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A procedure for estimating a few demographic indicators of Assam state and its districts

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Abstract
In India, as vital statistics reports bear flaws due to incomplete and irregular birth and death registration, researchers resort to the use of various indirect techniques of demographic estimation. In this regard, challenges faced by researchers in the area lie in the development effective indirect techniques of estimation. This paper has proposed a five parameters polynomial regression model for estimating the life expectancy at birth using child survivorship probabilities obtained from indirect techniques of estimation of infant and child mortality rates. Estimates of life expectancies at birth, infant mortality rates, under age five mortality rates and life expectancies at birth at sub-state level, i.e., district level of Assam, obtained in this paper, may provide a set of demographic indicators enormously useful to health and socio-economic planners of the state. Logit smoothing is done to child mortality estimates given by Trussell's variant of Brass methods on children ever born (CEB) and children surviving (CS) of 2001 and 2011 census of India, and then Weibull survival function is fitted to the smoothed estimates so as to finally obtain infant and child mortality estimates with enhanced precision. A procedure is adopted here in selecting a suitable model life table family in which two established techniques are simultaneously used. MORTPAK for Windows, the UN software package for demographic measurement in developing countries, is used in abridged life tables of Assam - 23 each for male, female and the combined, from 1970 to 2016, to get unabridged life tables from the abridged wherever required.

Keywords: Infant mortality rates (IMR), under five mortality rates (U5MR), life expectancy at birth

1. Introduction

Life expectancy at birth (e_0), i.e., the longevity of a new born based on age-specific death rates, is an important indicator to determine the mortality level of a population from which demographers can draw an idea about the socio-economic condition and health status of that particular population (Najafi, *et al*., 2018, Motlagh, *et al*, 2012) [7, 6]. However, life expectancies at ages other than zero are also used for studying mortality pattern of cohort population. In the case of most developing countries and historical populations, high incidence of infant and child mortality results in lower values of e_0 than at other childhood ages, and in such populations, those surviving the hazards of early childhood have a higher life expectancy than new born and the highest life expectancy does not occurs at birth but at later age (Romo and Becker, 2011) [9].

Phukon and Ahamed (2019) [8] estimated life expectancy at birth by developing two polynomial regression models comprising child survivorship probabilities at ages one, two, three and four, i.e., l_1, l_2, l_3 and l_4 using 54 set of SRS based abridged life tables of Assam. Prior to this, Romo and Becker (2011) [9] and Sarma and Choudhury (2012) [11] had estimated the life expectancy at birth by developing the linear and quadratic regression models between e_0 and survivorship function at age one respectively. In some of the earlier literatures, it can always be found that e_0 is somehow inextricably related to life expectancies at childhood ages. In retrospect, Lederman (1969) [5] developed a series of one parameter and two parameters regression models, and thus a number of life tables were constructed based on such models; the author proposed model life tables by generating the logarithmic regression equation between probability of dying at ages x and $(x+5)$.

A number of sets of regression coefficients for each equation based on different independent variables (e.g., e_0, $_1q_0$, $_5q_0$, $_{15}q_0$, $_{20}q_{30}$, $_{20}q_{45}$ and $m50+$) or a pair of variables were obtained.

Hence, it can be observed that e_0 is also indispensably influenced by mortality conditions in childhood ages. Roy (1989) [10] obtained reliable estimates of child survivorship functions, $l_x = 1 - q_x$, for India using logit smoothing.

In this paper, a five parameters polynomial regression model $e_0(t)=\lambda+\gamma l_1+\delta l_2+\phi l_3+\psi l_3^2$, where l_1, l_2 and l_3 are the survival probabilities at childhood ages one, two and three, have been derived. The model gives relationship, in the particular case of Assam, between e_0 and the survival probabilities l_1, l_2 and l_3 by fitting polynomial regression on aforesaid SRS data of Assam. Life expectancy at birth is estimated by using the fitted model as the estimating equation Assam. With the sequential application of Trussell's variant of Brass method, logit smoothing and fitting of Weibull survival function (Sarma and Choudhury, 2012, 2014) [11, 12] at district level of Assam, estimates of l_1, l_2 and l_3 from CEB and CS census data of 2001 and 2011 are obtained and these estimates are substituted in the estimating equations for estimating e_0. The estimated values of e_0, infant mortality rate (IMR), and under five mortality rate (U5MR) are presented in Table 2-4.

