Age-pattern of Mortality in India: An Exposition of “Recent Household Death” Approach

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ABSTRACT

In spite of an increasing demand for reliable information of cause and distribution of mortality, civil registration systems in most developing countries still do not yield the complete and accurate data required for the direct estimation of mortality rates. In India, where civil registration system and SRS lacks sufficient power to produce reliable estimates of mortality across life stages. Our knowledge of age-pattern of mortality depends largely on cross-sectional data from censuses /surveys providing us information on recent deaths in the households. Most of the household surveys are not designed to derive mortality estimates over all ages. This paper aims to fill this gap by analyzing large scale household survey (DLHS-III) conducted in 2007-2008 in India. We have computed age specific mortality rates for all age groups after adjusting infants/child exposure period by “Date by Year cohort” method. Brass two parameter logit model has been used to graduate non-linearity of estimated age specific mortality rates. This study clearly suggests that mortality estimates derived from “Recent household death” approach using district level data yield comparable results with official Sample registration system Death rates.
1. BACKGROUND

Accurate statistics on basic demographic events are the foundation of rational health and public policy. Yet there is substantial dearth of information pertaining to these events in developing countries. In particular, data on both the number and causes of death in developing countries are virtually nonexistent. Reliable data on levels—let alone causes of all age death simply do not exist for the majority of developing countries (Timeaus and Jasseh, 2004). Distribution and determinants of mortality varies across different age-segments by geographical regions. Mapping of variation in mortality can help in improving the programs in terms of allocation of scarce resources to the regions with high unmet need for health care.

About 46 million of the estimated 60 million deaths per year worldwide occur in developing countries (WHO, 2002). India has about 9.5 million deaths a year, or about one in six of all deaths worldwide. However, there is a dearth of reliable and accurate information on the causes and distribution of mortality. Measurement of all age mortality across the age-segments (excluding early age mortality) always subject to various restrictions. There is not any single source of data which provide reliable and adequate information for analyzing all age mortality. Main issue is related to big sample size which is required to estimate mortality precisely. Moreover, unlike child death for which mother or guardian are natural informants, for all age mortality there is no any single relative which can be used as appropriate informant. It may be difficult to obtain reliable estimates on all age mortality on the basis of retrospective surveys.

In India, there is basically four kind of database are available for analyzing mortality. In the Indian census, mortality estimates are derived from age distribution and marital status data. Age–distribution data in census does not provide reliable estimates due to migration factor, which distort age-distribution heavily. Hence deriving age-specific mortality rates from census are not viable from direct methods of mortality estimation. Secondly, most used data source for mortality assessment is civil registration system. In western countries civil registration is the accepted mortality measurement system with coverage nears 100%. While, in case of India completeness of estimates is still not attainable, since access to medical care is far less common and most deaths occur at home rather than in hospitals. Another source for extracting mortality information in India is the Medically Certified Causes of Death. However, this covers only about 0.4 million deaths and is largely confined to selected urban settings that are not representative of the general population (Mitra B. 1999, Jha P. 2001). The third is the SRS which is representative of both urban and rural settings of India, covering some 6,700 to 7,600 units randomly selected from the preceding census. The SRS is much smaller, though, covering only 0.05 million deaths. Thus, its chief drawback is that it cannot yet provide district-level data for local decision making, and it lacks sufficient power to analyze the determinants of mortality across the life course.

Since the advent of INFHS (I, II &III), Household surveys have been the other alternative source for reliable information for measuring infant and child mortality in India. The National Family Health surveys (NFHS) is a large scale, multi-round survey conducted in a
representative sample of household throughout India. In NFHS -II, question has been asked to the head of the household about the death of the any household member that occurred in the household two years preceding the survey. Alongside, socioeconomic condition of the household has also been collected. This is an added advantage of NFHS over SRS that does not provide tabulation by socioeconomic variable. Though, SRS estimates are assumed to be more reliable and accurate due to dual recording of the vital events. In later rounds of NFHS (NFHS-III) information related to deaths for all members in the household has not been resorted. Hence analyzing age pattern of mortality is not possible for the later rounds of the survey.

