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Extrapolation of Life Expectation at Birth up to year 2051 through Distribution Fitting of Age Specific Death Rates and using Life Table for the States in North East India

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Abstract

The data on age specific death rates(ASDR) from Census of India at the vital statistics section, is being utilised to compute the life expectation at birth(e_0^0) for the year 1991, 2001 and 2011 by the usual methods of life table for all the eight North eastern states of the country, where few articulated materials are available till date. The present work also attempts to compute e_0^0 up to the year 2051, through life table by projection the input data ASDR fitted with exponential distribution.

The findings reveals that in Sikkim, e_0^0 is not increasing for males and gender disparity exist of this indicator with females from 2011 to 2051. In Meghalaya, e_0^0 values is well below the country levels from 1991 to 2051. In Mizoram, the indicator is decreasing in case of females from 2021 through 2051. Trends of e_0^0 in other states in the region are encouraging.

Keywords Age specific death rates, Distribution fitting, Life table, Expectation of life at birth, North East states of India.

Introduction

The Sample Registration System (SRS) in India is a large scale demographic sample survey based on the mechanism of a dual record system with the objective of providing reliable estimates of fertility and mortality indicators at State and National levels for rural and urban areas separately. The estimated age-specific death rates(ASDR) derived from the SRS provide the necessary database for undertaking construction of abridged life tables which eventually depicts life expectation at various ages of the population. SRS periodically publishes the life tables for selected states from the years 1970 – 1975 to 2006 – 2010[1]. Most of the researchers[2,3,4] etc., have restricted this exercise of life table construction to major and bigger states of India .

However the exercises of construction of life table for smaller states were not carried out by the office of the Registrar General of India(RGI) for smaller states and information on expectation of life is not available for these states, including all the states of North Eastern India for any of the years. A few of the researchers like Burman[5] construct abridged life tables for all the seven smaller North Eastern states of India for the period 2001-05 separately for males, females and residence (rural, urban) by the use indirect demographic techniques. Ranjan[6] also attempt to generate model life tables for the major states of India and districts of Assam by generating period life tables for the year 2001-05. Apart from the above researchers, very few others made an attempt to construct the life table for states of North East. Thus in the absence of any other set of life tables for the smaller north eastern states of India, it is difficult to visualise the expectation of life by ages and make an age-by-age comparison by states.

Thus the first objectives in this study is the construction of Life table from data available on ASDR by sex for the years 1991, 2001, 2011, as the data is available at the office of the RGI recently as Compendium of India's Fertility and Mortality Indicators[7] at the vital statistics section. In continuation with the first objective, the second objective is to prepare the life expectation up to the year 2051 by the use of life table. In order to attempts such exercises, a techniques has to be evolve for the projection of the basic input of the life table viz ASDR by sex for the future years required for the construction of the table. In this connection similar works has been done by various researchers and organisation in extrapolating ASDR by different mathematical and statistical techniques[8,9, 10].

Methods and materials

The basic requirement in the construction of a life table is the ASDR and in India these rates are available through the SRS from the year 1975 onwards. However for the eight North eastern states of the country, data on ASDR are not available until till recently RGI has provided the above mentioned rates in the *Compendium of India's Fertility and Mortality Indicators* which can be obtained through the Census of India website.

In order to generate a life table, firstly, the ASDR ${}_nm_x$ for different age groups mentioned above are converted to death probabilities ${}_nq_x$, which is the probability of dying before reaching age $x+n$ for a person who is of exact age x . There are various formulation for the conversion of ${}_nm_x$ into ${}_nq_x$ and in the present work, Greville (1943) methods is chosen by considering the non-linearity of the ${}_nl_x$ (discussed below) values over the age interval $[x, x+n]$ and the formulation is given by

$$ {}_nq_x = \frac{{}_nm_x}{\frac{1}{n} + {}_nm_x\left\{\frac{1}{2} + \frac{n}{12}({}_nm_x - 0.095)\right\}} $$

and values for the age group (0 – 1) is computed using the formula

$$ q_x = \frac{2m_x}{2 + m_x} $$

The various columns of a Life table is computed as given in Pathak and Ram[11].

Base on the above formulation, the life table is constructed for each of the eight states in North East of the country for the year 1991, 2001 and 2011 respectively and as a result, expectation of life at different age 'x' (e_x^0) and also expectation of life at birth (e_0^0) can be observed for both males and females and for every states in the region.