2. Materials and Methods

In this paper, 69 sets of SRS-based abridged life tables of Assam, which was published by office of the Registrar General of India, from 1970-75 to 2012-16, 23 each for male, female, and male and female combined are used. The polynomial regression model proposed in this paper is fitted to this SRS data of Assam. For estimating the demographic parameters such as, e_0, IMR and U5MR for sub-state level of Assam, CEB, CS and total numbers of women in child bearing ages are taken from Indian Census data of 2001 and 2011 of Assam. Moreover, in selecting suitable standard model life table for Assam, each of five United Nations model life tables for developing countries (1983) [13] and four Princeton models-Coale & Demeny model life tables (1966) [3] is examined to find out which standard model is most appropriate for Assam.

2.1 Selection of a Model Life Table Family for Multipliers

The appropriate model life table family has been selected by using the following procedure.

At first, in graphical method, the estimates of $_4q_1$ are plotted against those of $_1q_0$ (Kenneth, 2013) [4] on a graph showing the corresponding relationships in model life tables, shown in Figure 1. Although observed data of Assam reflects trivial nature in this graphical representation, somehow the graph of model life table which is closely fitted to that of observed data is selected. Secondly, we calculate $\sum_{L=1}^{n}\left(1-\frac{m_x}{M_x}\right)^2$, where m_x is the Age Specific Mortality Rate (ASMR) of observed data, M_x is the ASMR of standard life table, L is the level that corresponds to that of observed data. The model set that minimizes the sum is taken as appropriate model life. In both methods, Assam's SRS data is found to be most compatible with United Nations South Asian model life tables.

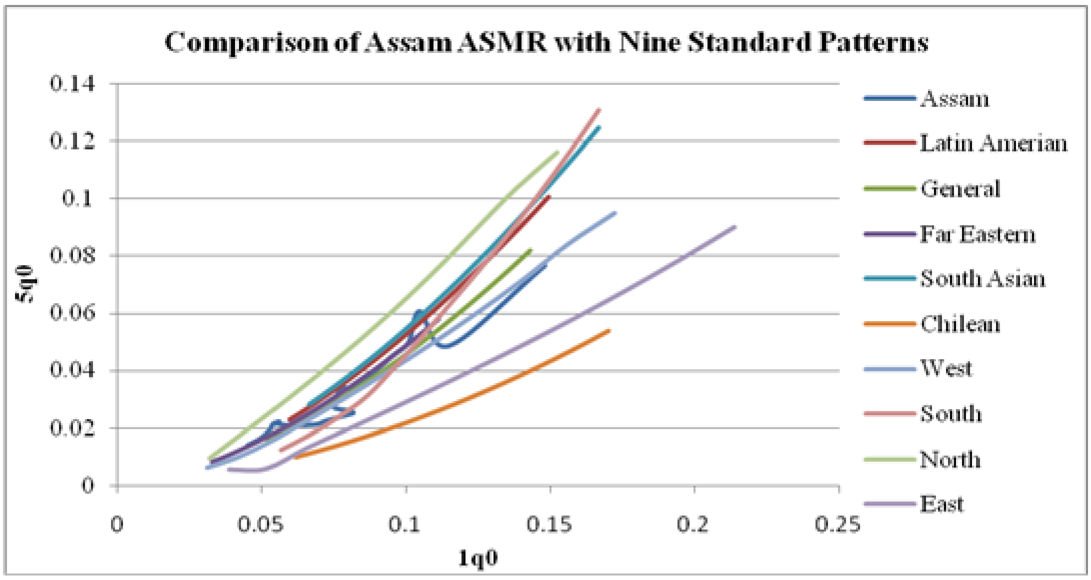

Fig 1: Child mortality patterns of Assam with those of nine standard model life tables

2.2 Trussell's Variant of Brass Method

Brass developed a method for converting the proportions dead of children ever born reported by women in childbearing ages into estimates of the probability of dying whereas translating proportions of children dead among children ever born into standard life table indicators was first pioneered by Brass and Coale (1968) [1]. If mortality has changed over time, the estimated probabilities of dying reflect the mortality rates that have prevailed at a range of ages and dates. The following steps are followed in estimating probability of dying.

