Adult male mortality in India: An application of the widowhood method

Nandita Saikia[1]
Abhishek Singh[2]
Faujdar Ram[3]

Summary

Background: Though the health and survival of adults are crucial for the well-being of households and country alike, searching the literature on adult mortality yields little evidence on the levels and trends in adult mortality in India. Estimates of adult mortality at local levels (district or block level) are even more scarce in India. This paper presents levels and trends of adult male mortality in India and its major states during the post-independence period obtained by applying the widowhood method on census data. In addition, it attempts to estimate adult male mortality at local levels.

Method: We used the well-known widowhood method, meant for measuring adult male mortality, using data from the Indian Censuses of 1961, 1971, 1981, 1991, and 2001 to examine the trends in adult male mortality since independence and also to examine the suitability of widowhood method for generating local level estimates. We estimated life expectancy at age 20 (e_{20}^{0}) for India and its 16 major states. Further, we adjusted our estimates for possible bias due to remarriages and examined the sensitivity of the adjusted estimates to different scenarios of remarriage rates. Finally, this method was applied to estimate adult mortality for five randomly-chosen districts of India with relatively low levels of information on adult mortality.

Findings: A comparison of widowhood estimates with direct estimates from official sources supports the credibility of widowhood estimates. Information obtained from widows aged 40-44 and 45-49 provided the most convincing patterns of adult mortality. Trends in adult mortality suggest the maximum gain in e_{20}^{0} for India as a whole and most of the states occurred in1949-1960. Adult male mortality varied substantially across the states of India. Although adult life expectancy has been rising in India and in most of its states, the rate of mortality reduction has been decreasing over the last few decades.

Conclusion: The widowhood method can be effectively used to estimate adult male mortality at local levels, such as districts and blocks, for which readymade estimates are not available. The Census of India must strive to collect information on marital status with respect to first marriage to facilitate more effective use of the widowhood method for estimating adult male mortality at the local levels.

[1] Assistant Professor, Population Research Centre, Institute of Economic Growth, University Enclave, University of Delhi, New Delhi. Email: nanditasts@gmail.com
[2] Assistant Professor, Department of Public Health & Mortality Studies, International Institute for Population Sciences, Govandi Station Road, Deonar, Mumbai. Email: abhi_iips@yahoo.co.in
[3] Director & Senior Professor, International Institute for Population Sciences, Govandi Station Road, Deonar, Mumbai. Email: fram@iips.net

1. Introduction

Accurate mortality statistics are essential in assessing the overall health of a population. Until a few decades ago, under-five mortality was considered to be the most important indicator of health status in developing countries. However, with the advent of ageing and health transitions in these countries, the picture has changed immensely. Mortality below age five has reduced considerably, and the burden of disease from non-communicable diseases among adults is rapidly increasing. Thus, the level of adult mortality is becoming an important indicator for the comprehensive assessment of mortality patterns even in developing countries.

Despite these newer developments, research on mortality in India still focuses largely on infant and child mortality (Arokiasamy 2004; Bang, Reddy and Deshmukh 2002; Claeson et al. 2000; Kravdol 2004; Singh, Hazra and Ram 2007; Singh, Mahapatra and Dutta 2008; Whitworth and Stephenson 2002). This focus is obviously due to considerably high levels of overall mortality during infancy and childhood. The infant mortality rate in India is 57 per 1000 live births with huge variations across the different states - from 73 per 1000 live births in Uttar Pradesh to 15 per 1000 live births in Kerala. Similarly, under-five mortality within India ranges between 96 per 1000 live births in Uttar Pradesh and 16 per 1000 live births in Kerala (IIPS and ORC Macro 2007).

Unlike infant and child mortality, adult mortality has not received appropriate attention in India, but there is an urgent need for research in this area for numerous reasons. Firstly, the adult population aged 15-59 in India is very large in both its absolute as well as its relative size. According to the 2001 Indian census, with a population of 585 million, the adult population aged 15-59 years constitutes 57% of India's total population. Calculations based on life tables derived from the Sample Registration System for the most recent period suggest that 89% of newborns are likely to survive to age 15, but only 72% of children aged 15 years are likely to survive to age 65 (Registrar General of India 2008). In addition, the maternal mortality rate is very high in India (Hogan et al. 2010) at 212 maternal deaths per 100,000 live births for the period 2007-09 (Registrar General of India 2011).

Secondly, examination of adult mortality trends can provide useful information on the pace of mortality decline and improvements in human survival, as well as on recent changes in mortality patterns due to newer and emerging infections like HIV/AIDS. Studies have shown that tuberculosis and HIV/AIDS, two of the three diseases covered by Millenium Development Goal 6, are largely killers of adults—95% and 85% of deaths from TB and HIV/AIDS, respectively, occur in people older than 15 years (Rajaratanam et al. 2010; Yamano and Jayne 2004), and in many countries of Sub-Saharan Africa such as Botswana, South Africa, Zimbabwe, the gains in human survival have been diluted by the increase in adult mortality from newer and emerging infections. In addition, there is evidence of increasing trends in deaths from external causes such as suicide, homicide, and road accidents in Southeast Asia, China, Phillipines, and the Russian Federation (Rebholz et al. 2011; Patton et al. 2009; Vecchia, Lucchini and Levi 1994; Wasserman, Cheng and Jiang 2005; WHO 2009). Further, adult mortality analysis can provide key inputs to country-level health/social sector policies and programmes. Finally, several studies have highlighted the adverse economic and social implications of adult mortality vis-à-vis under-five mortality in various country settings (Feachem et al. 1992; Roy, Kane and Khuda 2001).

Estimation of premature adult deaths for small geographical units in a diverse country like India can be particularly beneficial for monitoring the achievement of different population and health-related policies such as the National Population Policy of 2000, the National Health Policy of 2003, and the Millennium Development Goals. Such analysis gains special significance in the light of Millennium Development Goals 5 and 6, which attempt to reduce maternal mortality and mortality due to HIV/AIDS, tuberculosis, and malaria. Evidence further suggests significant variations in the spread of these infectious diseases at local levels and pockets in India. HIV/AIDS is still considered a concentrated epidemic in India, with very high prevalence among high-risk groups (viz. female sex workers, patients with sexually transmitted diseases, men having sex with men, injecting drug users etc.) and in certain geographical pockets (Jha et al. 2010; NACO 2008). For example, although the prevalence of HIV/AIDS among antenatal clinic attendees in Maharashtra (a high HIV/AIDS prevalence state) is below 1%, districts like Sangli, and Chandrapur have a prevalence of more than 3%. On the other hand, there are certain districts in low HIV/AIDS prevalence states like Ganjam in Orissa and Ganganagar in Rajasthan that have prevalence rates above 3% among the antenatal clinic attendees (NACO and NIHFW

2007). In addition, there are newer emerging hotspots in the urban areas of Delhi, Chandigarh, Punjab, and West Bengal. Similarly there exist huge inter-regional variations in the prevalence of tuberculosis within and across the states of India (DGHS 2010; IIPS and ORC Macro 2007; Singh 2010). According to the third round of the National Family Health Survey (NFHS-3) in 2005-2006, the TB prevalence rate varies from 104 per 100,000 in the northern state of Jammu and Kashmir to 1,111 per 100,000 in the northeastern state of Arunachal Pradesh (IIPS and ORC Macro 2007), and other studies show considerable variation in the prevalence of TB and malaria within Indian states (authors' calculation using District Level Household Survey round 2; Singh 2010; Dhingra et al. 2010). Maternal mortality rates are also found to vary considerably across the states and districts of India (Registrar General of India 2011; authors' own calculations using District Level Household Survey round 3). This evidence clearly underscores the need for mortality estimation at local levels to correctly estimate the impact of infections that are at times highly localized in nature. Such an exercise is also likely to help local policymakers and programme managers formulate evidence-based interventions.

