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Estimation of Life Expectancy from Infant Mortality Rate at Districts Level

Kesarwani Ranjana
Public Health Foundation of India, Fifth Floor, Plot No. 47, Sector 44, Institutional Area Gurgaon -122002 Haryana, INDIA

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Abstract

Monitoring the districts life expectancies is necessary for health policies and planning but it is difficult to get direct estimates because of the inaccessibility of age-specific death rates at the district level. Thus, the present study meets the challenges for the estimation of district level life expectancy. In this paper, I focused on the generation of mortality model for estimation of life expectancy at district level up to age 100+ and hence further to compute the abridged life table. For the development of the model, study exploited the age-specific death rate data from Sample Registration System for the period 1971-2010. It has been found that the linear regression model is the best fit method. The Study generated the regression model for India and all states by sex and then applied to districts of those states. The Study created the model by taking the only input as Infant mortality rate because at district level only the information on Infant and Child mortality is available, complete death information is unavailable. This study presents the life expectancies for districts of major states of India for the census year 2001. Examination for district variation reveals that life expectancy at birth is highest for district Udupi of state Karnataka and lowest for Kargil of Jammu and Kashmir. For themale, highest LEB is observed in Pune and Sangli of Maharashtra; for female, it is in Udupi of Karnataka. Thus, the study noted significant variation in life expectancy values across gender and district as well. At the same time, it has also brought out the extent of variation across districts within and between states in the country. Hence, results clearly affirm that the united approach of health interventions and policies will not work properly and henceforth may not help in reducing mortality differentials among districts. So, study recommends for health policies at small area level.

Keywords: Mortality, life expectancy, life table, regression, districts.

Introduction

Life expectancy at birth (LEB) and adult ages have been used as an indicator of health status and level of mortality experienced by any population for very long time. Life Expectancy is known as the summary measure of mortality for all ages that permit us to compare the longevity of the population between geographical areas over the period. The main advantage of estimating the life expectancy over the methods of measuring mortality is that itneitherreflects the effects of the age distribution of the actual population norrequires the adoption of a standard population for comparing the levels of mortality among different populations[1]. Although there are several alternative methods to derive the life expectancy, the most reliable means suggest the construction of life tables.

The construction of a life table requires reliable data on the age-specific death rates (ASDRs) calculated from information on deaths by age and sex (from vital registration system) and population by age and sex (from population censuses). In most of the world, especially Africa, parts of Asia and Latin America, there are pertinent either of the two problem relating to data. One, the basic data do not exist due to lack of functioning vital registration systems. Two, the basic data are unusable because of incompleteness of coverage or errors in reporting[2]. However in India, national and state level ASDRs data is available, but no data for a smaller area unit like the district is existing. There are many studies providing the abridged life tables for India and states using different techniques[3-6] but very few focus on smaller area like district level.

Millennium Development Goals (MDGs) endorsed by the Government of India also necessitates for precise estimates of the development indicators such as life expectancy at birth (LEB), infant mortality rate (IMR) and under-five mortality rates (U5MR) at below the state level for effective monitoring andevaluation of various human development programs including health, demographic changes at the district and lower levels. Decentralized district based health planning is essential in India because of the large inter-district variations. However, in the absence of vital and demographic data at the district level, the state level estimates are being employed for developing the district level plans and policies. In this process, we often used the state average for districts[7].

Presently, none of the survey or report provides an estimate of vital statistics as fertility and mortality indicators in India at the district level. However, District Level Household and Facility survey (DLHS) conducted with an emphasis on the maternal and child health indicators; along with this Annual

Health Survey (AHS) was performed to monitor the performance and outcome of various health interventions of Government of India those under the National Rural Health Mission (NRHM). AHS has been designed to present the benchmark of the vital and health indicators at the district level, but it covers only nine states (Assam, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Uttarakhand and Odisha) of India, it does not cover the entire states and henceforthentire districts of India. Therefore, in this context there is a growingneed, as observed in many governments and non-government organizations, to develop an appropriate mortality databases, to examine the differentials among the districts and to provide mortality indicators for effective monitoring and evaluation of various human development programs including health, demographic changes at district and lower levels. Thus, the present study is trying to provide a proper mortality database for districts of major states of India using the life table approach.

Methodology

Data Sources: The Study used two sets of data source, namely, Census of India and Sample Registration System (SRS).

Census of India: It is conducted by the Office of Registrar General and Census Commissioner, India under the Ministry of Home Affairs, Government of India. The Census covers various aspects such as population, economy, socio-cultural aspects, migration area and village profile, etc. This study used the information on IMR from Census 2001. The information on IMR is collected from the publication of the Office of the Registrar General of India "District Level Estimates of Child Mortality in India based on Census 2001 data". In this report, IMR is indirectly estimated by using Brass technique that requires the children ever born and children surviving data from the census[8].

Sample Registration System (SRS): Another source of data is Sample Registration System (SRS). The system was initiated by Office of Registrar General, India during 1967 with the objective of producing a reliable and continuous data on demographic indicators. This study used the information on ASDRs from SRS (1971-2010) for developing a model to estimate the life expectancy at district level[9]. This study also made some adjustment in the data set. First, SRS provide the ASDRs up to age 70+ for the period 1971 to 1995; however from 1996 onwards death rates are extended up to age 85+. Therefore, to maintain the uniformity in the death rates data, the death rates of the period 1971 to 1995 up to age 85+ are expanded using the regression method on the basis of mortality experience from 1996 onwards. Second, Death rate information for age group 0-1 and 1-4 is available from 1996 onwards and before 1996, SRS is allowing for age group 0-4 which is a combination of 0-1 and 1-4. Therefore, for the period previous to 1996, study split the death rates of age group 0-4 into 0-1 and 1-4.

Moreover, to estimate the life expectancy for entire districts of major states of India, study assume that all the districts of a particular state are following the same fertility and mortality pattern like the state.

Methods: Least Square Estimate of Expectation of Life: To estimate the life expectancy at the district level, study used the life table approach. Ideally, model life table system should have some essential characteristics. First, the system should be parsimonious and call for only one or few parameters to generate a full life table. Second, it should sufficiently and adequately capture the broad range of mortality age pattern observed in the actual population and must imply high predictive validity. Last, it should render an acceptable estimate of age-specific death rates for countries having high levels of mortality also. Thus, model life table system should generate age-specific mortality apparently valid time trend and the partial derivative of entry parameter should be positive with respect to age-specific mortality rate[10]. The first attempt to compute the mortality in countries with inadequate vital statistics by exploiting only the infant mortality rate is made by the Population Branch of the United Nations, Department of Social Affairs. The United Nations method was based on the analysis of 158 observed life tables for several countries over the different periods. These observed mortality rates were analyzed by fitting the second degree least square polynomials. The method assumes that the mortality rate of each age group is associated with the preceding age group. Life expectancy was calculated from Infant mortality rate (${}_1q_0$) applying the usual procedure to obtain the abridged life tables[11]. In the same direction, very recently some contributions have been made by many researchers to develop model life tables (MLTs) using the only information on either infant or child mortality or life expectancy at age x, LE(x), values[12-15]. Following the idea, the study developed a regression model by taking input as infant mortality rate (IMR) for India and states by sex and then applied to districts of those states. The study generated the model by taking the only input IMR as the district level only the information on Infant Mortality and Child mortality estimates are available and complete age-specific death rate data is not available.

