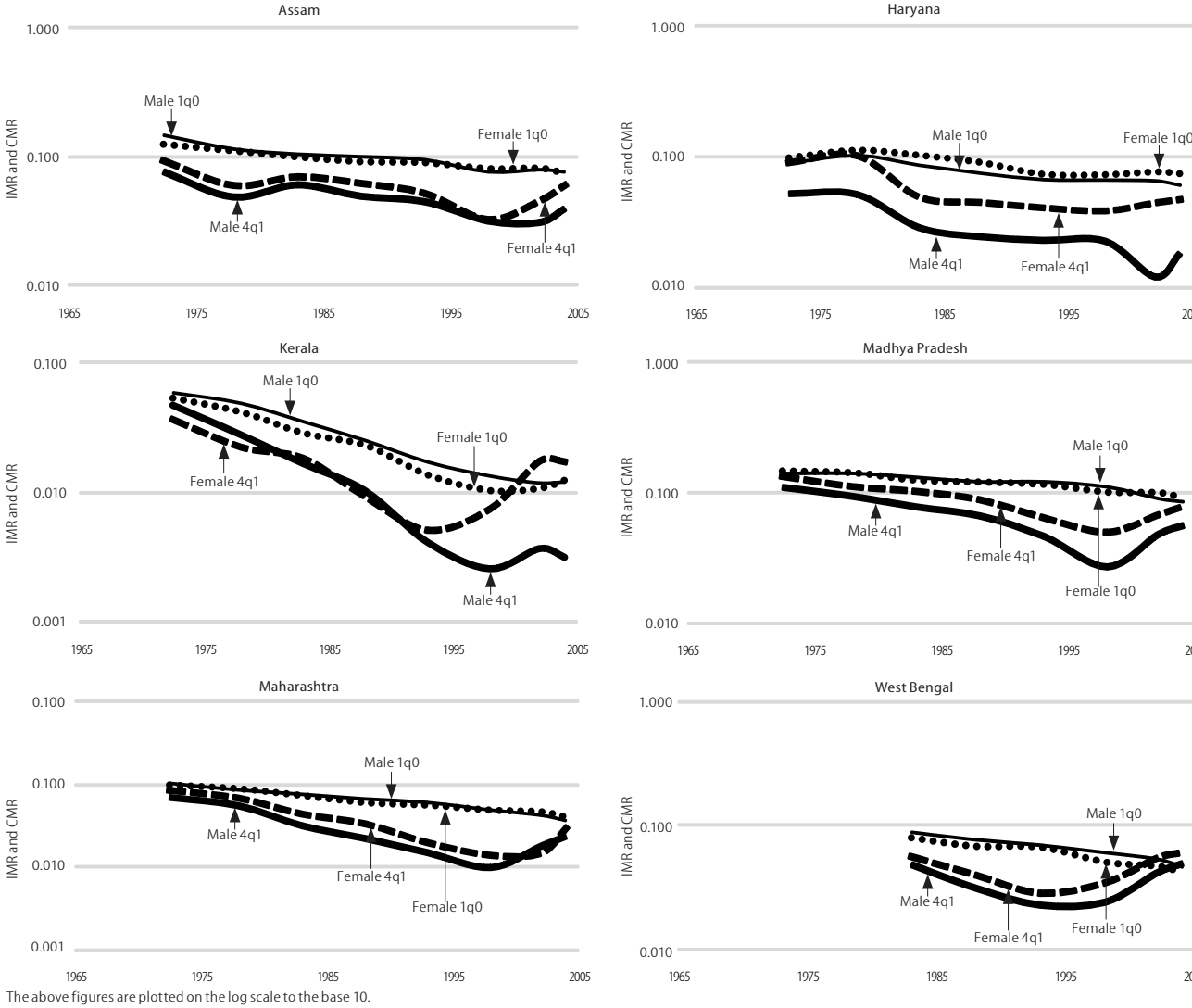
Since SRS started giving mortality rates from the early 1970s, our investigation is restricted to the period 1970-2006. Data from more than three decades is sufficient to examine mortality trends in India and in 16 major states. Figure 1 shows infant mortality rate ($_1q_0$) and child mortality rate ($_4q_1$) in India from SRS. Although infant mortality rate (IMR) decreased during the 1970s and 1980s, it has almost stagnated since the early 1990s.

The slope of IMR is seen to be much steeper during the 1970s and 1980s than in the 1990s or later. The situation is even worse in case of child mortality rate (CMR), which has shown a rising trend since the late 1990s and female CMR level has reached the level of IMR for the most recent period. Figure 2 shows IMR and CMR for six major states, one each from the north (Haryana), south (Kerala), east (West Bengal), west (Maharashtra), central (Madhya Pradesh) and north-east (Assam) representing six geographic regions of India. For all the states, IMR level completely stagnates for the last three points of time, viz, 1996-2000, 2000-04

Figure 1: Infant and Child Mortality Trends in India and Selected States
(1970-75 to 2002-06)

The above figure is plotted on the log scale to the base 10.

Figure 2: Infant and Child Mortality Trend in Selected States (1970-75 to 2002-06)



The above figures are plotted on the log scale to the base 10.

and 2002-06. During this period, child mortality registered a considerable increase in all these states. During the most recent period, CMR has either reached or crossed IMR level in some states such as Assam, Kerala, Madhya Pradesh, Maharashtra and West Bengal.

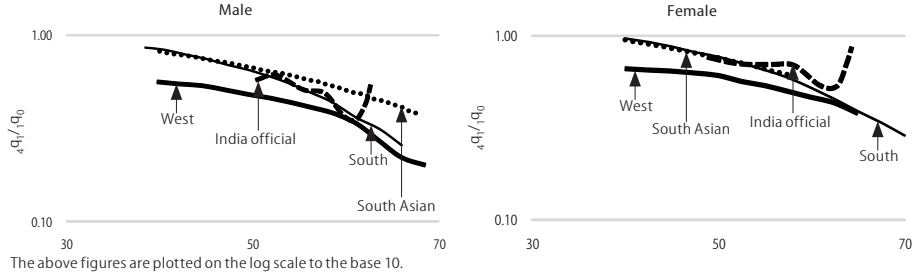
To check the consistency in IMR and CMR trends from the SRS, we make use of IMR and CMR data from the three rounds of the National Family Health Survey (NFHS) conducted in 1992-93, 1998-99 and 2004-05. The trends from the three rounds of NFHS clearly suggest a declining pattern in IMR and CMR during the last 15 years or so. Infant mortality (deaths per 1,000 live births) declined from 79 in 1989-93 to 57 in 2001-05. Similarly, child mortality (deaths per 1,000 live births) declined from 31.9 in 1990-93 to 18.4 in 2002-05 (IIPS and ORC Macro 1995, 2000, 2007). In addition, according to NFHS-III data, child mortality for the period 2002-05 was 14.2 and 22.9 for male and female respectively whereas the same rates from SRS were 32.8 and 54.4 for male and female. Similarly, IMRs from the NFHS data were lower than that of SRS. Therefore, the trends obtained from SRS data are not consistent with NFHS data, which is also a very reliable source of data on mortality.