In order to carry out the second objective of the present work, a projection of the basic input of the life table viz ASDR by sex for the future years is required for the construction of the table. In order to determine the acceptable distribution of ASDR with number of years based on the data available from 1991 to 2012 given in the above mentioned sources, *an Easy fit professional 5.6* software is utilised and the Goodness of fit is tested through the software using Anderson-Darling test [12,13] to test if a sample of data came from a population with a specific distribution. A similar work was attempted by Sultana[14]

and Joop [15]. In the exercise of the present work, exponential two parameter distribution (an example is shown in Fig 1 and Fig 3) finds acceptable in most of the ASDR by years for all states up to a certain degree of level of significance. The probability density function is given by

$$f(x) = \lambda e^{-\lambda(x-\gamma)}$$

where λ is a continuous inverse scaled parameter ($\lambda > 0$) and γ is a continuous local parameter.

The next step here is to carry forward the exponential distribution fitted above, in extrapolation of ASDR for all age group against number of years upto 2051, for both males and females for all states in the region. This exercises is carried in the excel sheet using the trend line technique and the exponential data fit, is extrapolate up to the year 2051(an example is shown in Fig 2 and Fig 4). In this exercise the R^2 value is in most cases of extrapolation of ASDR is greater than 70%, thus showing a good fit of the input data.

These extrapolate values of ASDR is noted for the years 2021, 2031, 2041 and 2051, which forms the basis inputs for the life tables for these years. Based on this data, life table is constructed for these years, with the same methodology discussed above and consequently e_x^0 and also e_0^0 can be observed for both males and females and for all states in the region except for Nagaland. The extrapolation for the state of Nagaland is not performed, as the data shows irregular pattern of ASDR for all age groups against number of years for both males and females.

Discussion

India's north eastern region comprises of eight states; Assam, Arunachal Pradesh Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim. The entire region (8 states) covers a total area of 262,000 sq. kms, accounting for about 3.7 per cent of the country's total geographic area. With a population of 45.6 million Census, 2011 [16], it accounts for 3.67 percent of the country's population comprising majority of the tribal population[17].

Expectation of life for various age group by through Life table techniques from existing data

The data on ASDR from the Compendium of India's Fertility and Mortality Indicators ,1971 – 2013 obtained from the Census of India website from the vital statistics section is being utilised to compute the expectation of live for different age groups for the year 1991, 2001 and 2011 by the usual

methods of life table for India and all the eight North eastern states of the country. In the exercise, Table 1 and 2 is an example of the computational output, using the formulation given in the methodology to obtained the different columns of the life table and by which the similar procedure is carried out to all the North Eastern states.

As one of the objective in this study is to investigate e_x^0 for males and females for various years and these information can be obtained from the last column of a life table. Table 3 to Table 11 is a snapshot of the required information of the last column of the life tables for India and all the eight North eastern states computed arbitrary for the years 1991, 2001 and 2011.

The above tables reveals that for India, e_0^0 steadily increases to reach 63.5 years for males and 66.6 years for females in 2011. The above tables reveal that for Assam, e_0^0 steadily increases to reach 60.4 years for males and 62.1 years for females in 2011. It is to be noted that e_{70+}^0 for the year 2011 is less comparatively to the years 2001 and 1991, which is a case of concerned for the elderly if this trend continues. In the state of Arunachal Pradesh, e_0^0 increases rapidly upto the year 2001 and then decreases for both males and females and this can be due to inconsistencies in the input data source. In Manipur, the above tables depicts an encouraging levels and trend of e_0^0 which increases to reach 70 years for males and 72.2 years for females in 2011.

In Meghalaya e_0^0 is above national level in 1991, but however the same indicator is well below the country level in the year 2011 for both males and females. Mizoram state depicts comparatively high levels of e_0^0 from 1991 through the year 2011. In the state of Nagaland, e_0^0 decreases up to the year 2001 and then increases for both males and this can be due to inconsistencies in the input data source. In case of females the indicator increases steadily to 72.1 years in 2011. In the state of Sikkim, e_0^0 for males falls steadily from 2001 to 2011 to 64.4 years in 2011 whereas the indicator shows an increasing trend for females from 1991 to 2011 to reach 69.7 years. Lastly, e_0^0 for the state of Tripura depicts that the indicator is lower at 2011 compare to the year 1991 for males, although the levels is well above national values at every year of computation. Females e_0^0 for the state is showing healthy and increasing trends reaching 70.8 years in 2011. Figure 5 to 7 depicts the comparative levels of e_0^0 for different states and for the years of computations.

Table 1. Life table entries for Males in India in 1991.