The average parity per woman is computed by using $P(i)=CEB(i)/N(i)$, where CEB is the children ever born for age group *i*, i = 1,2,…7 for age-groups called child bearing age groups, i.e., 15-19, 20-24,… 45-49 respectively and *N(i)* is the total number of women of the age-groups. The proportion of children dead for each age-group *i* is estimated as $D(i)=\left(CEB(i)-CS(i)\right)/CEB(i)$ and $CD(i)/CEB(i)$, where *CS(i)* is the number of children surviving for the age-group *i* and *CD(i)* is the children dead reported by the mothers belonging to the age-group *i*. The multipliers *K(i)* are computed according to the Trussell's variant of original Brass method. Equations are obtained as $K(i)=a(i)+b(i)*P_1/P_2+c(i)*P_2/P_3$, where *a(i), b(i)* and *c(i)* are coefficients for estimation of child mortality multipliers, which is taken from United Nations (1983)[13] South Asian model in this context. Multiplier is the factor to convert the proportion of children dead into a probability of dying which will be estimated by using, $q_x = K(i)*D(i)$.

2.3 Weibull Survival Function

The survival probability function for age *x* of Weibull distribution is $l_x = e^{-\alpha x^{\beta}}$; $\alpha > 0$, $\beta > 0$, and $x \geq 0$ (Choe, 1981) [2]; it can be written as $\ln\left(\ln\left(1/l(x)\right)\right)=\ln\alpha+\beta*\ln(x)$. We can also obtain $q_x = 1 - l_x = 1 - e^{-\alpha x^{\beta}}$. Initially l_x values for *x= 1, 2, 3, 5* are estimated by using Trussell's variant of Brass method on CEB and CS data of Assam for census 2001 and 2011. Then, the estimated values of l_x are made monotonically decreasing through logit smoothing in which we suppose $P_x = \log it(l_x)$, where $\log it(l_x) = 0.5*\ln\left(1-l_x/l_x\right)$.

The smoothed values of P_x are obtained from $\hat{P}_x = P_x^s + (1/3)\sum_{x=2,3,5}\left\{P_x - P_x^s\right\}$. P_x^s is the Brass logit standard values taken from Brass logit tables for *x*=2,3, 5 (Roy, 1989)[10]. Using the smoothed values of $\hat{P}_x$, l_x can be finally estimated by using the relation $\hat{l}_x = 1/1+e^{2\hat{P}_x}$.

These $\hat{l}_x$ values are used in the polynomial regression model fitted to SRS data of Assam to estimate life expectancies at birth for the state of Assam and her all districts.

2.4 Polynomial Regression Model

A second degree polynomial regression model has been derived by establishing the relationship between the life expectancy at birth, e_0 and the survivorship probabilities l_1, l_2 and l_3. Considering the equations used by Romo and Becker (2011) [9] and Sarma and Choudhury (2012) [11] respectively as follows:

$$e_0(t) = {}_1L_0(t) + e_1(t)\, l_1(t) \qquad (1)$$

$$e_0 = a + (b+c)l_1 + d\,l_1^2 \qquad (2)$$

where ${}_1L_0(t)$ is the person-years lived between birth and age one, $e_1(t)$ is the life expectancy at age one and $l_1(t)$ is the probability of survivorship function at age one.