The regression model is constructed separately for each sex as well as both sex combined with the help of 414 observed life table for male, 414 for female and 414 for a total population available in Sample Registration System (SRS) published regularly by the Registrar General of India over the period 1971-2010. Each regression model consisting of 19 set of the regression equation corresponding to each age group 0-1, 1-4, 5-9,……,80-84 and 85+. The coefficients of determination (R^2) values are also supplied next to each regression equation that explains the admissibility of the model. Initially, life expectancy at birth are estimated by using least square regression of the natural logarithmic value of LEB (e_0^0) on IMR (${}_1q_0$). From the scatter diagram, we found that the linear regression is the best fit method. Thus, regression model has the following form:

$$\text{Ln(LEB)} = a + b * \text{IMR} \quad (1)$$

$$\text{Alternatively, LEB} = \exp[a + b * \text{IMR}] \quad (2)$$

The results of least square regression for India are shown in Table-1. Following is an example of life expectancy at birth (e_0^0) computation for a total population. Given ${}_1q_0$ = 0.10, the value of e_0^0 from Table 1 is $\exp[4.364 + (-3.383) * 0.1] = 56.02$. The value of R^2 associated with e_0^0 is 0.99 implying high acceptability of the model.

Table-1
Regressions of life expectancy at each age x (LE(X)) on life expectancy at birth (LE(0)), India

LE(X)	PERSONS				MALES				FEMALES			
	Constant	Coefficient	R^2	Confidence Interval	Constant	Coefficient	R^2	Confidence Interval	Constant	Coefficient	R^2	Confidence Interval
LE(0)	4.364	-3.383	0.990	(-3.569 - -3.214)	4.329	-3.072	0.992	(-2.358 - 2.425)	4.400	-3.701	0.983	(-2.944 - 3.329)
LE(1)	1.329	0.692	0.998	(0.679 - 0.706)	1.460	0.659	0.998	(0.642 - 0.666)	1.211	0.721	0.997	(0.701 - 0.736)
LE(5)	2.265	0.458	0.991	(0.439 - 0.479)	2.363	0.431	0.989	(0.403 - 0.446)	2.176	0.483	0.991	(0.461 - 0.502)
LE(10)	2.307	0.431	0.988	(0.408 - 0.454)	2.414	0.401	0.983	(0.367 - 0.419)	2.215	0.457	0.988	(0.431 - 0.477)
LE(15)	2.155	0.448	0.986	(0.423 - 0.472)	2.278	0.413	0.980	(0.376 - 0.434)	2.053	0.477	0.987	(0.450 - 0.499)
LE(20)	1.991	0.466	0.984	(0.437 - 0.494)	2.101	0.434	0.978	(0.380 - 0.448)	1.902	0.494	0.985	(0.464 - 0.519)
LE(25)	1.826	0.484	0.979	(0.451 - 0.515)	1.897	0.460	0.973	(0.415 - 0.489)	1.769	0.504	0.981	(0.468 - 0.533)
LE(30)	1.613	0.510	0.973	(0.468 - 0.549)	1.621	0.501	0.967	(0.444 - 0.533)	1.606	0.520	0.975	(0.476 - 0.556)
LE(35)	1.363	0.543	0.967	(0.500 - 0.593)	1.309	0.548	0.961	(0.482 - 0.587)	1.406	0.542	0.971	(0.494 - 0.581)
LE(40)	1.061	0.586	0.962	(0.531 - 0.635)	0.947	0.604	0.953	(0.524 - 0.650)	1.155	0.573	0.966	(0.515 - 0.617)
LE(45)	0.712	0.636	0.958	(0.574 - 0.693)	0.562	0.663	0.946	(0.569 - 0.708)	0.840	0.615	0.963	(0.546 - 0.662)
LE(50)	0.310	0.695	0.960	(0.632 - 0.763)	0.145	0.725	0.945	(0.626 - 0.783)	0.468	0.667	0.964	(0.599 - 0.723)
LE(55)	-0.075	0.746	0.964	(0.673 - 0.814)	-0.285	0.786	0.948	(0.672 - 0.843)	0.079	0.719	0.966	(0.637 - 0.774)
LE(60)	-0.513	0.805	0.969	(0.740 - 0.888)	-0.690	0.838	0.952	(0.713 - 0.889)	-0.405	0.789	0.965	(0.695 - 0.853)
LE(65)	-0.787	0.823	0.964	(0.743 - 0.928)	-0.911	0.842	0.937	(0.663 - 0.874)	-0.736	0.819	0.961	(0.696 - 0.891)
LE(70)	-1.156	0.859	0.942	(0.748 - 0.993)	-1.276	0.879	0.899	(0.630 - 0.912)	-1.164	0.867	0.946	(0.711 - 0.967)
LE(75)	-1.429	0.870	0.901	(0.731 - 1.051)	-1.447	0.866	0.834	(0.538 - 0.911)	-1.577	0.910	0.912	(0.704 - 1.051)
LE(80)	-1.744	0.892	0.835	(0.721 - 1.143)	-1.735	0.883	0.743	(0.459 - 0.942)	-1.961	0.945	0.862	(0.672 - 1.131)
LE(85)	-1.912	0.877	0.751	(0.631 - 1.169)	-1.846	0.857	0.636	(0.331 - 0.921)	-2.220	0.950	0.797	(0.607 - 1.169)

After estimating the life expectancy at birth with the help of equation 2 and complying the idea suggested by Gabriel and Ronen[16], Sinha and Gupta[12] and Ponnapalli[6], study derived the remaining life expectancy values using the developed regression model, given below:

$$\text{Ln}[LE(x)] = a + b * \text{Ln}[LEB] \qquad (3)$$

Where; a = constant, b = coefficient, LE(x) = Life expectancy at age x, x≠0
Therefore, for computed value of LEB, one can estimate the life expectancy value for all other remaining ages by applying the parameters a and b from equation (3). For instance, for computed value of LEB (e_0^0) = 56.02, using table-1, life expectancy at age one can be calculated by $LE(1) = \exp[1.329 + 0.692 * (\text{Ln}(56.02))] = 61.24$ with R^2 value 0.99. After getting the complete LE(x) column, the full life table can be derived in reverse order by applying the usual steps mentioned below:

Step1: Assume $l_0 = 100000$. Estimate l_x column as follows:

$$l_1 = l_0 * \left[1 - \left(\frac{1 + e_1 - e_0}{1 + e_1 - {}_1a_0}\right)\right] \quad \text{where} \quad {}_1a_0 = 0.1$$

$$l_5 = l_1 * \left[1 - \left(\frac{1 + e_5 - e_1}{1 + e_5 - {}_4a_1}\right)\right] \quad \text{where} \quad {}_4a_1 = 1.6$$

$$l_{x+n} = l_x * \left[1 - \left(\frac{1 + e_{x+n} - e_x}{1 + e_{x+n} - {}_5a_5}\right)\right] \text{for } x = 5, 10, 15, \ldots 85+ \quad \text{and} \quad {}_5a_x = 2.5$$

Step2: Calculate ${}_nm_x = \dfrac{l_x - l_{x+n}}{(n * l_{x+n}) + {}_na_x * (l_x - l_{x+n})}$ and

$${}_nq_x = \frac{n * {}_nm_x}{1 + (n - {}_na_x) * {}_nm_x}$$

Step 3: ${}_nd_x = l_x - l_{x+n}$

Step 4: ${}_nL_x = n * l_{x+n} + {}_na_x (l_x - l_{x+n})$

For open ended age group say 85+ $L_{85+} = \dfrac{l_{85+}}{m_{85+}}$

Step 5: $T_x = T_{x+n} + {}_nL_x$

For open ended age group say 85+ $T_{85+} = L_{85+}$

Following the above steps, I developed the models for all major states of India. However, for smaller states, thestudy generated a general model by keeping the data of all major states together.

Life Table Extension up to 100+: Life table up to age 100+ have also been extended using the method suggested by Murray and colleges[17-18]. Detail description of life table extension method is provided here. The ASDRs is available up to the age 70+ for the period 1970 to 1995 and up to 85+ for the period 1996 to 2010. No age-specific information on mortality above 85 is available in India. In this study, a method given by Coale and Guo[19] is used for the estimation of life expectancy at older ages with an open interval above 100. (i.e. 100+) as the probability of dying has increased to age 110 in recent time for developing countries[20-22]. It is noticed that mortality rates at ages above 75 or 80 increases with age at a diminishing rate rather than at the constant Gompertz rate[23]. Thus, Coale and Guo[19] modified the procedure for closing out the model life tables above age 80. In this modified procedure, they make an assumption of a steady decrease rather than Gompertzian constancy in the rate of increase in mortality with age above 80. To compute the mortality rate at older ages they suggested the following steps:

Step 1: Calculate $k = \ln(\dfrac{{}_5m_{80}}{{}_5m_{75}})$

This logarithm of the ratio of mortality rates is assumed to decline by a constant increment as age x rises above 80.

Step 2: Assign an arbitrary high value of ${}_5m_{75} + 0.66$ to ${}_5m_{105}$.

In general, When LEB (e_0^0) is 70 years or higher (about 80 years) take $\eta = 0.71$

When LEB (e_0^0) is 70 years or below (about 70 years) take $\eta = 0.74$

Step 3: Estimate

$$R = \frac{((6 * k) - \ln(\eta / {}_5m_{75}))}{15}$$

Step 4: Compute

$${}_5m_{85} = {}_5m_{80} * \text{Exp}(k - R)$$

$${}_5m_{90} = {}_5m_{85} * \text{Exp}(k - 2 * R)$$

$${}_5m_{95} = {}_5m_{90} * \text{Exp}(k - 3 * R)$$

$$m_{100} = {}_5m_{95} * \text{Exp}(k - 4 * R)$$

To test the reliability of the procedure of closing out mortality rates at older ages, Coale and Guo compared the rates calculated by above method with rates calculated by Gompertz method and with actual rates at ages over 80. They found that new estimates are closer than Gompertz estimates. Thus, the above method for closing out the life table to age 100 and above is giving good results than the Gompertz method. The Murray and Associates recently used this method[17-18].

Consistency in the Estimates of Life Expectancy: A regression model based on the national data set is yielded in table-1. In the same way, state-specific models were also developed but not presented here for convenience, only the state specific regression models of state Uttar Pradesh is given in Table-2.

Table-2
Regressions of life expectancy at each age x (LE(X)) on life expectancy at birth (LE(0)), Uttar Pradesh

LE(X)	PERSONS				MALES				FEMALES			
	Constant	Coefficient	R^2	Confidence Interval	Constant	Coefficient	R^2	Confidence Interval	Constant	Coefficient	R^2	Confidence Interval
LE(0)	4.366	- 3.274	0.978	(-3.403 - - 2.750)	4.330	-2.921	0.972	(-2.296 - 2.323)	4.407	-3.648	0.975	(-3.283 - 2.894)
LE(1)	1.409	0.673	0.994	(0.551 - 1.289)	1.560	0.636	0.990	(0.619 - 1.410)	1.270	0.708	0.995	(0.482 - 1.256)
LE(5)	2.720	0.347	0.970	(0.320 - 0.373)	2.758	0.335	0.950	(0.298 - 0.370)	2.653	0.367	0.972	(0.341 - 0.396)
LE(10)	2.813	0.307	0.959	(0.281 - 0.336)	2.862	0.291	0.919	(0.247 - 0.326)	2.731	0.332	0.966	(0.304 - 0.357)
LE(15)	2.683	0.319	0.958	(0.291 - 0.347)	2.734	0.302	0.911	(0.256 - 0.342)	2.597	0.345	0.964	(0.319 - 0.378)
LE(20)	2.542	0.332	0.955	(0.304 - 0.364)	2.583	0.317	0.903	(0.261 - 0.358)	2.476	0.354	0.962	(0.322 - 0.385)
LE(25)	2.387	0.347	0.951	(0.315 - 0.382)	2.369	0.346	0.896	(0.285 - 0.393)	2.348	0.364	0.957	(0.333 - 0.400)
LE(30)	2.195	0.370	0.944	(0.334 - 0.411)	2.117	0.381	0.890	(0.311 - 0.436)	2.190	0.379	0.950	(0.342 - 0.418)
LE(35)	1.959	0.400	0.940	(0.361 - 0.446)	1.797	0.431	0.889	(0.357 - 0.495)	2.000	0.399	0.945	(0.357 - 0.441)
LE(40)	1.666	0.440	0.935	(0.395 - 0.491)	1.414	0.492	0.895	(0.405 - 0.564)	1.754	0.430	0.938	(0.385 - 0.482)
LE(45)	1.362	0.480	0.928	(0.425 - 0.533)	1.068	0.541	0.870	(0.429 - 0.624)	1.457	0.469	0.930	(0.413 - 0.528)
LE(50)	1.023	0.524	0.926	(0.468 - 0.592)	0.730	0.585	0.855	(0.464 - 0.686)	1.084	0.522	0.919	(0.459 - 0.597)
LE(55)	0.700	0.560	0.924	(0.497 - 0.634)	0.382	0.627	0.842	(0.488 - 0.742)	0.717	0.569	0.900	(0.487 - 0.664)
LE(60)	0.428	0.578	0.895	(0.515 - 0.684)	0.225	0.617	0.713	(0.421 - 0.788)	0.237	0.638	0.868	(0.532 - 0.765)
LE(65)	0.315	0.555	0.805	(0.475 - 0.703)	0.117	0.592	0.542	(0.308 - 0.833)	- 0.189	0.693	0.769	(0.531 - 0.908)
LE(70)	0.113	0.550	0.679	(0.449 - 0.766)	- 0.058	0.581	0.384	(0.193 - 0.910)	- 0.707	0.765	0.672	(0.537 - 1.068)
LE(75)	- 0.037	0.531	0.514	(0.396 - 0.829)	- 0.013	0.513	0.221	(0.009 - 0.960)	- 1.347	0.867	0.582	(0.559 - 1.285)
LE(80)	- 0.111	0.493	0.348	(0.311 - 0.883)	- 0.007	0.455	0.119	(-0.194 - 1.042)	- 1.787	0.917	0.478	(0.518 - 1.462)
LE(85)	- 0.133	0.442	0.217	(0.222 - 0.935)	0.148	0.361	0.053	(-0.425 - 1.081)	- 2.174	0.955	0.400	(0.475 - 1.641)