Literature suggests that under-five mortality is negatively associated with the level of child immunisation, better socio-economic status and better nutritional status (Mosley and Chen 1984; Martin et al 1983; Mishra et al 2005; Fotso et al 2007). The three rounds of NFHS data show increasing trends in child immunisation, institutional delivery, educational attainment, standard of living, and other socio-economic conditions of people in India (IIPS and ORC Macro 1995, 2000, 2007). For example, from NFHS-I to NFHS-III, the percentage increase in the coverage of polio, BCG and measles vaccines among children of age 12-23 months was 24.6, 15.9 and 16.6, respectively. Similarly, the percentage of women who received antenatal care within the first trimester of pregnancy has increased from 24.9 in 1992-93 to 43 in 2004-05; percentage of births delivered in a health facility has risen from 26.1 in 1992-93 to 40.8 in 2004-05 (IIPS and ORC Macro 1995, 2007). The median number of years of schooling completed among females aged six and over has increased from zero years to two years during 1992-93 to 2005-06. All the facts given above provide no reason to accept increase in CMRs as suggested by SRS during the last decade. Second, whether CMR can really exceed IMR at a certain level of mortality is an important subject of investigation. This issue can be examined with the help of statistical and empirical models available in demographic literature.

Relationship between Life Expectancy and $_4q_{1/1}q_0$

Figure 3 shows the relationship between life expectancy at birth and ratio of $_4q_{1/1}q_0$ from three different model life tables (Coale and Demeny 1966; United Nations 1982) along with SRS life table. Model life tables are the tabular representations of age pattern of mortality which present all the life table functions for populations at a particular "level" of mortality (Preston et al 2001). High correlation exists among death rates in different age groups, i e, when death rates are high at ages one to four, they also tend to be high at ages 40-44 and 80-84 (ibid). These tables are based on empirical data collected from different sections of population and at different time periods. We have chosen three patterns of model life tables (south Asian, south and west) only for that period when life expectancy at birth (e^o_x) varies from 40 to 70 years corresponding to the e^o_x of 49 and 62 years in 1970-75 and 2002-06 SRS life tables, respectively. Previous studies have shown that these three patterns are most suitable to study mortality levels and trends in India (Bhat 1998; Parasuraman 1990; Ram 1984). In Figure 3, we plot a scatter diagram taking life expectancy at birth on the X-axis and the ratio of $_4q_{1/1}q_0$ on the Y-axis. A downward slope of the graph from left to right side specifies that as life expectancy at birth increases, the ratio $_4q_{1/1}q_0$ decreases. In other words, child mortality ($_4q_1$) reduces faster with the increase in life expectancy at birth. The ratio $_4q_{1/1}q_0$ follows a downward trend because the share of infants in under-five rates varies with the level of mortality. Usually, at high levels of mortality, deaths are more uniformly distributed over the age range; at low levels of mortality deaths are concentrated more at younger ages. Thus, $_4q_{1/1}q_0$ should decrease as mortality decreases.

Figure 3: Relationship between Life Expectancy at Birth and $_4q_{1/1}q_0$ from Model Life Table and SRS Life Table for Male and Female (1970-75 to 2002-06)



The above figures are plotted on the log scale to the base 10.

For all three sets of model life tables, we observe a declining trend in $_4q_{1/1}q_0$ with increasing life expectancy. The levels of $_4q_{1/1}q_0$ and the pace of decline in $_4q_{1/1}q_0$ may vary for the three sets of model life tables but the pattern of decline is almost similar in all the three sets of model tables. The ratio $_4q_{1/1}q_0$ with life expectancy from India's official life table does not follow any of the model life table patterns especially during the recent period. The pattern is convincing when life expectancy varies from 49 to 60 years in spite of temporary increase in the ratio corresponding to point 56 and 58. On the other hand, the pattern is reasonably unrealistic for the most recent period especially for Indian females. We find no trend in $_4q_1/_1q_0$ for Indian females during the last two decades. The ratio kept declining up to the 1980s and then started rising, which is in complete contrast to the patterns observed in any model life table pattern. To explore the statistical relationship between $_4q_{1/1}q_0$ and e^o_x, we fitted six linear regressions taking e^o_x as the independent variable and $_4q_{1/1}q_0$ as the dependent variable. Separate regression equations were fitted for the three model life table patterns. The fourth regression equation was fitted on the SRS abridged life table data for the period 1970-75 to 2002-06. The fifth and the sixth regression equations

were fitted for the periods of 1970-75 to 1991-95 and 1996-2000 to 2002-06, respectively. The fifth and sixth regression equations were fitted to compare the quality of fit for the two different periods versus the quality of fit for the complete period, i e, 1970-75 to 2002-06. Table 1 presents the fitted regression from all the above-mentioned patterns.

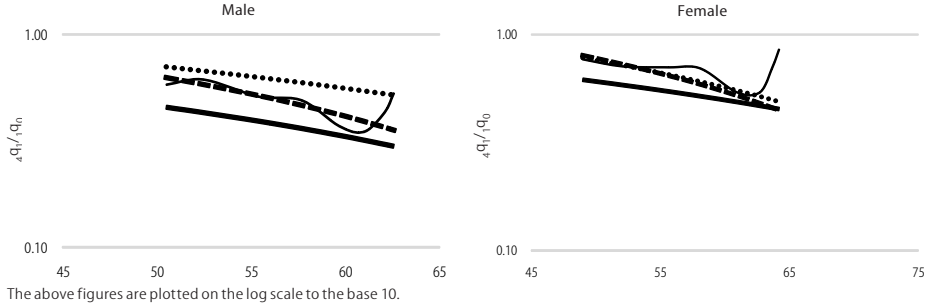
Table 1: Multiple Regression Results Assessing Association between Life Expectancy at Birth and $_4q_1/_1q_0$ (1970-75 to 2002-06)

Life Table	α		β	
	Female	Male	Female	Male
South Asian model life table	-0.019	-0.015	1.707	1.459
West model life table	-0.011	-0.013	1.155	1.112
South model life table	-0.023	-0.022	1.922	1.735
India official, 1970-75 to 2002-06	-0.003	-0.014	0.912	1.347
India official, 1970-75 to 1991-95	-0.015	-0.023	1.523	1.787
India official, 1996-2000 to 2002-06	-12.24	-6.219	0.203	1.07

Results presented in Table 1 clearly suggest that the coefficients α and β from all three model life tables have similar values. To some extent, the coefficients obtained from the SRS life table for the period 1970-75 to 1991-95 follow the pattern that is observed in the three model life table patterns. On the other hand, coefficients obtained for the period 1996-2000 to 2002-06 have quite a contradictory pattern to the model life table pattern. For example, the β coefficient (slope coefficient) ranges from 1.15 in the west model table to 1.92 in the south Asian model table. The β coefficient for SRS life tables for the period 1970-75 to 1991-95 goes well with the three model life patterns. In contrast, the β coefficient observed from SRS life tables for the period 1996-2000 to 2002-06 varies drastically from any model life table patterns. This apparently indicates towards possible biases or inconsistencies in SRS life tables for the period 1996-2000 to 2002-06 and contradicts available empirical mortality laws.