The equation (1) can be extended as

$$e_0(t)=\int_0^1 l(\alpha,t)d\alpha+\int_1^2 l(\alpha,t)d\alpha+\int_2^3 l(\alpha,t)d\alpha+\int_3^{\eta} l(\alpha,t)d\alpha$$

where η is the highest age attained by a member of population.

Considering the effect of childhood mortality changes in age interval (0-3) on e_0, the following equation can be obtained:

$$e_0(t) = {}_1L_0(t) + {}_1L_1(t) + {}_1L_2(t) + e_3 * l_3(t)$$

${}_1L_0(t)$ is a weighted linear function of $l_1(t)$ and so also ${}_1L_1(t)$ and ${}_1L_2$ are a weighted linear function of $l_1(t)$, $l_2(t)$ and $l_2(t)$, $l_3(t)$ respectively. Moreover By assuming $e_3(t)$ as a linear function of $l_3(t)$, the above equation may be expressed as:

$$e_0 = f + g*l_1 + h*l_1 + i*l_2 + j*l_2 + (m + n l_3)*l_3$$

$$e_0(t) = \lambda + \gamma*l_1 + \delta*l_2 + \phi*l_3 + \psi*l_3^2 \qquad (3)$$

where, $\lambda, \gamma, \delta, \phi,$ and ψ are the five parameters (regression coefficients) of the second degree polynomial equation. The assumption that $e_3(t)$ is linear function of $l_3(t)$ has got its perspective from the empirical examination results shown in Table 5. It is seen from this table that Pearson correlation co-efficient between $e_3(t)$ and $l_3(t)$ in all model life table families are exceptionally high. It is also known that Pearson correlation coefficients are often used as an indicator of strength of linearity between two variables. Moreover, the consistency of this assumption is reflected in the final results given by the model constructed based on the assumptions.

3. Results

Table 1 is presents fitted polynomial regression models along with coefficients of determination (R^2) and standard errors (SE), in each case, in all five United Nations model life tables and four Princeton-Coale & Demeny's model life tables sex-wise, and also for Assam sex-wise as well as total of male and female. The goodness of fit has been seen from the high coefficients of determination and low standard errors of fitting in all model life table families and SRS life tables of Assam. It is analytically justifiable that the polynomial regression model constructed based on certain assumptions and mathematical formulation of vital statistics works realistically in estimating life expectancy at birth. Tables 2 to 4 present the estimated life expectancies at birth, IMRs and U5MRs of Assam and its districts in 2001 and 2011 along with their percentage increase/decrease respectively.

Table 1: Polynomial Regression Models fitted to SRS data of Assam and model life table families