Before applying the state-specific models to districts of the particular states, I checked the applicability of the model. In Figure-1 and Figure-2, I made a comparison of estimated and observed life expectancy of state Uttar Pradesh (U.P.) for two time periods say, 1986-90 and 2006-10 for male and female respectively. From both the figures, it is clear that the developed model life table is giving good results for state Uttar Pradesh for both sexes as well as for the total population. Differences between observed and estimated life expectancies is negligible almost at all ages and implying that model is rendering satisfactory result at state level. In the similar way, study also tested the applicability of the state models to the respective states and found appreciable results. On this basis, I decide to apply the state specific regression model to the districts of particular states with the considered assumption of homogeneity in fertility and mortality pattern within the states.

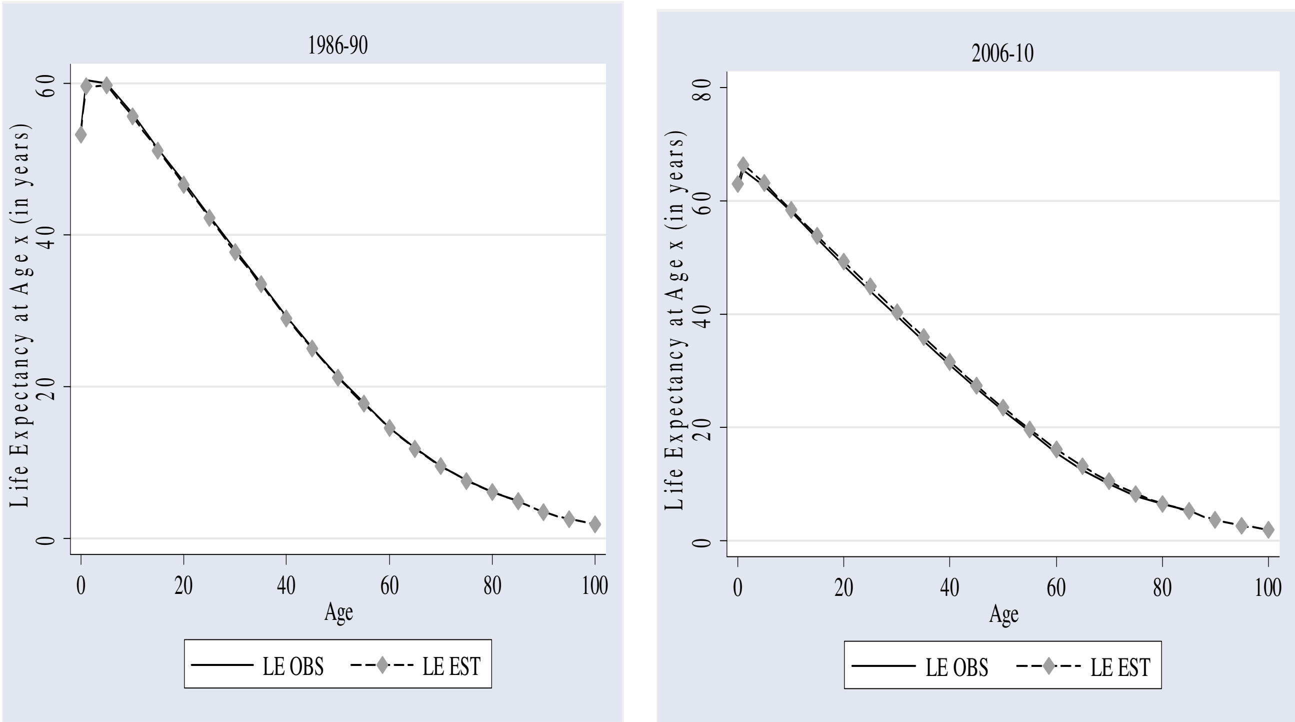

Figure-1
Applicability of regression based model life table for Uttar Pradesh, Male