Overview of adult mortality in India and states

Figure 1 depicts the adult mortality trends (${}_{45}q_{15}$) in India and its major states by sex (Source: Office of Registrar General 1984, 1985a, 1989; Registrar General of India 1994a, 1998, 2004, 2007, 2008). Significant variations in levels and trends of adult mortality are found across the different states of the country. Though adult mortality has been declining consistently, the pace of decline differs from state to state. While Kerala has the lowest probability of death for both sexes, Assam has the highest mortality rates among all states. The pace of decline in child and adult mortality in India has slowed down after the 1990's, implying a leveling of mortality at a rather high level (Saikia et al. 2011). Mortality differentials across states in India have been shrinking over the last four decades with considerable inter-state differences in the pace of health improvements over time. As is the trend in other South Asian countries, the risk of mortality has declined substantially faster for women than for men in India (Rajaratnam et al. 2010; Saikia et al. 2011). Despite such impressive improvements, however, women aged 15-59 in India still experience mortality levels that are more than three times higher than those of their Japanese counterparts (Rajaratnam et al. 2010).

Figure 1 about here

According to the most recent report by the Office of Registrar General of India, non-communicable diseases are the leading causes of death in the country, constituting 42% of all deaths (Registrar General of India 2009). Among young adults aged 15-24 years, the mortality rate is dominated by non-medical causes such as intentional self harm, unintentional injuries, and motor vehicle accidents, while cardiovascular diseases, responsible for 25% of deaths, are the leading cause of death among adults aged 25-69 years. Both this report and a recent study by Saikia (2011) reveal wide regional variation in the causes of death among adults, as different geographic regions of India are in different stages of the epidemiological transition; while most of the southern states are in the second stage of the epidemiological transition (i.e. fighting against non-communicable diseases as a major health threat), most of the northern and central Indian states are still fighting against communicable diseases. On the other hand, there are some states like Madhya Pradesh and Haryana that have entered the second stage of epidemiological transition before completing the first stage and hence are doubly burdened by communicable and non-communicable diseases (Saikia 2011).

Wide inter-state and intra-state variations are also noticeable with respect to newer and emerging infections such as HIV/AIDS in India. A recent study by Jha et al. (2010) indicated significant variations in mortality attributable to HIV/AIDS across the states and districts of India, with more than three-fourths of the deaths occurring in high-prevalence states. Though the burden of HIV/AIDS related mortality among the adults (3.2%) was lower than that of other communicable and non-communicable diseases, it is important to note that about 1 in 12 deaths at age 25-34 in India in 2004 was because of HIV/AIDS.

Previous attempts to estimate adult male mortality in India

A literature search suggests only limited attempts to estimate adult mortality in India and its major states using census data. Malaker (1986) first attempted to estimate adult mortality in India using 1971 and 1981 census data, and further extended his study to examine district-level variations in adult mortality in West Bengal. The widowhood method used by Malaker provided consistent estimates of adult mortality for males, but adult female mortality estimates were severely underestimated (Malaker and Crook 1989). The second attempt to estimate adult male mortality using the widowhood method was undertaken by Bhat (1998), which found that the estimates of adult male mortality using widowhood data from women below age 40 were less acceptable than those obtained from widowhood data from women over age 40 (Bhat 1998). A study by Saikia and Bhat (2006) confirmed this finding, showing that the mortality estimates derived using data from women in the age groups 45-49 and 50-54 were better than those based on data obtained from women of other age groups and determining that this improvement was simply due to high rates of remarriage among young widows.

Given the dearth of studies addressing levels and trends in adult mortality in India, especially at local levels, and given the relevance of such studies, it is very important to systematically study adult mortality patterns since India's independence. It is worth mentioning that none of the official sources provide estimates of adult mortality during the 1950s, 1960s, or early 1970s. The Sample Registration System (SRS), which is the only reliable source of data on adult mortality in India, came into existence only in the 1970s. Though sources such as SRS, the NFHS, and other household surveys provide estimates of adult mortality, their scope is relatively limited, as they mostly provide estimates at national and state levels. In addition, these estimates are usually based on small sample sizes and mostly refer to recent time periods. Therefore, indirect estimation using census data is the only alternative for studying historical trends in adult mortality, particularly for smaller geographic units. In addition, indirect estimates derived from census data provide an independent check of the other official estimates. Hence, taking into account the advantages and applicability of indirect methods using census data in examining historical trends at local levels, this paper aims to examine the following three objectives:

1) To examine whether the widowhood method applied to marital status data from the Indian census yields plausible trends in adult mortality for India and its states since independence.

2) To understand trends in adult mortality for India and its states since independence

3) To apply the widowhood method for estimating adult male mortality at local levels (i.e. at levels below state)

2. Data and Methods

We use the well-known widowhood method developed by (Hill and Trussell 1977) to examine the levels and trends in adult male mortality using data on marital status from the Indian censuses of 1961, 1971, 1981, 1991 and 2001. We restrict our time frame to censuses in 1961 and later because of the consistency in the definition of marital status in and after 1961 census. Further, we adjust our estimates for possible biases in adult male mortality rates due to remarriages using the revised widowhood method. We propose to use the revised widowhood method because two of the three underlying assumptions of this method are valid in India; first, unlike western countries, marriage is a well-defined and nearly universal event in India, and as a result, the information on marital status in the Indian census is of relatively better quality compared to such data for other countries.

The widowhood method assumes that mortality does not vary significantly by marital status. While evidence from the developed world suggests relatively higher risks of death for unmarried individuals compared to married individuals (Hummer, Rogers and Eberstein 1998), we do not find any such systematic evidence documenting differential mortality risks by marital status in India. Since India has such a high rate of marriage among its adult population, the proportion of unmarried and never-married individuals to currently-married individuals is likely to be very small and small differentials in mortality risks by marital status are least likely to bias the estimates presented in the paper.

The revised widowhood method seeks to estimate probabilities of survival for males from age 20 to age n (n=25, 30, 35, 40, 45, 50, 55, 60). The reason for estimating survivorship probability from age 20 to age n is that age 20 is close to the average age at marriage of women. The application of this method requires data on the proportion of ever-married women in each five-year age-group whose first husbands were alive at the time of the census and on the proportion of ever-married males and females in each five year age-group to compute the singulate mean age at marriage for men ($SMAM_m$) and women ($SMAM_f$). The adjustment for remarriages requires additional information on remarriage rates. The details of the computational procedures involved in using the revised widowhood method are given in United Nations Manual X (United Nations 1983).

An obvious limitation of this method, however, is that it cannot provide the frequently-used measures of adult mortality such as life expectancy at age five and probability of deaths in age groups 15-45 or 20-45 (Lopez et al. 2002; Rajaratnam et al. 2010). As a result, we are left with only one measure for use in the present analysis: life expectancy at age 20. The estimated survivorship probabilities from age 20 to age n were converted into life expectancy at age 20 using the South Asian model life table system and the West model life table system (Coale and Demeny 1966; United Nations 1983). The choice of the aforementioned families of model life tables was guided by numerous studies that have clearly shown their suitability for describing Indian mortality patterns (Bhat 1998; Parasuraman 1990; Ram 1984).