Although the contribution of and necessity for surveys is clear, they do have certain limitations with respect to mortality measurement for all ages. In surveys, information has not been sought to assess mortality across age-segments. In this context, District level household survey data (DLHS-III, 2007-08) is fulfilling this need by providing information about deaths in the household prior to four year of survey. In these survey more than 0.1 million deaths over all ages has been recorded at the state/district level, which provides ample scope for deriving reliable information for assessing age structure of mortality at sub-national level.

1.1 Studies on Age pattern of Mortality in India

In India, Study on regional variation of mortality at sub-national level has been come into foray in the social research domain from several decades. Most of research has been focused on regional variation of mortality indicators of infant and child mortality (Dyson and Moore 1983, Murthy et al. 1995). Nonetheless, much less is known about irregularities in all age mortality. In a landmark study on mortality trends and patterns in India, Bhat (1987) found that although southern states experienced significantly lower levels of child mortality, adult mortality appears to be somewhat lower in the north-western parts of the country. He also found that there is a notable variation across the states in the speed of mortality reductions: the fastest decline in mortality between 1951-1961 and 1971-1981 occurred in southern state of Karnataka, whereas the slowest progress during the same period was observed in eastern state of Orissa. Later, Chaurasia (2010) analyzed mortality transition across the states of India. In another study, Saikia et al. (2011) examined the overall and region specific mortality changes and regional mortality variations in India since the 1970s.

In the light of forgoing discussion this paper basically deals with the application of “recent household death” approach to estimate age-specific mortality rates using DLHS-III (2007-08). This household survey is most recent large scale household survey, which provides information regarding deaths in the household for all age-groups at State/District level. The District Level Household and Facility Survey (DLHS) is also a multi-round survey conducted by Government of India in order to monitor the ongoing health and family welfare programmers. DLHS–III provides information about the deceased members in the household since January,
2004 at state/district level. This round of survey over all provides male/female and urban/rural wise death counts for four years preceding the survey. In this study we have tried to explore quality of mortality data based on 1, 02,633 deaths in 7, 20,320 households. In the next section, we will discuss specifics about methods and material used in this study.

This paper has two fold objectives

- To assess age-pattern of mortality based on “recent household death” approach for some selected Indian states.
- To obtain smoother series of Age specific death schedule for all major Indian states.

2. DATA

The District Level Household and Facility Survey (DLHS) were undertaken by Government of India in order to monitor the ongoing health and family welfare programmers. In this paper we use DLHS-III (2007-08) which is third in the series preceded by DLHS-I in 1998-99 and DLHS-II in 2002-04. DLHS-III is one of the largest ever demographic and health surveys carried out in India, with a sample size of about 7, 20,320 households from 28 States and 6 Union covering all districts of the country. From these households, 6, 43,944 ever-married women aged 15-49 years and 1, 66,620 unmarried women aged 15-24 years were interviewed. This survey is designed to provide estimates on maternal and child health, family planning and other reproductive health indicators. DLHS-III adopted a multi-stage stratified probability proportion to size sampling design. In the household questionnaire, information on all members of the household and socio-economic characteristics of the household, assets possessed, number of marriages and deaths in the household since January 2004, etc. were collected. Official estimates of ASDR from Sample Registration system (SRS-2007) has been used for the comparison purpose.

2.1 METHODS

Timaeus and Graham (1989) and Hill (2001) describe a number of different methods for age-specific mortality estimation by household surveys. Mainly, there are two direct estimation methods, the first based on detailed sibling histories and the second based on data on recent deaths in the household (United Nations, 2011/12).