Age Group	Age	${}_nm_x$	${}_nq_x$	${}_nl_x$	${}_nd_x$	${}_nL_x$	T_x	e_x^0
0 - 1	0	0.081	0.07643	100000	7643	94361	5691803	56.9
1 - 4	1	0.01291	0.05	92357	4618	357525	5597442	60.6
5 - 9	5	0.0026	0.0129	87739	1133	435861	5239916	59.7
10 - 14	10	0.0014	0.0069	86606	604	431518	4804055	55.5
15 - 19	15	0.0018	0.0089	86002	771	428171	4372537	50.8
20 - 24	20	0.0025	0.0124	85231	1059	423606	3944366	46.3
25 - 29	25	0.0029	0.0143	84172	1212	417892	3520759	41.8
30 - 34	30	0.0033	0.0163	82960	1358	411500	3102867	37.4
35 - 39	35	0.0042	0.0207	81602	1696	403908	2691367	33.0
40 - 44	40	0.0051	0.0251	79906	2013	394797	2287459	28.6
45 - 59	45	0.0091	0.0445	77892	3471	381416	1892662	24.3
50 - 54	50	0.0134	0.0649	74421	4834	360738	1511246	20.3
55 - 59	55	0.0212	0.1009	69587	7025	331382	1150508	16.5
60 - 64	60	0.033	0.1528	62562	9563	289784	819126	13.1
65 - 79	65	0.0459	0.2069	52999	10969	238976	529341	10.0
70+	70	0.0965	0.3894	42030	16367	169602	290365	6.9

Table 2. Life table entries for Females in India in 1991.

Age Group	Age	${}_nm_x$	${}_nq_x$	${}_nl_x$	${}_nd_x$	${}_nL_x$	T_x	e_x^0
0 - 1	0	0.0800	0.0755	100000	7553	94408	5839562	58.4
1 - 4	1	0.0129	0.0500	92447	4622	357889	5745154	62.1
5 - 9	5	0.0029	0.0144	87825	1264	435964	5387265	61.3
10 - 14	10	0.0016	0.0080	86561	690	431079	4951301	57.2
15 - 19	15	0.0025	0.0124	85871	1067	426829	4520222	52.6
20 - 24	20	0.0031	0.0154	84804	1305	420825	4093393	48.3
25 - 29	25	0.0033	0.0164	83499	1366	414052	3672568	44.0
30 - 34	30	0.0029	0.0144	82133	1182	407723	3258516	39.7
35 - 39	35	0.0036	0.0178	80951	1444	401220	2850793	35.2
40 - 44	40	0.0039	0.0193	79506	1536	393826	2449573	30.8
45 - 59	45	0.0057	0.0281	77970	2193	384730	2055747	26.4
50 - 54	50	0.0091	0.0446	75777	3376	371004	1671017	22.1
55 - 59	55	0.0138	0.0669	72401	4840	350744	1300013	18.0
60 - 64	60	0.0240	0.1136	67561	7676	319829	949270	14.1
65 - 79	65	0.0375	0.1726	59885	10333	275552	629440	10.5
70+	70	0.0868	0.3588	49552	17781	204853	353888	7.1

Table 3. Expectation of life at different age in ***India*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)					
		1991		2001		2011	
		Male	Female	Male	Female	Male	Female
0 - 1	0	56.9	58.4	60.4	62.4	63.5	66.6
1 - 4	1	60.6	62.1	63.3	65.7	65.2	68.6
5 - 9	5	59.7	61.3	61.2	63.7	62.5	66.0
10 - 14	10	55.5	57.2	56.8	59.3	57.8	61.3
15 - 19	15	50.8	52.6	52.1	54.6	53.0	56.5
20 - 24	20	46.3	48.3	47.5	50.1	48.3	51.9
25 - 29	25	41.8	44.0	43.0	45.7	43.7	47.3
30 - 34	30	37.4	39.7	38.5	41.3	39.2	42.6
35 - 39	35	33.0	35.2	34.1	36.8	34.7	38.0
40 - 44	40	28.6	30.8	29.8	32.3	30.3	33.2
45 - 59	45	24.3	26.4	25.5	27.8	26.0	28.6
50 - 54	50	20.3	22.1	21.4	23.4	21.9	24.1
55 - 59	55	16.5	18.0	17.5	19.3	17.9	19.8
60 - 64	60	13.1	14.1	14.0	15.4	14.2	15.6
65 - 79	65	10.0	10.5	10.6	11.6	10.6	11.7
70+	70	6.9	7.1	7.6	8.2	7.4	8.0