Another challenge with the revised widowhood method is the choice of data on remarriage rates in the population under study. The marital status data in the Indian census suffers from a major drawback in that it does not provide specific information on remarriages. As a result, the adult male mortality rates generated from Indian census data are likely to be underestimated because some women who report their marital status as ‘currently married’ at the time of census enumeration might actually be married for the second time due to the death of their first husband. Therefore, we rely on other sources for information on remarriage rates in India and its major states. Unfortunately, we could not come across any systematic study that documents the extent of widow remarriages in India. However, fragmented evidence since independence suggests that remarriage rates varied from 9% in Orissa to 38 % in central India (Driver 1963; Superintendent of Census Operations 1968). Agarwala (1967) concluded that about 80-90% of widows under age 19 in rural northern India remarried with overall remarriage rates ranging between 19% in Mathura district in Uttar Pradesh to 38% in Delhi in the early 1960s. Bhat and Kanbargi (1984) using data on adult mortality and age-at-marriage found that about 34% of ever-married Indian women remarried. With the increase in female education and breaking of the cultural taboos and social norms, the remarriage rates of widows are likely to go up, and we therefore cannot ignore the importance of remarriage rates while estimating trends in adult male mortality using the widowhood method.

Calculation of remarriage rates is a challenging task given the unavailability of such information in existing data sources such as the census, SRS, National Sample Survey Organization (NSSO) or NFHS. The three rounds of NFHS data for 1992-93, 1998-99 and 2005-06, however, give some clues on the number of unions for currently and formerly married women (IIPS and ORCMacro 1995, 2000, 2007). Though NFHS does not provide direct evidence on remarriage rates, it is interesting to note a negligible change in the percentage of women married more than once by age groups over the three survey rounds (Table 1). State-level trends in remarriage among women also show negligible fluctuations over time (Table 2). The maximum increase for all women aged 15-49 among states was in Punjab with an increase of 1.3 % (from 0.90 %to 2.21 %). Though NFHS was not designed to measure widow remarriages in India and its major states, it provides a starting point in the absence of any other reliable data for recent time periods.

Table 1 & 2 about here

Since NFHS only provides clues regarding remarriage rates in India and its states, we decided to produce adjusted adult male mortality rates under three alternative scenarios in India and its states: 1) estimates obtained by using NFHS-2 remarriage rates, 2) estimates obtained by increasing the NFHS-2 remarriage rates by 10%, and 3) estimates obtained by increasing the NFHS-2 remarriage rates by 20%. Since we were not very sure about the reliability of remarriage rates obtained from the different rounds of NFHS, we used the remarriage rates from NFHS-2, as it provides average of sorts for the estimates obtained from the three survey rounds. Also, since the remarriage rates obtained from the three rounds of NFHS were very similar, our choice of remarriage rates should not bias the results significantly. Though the choice of remarriage rates is arbitrary, the current approach has definite merit over one which produces estimates based solely on NFHS remarriage rates.

3. Results

3.1 Suitability of widowhood method for estimating trends of adult mortality in India

Figure 2 shows the unadjusted widowhood estimates of e_{20}^{0} using South Asian and West Model life tables. Each line indicates the trend in e_{20}^{0} obtained from the proportion of widows in a specific age group. For example, the line corresponding to 20-24 indicates the trend in adult male mortality obtained from the proportion of widows ages 20-24. While estimates obtained using different age groups were close for recent time periods, they were quite apart for the earlier periods.

Figure 2 about here

Estimates of life expectancy at age 20 (e_{20}^{0}) obtained using data on young widows were much higher than those obtained using data on old widows. For example, e_{20}^{0} obtained from widows aged 25-29 was 49.2 in 1955, whereas the same from widows aged 45-49 was 44.0 in 1958. Three important points can be noticed from this figure: first, widowhood estimates of e_{20}^{0} using any of the age groups are higher than the official SRS estimates of e_{20}^{0}. This indicates that widows' remarriage rates were considerably high. Second, widowhood estimates of e_{20}^{0} show a consistently increasing trend until 1980, after which e_{20}^{0} begins to decline. Thus, the gap between widowhood and SRS-based trends of e_{20}^{0} remained parallel until 1980 and shrank during 1990s. The above evidence points towards possible inconsistencies in marital status data in the Indian census. Third, although the patterns were similar, the widowhood and SRS estimates were closer for the South Asian Model Life Table than the West Model Table.

The estimates of adult male mortality adjusted for remarriage rates are presented in figure 3. The adjusted results show that the estimates obtained from the widowhood method were completely in line with SRS estimates. It is interesting to note that, except for the estimates obtained from the proportion of very young widows aged 20-24 and 25-29, the estimates based on the remaining age groups were quite close to SRS estimates. Prior to the adjustment, younger cohorts yielded the highest life expectancy at age 20, whereas after adjustment these cohorts yielded the lowest estimates. One reason for higher estimates of mortality from young widows after adjustment could be the difference between actual remarriage patterns and those used in the present exercise. Interestingly, the differences in the trends obtained from widows in the age groups 30-34, 35-39, 40-44 and 45-49 and those obtained from SRS appear to be negligible.

Figure 3 about here

The finding that puzzles us is the decrease in e_{20}^{0} during the 1990s (Figures 2 and 3). To unfold this puzzle, we examined the trend in the proportion of widowed during 1961-2001 in India and its major states. The proportion of widows revealed a declining trend till 1991, after which it registered a sudden increase in the 2001 census. The finding that surprised us even more was the consistent decline in the proportion of widowers during 1961-2001. That the proportion of widowers has consistently declined during 1961-2001 and the proportion of widows has increased during 1991-2001 points towards the poor quality of marital status data either in 1991 or 2001 census, meaning that widows were either undercounted in the 1991 census or overcounted in the 2001 census. Given the fact that the life expectancy at birth has increased faster for females than for males since the mid-1980s, the possibility of overcounting widows in the 2001 census is unlikely. Problems are more likely in the coverage of widows in 1991 census, which is well-known for its under-enumeration of females. Numerous studies have attributed the large decline in sex ratio during 1981-1991 (934 females per 1000 males in 1981 to 927 females per 1000 males in 1991) to under-enumeration of females in the 1991 census (Parasuraman and Roy 1991; Srinivasan 1991, 1994). Moreover, these studies have revealed that the 1991 Census was likely to have missed about 3.7 million more females than males due to the extremely volatile political and social environment that prevailed in many parts of the country during the six-month period prior to the 1991 census. Widows are the most vulnerable to being missed in the census due to their lower status in the Indian marital household; widows are often unwelcome at social events and religious festivals and are avoided by others because they are considered bad luck (Chen and Drèze 1995; Chen 2000; Sood 1994).

Examination of trends in the proportion widowed also confirms possible biases in coverage of widows in the 1991 census. If we fit a trend line to the proportion of widows from various censuses after Indian independence, we find that the proportion of widows obtained from 1991 census stands as the only outlier. This evidence leads us to conclude that a major portion of the decline in life expectancy at age 20 in the 1990's was because of the biases present in the marital status information obtained from the 1991 census.

To resolve this problem, we estimated the proportion widowed in 1991 by fitting a linear regression on data from the 1961, 1971, 1981 and 2001 Indian censuses and used the estimated proportion widowed in 1991 to recalculate e_{20}^{0}. Results presented in figure 4 clearly indicate that the sudden increase of e_{20}^{0} in the 1980s disappears, and the new estimates are consistent with life expectancy at age 20 obtained from other censuses. The trends obtained from the age groups 30-34, 35-39 and 40-44 show patterns very close to SRS trends in e_{20}^{0}, and the trend obtained from ages 45-49 exactly concurs with the SRS trend of e_{20}^{0} during 1970-75 to 1986-90.