Figure 4 and Appendix A (p 68) present the relationship between life expectancy at birth and $_4q_1/_1q_0$ in the original SRS life tables and predicted from regression equation based on model life tables. Here $_4q_1/_1q_0$ is predicted from the regression equation derived from model life table (Table 1) taking original e^o_x from SRS as predictor. In other words, we have estimated what should be the pattern of $_4q_1/_1q_0$ according to three different model life tables at the level of life expectancy at birth obtained from SRS.

Figure 4: Relationship between Life Expectancy at Birth and $_4q_1/_1q_0$ in Original SRS Life Table and Predicted from Regression Equation based on Model Life Tables

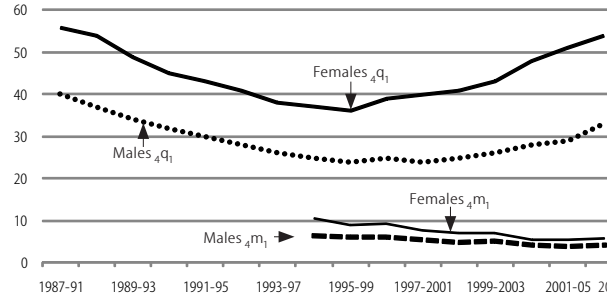


The above figures are plotted on the log scale to the base 10.

As we observe from the figure, the SRS original trend is very different from the predicted trends from different model life tables. One can accept the trend up to the time period 1996-2000 as the slope of the SRS trend is downward; but it is not at all realistic beyond that, as it goes just opposite to model life table patterns (Figure 4). This is also true for most of the states where child mortality has increased since the mid-1990s, e g, Assam, Bihar, Himachal, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and West Bengal. A comparison with the predicted model life table patterns raises serious doubt about $_4q_1/_1q_0$ provided by the SRS.

The trends in $_4q_1$ and $_4m_1$ values (age-specific death rate for the one-five age group) obtained from SRS published life tables and reports during the period 1996-2006 at the national level are plotted in Figure 5, which clearly indicates inconsistencies in $_4q_1$ and $_4m_1$ values. The $_4m_1$ values show a consistent decline while the $_4q_1$ values show a declining trend up to 1996-2000 and then start increasing over the most recent period. There is no reason to believe such inconsistencies in $_4q_1$ and $_4m_1$ values during the most recent period.

Figure 5: Trends in $_4q_1$ and $_4m_1$ from SRS Life Tables and SRS Reports (1996 to 2006)



The third piece of evidence that indicates inconsistency in SRS estimates comes from the fact that theoretically the $_4q_1$ values cannot exceed four times the age-specific death rate for the one-four age group (ASDR 1-4) $_4m_1$ value. Figure 6 (p 66) depicts the scatter plot between $_4q_1$ and $_4m_1$ with a line indicating four times $_4m_1$. The dots are the actual estimates of $_4q_1$ from the SRS life table whereas the line depicts the maximum limit of $_4q_1$, i e, four times of $_4m_1$. Theoretically, $_4q_1$ estimates should lie below the line ($4*_4m_1$). The scatter plot clearly suggests that for the recent periods $_4q_1$ estimates exceed four times $_4m_1$ value which is not possible under any case. All the $_4q_1$ estimates from SRS lie above the line. In addition, the scatter plot suggests deterioration in the SRS estimates with increase in time after the year 1991-95. The SRS points keep on moving away from the line as we move from the 1996-2000 life table to the 2002-06 life table. It is again important to note that the deviation is more in case of females than in males.

Thus the increasing trend observed in child mortality in India and its states seems to be very unrealistic. The only way to deal with this issue is to reproduce the published life tables using age-specific death rates from SRS annual reports for the corresponding period and to check whether the new $_4q_1/_1q_0$ pattern follows the model life table pattern or not.

Construction of New Life Tables: India and Major States

While constructing conventional life tables using age-specific death rates from the SRS annual reports, we apply the same method used by the SRS for constructing its official life table so

Figure 6: Scatter Diagram Showing the Relationship between $_4m_1$ and $_4q_1$ from SRS (1996-2000 to 2002-06)

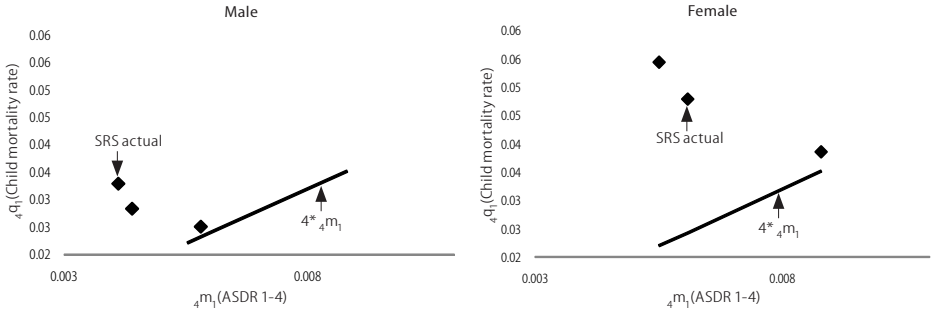
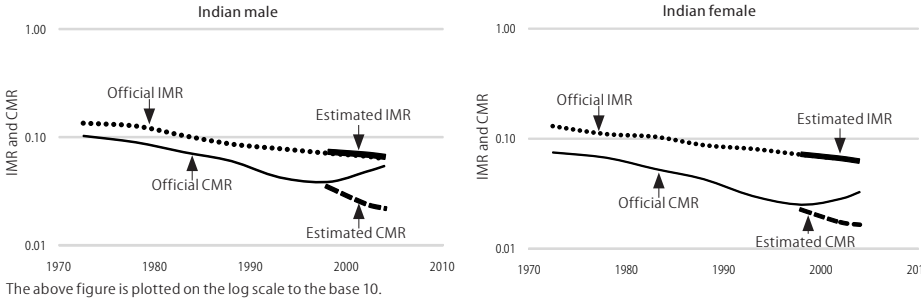


Figure 7: Comparison of IMR and CMR (Per 1,000) from Newly Estimated Life Tables and SRS Official Life Tables, India (1996-2000 to 2002-06)



The above figure is plotted on the log scale to the base 10.

that any differences in IMR or CMR between the official and new estimates cannot be attributed to a difference in methodology. The detailed methodology used by SRS for constructing life tables can be obtained from any of the SRS based abridged life tables report (Registrar General of India 2007). As discussed in the earlier sections, the problem basically lies in the recent period. Therefore we restrict the construction of new life tables to the period 1996-2000, 2002-04 and 2004-06 and examine whether new estimates follow model life table patterns or not.