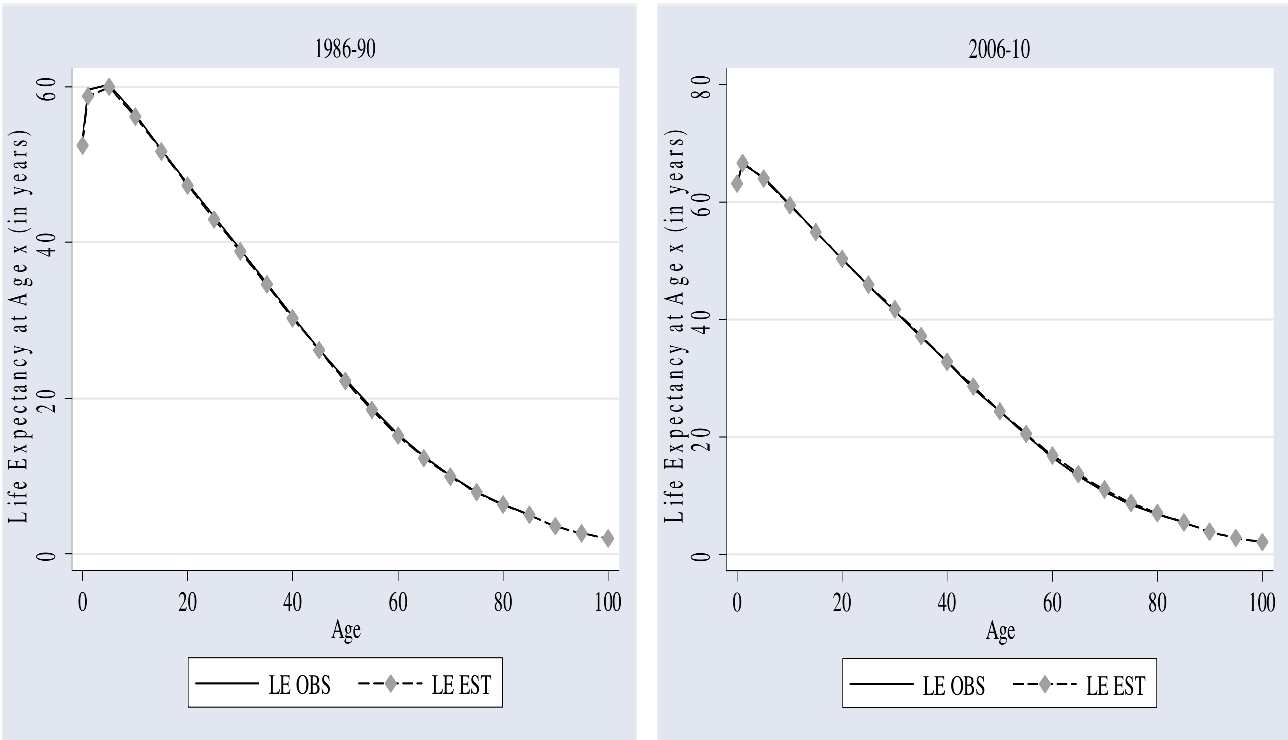

Figure-2
Applicability of regression based model life table for Uttar Pradesh, Female

Results and Discussions

To demonstrate the results in a compact manner, I created figures for life expectancy estimates at different ages using the software ARCGIS version 10[24]. Since, it is not possible to explain the differentials at each age mortality values among all districts, so I choose the life expectancy at age 0, 15 and 60 to explain differentials as these ages have prominent changes in life expectancy values.

District level variation in Life Expectancy at Birth by Sex: Life expectancy at birth (LEB) is one of the most desirable indicators in demographic and health analysis. It manifests the average number of years that a newborn is expected to survive under the current schedule of mortality. Life expectancy at birth is viewed as a proxy measure for various dimensions of nutrition, good health, education, etc. Besides, it is used in the construction of the human development index (HDI). Therefore, LEB is of importance in formulating the population policies at national and sub-national level. However, the heterogeneity in health and development within the country leads the different mortality conditions and henceforth contribute the variation in life expectancy value at the district level.

In the present section, the study discussed the district level variation in life expectancy at birth value for India for total, male, and female population as well. Figure 3 to 5 show the distribution of life expectancy at birth among the districts of India for the census year 2001 for total, male and female population respectively. Life expectancy at birth for both sex combined is ranging between 45.9 years to 70.2. However, the range for males is 46.2 to 69.0 years and for a female it is 44.4 to 71.2 years. Examination for district variation reveals that life expectancy at birth (LEB) is highest for district Udupi of state Karnataka followed by Mahe of Pondicherry. The lowest LEB for both sex combined is noticed in district East Kameng of Arunachal Pradesh. For the male, highest LEB is observed in Pune of state Maharashtra and for female in Udupi. One salient feature in district pattern of mortality is the very low value of male and female LEB for districts Kargil of Jammu and Kashmir and East Kameng of Arunachal Pradesh. The study observed a significant variation in life expectancy values across gender and district as well. The highest gender difference in LEB is observed in Sheohar district of state Bihar. In Sheohar, male have 6.3 years more LEB than female.