Figure 4 about here

Table 3 presents the male e_{20}^{0} from the widowhood method and its comparison with the SRS estimates for India and major states. The SRS estimates refer to 1983 and 1993, whereas widowhood estimates refer to 1978 and 1990. Though there are some discrepancies between figures from the two sources, the highest deviation in e_{20}^{0} from one source to another is only 3.5 years in case of Uttar Pradesh, and the least deviation is 0.1 years in Andhra Pradesh and Assam. At the national level, estimates from both sources are quite close.

Except for a few states viz. Bihar, Kerala, Rajasthan, Uttar Pradesh and West Bengal, widowhood estimates of e_{20}^{0} either coincided with that of SRS or the difference in e_{20}^{0} between widowhood and SRS was even less than one year. In Bihar, Rajasthan and Uttar Pradesh, new estimates of adult male mortality are lower than the SRS estimates, indicating that SRS data provides better coverage of adult male mortality than the census. This pattern is different from the rest of the states. There may be several reasons for this; first, there is a possibility of under-enumeration of widows beyond age 45 in the census in these geographically contiguous states. If widows are under-enumerated, life expectancy for males will be high due to under reporting of male deaths. Secondly, there is a high chance of digit preference for age 50 among the widows in these states. Thus, widows who are actually of age 45-49 might have stated their age as 50 or more. In such cases, life expectancy obtained from the widowed in the age group 45-49 is likely to be higher than the corresponding SRS values. The third plausible reason could be the choice of widow remarriage rates in these states. For example, the actual widow remarriage rates in these states might be higher than the remarriage rates assumed in this analysis. This could be the most plausible reason in the light of findings of some small-scale studies conducted just after Indian independence confirming that widow remarriage rates were indeed highest in the northern states of India (Agarwala 1967; Driver 1963; Superintendent of Census Operations 1968). However, the only way to resolve the problem associated with estimation of widow remarriage is to get information about widow remarriage rates from small-scale surveys in these areas; such surveys would provide a potential area for future research. The estimates obtained for these states using widowhood method should therefore be considered as the upper limit of e_{20}^{0}.

The situation is different in case of southern state Kerala where widowhood estimates of mortality were much higher than the SRS estimates (table 3). Interestingly, e_{20}^{0} of Kerala obtained from widowhood method without adjusting for widow remarriage was much closer to the corresponding SRS estimates (i.e., 47.8 years in C.1978 and 49.4 in C.1990 years; not shown in the table). Thus the adjustment for widow remarriage may not be necessary in Kerala for two reasons. First, the level of adult mortality in Kerala is very low (Saikia et al. 2011). Thus, women from Kerala have a very low probability of becoming widow during their adulthood. For the same reason, the proportion of remarried widows in Kerala is likely to be least. Secondly, a higher proportion of women who have married more than once in Kerala might have done so due to divorce and not due to widowhood. Thus tha assumption that remarriage pattern of the widowed is the same as that of currently and ever married women may not be valid in case of Kerala.

Table 3 about here

To confirm the applicability of widowhood estimates for the pre-SRS period, we compare widowhood and official estimates of e_0^0 for the period 1941-1971, as shown in table 4. We use e_0^0 because official estimates of life expectancies are available only at age 0 and 5 for each decade. The official estimates refer to longer periods (usually 10 years) whereas widowhood estimates refer to specific years and months. Nevertheless, this comparison gives us quite an optimistic picture; most of the estimates derived from widowed women aged 45-49 coincided with the official estimates.

Table 4 about here

The findings presented above do provide sufficient evidence that widowhood estimates adjusted for remarriage rates provide convincing trends of adult male mortality under Indian conditions. The adult male mortality trends are not only convincing during the SRS period, but they hold even in the pre-SRS period just after independence.

3.2 Levels and trends in adult male mortality in India

Results presented in table 5 suggest that life expectancy at age 20 was around 39 years at the time of India's independence and has risen slowly and steadily during the past 50 years to 48 years in 1990. Overall, the life expectancy at age 20 increased by a modest 9 years in the 40-year period after independence. While many countries of the world, especially countries from sub-Saharan Africa and countries in or related to the former Soviet Union were observing a reversal in the gains in adult life expectancy due to infections like HIV/AIDS or civil war during this period (Men et al. 2003; Rajaratnam et al. 2010; Shkolnikov, McKee and Leon 2001), India continued to maintain steady improvements in life expectancy during this period, though at a slower pace. Further, the gain in e_{20}^0 was highest in the decade immediately after independence with mortality reductions slowing down particularly during 1970s and 1980s.

Trends in adult mortality at the state level present a mixed picture. Bihar (gain of 12 years) and West Bengal (gain of 11 years) observed the maximum increase during C.1947 to C.1990, with Madhya Pradesh also not much behind (gain of 10 years). On the other hand, there were states where life expectancy at age 20 did not increase much, with Haryana and Punjab occupying the topmost positions in this league of states. Assam was also no different with a gain of only 0.2 years. The south Indian states on an average gained around 10 years in life expectancy at age 20. As in case of India, mortality reduction started slowing down during 1970s and 1980s in most of the states and it was even slower in the following decades. Kerala, Tamil Nadu and West Bengal, on the other hand, managed to retain the same pace of gain in e_{20}^{0} over the last five decades.

Table 5 about here

It is important and surprising to note hardly any change in life expectancy at age 20 in Assam over the last four decades; the e_{20}^{0} for Assam was unusually high compared to India average during 1950-1960, and these were considerably higher when estimated using the 1961 and 1971 census (44.4 years in C.1947 and 43.1 in C.1958). These results appear to be unrealistic given the historically high prevalence of tuberculosis and malaria among adults in Assam (Patra and Dev 2004; Sehgal et al. 1973) and may also be due to the huge difference between the assumed remarriage rate and actual remarriage rate in Assam before the division of the state during 1961-1971. The widow remarriage rate assumed in this analysis is based on the data from divided Assam obtained from NFHS-2, whereas the 1961 and 1971 census data relate to undivided Assam, which included the current states of Meghalaya and Nagaland. Demographic differences in the states of the former undivided Assam could also play a role. According to the 2001 census, the percentage share of scheduled tribe population to total population in Meghalaya, Mizoram and Nagaland was notably higher than in Assam (85.94% in Meghalaya, 94.44% in Mizoram and 89.14% in Nagaland and 12.41% in Assam), and the absolute number of scheduled tribe members in Assam is less than the total scheduled tribe population in the remaining north-eastern states. Since Assam and remaining north-eastern states are demographically and culturally different, it is likely that widow remarriage patterns in undivided Assam during 1960s and 1970s were very different from the widow remarriage patterns obtained from NFHS for divided Assam in the late nineties. Hence, there it is possible that there is a huge mismatch between assumed and actual remarriage rates in Assam, particularly during the earlier periods.

Figure 5 presents trends in e_{20}^{0} obtained from different cohorts of women along with the trends obtained after increasing the widow remarriage rate by 10% and 20%. As in earlier cases, life expectancies obtained from younger cohorts seem to be lower than the corresponding SRS figures. Most importantly, there was hardly any change in the estimates even when we increased the proportion of remarriages by 10 or 20 %. This stability in trends could be because the remarriage rates used for adjustment were so small that a 10 or 20% increase in remarriage rates may not change the scenario altogether. However, a substantial change in widow remarriage rates may change the adult male mortality rates, which is clearly indicated by the substantial deviations of adult male mortality based on younger cohorts of widowed women from SRS. The rates of widow remarriage among the younger cohorts, as suggested by some of studies, are likely to be much higher than what is assumed in the present analysis.

The second important point is that among all estimates obtained from different cohorts of women, the estimates obtained from the women aged 45-49 for the most recent period (C.1980 and C.1990) coincided with the corresponding SRS figures. Thus, as in case of earlier studies, estimates obtained from proportion widowed in the age groups 45-49 appear to be better than estimates obtained from any other age groups. Henceforth, we have considered only this age group for estimating adult male mortality at the sub national level.