Life Tables			Polynomial Regression Model	R^2	SE
Chilean Pattern	United Nations	Male	$49.41+614.42 l_1 -1428.72 l_2 +634.28 l_3 +210.28 l_3^2$	0.9993	0.3423
		Female	$-254.10+2061.84 l_1 -4238.11 l_2 +2513.2 l_3 +3.76 l_3^2$	0.9999	0.0447
Far Eastern		Male	$-790.47+1512.22 l_1 +256.62 l_2 -621.84 l_3 -277.1 l_3^2$	0.9998	0.1640
		Female	$-427.49+6014.31 l_1 -13713.64 l_2 +8013.07 l_3 +201.02 l_3^2$	0.9995	0.2962
General Pattern		Male	$-290.60+3580.38 l_1 -8229.1 l_2 +4980.08 l_3 +41.12 l_3^2$	0.9999	0.0661
		Female	$5.33+5656.13 l_1 -14366.41 l_2 +8350.93 l_3 +440.56 l_3^2$	0.9998	0.1770
Latin American		Male	$-283.11+266.65 l_1 +1155.45 l_2 -1064.76 l_3 +10.88 l_3^2$	0.9999	0.0675
		Female	$-195.50+2337.21 l_1 -4895.44 l_2 +2644.84 l_3 +196.73 l_3^2$	0.9999	0.0213
South Asian		Male	$-233.03+2066.37 l_1 -4402.85 l_2 +2603 l_3 +49.4 l_3^2$	0.9999	0.0442
		Female	$-135.92-128.11 l_1 +1045.95 l_2 -727.42 l_3 +29.59 l_3^2$	0.9999	0.0767
East Model	Coale & Demeny	Male	$-65.04+3665.74 l_1 -10700.73 l_2 +7147.2 l_3 +29.489 l_3^2$	0.9998	0.3235
		Female	$-1.69.23+6216.15 l_1 -16475.51 l_2 +10438.67 l_3 +72.14 l_3^2$	0.999	0.2354
North Model		Male	$-117.89+1183.88 l_1 -1534.84 l_2 +318.97 l_3 +231.48 l_3^2$	0.9999	0.2235
		Female	$-72.94+189.8 l_1 +1107.67 l_2 -1434.27 l_3 +299.12 l_3^2$	0.9998	0.2683
South Model		Male	$-35.43+216.55 l_1 -138.05 l_2 -92.47 l_3 +132.44 l_3^2$	0.9999	0.1087
		Female	$9.03-112.76 l_1 +504.56 l_2 -468.1 l_3 +152.78 l_3^2$	0.9999	0.1561
West Model		Male	$-119.96+3487.3 l_1 -9605.35 l_2 +6265.76 l_3 +40.47 l_3^2$	0.9999	0.1884
		Female	$-65.12+537.03 l_1 +39.77 l_2 -666.18 l_3 +235.54 l_3^2$	0.9998	0.2593
Assam		Male	$77.22+113 l_1 -614.04 l_2 +356.7 l_3 +139.02 l_3^2$	0.9880	0.5343
		Female	$-61.06+527.79 l_1 -1396.04 l_2 +940.79 l_3 +67.03 l_3^2$	0.9969	0.3384
		Total	$56.51+236.56 l_1 -739.26 l_2 +357.98 l_3 +163.69 l_3^2$	0.9937	0.4354

Table 2: Percentages of increase/decrease in Life Expectancy at Birth (e_0), Assam and its Districts

Districts	Male			Female			Total		
	e_0 for 2001	e_0 for 2011	Increase/ Decrease (%)	e_0 for 2001	e_0 for 2011	Increase/ Decrease (%)	e_0 for 2001	e_0 for 2011	Increase/ Decrease (%)
Kokrajhar	57.14	60.12	5.21	58.61	55.48	-5.34	58.07	60.29	3.82
Dhubri	53.12	56.53	6.43	54.21	58.25	7.45	53.86	57.56	6.87
Goalpara	54.94	59.02	7.42	57.27	60.12	4.98	56.19	59.81	6.45
Bongaigaon	55.64	59.16	6.34	57.43	63.72	10.95	56.67	61.41	8.35
Barpeta	56.12	60.01	6.93	58.26	59.50	2.14	57.31	60.13	4.93
Kamrup	59.15	59.90	1.27	61.88	63.96	3.36	60.63	61.94	2.17
Darrang	54.01	56.82	5.20	54.93	60.85	10.76	54.69	58.79	7.48
Marigaon	55.80	57.40	2.86	58.69	59.67	1.67	57.28	58.66	2.41
Nagaon	56.38	58.61	3.95	58.58	61.88	5.64	57.59	60.30	4.69
Sonitpur	57.18	59.40	3.88	59.77	59.07	-1.17	58.56	59.60	1.76
Lakhimpur	58.50	60.87	4.06	61.83	62.74	1.48	60.21	62.02	3.00
Dhemaji	59.02	53.81	-8.82	62.20	53.13	-14.57	60.67	52.39	-16.2
Tinsukia	61.26	62.06	1.31	65.04	64.70	-0.53	63.22	63.56	0.53
Dibrugarh	62.94	60.62	-3.70	66.30	65.56	-1.11	64.76	63.49	-1.97
Sivasagar	58.39	59.90	2.58	61.51	65.32	6.20	60.01	62.50	4.15
Jorhat	60.22	61.23	1.68	63.38	66.23	4.49	61.89	63.69	2.90
Golaghat	60.15	59.93	-0.35	63.30	64.65	2.12	61.82	62.25	0.69
Karbi Anglong	56.49	57.84	2.38	57.55	59.62	3.61	57.25	58.91	2.90