2.1.1 Survey Questions used for analysis

Information on deaths occurred in the household in the recent past have been widely employed in censuses in developing countries and have also been used in a number of Household surveys (e.g., WFS, India NFHS). The method is simple in that it just asks about deaths that have occurred in the past x years, where x is typically one year in censuses, but has been three/four years in many of the surveys that have used the approach. Generally for each death in the recent
time period, the sex of the deceased and the age at death are asked. The total living population from the survey provides the denominator for the mortality rates. Questions on recent household deaths are also the only survey questions that potentially provide data on mortality over the entire age span. For the recent household deaths approach, the data requirements are quite simple. For each person that died in the time period, the following information is elicited

- **Sex of the person.**
- **Age at death.**
- **Date of death.**

### 2.2.2 Consideration in using recent household death approach

The choice of the period of analysis using the recent household deaths approaches very vital in context of accuracy produced in the method this is decided normally prior to the data collection. In DLHS-III(2007-08), the interviewers have been asked for all deaths in the household on or after January 1, 2004. While calculating age-specific mortality rates, due consideration has been given in computing the denominator (Exposure period) of the population especially for infants. “Data by year and cohort” has been used to correctly estimate the infant mortality of a particular year. Alternatively it could be assumed that a person aged x at the time of interview contributed on average one half of a person-year of exposure at age x and one half at age x-1 in the preceding one year period. For a two-year period, this would be one half of a person-year at age x, one whole person year at age x-1 and one half at age x-2.

The algorithm for computing age-specific mortality rates consists in the following steps

- To compute the numerator of the age-specific mortality rate tally any death that occurred within the period of analysis according to the age group in which the person died.
- To obtain the denominator, from the household schedule (or listing) of all household members first select the correct population of household members (typically *de jure* household members).
- Calculate the age-specific mortality rate by dividing the numerator for each age group by the denominator for that group.

### 3. PLAUSIBILITY OF MORTALITY ESTIMATES FOR ALL-AGES FROM DLHS-III

It is well known fact that degree of completeness of death registration and reporting may vary among young and adult age. In adult age group mortality information are more reliable since reporting is more accurate than any other age groups. While, Child death estimates from survey are reliable since these information normally sought from mother of the deceased child.
To evaluate the quality of data as whole for any survey pertaining to mortality, it is very important to assess completeness of infant and child death. Because registering death is subject to various kind of error starting with restrictive definition of live birth, recall lapse in retrospective surveys, age misstatement and underreporting of deaths. Hence it is vital to investigate the agreement between the two data sources in different geographical region of India. In Fig. 1 we plotted infant mortality rates from SRS (2005-2009) and DLHS-III conducted in 2007-2008. Infant mortality rate from DLHS-III refers to infant mortality rates during a 4-year period before the survey in 15 major states of India. It can be observed from the Figure.1 that for most of the states (excluding West Bengal, Bihar, Punjab and Kerala) Infant mortality rates from SRS slightly higher than the corresponding figure of DLHS-III. Sample Registration System estimates are assumed to be reliable due to its dual record system.

To understand the quality of data of SRS for different states by types of residences, we have plotted the infant mortality ratio of SRS and DLHS in the Figure 1.1. To compute the mortality ratio, the infant mortality rate from SRS for period 2005-2009 is divided by IMR obtained from DLHS for period 2007-2008. Mortality ratio equals to one indicates that there complete concordance of the mortality estimates for both the data sources. While, mortality ratio less than one suggests underestimation of mortality indicator by SRS and vice versa.

It is evident from Figure 1 that except Himachal Pradesh and Madhya Pradesh mortality ratio varies from 0.56 to 2.07, irrespective of type of residence. However, for most of the states, SRS rates are higher than NFHS which reveals a new aspect for analysis. In case of Himachal Pradesh mortality ratio is three times and two times respectively for rural and urban area.
3.1 Comparison of ASDR from SRS and DLHS for India and States

Comparisons of age-specific death rates between SRS and DLHS by sex and type of residence are shown in Figure 1.2 to 1.4. One can easily observe that there is considerable agreement of ASDR from DLHS for period 2007-2008 and SRS for period 2007. In addition, coverage of SRS seems to be better for most of the age-groups. Disagreement between the two sources is visible only after the age of 60. This significant difference in the mortality rates can be attributed to age-misstatement at older ages. Bhat (1987) has mentioned that most of the Indian have imprecise knowledge of their age. Moreover, analysis based on census data shows that age-exaggeration is more common among males than females, while female is more likely to understate their ages.
Comparison of age-specific death rates between DLHS-III (2007-2008) and the SRS (2007)
4. SMOOTHING BY BRASS’S RELATIONAL MODEL