Figure 5 about here

3.3. Application of widowhood method for small area estimation

The utility of indirect methods of estimating adult male mortality gains significance when it comes to estimating mortality at local levels such as districts and community development blocks (CDBs) for which direct data are not available. As marital status data from the census is available at the district level, we can easily apply the widowhood method for estimating adult mortality for the various districts of India. As an example, we apply the widowhood method to estimate adult male mortality for three randomly chosen districts (Allahabad, Ganganagar, and Golaghat) from demographically poorly-performing states and two (Mumbai and Chennai) from states that are performing better. It must be noted that no direct estimates of adult mortality for these districts are available, and hence it is difficult to comment on the accuracy of estimates thus obtained. However, if our interest is to examine the district level variation or to rank districts according to the mortality level, widowhood estimates undoubtedly give the most plausible picture.

Findings reveal that Mumbai, which belongs to a progressive and better performing state in terms of economy, indicators like fertility and mortality, and other social indicators, performs worst in terms of premature mortality among the selected districts (Table 6). This finding does not come as a surprise given that the life expectancy at birth in Mumbai has been much lower than that in Maharashtra as a whole. Recent estimates of life expectancy at birth for males and females in Mumbai were lower than those in Maharashtra by 13 and 10 years respectively (Municipal Corporation of Greater Mumbai 2009; Registrar General of India 2008). Some of the plausible reasons for lower life expectancy in Mumbai include relatively high prevalence of HIV/AIDS among adult population (NACO and NIHFW 2007), about 55% of the population living in slums lacking basic amenities (according to 2001 Indian census), high accidental deaths (National Crime Records Bureau 2009) and deaths due to life-syle related diseases including deaths due to tobacco use (Municipal Corporation of Greater Mumbai 2009; Gupta, Pednekar, Parkin, and Sankarnarayanan 2005), etc. The estimated e_{20}^{0} was highest for Allahabad, a district coming from a low-performing state of Uttar Pradesh. Golaghat in Assam ranks second highest in terms of adult male mortality among the selected districts, a finding that is consistent with Saikia (2011), which also ranks Assam at the top in terms of adult male mortality.

Table 6 about here

Similar estimations at the local levels can be of immense value for programme interventions and policy making. Such exercise can bring to the forefront those areas or regions that need immediate attention. It is also likely to help district-level planners to formulate interventions that are best suited for their area instead of following a set of standard interventions. It is important to note here that the National Rural Health Mission (NRHM) 2005-2012 has given special thrust on local area health planning and emphasized on preparing of district health plans for improving health of the masses (MoHFW 2007). Local area health planning is impossible in the absence of statistics related to mortality and morbidity at the local levels. Widowhood method provides a promising alternative to generating statistics of mortality at the local levels as the data required for estimation is readily available at the local levels.

4. Summary and Conclusion

Due to the considerable reduction in infant and child mortality, adult mortality indicators have now become critical for comprehensive assessment of mortality in many developing countries. However, studies addressing adult mortality are fewer than those on under-five mortality due to the paucity of data in countries like India. Since the Civil Registration System in India has not improved significantly over the last few decades (Mahapatra et al. 2007; WHO 2007), it is risky to rely on these data for estimating demographic indicators. Demographic and Health Surveys, although very popular, typically rely on small sample sizes and are restrictive in terms of their suitability to geographic disaggregation; in India such survey, can provide estimates only at the national and state levels. The application of indirect methods for estimating fertility, mortality and migration is the only plausible alternative for filling data gaps in developing countries. These techniques can add a significant amount of knowledge about the demographic scenario in India, even in the pre-SRS era.

Though indirect estimation provides a great opportunity to understand trends in adult male mortality, the application of such methods is marked by issues of appropriateness of methodology to context, quality of input data, and underlying assumptions, and the widowhood method is no exception. For example, while applying widowhood method (Hill and Trussell 1977) to estimate adult male mortality, it is assumed that marriage is a universal phenomenon in the given population. Thus, this method is likely to yield better results in populations where marriage is well-defined and nearly universal. It is important to note that two of the three assumptions of the widowhood method hold well in the Indian conditions, namely the universality and well-defined nature of marriage. However, the quality of relevant data, particularly data on age of the individuals, the Indian census suffers from the drawbacks of age-misreporting and digit preferences. Since the accuracy of any indirect estimate is highly dependent on age, we cannot rule out the effect of age misreporting on our estimates. However, the findings presented above, in conjunction with comparisons of our estimates with other official estimates, do suggest that our estimates were least affected by errors in age-misreporting.

Additionally, with improvements in the quality of age data in each successive census (Bhat 2002), the widowhood method is likely to provide much more plausible and reliable estimates of adult male mortality when used with 2011 and subsequent census data.

An important factor that is likely to have affected our estimates, which we have ignored, is migration. Since international migration from India is negligible, we can convincingly state that the estimated trends in adult male mortality at the national level are not at all affected by migration. However, we cannot rule out the effect of inter-state migration on adult male mortality trends at the state and district levels, though inter-state migration is only likely to play an important role if a widow returns to her province of origin on her husband's death. Currently, there is no evidence to suggest that such moves occupy a central place in Indian inter-state or inter-district migration. Absence of evidence in no way suggests that we completely rule out this phenomenon, but we restrained ourselves from making such an attempt particularly because adjustments for migration are potentially a methodological issue and do not fit in the scope of this paper.

Application of the widowhood method for estimating adult male mortality in India and major states unveils many interesting findings. Information obtained from widows aged 40-44 and 45-49 provides the most convincing pattern of adult male mortality. Comparison of widowhood estimates of e_{20}^{0} with those of SRS confirms the robustness of the widowhood method in Indian conditions. The trend of adult male mortality shows that while adult male life expectancy has been increasing in India and in most of the states after independence, the rate of mortality reduction has been decreasing over the decades, with the maximum gain in e_{20}^{0} occurring from 1949-1960. Additionally regional variations in adult male mortality are stark. According to widowhood estimates, Assam experienced the highest adult male mortality (e_{20}^{0} of 45.9 years), whereas Bihar experienced the least (e_{20}^{0} of 51.8 years). Estimates obtained from this method seem to reliably depict the changes in male mortality differential over time and place. Hence, such estimates can be effectively used to monitor the Millennium Development Goal 6 in small geographical areas and are extremely relevant for policy formulation.

The findings further` confirm that there are huge variations across the districts within a state, indicating that there could be districts in developed states that can be similar to districts in less developed states in terms of adult male mortality. Conversely, there can be districts in less developed states that fare better than certain districts in developed states in terms of adult male mortality (for example, Allahabad fares better than Mumbai). In the absence of local level estimates, there is a general impression among the public, and among the policy makers in particular, that local areas within better performing states are always better than local areas within poor performing states, which our results show to be incorrect. Moreover, the district level estimates presented above clearly highlight the fact that state level averages hide important within state disparities and thus underscore a need for estimation of adult mortality trends at the local levels.

The main hurdle in effectively using the widowhood method for estimation of trends in adult mortality in India is that the censuses do not provide any information on remarriages. In the absence of such information, researchers have to either rely on less efficient small-scale studies or make strong assumptions based on data from other less relevant sources. It is, therefore, highly recommended that the Indian census collect data on the marital status of the population with respect to their first marriage. By doing so, the census can help provide accurate adult mortality rates for both males and females at minimum cost and effort.