North Cachar Hills/Dima Hasao	58.55	60.83	3.88	60.11	64.06	6.56	59.53	62.45	4.91
Cachar	54.81	59.93	9.35	58.41	63.90	9.40	57.34	61.93	8.00
Karimganj	56.07	57.38	2.33	55.59	60.77	9.32	55.42	59.09	6.63
Hailakandi	56.35	55.78	-1.01	57.47	60.23	4.81	57.13	57.87	1.30
Chirang	-	59.54	-	-	62.42	-	-	61.08	-
Kamrup Metro	-	61.57	-	-	64.67	-	-	63.99	-
Baksa	-	60.12	-	-	62.99	-	-	61.68	-
Udalguri	-	58.16	-	-	62.70	-	-	60.36	-
Nalbari	58.36	61.73	5.77	61.06	65.87	7.87	59.81	63.85	6.76
Assam	56.66	59.16	4.41	58.50	61.87	5.76	58.34	60.63	3.93

Table 3: Percentages of increase/decrease in Infant Mortality Rate (IMR), Assam and its Districts

Districts	Male			Female			Total		
	IMR for 2001	IMR for 2011	Increase/ Decrease (%)	IMR for 2001	IMR for 2011	Increase/ Decrease (%)	IMR for 2001	IMR for 2011	Increase/ Decrease (%)
Kokrajhar	71	73	3.12	70	82	17.14	71	78	10.18
Dhubri	94	74	-21.22	88	72	-17.89	91	73	-19.65
Goalpara	83	61	-27.23	76	65	-14.33	80	63	-21.11
Bongaigaon	79	60	-24.48	75	52	-31.44	77	56	-27.92
Barpeta	77	55	-27.58	72	67	-6.57	74	61	-17.40
Kamrup	60	56	-6.56	58	51	-13.14	59	53	-9.76
Darrang	89	73	-18.24	85	62	-26.71	87	68	-22.35
Marigaon	78	69	-11.42	70	67	-5.30	74	68	-8.60
Nagaon	75	63	-16.30	71	58	-17.58	73	61	-16.90
Sonitpur	71	59	-16.95	66	69	4.01	69	64	-6.86
Lakhimpur	63	51	-19.63	59	55	-5.79	61	53	-13.05
Dhemaji	61	90	48.37	57	92	60.93	59	89	49.15
Tinsukia	49	45	-8.23	47	48	2.68	48	46	-2.96
Dibrugarh	41	52	28.74	42	45	6.30	41	47	12.93
Sivasagar	64	56	-12.49	60	46	-23.50	62	51	-17.65
Jorhat	54	49	-9.52	53	42	-19.65	54	46	-14.37
Golaghat	55	56	2.02	53	48	-9.28	54	52	-3.45
Karbi Anglong	74	67	-10.01	75	67	-10.59	75	67	-10.29
North Cachar Hills/Dima Hasao	63	51	-18.86	65	50	-22.55	64	51	-20.11
Cachar	84	56	-33.61	72	51	-28.75	74	53	-27.92
Karimganj	77	69	-9.52	82	63	-24.08	83	66	-20.72
Hailakandi	75	78	4.31	75	65	-14.01	75	72	-4.61
Chirang	-	58	-	-	56	-	-	57	-
Kamrup Metro	-	47	-	-	48	-	-	45	-
Baksa	-	55	-	-	54	-	-	55	-
Udalguri	-	65	-	-	55	-	-	60	-
Nalbari	64	47	-27.28	62	44	-28.80	63	45	-28.01
Assam	71	60	-15.89	71	58	-17.85	70	59	-14.90

Table 4: Percentages of increase/decrease in Under Five Mortality Rate (U5MR), Assam and its Districts