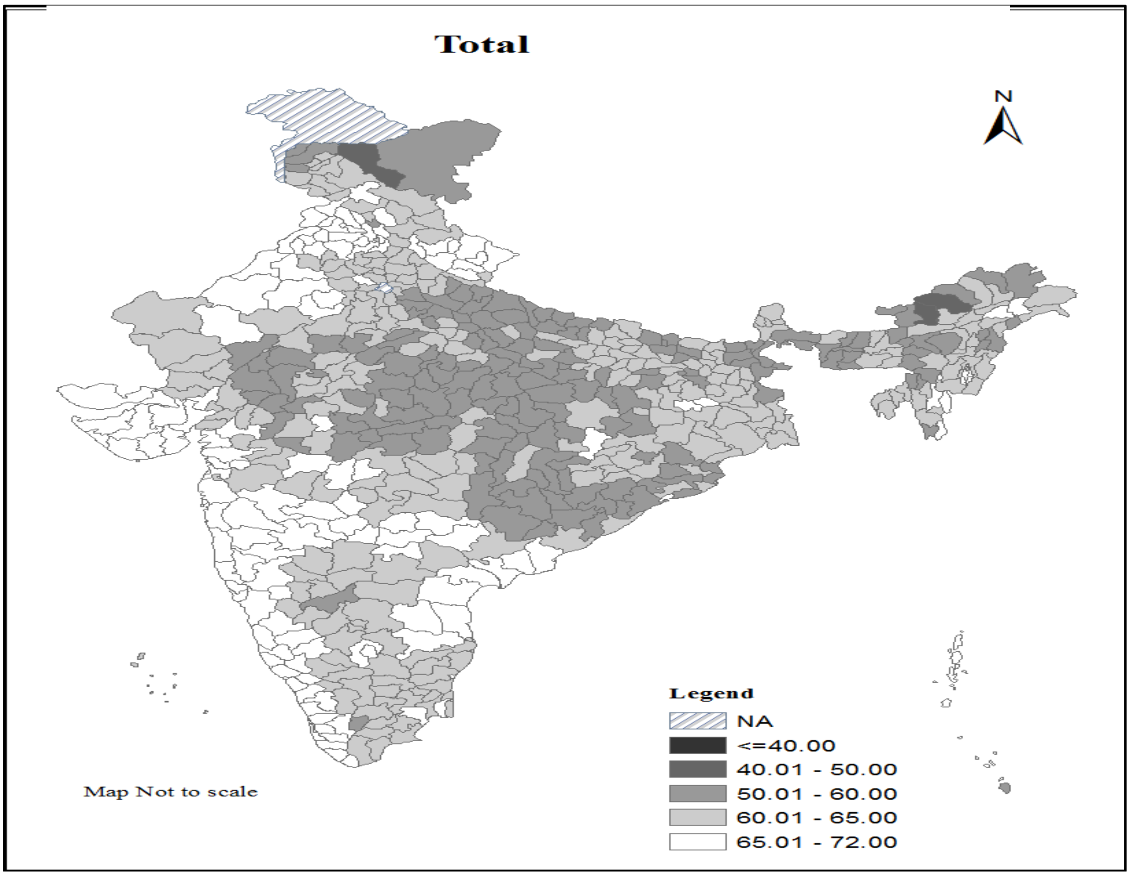

Figure-3
Distribution of Life Expectancy at Birth in India, 2001, Total

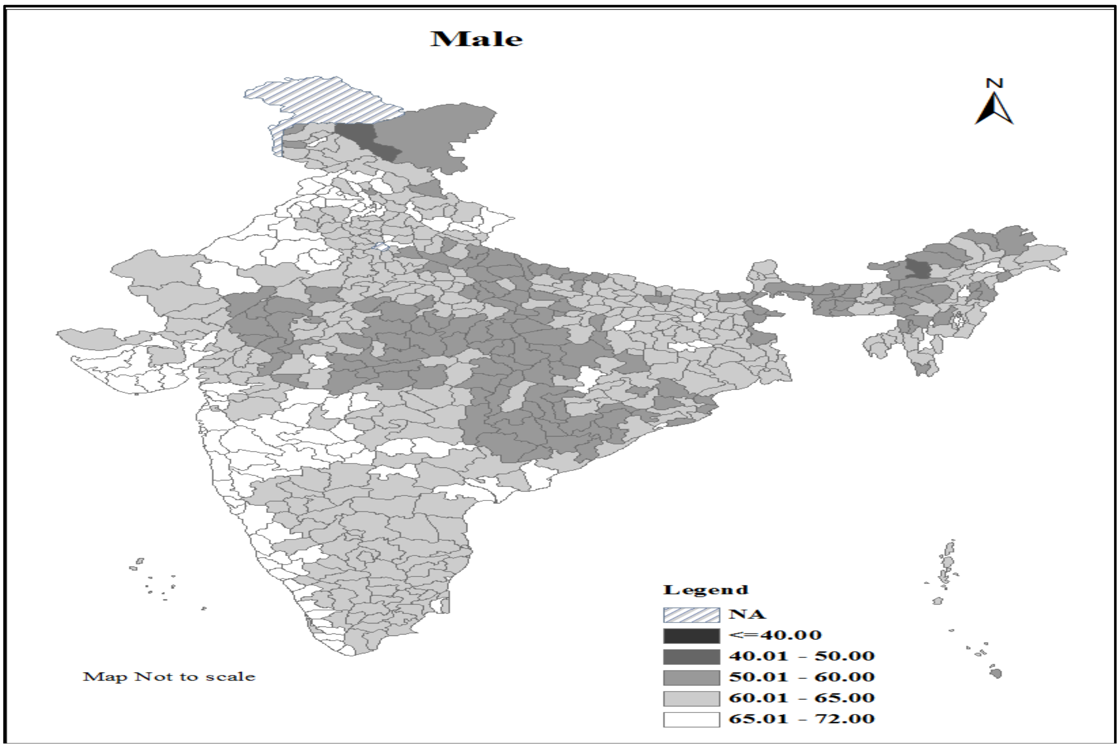

Figure-4
Distribution of Life Expectancy at Birth in India, 2001, Male

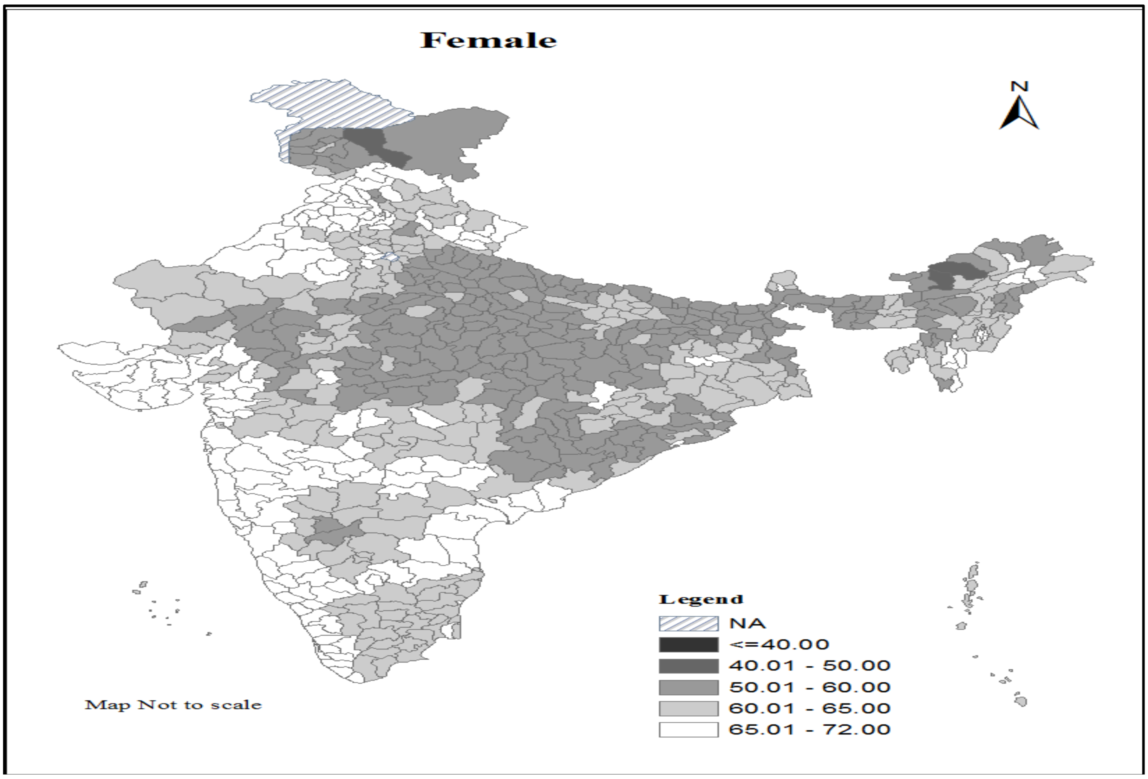

Figure-5
Distribution of Life Expectancy at Birth in India, 2001, Female

According to Census 2001, the overall literacy rate in district Udupi was 81.3 percent that is much greater than the national average (64.8 percent)[25]. The health facility and accessibility are found good in Udupi. Moreover, Udupi is considered in the better performing district of state Karnataka in terms of safe delivery, live births, a high level of full vaccination coverage, receiving the BCG vaccination. In addition, 99 percent women got the minimum three Antenatal Care (ANC)[26]. All these factors lead the lowinfant deaths and hence resulting in high level of LEB in district Udupi. In the same way, Mahe is one of the important districts of Union Territory Pondicherry. It is primarily urban and having overall literacy rate above 95 percent. The prevalence of women having minimum three ANC is about 99 percent. The high coverage of BCG and other vaccination are leaving the better health outcome[26]. East Kameng is primarily rural area. Only 46 percent of currently married women received any ANC and 20 percent institutional deliveries were observed. Only 7 percent of women were aware of danger signs of pneumonia[26]. Thus, insufficient utilization of health services are affecting the child health and hence turning out with a lower life expectancy at birth.