Table 2 shows the comparison between IMR and CMR obtained from newly constructed life tables and SRS official life tables for the three recent points of time. In addition, Appendix B (p 69)

Table 2: Comparison of IMR and CMR (Per 1,000) from Newly Estimated Life Tables and SRS Official Life Tables, India (1996-2000 to 2002-06)

	Female				Male			
	IMR		CMR		IMR		CMR	
Year	Estimated	Official	Estimated	Official	Estimated	Official	Estimate	Official
1996-2000	73.35	72.07	34.46	38.57	72.83	71.43	22.79	24.95
2000-04	68.87	67.76	24.044	47.87	66.83	65.64	17.29	28.24
2002-06	65.25	64.06	21.85	54.38	62.92	61.69	16.35	32.82

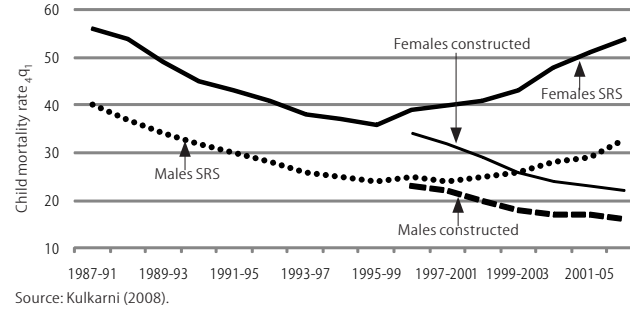
shows the trend of new and old estimates of India and selected states. The level of agreement between new and old estimates is fairly good in case of IMR but it is completely opposite in case of child mortality. For 2000-04 and 2002-06, child mortality rates obtained from official life tables are twice (even more than twice in 2002-06) the newly estimated child mortality rates.

Figure 7 shows the comparison of infant and child mortality rates from newly estimated life tables and SRS official life tables for the periods 1996-2000 to 2002-06 separately for male and female. Results suggest marked differences between the new estimates and those published by the SRS. The newly estimated CMR was much lower than the official CMR provided by SRS for the recent periods. Unlike the official trend, the new estimates of CMR show a declining trend which is quite consistent with trends observed for the periods (1970-75 to 1991-95) and with other efforts being made by the government in health, education and rural development sectors (especially making drinking water and sanitation facilities available). On the other hand, new estimates of IMR coincide with the official estimates, pointing towards the fact that the problem basically lies with CMRS and not really with IMRS. Appendix B shows the comparison for selected states which reiterates similar findings for each of the states.

We also present in Figure 8 the comparison of infant and child mortality rates from newly estimated life tables and SRS official life tables for each year starting from 1987-91 to 2002-06 to have a better picture of the deviation between the SRS official estimates and the estimates obtained from newly constructed life tables. It is very clear that the margin of difference between the SRS official estimates and the estimates obtained from newly constructed life tables increase over time during the recent periods. This is consistent with our argument presented in the earlier section related to Figure 6. The problem apparently seems to be more common in case of females as compared to males.

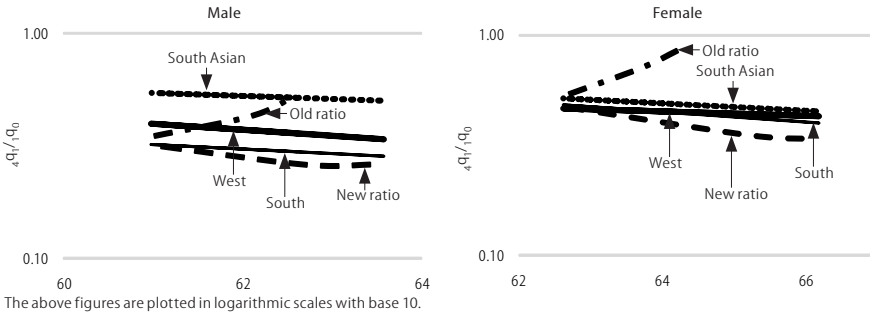
Figure 9 (p 67) and Appendix C (p 70) present the relationship between life expectancy at birth and $_4q_{1/1}q_0$ from three different sources: predicted pattern obtained from model life tables, pattern directly obtained from SRS official life tables and estimated pattern obtained from new life tables constructed by the authors for the period 1996-2000 to 2002-06. While obtaining the predicted pattern from model life table, we use regression equations presented in Table 1 by considering old and new estimates of e^o_x from SRS as the values of the independent variable to estimate the ratio $_4q_{1/1}q_0$. For the official pattern, we used $_4q_{1/1}q_0$ and e^o_x directly from the SRS abridged life tables for the period 1996-2000 to 2002-06 whereas for the estimated pattern these values are obtained from the new life tables constructed by the authors. Figure 8 clearly shows that the newly estimated trend of $_4q_{1/1}q_0$ against life expectancy at birth has a pattern similar to the pattern observed in model life tables. The newly constructed $_4q_{1/1}q_0$

Figure 8: Trends in $_4q_1$, SRS Life Tables versus Newly Constructed Life Tables (1987/91-2002/06)



Source: Kulkarni (2008).

Figure 9: Comparison of $_4q_{1/1}q_0$ Plotted against e^0_x from Different Sources: Regression Equation-Based on MLT, SRS Original Life Table and Newly Constructed Life Table



The above figures are plotted in logarithmic scales with base 10.

decreases with increase in life expectancy at birth. This is in contrast to SRS official estimates which show an increasing trend with increase in life expectancy at birth.

It is worthwhile to mention that the newly fitted regression equation for the complete period 1970-1975 to 2002-06 by substituting old estimates with newly constructed estimates for the period 1996-2000 to 2002-06, gives results similar to model life table patterns (R^2=0.93 for male and 0.88 for female). For example, the corrected α and β values for male are -0.029 and 2.11, respectively. Similarly, the corrected α and β values for female are -0.026 and 2.095, respectively. Findings were similar for the selected states as well. This is generally more prominent in the states where child mortality is still very high. Thus new estimates are much more realistic and convincing as these follow patterns that are similar to those observed in other human populations of the world.