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Table1: Percentage of currently married women aged 15-49 by the number of marital unions from NFHS-1 (1992-93), NFHS-2 (1998-99) and NFHS-3 (2005-06), India

	percentage of women married only once			percentage of women married more than once		
Age-group	NFHS -1 1992-93	NFHS -2 1998-99	NFHS -3 2005-06	NFHS -1 1992-93	NFHS -2 1998-99	NFHS -3 2005-06
15-19	99.37	99.36	99.35	0.63	0.64	0.65
20-24	98.76	98.75	98.76	1.24	1.25	1.24
25-29	98.17	98.35	97.90	1.83	1.65	2.10
30-34	97.88	98.08	97.52	2.12	1.92	2.48
35-39	97.84	97.58	97.28	2.16	2.42	2.72
40-44	97.73	97.71	97.48	2.27	2.29	2.52
45-49	97.80	97.82	97.17	2.20	2.18	2.83

Table 2: Percentage of currently married women aged 15-49 who married more than once from NFHS-1 (1992-93), NFHS-2 (1998-99) and NFHS-3 (2005-06), major states of India

Group	**Andhra Pradesh**			**Assam**			**Bihar**			**Gujarat**		
	NFHS			**NFHS**			**NFHS**			**NFHS**		
Age	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
15-19	0.68	0.71	0.00	1.06	0.00	1.68	1.53	0.48	0.56	1.76	1.26	3.03
20-24	2.22	0.91	0.54	1.25	1.20	0.86	1.89	1.48	2.40	1.99	3.18	3.58
25-29	1.94	1.12	0.77	2.91	0.74	1.80	2.14	1.98	2.24	2.82	4.12	3.57
30-34	1.64	1.82	1.26	3.16	0.45	2.82	1.81	2.31	2.26	2.58	2.79	4.68
35-39	1.51	1.21	1.04	2.34	1.41	2.76	2.81	1.85	2.91	3.82	2.95	4.07
40-44	2.91	1.35	1.48	4.08	1.87	1.96	3.07	2.10	2.52	2.66	3.86	2.36
45-49	1.96	0.50	0.80	1.97	1.39	4.10	2.69	1.34	2.69	3.40	4.47	4.25
Total	1.80	1.10	0.91	2.43	1.00	2.22	2.17	1.70	2.25	2.71	3.36	3.71
	Haryana			**Himachal Pradesh**			**Karnataka**			**Kerala**		
	NFHS			**NFHS**			**NFHS**		**NFHS**			
Age	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
15-19	0.65	0.55	0.00	0.78	0.00	0.00	0.00	0.23	0.33	0.60	1.18	0.00
20-24	0.50	0.39	0.76	1.03	0.00	0.63	0.70	0.39	0.49	2.18	0.55	0.66
25-29	1.08	0.50	1.76	1.74	0.16	1.36	0.56	0.70	0.53	2.63	1.45	1.22
30-34	2.10	1.25	3.27	2.10	0.84	0.41	0.84	0.56	0.46	2.88	2.07	1.17
35-39	1.82	0.72	1.33	2.29	1.40	2.51	0.52	0.95	0.68	3.15	3.26	3.28
40-44	1.82	0.87	0.73	2.93	0.70	2.18	0.42	0.37	0.80	3.40	3.79	3.52
45-49	1.49	1.07	1.33	3.19	0.87	2.23	0.75	0.72	0.46	4.62	4.45	4.51
Total	1.30	0.76	1.51	1.99	0.63	1.49	0.57	0.57	0.55	2.95	2.53	2.38
	Madhya Pradesh			**Maharashtra**			**Orissa**			**Punjab**		
	NFHS			NFHS			NFHS			NFHS		
Age	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
15-19	0.90	0.67	0.34	1.00	1.66	1.08	0.29	0.00	0.00	0.00	0.00	0.00
20-24	2.26	2.17	1.02	1.37	1.18	0.76	1.53	0.88	1.25	0.76	0.00	0.46
25-29	3.60	2.26	1.68	1.57	1.29	2.29	1.79	1.17	2.05	0.82	1.06	0.92
30-34	2.94	2.81	2.84	2.65	1.24	1.36	1.70	1.82	2.01	0.54	0.36	3.04
35-39	3.13	3.14	1.85	2.62	1.35	2.51	2.48	1.31	1.58	1.33	1.46	3.70
40-44	2.45	2.73	2.29	3.62	2.06	1.63	3.21	1.42	2.37	1.07	1.78	3.29
45-49	1.75	1.99	1.42	2.59	2.24	2.89	2.33	1.97	1.84	1.45	0.00	2.33
Total	2.54	2.28	1.77	2.09	1.48	1.82	1.88	1.29	1.74	0.90	0.00	2.21
	Rajasthan			**Tamil Nadu**			**Uttar Pradesh**			**West Bengal**		
	NFHS			**NFHS**			**NFHS**			**NFHS**		
Age	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
15-19	0.00	0.82	0.41	0.00	0.00	0.00	0.50	0.65	0.77	0.76	1.55	1.01
20-24	0.71	1.32	0.34	0.41	0.52	0.32	1.12	1.43	1.94	1.64	1.28	0.58
25-29	1.09	1.70	1.66	1.69	0.51	1.02	1.56	2.04	2.52	3.40	1.53	2.15
30-34	1.43	1.72	1.12	1.96	0.61	1.13	2.50	1.84	2.45	3.21	2.21	2.75
35-39	1.73	2.20	1.27	0.84	0.94	1.24	2.11	2.92	3.09	3.62	2.25	1.66
40-44	1.38	2.89	1.25	1.50	0.66	1.07	1.55	2.30	2.12	1.34	1.66	1.84
45-49	1.65	1.10	0.88	1.49	0.98	1.65	2.52	1.70	3.14	3.23	2.78	2.43
Total	1.13	1.69	1.03	1.22	0.64	1.04	1.67	1.85	2.37	2.50	1.86	1.83

Table 3: Estimates of male e_{20}^{0} from Widowhood Method and their comparison with the SRS estimates, India, 1980 -1990

State	**C 1978** SRS	**C1978** Widowhood	Difference	**C1990** SRS	**C 1990** Widowhood	Difference
	1	2	(3)=(1)-(2)	4	5	(6)=(4)-(5)
Andhra Pradesh	44.9	45.4	-0.5	47.1	47.5	-0.4
Assam	43.1	45.0	-1.9	45.4	45.9	-0.5
Bihar	NA	49.2	NA	48.0	51.8	-3.8
Gujarat	45.5	44.9	0.6	47.1	46.0	1.1
Haryana	48.3	49.5	-1.2	50.1	49.1	1.0
Himachal Pradesh	48.3	47.2	1.1	50.3	48.6	1.7
Karnataka	46.9	45.0	1.9	48.4	46.9	1.5
Kerala	49.2	44.9	4.3	50.9	46.3	4.6
Madhya Pradesh	45.8	46.3	-0.5	47.2	49.1	-1.9
Maharashtra	46.1	45.7	0.4	48.8	47.3	1.5
Orissa	44.1	45.6	-1.5	47.7	47.6	0.1
Punjab	51.2	49.8	1.4	51.8	49.7	2.1
Rajasthan	46.3	49.1	-2.8	47.2	50.0	-2.8
Tamil Nadu	46.0	44.6	1.4	47.6	46.6	1.0
Uttar Pradesh	46.0	49.7	-3.7	47.3	50.6	-3.3
West Bengal	NA	43.8	NA	48.7	46.2	2.5

Note: 1. Calculated from 45-49 age group using South Asian Model Life Table. 2. SRS C.1978 is obtained from SRS abridged life table for the period 1976-80 and SRS C.1990 is obtained after averaging SRS abridged life table for the period 1986-90 & 1991-95.