Districts	Male			Female			Total		
	U5MR for 2001	U5MR for 2011	Increase/ Decrease (%)	U5MR for 2001	U5MR for 2011	Increase/ Decrease (%)	U5MR for 2001	U5MR for 2011	Increase/ Decrease (%)
Kokrajhar	109	113	3.46	109	127	16.26	109	120	9.86
Dhubri	143	114	-20.30	134	111	-17.13	139	113	-18.80
Goalpara	128	94	-26.25	117	101	-13.78	122	97	-20.33
Bongaigaon	122	93	-23.61	116	81	-30.47	119	87	-26.99
Barpeta	118	86	-26.68	111	104	-6.31	114	95	-16.77
Kamrup	93	87	-6.34	91	79	-12.75	92	83	-9.45
Darrang	136	112	-17.46	130	97	-25.72	133	104	-21.46
Marigaon	120	107	-10.96	109	103	-5.09	115	105	-8.26
Nagaon	115	97	-15.70	109	91	-16.97	113	94	-16.29
Sonitpur	109	91	-16.36	103	107	3.85	106	99	-6.60
Lakhimpur	98	80	-19.04	91	86	-5.60	95	83	-12.63
Dhemaji	94	137	45.83	89	140	57.66	92	139	51.08
Tinsukia	77	70	-8.01	73	75	2.61	75	73	-2.88
Dibrugarh	64	82	27.84	66	70	6.13	65	73	12.57
Sivasagar	99	87	-12.07	93	72	-22.86	96	80	-17.12
Jorhat	85	77	-9.24	82	67	-19.15	84	72	-13.97

Golaghat	85	87	1.95	83	75	-9.01	84	81	-3.34
Karbi Anglong	115	104	-9.61	115	103	-10.17	115	104	-9.89
North Cachar Hills/Dima Hasao	98	80	-18.29	101	79	-21.87	99	80	-19.50
Cachar	129	87	-16.67	110	80	-12.06	114	83	-10.48
Karimganj	118	107	2.06	126	97	-20.78	128	102	-13.41
Hailakandi	116	120	-30.92	116	100	-31.94	116	111	-30.91
Chirang	-	90	-	-	88	-	-	89	-
Kamrup Metro	-	74	-	-	75	-	-	70	-
Baksa	-	85	-	-	85	-	-	85	-
Udalguri	-	101	-	-	86	-	-	94	-
Nalbari	99	73	-26.52	95	69	-28.04	97	71	-27.25
Assam	110	93	-15.33	110	91	-17.23	107	92	-14.37

Table 5: Pearson's Correlation coefficients between e_3 and l_3 for model life tables and SRS life tables of Assam

	United Nations Model Life Tables					Princeton-Coale & Demeny Model Life Table				Assam: SRS-based Abridged Life Table
Model	**Chilean**	**Far Eastern**	**General**	**Latin American**	**South Asian**	**East**	**North**	**South**	**West**	
Male	0.9690	0.9822	0.9917	0.9945	0.9956	0.9885	0.9851	0.9927	0.9855	0.9755
Female	0.9981	0.9740	0.9971	0.9980	0.9987	0.9868	0.9861	0.9940	0.9848	0.9730
Total	-	-	-	-	-	-	-	-	-	0.9898
Levels	41	41	41	41	41	25	25	25	25	23

4. Discussion and Conclusion

It is worth-noting that the estimation of life expectancy at birth (e_0), IMR and U5MR are the key demographic measures of health status and socio-economic conditions of a country. Tables 2 to 4 present life expectancy at birth, IMR and U5MR, which are defined in terms of probability of dying before reaching of one's first and fifth birthday anniversary respectively, calculated per 1000 live births, for Assam and its districts as per Censuses 2001 and 2011.

When we look into the estimated gain or loss of life expectancy district-wise and sex-wise in Assam, Table 2 shows, in most cases, female life expectancies are a matter of serious concern. Dhemaji is predominantly tribal populated area in which a sheer decrease of life expectancies of females (14.57%) is seen. Moreover, Barpeta, Sonitpur and Dibrugarh have shown decrease in female life expectancies, whereas Golaghat, Hailakandi, Kamrup have shown drop in life expectancies of males. If we look at Assam as a whole, there is increase of life expectancy by 3.93% for persons, 4.41% for males and 5.76% for females.