New Estimates and Its Implications

Table 3 gives the new life expectancies at birth from the newly constructed life tables along with the existing SRS life table estimates for India and selected states by sex. In addition, Appendix D (p 70) gives l_x and e^o_x columns of the newly estimated life table by sex for 1996-2000, 2000-04 and 2002-06. We present only l_x functions for the simple reason that all the other functions of the life table can be easily obtained by using l_x values. The life expectancy values are also presented for ready reference of those researchers who are not familiar with life table functions. The most striking finding comes out in terms of gender differentials in mortality. The new estimates clearly suggest that females were at an advantage in terms of life expectancy during the late 1990s and later in all the states of India. On the other hand, the official SRS life table showed otherwise for some states like Uttar Pradesh, Madhya Pradesh and Bihar. In addition, the gender differences in estimated values were considerably higher than those observed in official values. This is particularly true for the period 2000-04 and 2002-06. For example, for the period 2002-06, the estimated difference between female and male life expectancy in Haryana was 3.5 whereas the official difference in the same was 0.4 years. Similar discrepancies are found in the case of Assam, Madhya Pradesh and West Bengal.

We observe some other important points from this table. First, female life expectancy has risen faster according to the new estimates as compared to the official estimates during the three recent time points. Second, the difference between estimated and official female e^o_x was higher than that of male, particularly in 2000-04 and in 2002-06. This indicates that mortality among females was overestimated as compared to that of males.

Usually, e^o_x is considered as one of the best indicators of adult mortality in a given population. To know whether or not, the new analysis has any implications on adult mortality we compare

Table 3: Comparison of e^0_x from Newly Estimated Life Table and SRS Original Life Table (1996-2000, 2000-04 and 2002-06)

	1996-2000								2000-04								2002-06							
Country/State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	E	O	E-O	E	O	E-O	F-M	F-M	E	O	E-O	E	O	E-O	F-M	F-M	E	O	E-O	E	O	E-O	F-M	F-M
	M	M	M	F	F	F	E	O	M	M	M	F	F	F	E	O	M	M	M	F	F	F	E	O
India	61.1	61.0	0.1	62.7	62.7	0.0	1.6	1.7	62.7	62.1	0.6	65.2	63.7	1.5	2.5	1.6	63.5	62.6	0.9	66.1	64.2	1.9	2.6	1.6
Andhra Pradesh	61.0	61.7	-0.7	64.6	64.3	0.3	3.6	2.6	62.3	62.4	-0.1	67.2	65	2.2	4.9	2.6	63.0	62.9	0.1	67.8	65.5	2.3	4.8	2.6
Assam	57.2	57.4	-0.2	57.7	57.7	0.0	0.5	0.3	57.8	58.0	-0.2	59.6	58.6	1.0	1.8	0.6	58.7	58.6	0.1	60.9	59.3	1.6	2.2	0.7
Bihar	61.1	60.9	0.2	59.9	59.1	0.8	-1.2	-1.8	64.2	61.8	2.4	63.8	59.9	3.9	-0.4	-1.9	64.5	62.2	2.3	64.1	60.4	3.7	-0.4	-1.8
Gujarat	63.1	62.1	1.0	66.0	64	2.0	2.9	1.9	63.5	62.7	0.8	67.7	64.8	2.9	4.2	2.1	63.7	62.9	0.8	67.9	65.2	2.7	4.2	2.3
Haryana	63.8	64.4	-0.6	64.9	65.1	-0.2	1.1	0.7	65.2	65.3	-0.1	68.1	65.8	2.3	2.9	0.5	65.1	65.9	-0.8	68.6	66.3	2.3	3.5	0.4
Himachal Pradesh	65.7	65.4	0.3	68.6	66	2.6	2.9	0.6	67.1	66.1	1	67.1	66.8	0.3	0.0	0.7	67.3	66.5	0.8	72.1	67.3	4.8	4.8	0.8
Karnataka	65.0	62.5	2.5	66.4	65.8	0.6	1.4	3.3	63.3	63.1	0.2	68.7	66.7	2.0	5.4	3.6	64.2	63.6	0.6	68.8	67.1	1.7	4.6	3.5
Kerala	69.0	70.7	-1.7	75.1	76.1	-1.0	6.1	5.4	70.2	71.0	-0.8	76.3	76.1	0.2	6.1	5.1	70.8	71.4	-0.6	76.9	76.3	0.6	6.1	4.9
Madhya Pradesh	56.6	56.6	0.0	57.6	56.3	1.3	1.0	-0.3	58.7	57.5	1.2	60.0	57.2	2.8	1.3	-0.3	59.5	58.1	1.4	61.3	57.9	3.4	1.8	-0.2
Maharashtra	64.0	64.7	-0.7	67.6	67.2	0.4	3.6	2.5	65.6	65.5	0.1	69.0	67.8	1.2	3.4	2.3	66.7	66.0	0.7	70.3	68.4	1.9	3.6	2.4
Orissa	57.7	57.8	-0.1	58.7	58.0	0.7	1.0	0.2	59.3	58.9	0.4	61.5	58.9	2.6	2.2	0.0	60.1	59.5	0.6	62.4	59.6	2.8	2.3	0.1
Punjab	65.3	67.1	-1.8	68.0	69.2	-1.2	2.7	2.1	67.2	67.8	-0.6	69.6	69.8	-0.2	2.4	2.0	67.6	68.4	-0.8	70.5	70.4	0.1	2.9	2.0
Rajasthan	61.4	60.1	1.3	62.9	61.1	1.8	1.5	1.0	62.6	60.9	1.7	65.1	62	3.1	2.5	1.1	63.3	61.5	1.8	66.1	62.3	3.8	2.8	0.8
Tamil Nadu	63.5	63.9	-0.4	66.2	65.9	0.3	2.7	2.0	65.2	64.6	0.6	68.2	66.8	1.4	3.0	2.2	65.9	65	0.9	69.1	67.4	1.7	3.2	2.4
Uttar Pradesh	59.5	59.1	0.4	58.6	57.9	0.7	-0.9	-1.2	60.3	59.9	0.4	60.5	59	1.5	0.2	-0.9	60.9	60.3	0.6	61.5	59.5	2.0	0.6	-0.8
West Bengal	63.4	63.0	0.4	65.8	64.5	1.3	2.4	1.5	65.5	63.7	1.8	68.2	65.2	3.0	2.7	1.5	66.4	64.1	2.3	69.2	65.8	3.4	2.9	1.7

E=Estimated, O=Official, M=Male, F=Female, F-M= Difference between male and female.

estimated e^o_x with the SRS e^o_x. It is found that the difference between estimated and original SRS e^o_x is quite negligible for almost all states. Numerically, the difference between estimated and observed e^o_x lies below one year for almost all states (the exception being male Kerala). This also hints towards inconsistencies and biases only in the CMRS.