Brass (1971) found a simple linear relationship between the logit transformed life table parameter \( l_x \) of an observed population and of a standard population (Equation 1). The Brass Relational Model is a powerful tool for assessing life tables, smoothing empirical data, completing a partial life table, and for population projection (Preston et al. 2001). The success of its application depends on the choice of the standard population, in particular, whether the standard population and study population belongs to the same “family”. Brass (1971) suggests that the standard life table “must be some kind of average.”

\[
\log ii(t_x) = \alpha + \beta \log ii(t_{sx})
\]  

(1)

\[
y_x = \logit(l_x) = \frac{1}{2} \ln \left[ \frac{1 - l_x}{l_x} \right]
\]  

(2)

and \( l_{sx} \) represents the survivorship probabilities of the ’standard' life table, i.e., the life table with which other life tables are compared. We have chosen Sample Registration System (SRS-2007) as standard age-specific death rates for India and their states. Age-specific death rates from SRS assumed to represent the overall mortality pattern of the state. It is assumed to average of “Some kind of average”. The model parameter \( \alpha \) is an indicator of the level of mortality that affects all ages about equally, while \( \beta \) modifies this effect by age. Values of \( \beta > 1 \) imply, relative to the standard, lower mortality at younger ages but higher mortality at older ages, while values of \( \beta < 1 \) imply the vice versa. In this paper brass relational model has been used to obtain smoother series of ASDR for selected states of India. The \( l_{sx} \) values, defined earlier, are taken from SRS-2007 and then value of \( \alpha \) and \( \beta \) can be estimated through least square method. Finally the graduated or smoothed series of \( l_x \) values can be obtained by applying the equation (2) in the reverse order after obtaining the graduated or smoothed series of \( y_x \) values through the above linear regression model (1).

5. APPLICATION OF BRASS RELATIONAL MODEL ON INDIAN STATES

Brass relational model has been used to obtain the smoother series of age-specific death rates for India and its states. We can observe from the Figure 2.1-Fig. 2.3 that Mortality estimates are considerably matching except the age one and oldest ages because mortality in those age groups is subject to large reporting errors. Comparing the results from Brass smoothing with the raw data, we see that the Brass model smoothing corrects some of the irregularities and underreporting problems in mortality. As observed in Figure ASDR values based on the raw data, deaths are seriously underreported in some state-level units. After smoothing, the deviation from the SRS values are reduced, while there are only minor changes at the low end, indicating that the smoothing is correcting for death underreporting.
Fig. 2.1 Comparison of Age specific death rates between DLHS-3(2007-2008) and SRS-2007

Fig. 2.2

Fig. 2.3
As it can be clearly observed from above figures that Brass-Relational model produces estimates, which is considerably close to official age-specific mortality rates except for age one and older ages. In next exercise, this relational model has been applied on state level to observe the reliability of mortality estimates at state level. Once again we can observe good concordance between DLHS and SRS estimates. The disagreement becomes visible after the age 60 years. Moreover, it has also been documented in previous literatures that SRS tend to show lower proportion of age returns at older ages (Bhat, 1987). This discrepancy may be attributed to sampling and other errors. Hence we cannot conclude that mortality estimates at older ages from both the sources are plausible or not.