Table 4: Estimates of male e_{0}^{0} from Widowhood Method and their comparison with the actuarial and other estimates, INDIA, 1941-1991

Census	40-44		45-49		Official estimates	Reference period
	Widowhood estimates	Reference period	Widowhood estimates	Reference period		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1961	32	Apr,1949	32.2	Jun, 1947	32.4	1941-51
1971	40.9	Feb, 1960	41.7	Jun, 1958	41.9	1951-61
1981	46.6	Sep, 1970	48.2	Feb, 1969	46.4	1961-71
1991	48.54	Jan, 1981	50.65	Jun, 1979	51.5	1971-81
2001	51.6	Jul, 1991	54.4	Dec,1989	56.5	1981-91

Notes: 1. Source of official estimates is Bhat 1998 2. Following South Asian Life Table pattern

Table 5: Change in male e_0^{20} estimated from widowhood method on Census of India, 1961-2001 for the period 1947 -1990, India and major states

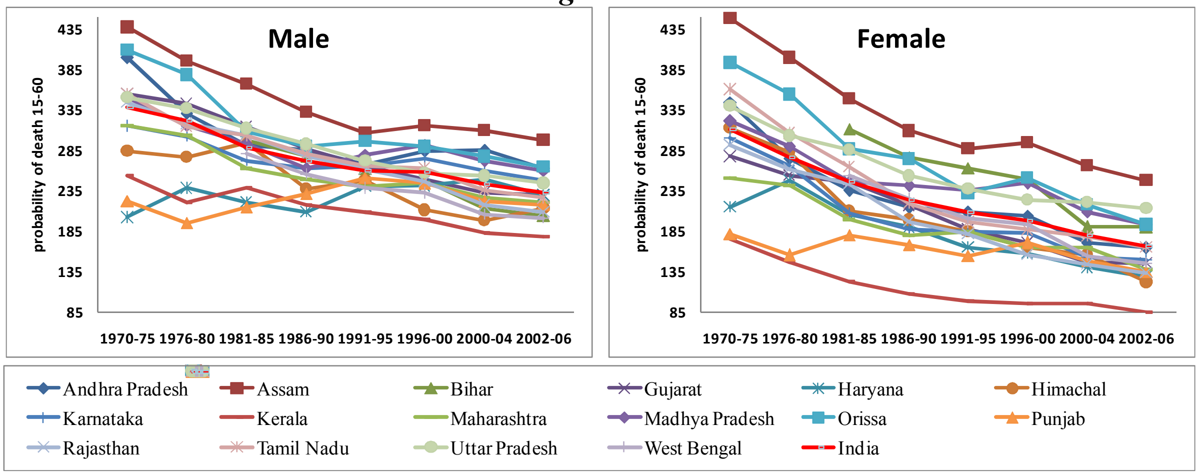
State	C.1947 (1)	C.1958 (2)	C.1969 (3)	C.1979 (4)	C.1990 (5)	Change (6)=(5)-(1)
Andhra Pradesh	37.7	40.9	44.3	45.4	47.5	9.8
Assam	44.4	43.1	-	45.0	45.9	1.5
Bihar	39.3	43.6	47.5	49.2	51.8	12.4
Gujarat	39.5	42.4	44.3	44.9	46.0	6.4
Haryana	-	48.9	50.6	49.5	49.1	0.2
Himachal Pradesh	41.5	44.2	46.7	47.3	48.6	7.1
Karnataka	37.1	41.3	43.9	44.9	46.9	9.7
Kerala	43.6	41.6	42.3	44.9	46.3	2.7
Madhya Pradesh	38.9	43.0	46.3	47.4	49.1	10.2
Maharashtra	37.7	42.1	44.8	45.7	47.3	9.6
Orissa	39.0	42.5	43.7	45.6	47.6	8.6
Punjab	45.0	49.1	50.0	49.8	49.7	4.7
Rajasthan	41.5	45.8	48.6	49.1	50.0	8.5
Tamil Nadu	37.5	40.8	43.1	44.6	46.6	9.1
Uttar Pradesh	42.5	46.7	49.5	49.7	50.6	8.1
West Bengal	35.1	39.6	41.6	43.7	46.2	11.1
India	39.1	42.8	45.3	46.3	47.8	8.6

Table 6: Estimates of male e_{20}^{0} from Widowhood Method in five randomly chosen districts of India

Districts	40-44		45-49	
	Widowhood estimates	Reference period	Widowhood estimates	Reference period
(1)	(2)	(3)	(4)	(5)
Allahabad (Uttar Pradesh)	48.89	June, 1991	51.43	January, 1990
Chennai (Tamil Nadu	46.42	February, 1993	47.30	June, 1991
Ganganagar (Rajasthan)	47.19	March, 1991	49.80	October, 1989
Golaghat (Assam)	45.10	April, 1992	46.13	August, 1990
Mumbai (Maharashtra)	44.61	June, 1992	45.60	September 1990

Note: The estimates were derived using South Asian Life Table pattern

Figure 1: Probability of death (per 1000) for adults aged 15-60 years for India and major states during 1970-75 to 2002-06



Source: (Office of Registrar General, 1984 1985a 1989; Registrar General of India 1994a 1998 2004 2007 2008)

Figure 2: Life expectancy at age 20 (e_{20}^{0}) for males obtained from SRS and using widowhood method, India, 1940-2000

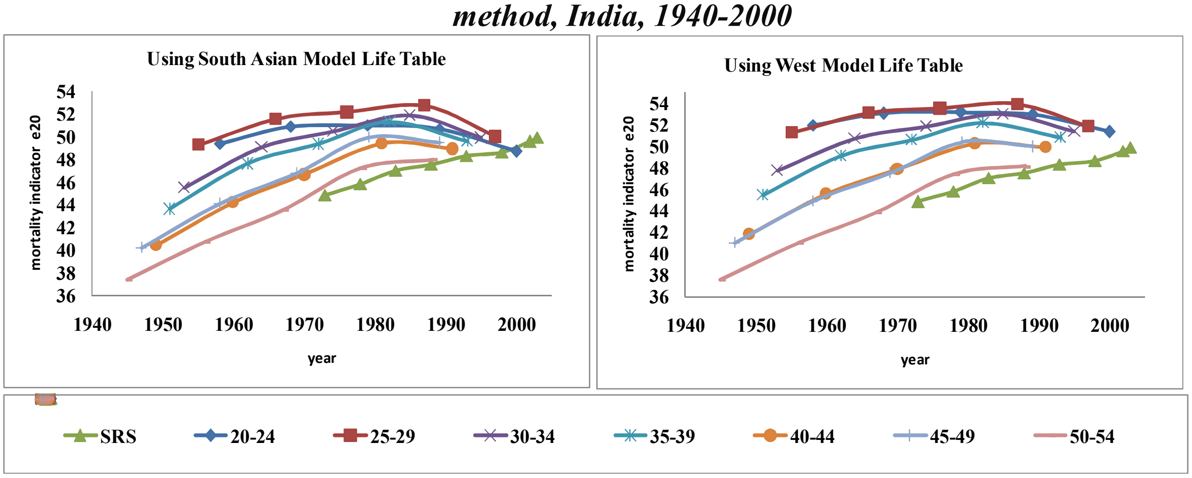


Figure 3: Comparison of male life expectancy at age 20 (e_{20}^{0}) computed by widowhood method and SRS, 1940-2000 after adjusting for widow remarriage, India