The findings of this analysis are of great importance from the policy point of view. Over the years, projections of population in India have been based on mortality indicators obtained directly from SRS life tables. For example, while projecting the population of India and the states for the period 2001-26, future mortality patterns of each state were assumed on the basis of e^o_x obtained from the SRS life tables for the period 1990-94 and 1995-99 (Office of the Registrar General and Census Commissioner 2006). This may lead to serious biases in the projected figures particularly when the mortality indicators obtained from SRS are seriously biased. The mortality assumptions can go drastically wrong for the projection period as we clearly see a difference of two-four years in the newly constructed life expectancies and the official life expectancies by the SRS. The most important implication for the projection of population will be due to the missing women who are not taken into account in the SRS life tables. Contrary to the direct estimates from the SRS official life table, it is clear that the estimated life expectancy at birth is much higher than the observed life expectancy at birth, particularly for females. Thus new estimates indicate that there are more women survivors who are omitted in SRS life tables in the recent period. If these missing women can be counted in the projection of population, there will be a huge impact on the total size and age-sex composition of the population. The difference between total male and female population may show a reverse trend which is again very important for policy implications in the future. The amount of bias in the population projection can be seen by undertaking new projections based on new assumptions obtained after eliminating biases from the SRS data.

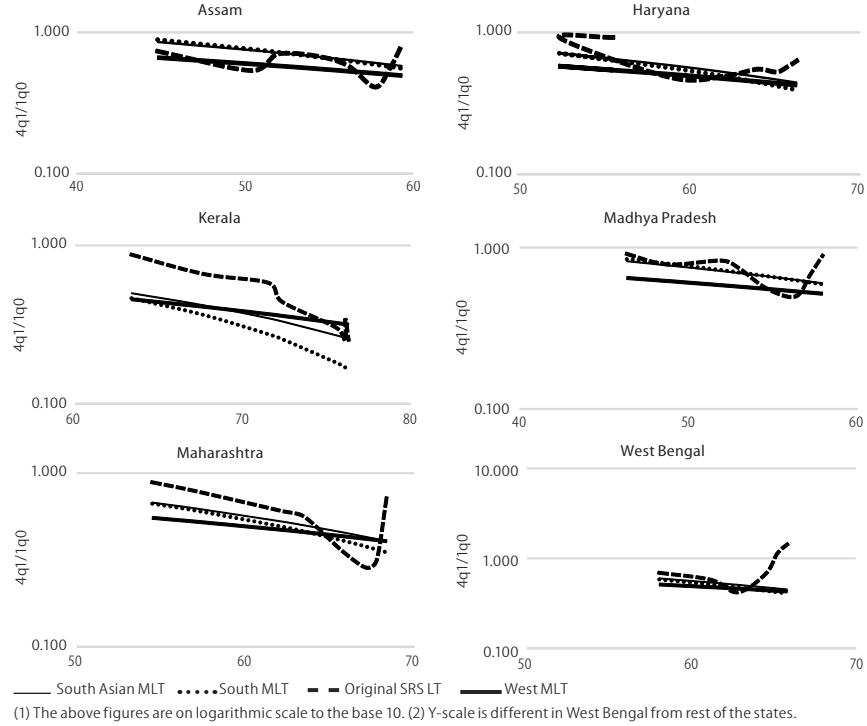
Another important implication of this analysis is that the new estimates may have a substantial impact on some welfare indices such as Human Development Index or Gender-related Development Index, etc. One of the three components used in the construction of these indices is life expectancy at birth. If we replace the earlier e^o_x from SRS by new estimates while calculating gender-related indices, we can expect more gender equality in India.

Conclusions

The SRS life table presents a stagnant infant mortality trend and an increasing child mortality trend for all major states in India for the recent period. This study attempts to evaluate the reasons behind this unusual increase in child mortality in all major states (where SRS data are available). As literature does not indicate any rationale for increasing child mortality in India, we tried to appraise them by evaluating the relationship between life expectancy at birth and the ratio of child and infant mortality with the help of model life tables. In simple words, the principle of constructing model life table is observed correlation among age-specific pattern of mortality obtained from empirical data from many countries. Thus one can estimate, for instance, the level of adult mortality on the basis of mortality rates during infancy or childhood or any other age group. It has been found that there exists systematic deviation of SRS mortality indicators from that of model life table indicators for the most recent period. As the pattern of the problem remains the same for almost all states during the recent periods, one can infer that there may be some methodological errors in the construction of life table in this period. Using the same age-specific death rate with the same methodology, we construct new life tables for the recent periods, which give globally comparable patterns of infant and child mortality which were not observed in the published SRS life tables.

The results of this analysis have considerable importance from the policy point of view. This is because of the direct application of SRS mortality indicators in the projection of India's future population which, in turn, shapes the population policy and programme of the country. It is also relevant because various indicators used to track the improvement in the Millennium Development Goals and other government programmes are either based on or derived from the SRS-based life tables. The reconstructed life tables clearly show that the life expectancy at the national level for females and males was higher by two years and one year respectively, compared to those published in the

Appendix A: Predicted and Original $_4q_{1/1}q_0$ Corresponding to Original e^o_x for Selected States (Only for Females)



(1) The above figures are on logarithmic scale to the base 10. (2) Y-scale is different in West Bengal from rest of the states.

SRS life tables for the most recent period. In some states, the error is even higher. So, it is high time to correct all the SRS life tables for the recent periods.

(A detailed analysis of all major states of India is with the authors. Results can be made available to readers on request.)

REFERENCES

Anand, K, S Kant, G Kumar and S K Kapoor (2000): "Development Is Not Essential to Reduce Infant Mortality Rate in India: Experience from the Balladgargh Project", *J Epidemiol Community Health,* Vol 54(1), pp 247-53.

Bhat, P N M (1998): "Demographic Estimates of Post-Independence India: A New Integration", *Demography India,* Vol 27(1), pp 23-37.

– (2002): "Completeness of India's Sample Registration System: An Assessment Using the General Growth-Balance Method", *Population Studies,* Vol 56(2), pp 119-34.

Claeson, M, E R Bos, T Mawji and I Pathmanathan (2000): "Reducing Child Mortality in India in the New Millennium", *Bulletin of the World Health Organisation*, Vol 78(10), pp 1192-99.

Coale, A J and P Demeny (1966): *Regional Model life Tables and Stable Populations* (New Jersey: Princeton University Press).