District level variation in Life Expectancy at age 15 by Sex: In the last two decades, most of the developing countries are experiencing an increase in longevity and decline in infant and child mortality. However, this could not be extending to an infinite length of life. It is associated with the less premature mortality, higher life expectancy and healthy and disease free life. Presently India is experiencing the double burden of disease. While the reduction of infant and child mortality due to infectious disease is still incomplete, the increment in non-communicable disease is observed among adults. Thus, the prevention of deaths among children and adults is significant public health goal at this moment. However, there exist a very considerable diversity both within and among countries/states/districts about mortality experience of adults. This diversity has been well captured and described in numerous studies at national, as well as state level but did not explain at the district level. So, the present section deals with explaining the variation in young adult mortality by considering the life expectancy at age 15 as an indicator of young adult mortality.

Figure 6 to 8 show the distribution of life expectancy at age 15 by districts of India for the census year 2001 for total, male and female population respectively. For a total population, life expectancy at age 15 (LE(15)) lies between 43.5 to 58.9 years. The lowest LE(15) is observed for Kargil (43.5 years) of state Jammu and Kashmir and highest is noticed for Rupnagar (58.9 years) of state Punjab. For the male, minimum life expectancy at age 15 is found in Kargil and highest for Hanumangarh (56.9 years) of Rajasthan. Unlike the male, for female lowest LE(15) is remarked for Kargil (41.6 years). The highest LE(15) for female (61.0 years) is detected in district Rupnagar. The variation in life expectancy at adult ages can be explained through lifestyle factors (like overeating, obesity, physical activity, etc.), health behavior (like smoking, alcohol, diet, etc.), health condition (self-reported status) and physiological influences (height, weight, stress, Genetic, etc.). It is observed that the other leading cause of variation in adult mortality is certain infectious and parasitic diseases like tuberculosis, disease of the respiratory system[27].

District level variation in Life Expectancy at age 60 by Sex: Like many other countries in the world, India has witnessed a marked decline in old age mortality in recent decades. The phenomenon of population aging is becoming a major concern for the policy makers all over the world, for both developed and developing countries. Aging population is mainly affected due to downward trends in fertility and mortality. Low birth rates coupled with long life expectancy, push the population towards aging.