Regarding the increase and decrease of IMR, for Assam state as a whole, IMR decreases: 15.89% for males, 17.85% for females and 14.90% for persons. However, when we look into the state of affairs district-wise, Kokrajhar, Dibrugarh, Dhemaji and Tinsukia (for females) have shown increasing IMR among which Dibrugarh and Dhemaji districts have shown exceptional increase.

Under-five mortality rate is also another good indicator of vital statistics. In the regions where socio-economic condition is relatively backward and adequate child care incentives are not available, usually children under age five are prone to sickness and death. When we look at the scenario of Assam and its districts from this aspect of demographic determinant, the state as a whole has shown decrease in U5MR by 15.33% for male, 17.23% for female, and 14.37% for person. But in the districts Kokrajhar, Dhemaji, Dibrugarh, Karimganj, Sonitpur and Tinsukia, we have seen increase in U5MR. Most of these districts are tribal majority populated areas. It calls for proper investigation that whether child health care facilities, immunization and adequate nutrition are available without discrimination in these areas.

The state development planners have to initiate inward-looking substantial measures. The existing disparities must be fairly addressed. The results provided in this paper in the form of research findings may provide insight comprehensively into a few components of human development index in Assam. Tribal inhabited areas and flood prone districts have shown serious problems. High disparity shown in terms of human development factors is a matter of serious concern.

5. References

1. Brass W, AJ Coale. Methods of analysis and estimation, in Brass, W, AJ Coale, P Demeny, DF Heisel, *et al*. (eds). The Demography of Tropical Africa. Princeton NJ: Princeton University Press, 1968, 88-139.
2. Choe MK. Fitting the Age Pattern of Infant and Child Mortality with the Weibull Survival Distribution. Asian and Pacific Census Forum. 1981; 7:10-13.
3. Coale AJ, Demeny P. Regional Model Life Tables and Stable Populations. Princeton University Press, Princeton N J, 1966.
4. Hill K. Indirect estimation of child mortality, in Moultrie, T, R Dorrington, A. Hill, K, Hill, Timaeus and B. Zaba. Tools for Demographic Estimation, International Union for the Scientific Study of Population (IUSSP), France, 2013.
5. Lederman, S. Nouvelles tables-type de mortalite: travaux et document. Paris Institut National d'Etudes Demographiques, 1969.
6. Motlagh ME, Safari R, Karami M, Khoseavi A. Life expectancy at birth in rural areas based on corrected data of Iranian vital horoscope. Iranian J Publ Health. 2012; 41(9):18-24.
7. Najafi F, Saeedi F, Bashiri Y, Tatari M. Estimating life expectancy at birth using direct method in Torbat Heydariyeh country in Iran during 2015-2016. Journal of Research in Medical and Dental Science. 2018; 6(3):382-386.
8. Phukon M, Ahamed MI. A few methods for estimating life expectancy. J Sci. Res. 2019; 11(3):321-338.
9. Romo VC, Becker S. The crossover between life expectancies at birth and at age one: The imbalance in the life table. Demographic Research. 2011; 24(4):113-144.

10. Roy SG. Estimating Child Mortality and Modeling its Age Pattern for India. Janasamkhya. 1989; 7:21-39.
11. Sarma R, Choudhury L. A Critique of infant mortality estimates in India. Journal of Data Science. 2012; 10:563-578.
12. Sarma R, Choudhury L. A new model for estimating district life expectancy at birth in India, with special reference to Assam state. Canadian Studies in Population. 2014; 41(1-2):180-191.
13. United Nations. Demographic models. Manual X: Indirect techniques for demographic estimation. Department of International Economic and Social Affairs, Population studies. ST/ESA/SER.A/81. United Nations Publications. 1983; 81:11-26.