Fotso, J-C, A C Ezeh, N J Madise and J Ciera (2007): "Progress Towards the Child Mortality Millennium Development Goal in Urban Sub-Saharan Africa: The Dynamics of Population Growth, Immunisation, and Access to Clean Water", *BMC Public Health,* Vol 7, p 218.

IIPS (1995): *National Family Health Survey 1992-93* (Mumbai: IIPS/ORC Macro International).

– (2000): *National Family Health Survey 1998-99* (Mumbai: IIPS/ORC Macro International).

– (2007): *National Family Health Survey 2005-06* (Mumbai, IIPS/ORC Macro International).

Kulkarni, P M (2008): "Infant and Child Mortality in India: Recent Trends and Prospects", paper presented at a national seminar on "Methodological Issues in Measuring Millennium Development Goals (MDG) in Districts of India", 12-13 December (Mumbai: IIPS).

Martin, L G, J Trussell, F R Salvail and N M Shah (1983): "Co-variates of Child Mortality in the Philippines, Indonesia, and Pakistan: An Analysis Based on Hazard Models", *Population Studies,* Vol 37(3), pp 417-32.

Mathers, C D, D M Fat, M Inoue, C Rao and A D Lopez (2005): "Counting the Dead and What They Die from: An Assessment of the Global Status of Cause of Death Data", *Bulletin of World Health Organisation*, 83(3), pp 171-80.

Mishra, V, T K Roy and R D Retherford (2005): "Sex Differentials in Childhood Feeding, Healthcare, and Nutritional Status in India", *Population and Development Review,* Vol 30(2), pp 269-95.

Mosley, W H and L C Chen (1984): "An Analytical Framework for the Study of Child Survival in Developing Countries", *Population and Development Review,* Vol 10, pp 25-45.

Office of the Registrar General and Census Commissioner (2006): "Population Projections for India and States 2001-26", *Report of the Technical Group on Population Projections Constituted by the National Commission on Population,* New Delhi.

Parasuraman, S (1990): "Age Patterns of Mortality in India" in K Srinivasan and K B Pathak (ed.), *Dynamics of Population and Family Welfare 1989* (Mumbai: Himalaya Publishing House).

Preston, S H, M Heuveline and M Guillot (2001): *Demography Measuring and Modelling Population Process* (US: Blackwell Publishers).

Ram, F (1984): "Some Contribution Onwards the Estimation of Vital Rates from Incomplete Data", Unpublished PhD Thesis Submitted to Bombay University, IIPS.

Registrar General India (1983): "Report on Intensive Enquiry Conducted in Sub-Sample of SRS Units (1980-81)", *Occasional Paper No 2 of 1983* (Delhi: Controller of Publication).

– (1988): "Report on Intensive Enquiry Conducted in Sub-Sample of SRS Units", *Occasional Paper No 1 of 1988* (Delhi: Controller of Publication).

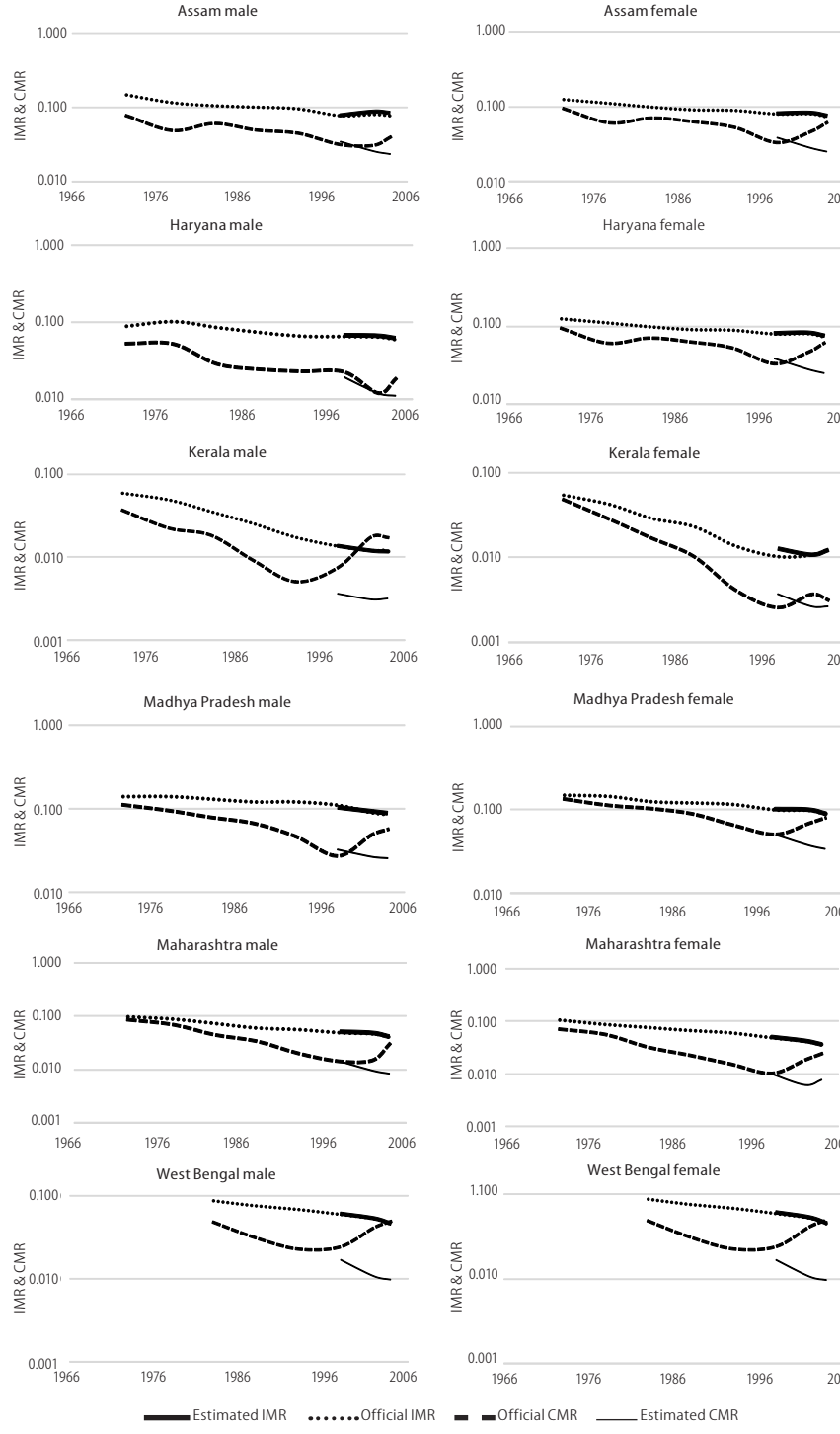
– (2007): "SRS-based Abridged Life Tables 2002-06, 2007, Registrar General, New Delhi.