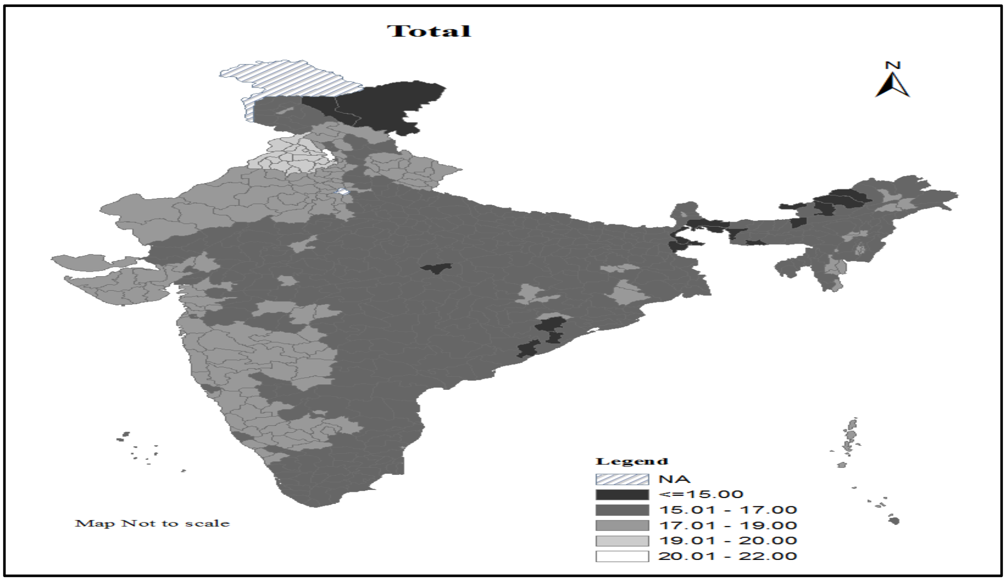

Figure-9
Distribution of Life Expectancy at age 60 in India, 2001, Total

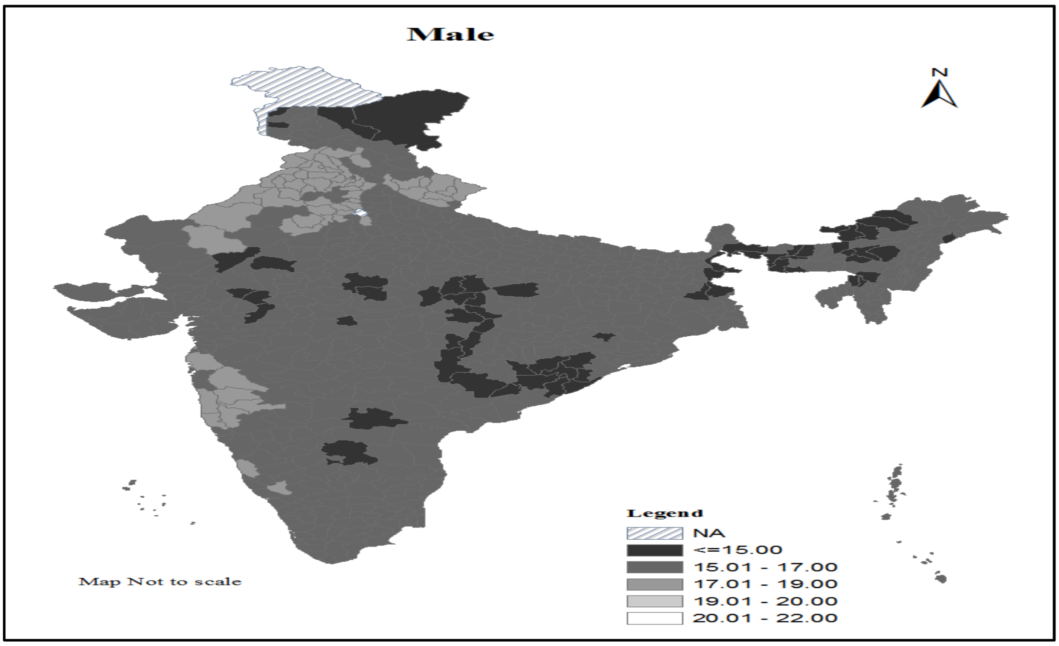

Figure-10
Distribution of Life Expectancy at age 60 in India, 2001, Male

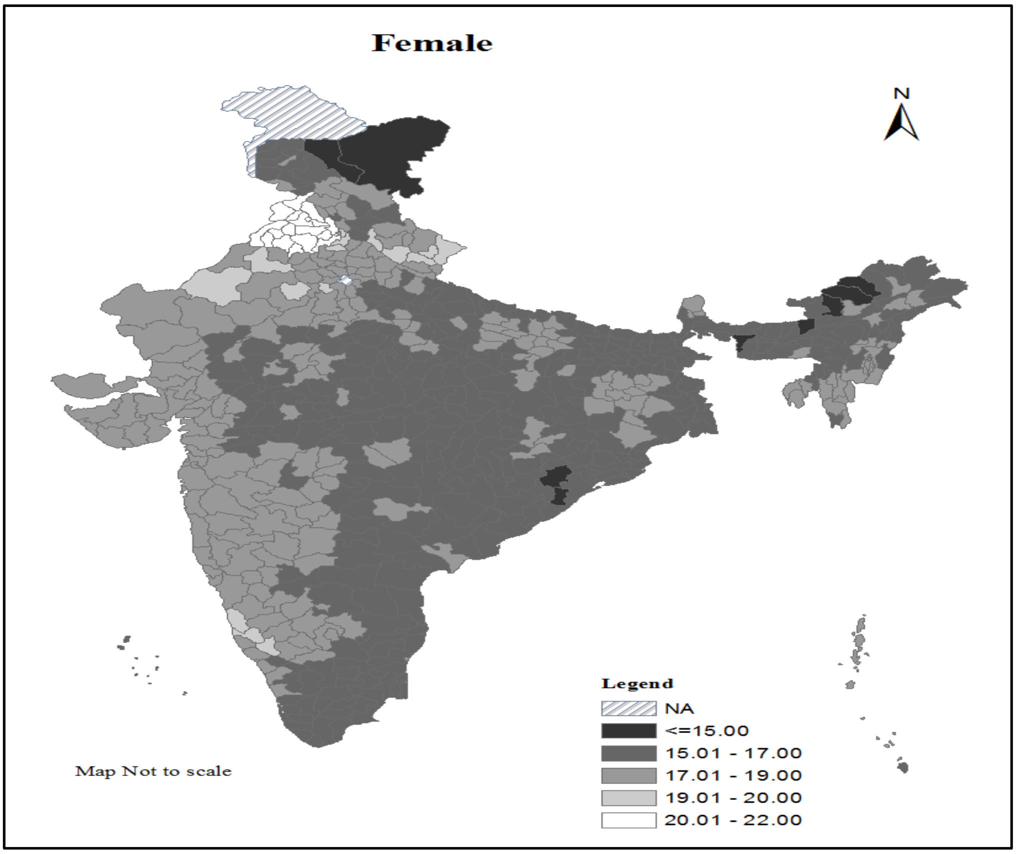

Figure-11
Distribution of Life Expectancy at age 60 in India, 2001, Female

Figure 9 to 10 deliver the distribution of life expectancy at 60 (LE(60)) for districts of India for total, male and female population respectively. Among males and female, lowest LE(60) is detected for district Kargil (11.2 years and 11.8 years respectively) of state Jammu and Kashmir; whereas highest is observed for Rupnagar (18.8 years and 21.1 years respectively) of Punjab. The highest gender difference in LE(60) value is noticed in districts Bhatinda (2.5 years) and Mansa (2.5 years) of state Punjab.

Conclusion

The primary objective of the United Nations study had been "to render a technique with the support of which the mortality level and its probable age variation can be estimated approximately" using basic information on infant mortality rates. However, the indefiniteness of this technique has made it hard to determine what the most suitable statistical method of obtaining this procedure might be[16]. Thus, more specifically, the aim of this paper is to supply the best linear regression estimates; best in the sense of high value of the coefficient of determination (R^2) by using the least square procedure.The study has suggested that there is only a slight variation between the computed and observed estimates. Hence, the use of regression technique also gives very satisfactory estimates of life expectancy value. To furnish the separate results for each sex, different regression equation are derived and yielded in the results.

The present study also made an attempt to develop a mortality database at small area level like district using the information only on infant mortality rate by applying state-level regression equations. The database comprises of information on life expectancy and hence other mortality indicators like number of survivors; total person-years lived, etc. can be derived with the help of life expectancy estimate. This mortality database can be considered as the latest information at the district level. The analysis is done for all districts of major states of India for Census year 2001.

Examination for district variation reveals that life expectancy at birth (LEB) is highest (70.2 years) for district Udupi of state Karnataka followed by Pune (69.7 years) of Maharashtra. However, for male highest (69.0 years) LEB is observed in Pune and Sangli of Maharashtra and for female (71.2 years) in Udupi of Karnataka. The study found significant variation in life expectancy values across gender and district as well. An important finding is that the district has high LEB, also have a high level of life expectancy at age 15 and 60 and vice versa. Finding shows that different age group mortality is correlated. At the same time, it has also brought out the extent of mortality variation across districts within and between states in the country. Thus, results clearly affirm that the united approach of health interventions and policies will not work properly and henceforth will not help in reducing mortality at the smaller area level. So, the study recommends for different health interventions at district and lower level. From a policy point of view, information linked to mortality rates are needed continuously not only for prioritizing action but also for tracking progress in these indicators. Despite the implementation of decentralization in India, it is very difficult to get a direct estimate at the district level. One has to rely on the decennial information from the census by employing an indirect approach to estimating the district indicators. Indirect estimation always involves some assumptions; thus, there is a need to improve and regularize the administrative data system particularly at the smaller area level.

Though, the study has addressed a number of technical issues related to mortality estimation at the smaller area, the study, however, has some limitations related to data and measures that need to be mentioned. First, the study used the age-specific death rates provided by SRS. Bhatt[28] has doubted the completeness of India's SRS data. Nevertheless in a study, Mahapatra[29] re-examined the quality of SRS and remarked that completeness of the data during 1980s but worsen during 1990s and after that. Therefore, the study assumes that SRS is the reliable and trusted the source of mortality data in India. The study focused on the short period (1971-2010), as the mortality data is available only for this period. The life expectancy estimation could be done with more significantly unlike the developed countries, where mortality data is quite reliable and accurate and available for longer period. In addition, the main emphasis of the study is the generation of the district level mortality databasethat required the age-specific death rates as an input for each district, but it is not available. So, the study exploited the available information of infant mortality rate only. Moreover, research work generated the regression model, for the development of district level model life, which is based on the data for the period 1971-2010. There is a possibility that the model would not work appropriately outside this time range. So it needs to update the model by time. Along with this, the study assumes that homogeneity in mortality and fertility pattern within the state which is not possible in practice.

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