5.1 Quality of all-age mortality data in DLHS-III

Advent of demographic and health surveys in India during early 1990s was vital step towards measuring health and demographic outcome at large scale level. These surveys has provided opportunity to estimate precise health outcome due to its huge coverage, meticulous planning and execution, quick and wide dissemination of the data. Mortality information in this survey is basically limited to early ages. The first National family health survey (NFHS) has provided birth history information for estimating infant and child mortality. Lack of data for analyzing mortality for age-segment has been the main limitation of NFHS except in the second wave of the survey in which information about recent household death has been sought. District level household survey provides unique opportunity in its third round (2007-2008) to analyze mortality (deceased number of household member) with socio-demographic situation in India and its states and its district. This is definitely an advantage over SRS which provides aggregate measures of mortality according to sex and place of residence. To better understand quality of death information between SRS (2005-2009) and DLHS (2007-08), infant mortality rates have been plotted for different regions of India. Infant mortality rates from DLHS were computed by birth history information of the women, Infant mortality rate from DLHS-III refers to infant mortality rates during a 4-year period before the survey in 15 major states of India. It can be observed that for most of the states (excluding West Bengal, Bihar, Punjab and Kerala). Infant mortality rates from SRS slightly higher than the corresponding figure of DLHS-III. Sample Registration System estimates are assumed to be reliable due to its dual record system. To understand the quality of data of SRS for different states by types of residences, we have plotted the infant mortality ratio of SRS and DLHS. To compute the mortality ratio, the infant mortality rate from SRS for period 2005-2009 is divided by IMR obtained from DLHS for period 2007-2008. It is evident from analysis that except Himachal Pradesh and Madhya Pradesh mortality ratio varies from 0.56 to 2.07, irrespective of type of residence. However, for most of the states, SRS rates are higher than NFHS. In case of Himachal Pradesh mortality ratio is three times and two times respectively for rural and urban area. Our results suggest that age-specific death rates estimated from DLHS-3(2007-2008) is considerably matching with official age-specific death rates from SRS (2007) at national as well as at state level. However, there are significant disagreement between two sources under age one and at older ages. One of the reasons of these irregularities is age-misstatement in
India specifically for early and older ages (Bhat, 1987). One of the major shortcomings of recent household death approach is that sampling error may creep in data due to small sample size. Since database used in this study based on the information from 7, 20,320 households with 102,633 deaths any possibility of sampling errors minimized automatically. Other issues related to data quality of age distribution of death in the survey data have been found to be quite good except for the old ages.

6. SUMMARY AND CONCLUSIONS

In this paper an attempt has been made to assess the age-pattern of mortality in India by using recent household death information from District level household survey. Household level information regarding death has been used as an input for the analysis. In this study we have tried to explore quality of mortality data based on deaths in 7, 20,320 households. There were 1, 02,633 individuals, who died in the four years prior to household survey. To better understand quality of death information between SRS (2005-2009) and DLHS (2007-08), infant mortality rates have been plotted for different states of India. It can be observed that for most of the states (excluding West Bengal, Bihar, Punjab and Kerala) Infant mortality rates from SRS slightly higher than the corresponding figure of DLHS-III. To understand the quality of data of SRS for different states by types of residences, we have plotted the infant mortality ratio of SRS and DLHS. It is evident from analysis that except Himachal Pradesh and Madhya Pradesh mortality ratio varies from 0.56 to 2.07, irrespective of type of residence. However, for most of the states, SRS rates are higher than DLHS due to overestimation SRS (Bhat, 1987). Our results suggest that age-specific death rates estimated from DLHS-3(2007-2008) is considerably matching with official age-specific death rates from SRS (2007) at national as well as at state level. However, there are significant disagreement between two sources under age one and at older ages. One of the reasons of these irregularities is age-misstatement in India specifically for early and older ages (Bhat, 1987). Moreover, for dealing with irregularities in ASDR across age-groups for Indian states Brass relational logit model used to graduate non-linearity of estimated the direct estimates of ASDR from DLHS. Smoother series of ASDR produces better match with the SRS estimates than the direct estimates from DLHS. These estimates can be used to generate survival probabilities and subsequently constructing Life table for states of India. With keeping age-pattern of mortality in perspective, our analysis suggests that it will be reasonably good research endeavor to assess survival pattern across the life course for different socio-economic groups using the DLHS-III household mortality information.
REFERENCES