Roy, T K and S Lahiri (1988): "Recent Levels and Trends in Mortality in India and Its Major States: An Analysis based on SRS Data" in K Srinivasan and S Mukerji (ed.), *Dynamics of Population and Family Welfare (1987)* (Bombay: Himalaya Publishing House), pp 279-349.

Saikia, N, D Jasilionis, F Ram and V Shkolnikov (2009): "Trends in Geographical Mortality Differentials in India", MPIDR Working Paper 2009-13, Max Plank Institute for Demographic Research, Germany.

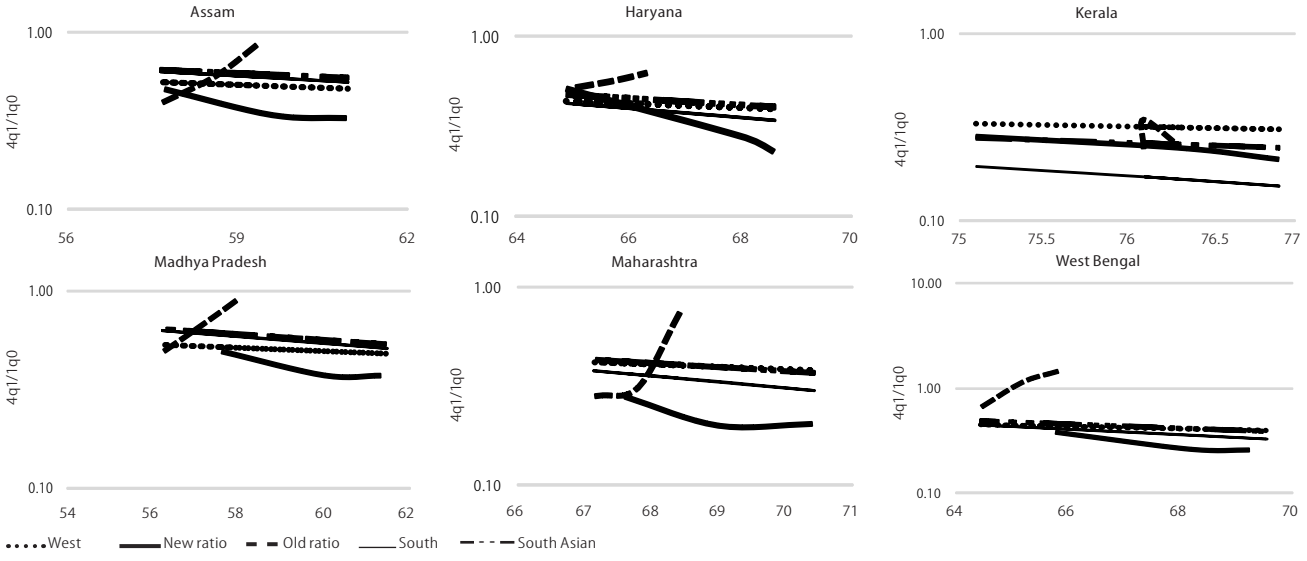
United Nations (1982): *Model Life Tables for Developing Countries,* United Nations Publication, Sales No E 81 XIII.

Appendix B: Comparison of Infant and Child Mortality Rate (Per 1,000) from Newly Estimated and SRS Official Life Tables, 1996-2000 to 2002-06, Selected States



The above figures are on logarithmic scale to the base 10.

Appendix C: Comparison of $_4q_{1/1}q_0$ from Different Sources: Regression Equation Based on MLT, SRS Original Life Table and Newly Constructed Life Table, Six Major States Only for Female



The above figures are on logarithmic scales to the base 10.

Appendix D: l_x and e^0_x Functions of the Newly Constructed Life Tables by Sex, India (1996-2000, 2000-04 and 2002-06)

	Males, 1996-2000		Females, 1996-2000		Males, 2000-04		Females, 2000-04		Males, 2002-06		Females, 2002-06	
Age	l_x	e^0_x	l_x	e^0_x	l_x	e^0_x	l_x	e^0_x	l_x	e^0_x	l_x	e^0_x
0-1	1,00,000	61.1	1,00,000	62.7	1,00,000	62.7	1,00,000	65.2	1,00,000	63.5	1,00,000	66.1
1-4	92,717	64.8	92,665	66.6	93,316	66.2	93,113	68.9	93,708	66.7	93,471	69.6
5-9	90,603	62.3	89,471	64.9	91,702	63.3	90,874	66.6	92,175	63.8	91,429	67.1
10-14	89,791	57.8	88,438	60.6	91,017	58.7	90,096	62.1	91,532	59.2	90,711	62.7
15-19	89,281	53.1	87,874	56.0	90,526	54.1	89,601	57.5	91,084	54.5	90,250	58.0
20-24	88,587	48.5	86,973	51.5	89,868	49.4	88,763	53.0	90,431	49.9	89,459	53.4
25-29	87,617	44.0	85,789	47.2	88,964	44.9	87,721	48.6	89,549	45.3	88,498	49.0
30-34	86,442	39.6	84,655	42.8	87,797	40.5	86,648	44.1	88,427	40.9	87,538	44.5
35-39	85,044	35.2	83,486	38.4	86,394	36.1	85,597	39.7	87,057	36.5	86,571	40.0
40-44	83,258	30.9	82,283	33.9	84,597	31.8	84,389	35.2	85,289	32.2	85,435	35.5
45-49	80,900	26.7	80,734	29.5	82,342	27.6	83,016	30.7	83,065	28.0	84,104	31.0
50-54	77,653	22.7	78,589	25.2	79,259	23.6	81,029	26.4	80,076	23.9	82,190	26.6
55-59	72,821	19.1	75,223	21.2	74,836	19.8	78,176	22.3	75,835	20.1	79,550	22.4
60-64	66,199	15.7	70,280	17.5	68,491	16.4	73,532	18.5	69,896	16.6	75,224	18.6
65-69	57,021	12.8	63,026	14.3	60,061	13.3	66,926	15.1	61,572	13.5	68,591	15.1
70-74	45,658	10.3	53,228	11.4	48,593	10.8	57,247	12.2	50,427	10.9	59,213	12.1
75-79	33,171	8.3	40,711	9.1	36,441	8.6	45,324	9.7	37,789	8.6	46,648	9.7
80-84	20,834	6.7	27,595	7.3	23,413	7.0	31,633	7.8	24,592	6.9	33,168	7.6
85+	11,336	5.2	15,929	5.8	13,289	5.4	19,350	6.2	13,743	5.4	20,031	5.9