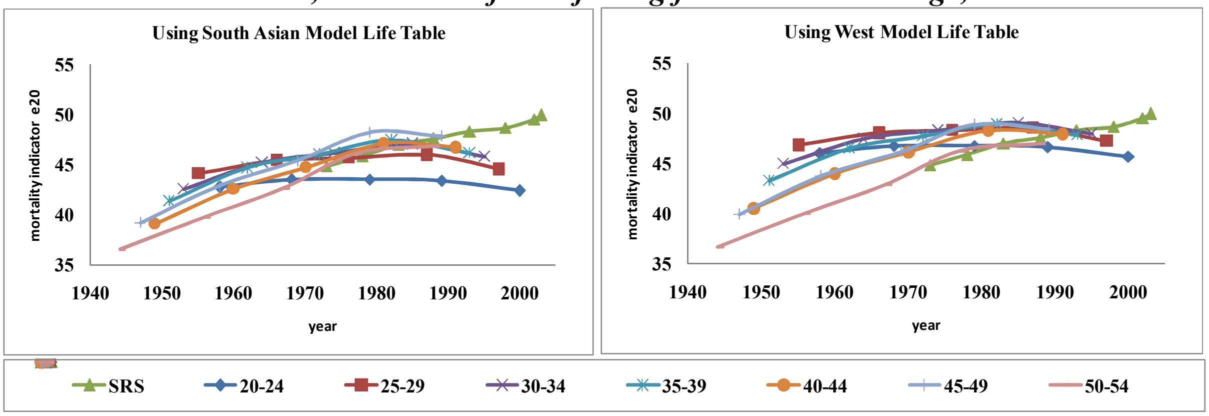


Figure 4: Comparison of male life expectancy at age 20 (e_{20}^{0}) computed by widowhood method and SRS, 1940-2000 after adjusting for widow remarriage and proportion of widows in1991 census, India

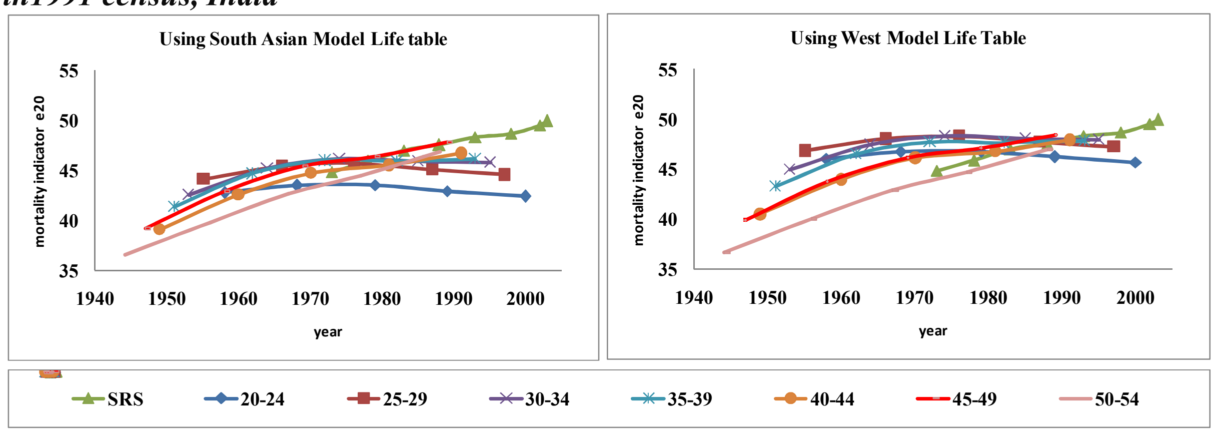
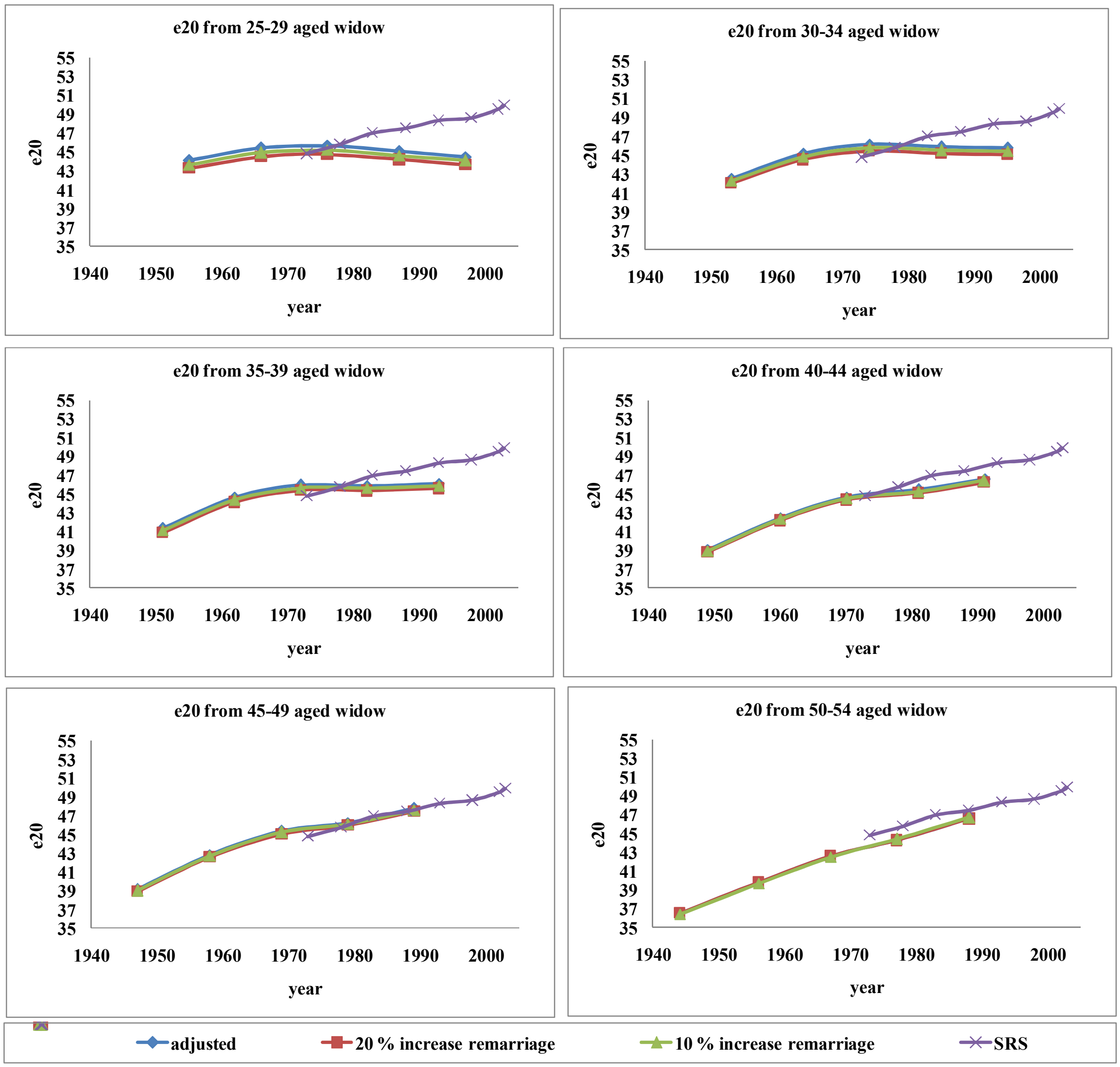


Figure 5: Comparison of male life expectancy at age 20 (e_{20}^{0}) computed by widowhood method and SRS, 1940-2000 after adjusting for widow remarriage and proportion of widows in 1991 census, India[4]



[4] Here we examine the effect of 10 and 20 percent increase in widow remarriage on the adult mortality estimates.