Table 4. Expectation of life at different age in ***Arunachal Pradesh*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)					
		1991		2001		2011	
		Male	Female	Male	Female	Male	Female
0 - 1	0	54.0	56.7	66.9	65.9	63.6	65.4
1 - 4	1	56.6	59.3	68.3	66.9	64.7	66.4
5 - 9	5	55.5	58.3	66.0	64.4	61.9	65.0
10 - 14	10	52.5	55.3	61.9	60.6	57.2	60.6
15 - 19	15	48.3	51.3	57.2	56.3	52.7	56.2
20 - 24	20	44.5	47.2	52.8	52.2	48.4	51.4
25 - 29	25	40.0	42.5	48.3	47.5	44.0	46.9
30 - 34	30	36.2	38.0	43.8	43.0	39.8	42.3
35 - 39	35	31.8	33.8	39.3	38.4	35.3	37.6
40 - 44	40	28.0	30.4	34.9	34.0	30.7	33.2
45 - 59	45	23.8	26.6	30.8	29.8	26.5	28.4
50 - 54	50	20.8	23.6	26.7	25.9	22.7	24.4
55 - 59	55	16.9	20.1	22.8	22.4	19.1	20.0
60 - 64	60	13.3	17.2	19.9	19.3	15.7	16.6
65 - 79	65	9.8	14.6	17.6	16.2	11.2	12.7
70+	70	7.3	13.0	15.4	12.9	7.6	9.5

Table 5. Expectation of life at different age in ***Assam*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)					
		1991		2001		2011	
		Male	Female	Male	Female	Male	Female
0 - 1	0	54.2	53.9	56.3	57.9	60.4	62.1
1 - 4	1	58.1	57.0	59.2	61.6	62.7	64.6
5 - 9	5	57.0	55.9	57.6	60.1	60.6	62.6
10 - 14	10	53.2	52.5	53.6	55.9	55.9	57.8
15 - 19	15	48.7	48.2	49.2	51.3	51.2	53.0
20 - 24	20	44.2	43.9	44.7	47.1	46.6	48.4
25 - 29	25	39.9	40.1	40.5	43.0	41.9	43.9
30 - 34	30	35.3	36.1	36.1	39.2	37.5	39.2
35 - 39	35	31.1	32.2	31.7	34.8	33.1	34.6
40 - 44	40	26.8	28.1	27.4	30.5	28.6	29.8
45 - 59	45	22.9	23.9	23.4	26.1	24.3	25.2
50 - 54	50	18.9	19.7	19.4	22.1	20.0	21.0
55 - 59	55	15.6	16.1	15.9	18.1	15.8	17.2
60 - 64	60	12.6	12.5	12.8	15.0	12.5	13.4
65 - 79	65	9.6	9.4	9.9	12.0	9.1	9.2
70+	70	7.4	6.6	7.2	9.6	5.7	6.0

Table 6. Expectation of life at different age in ***Manipur*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)					
		1991		2001		2011	
		Male	Female	Male	Female	Male	Female
0 - 1	0	64.3	67.3	67.5	70.6	70.0	72.2
1 - 4	1	65.1	67.3	67.1	70.5	69.6	72.2
5 - 9	5	62.4	64.1	63.7	67.2	65.8	68.8
10 - 14	10	58.0	59.5	59.2	62.4	61.0	64.0
15 - 19	15	53.3	54.7	54.6	57.5	56.1	59.3
20 - 24	20	48.8	50.0	49.9	52.7	51.4	54.4
25 - 29	25	44.1	45.4	45.3	47.9	46.7	49.5
30 - 34	30	39.6	40.6	41.1	43.1	42.1	44.6
35 - 39	35	35.3	36.0	36.9	38.5	37.5	39.7
40 - 44	40	30.8	31.5	32.8	33.9	33.2	35.0
45 - 59	45	26.5	27.0	28.6	29.4	28.9	30.2
50 - 54	50	22.4	22.5	24.6	24.9	24.5	25.5
55 - 59	55	18.2	18.4	20.4	20.5	20.3	21.0
60 - 64	60	14.4	14.5	16.3	16.5	16.0	16.4
65 - 79	65	10.8	10.8	12.1	12.5	11.7	12.0
70+	70	7.5	7.1	8.6	8.6	7.3	7.6

Table 7. Expectation of life at different age in ***Meghalaya*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)					
		1991		2001		2011	
		Male	Female	Male	Female	Male	Female
0 - 1	0	58.1	60.1	57.2	64.6	58.0	61.9
1 - 4	1	60.3	62.7	59.2	66.9	60.0	64.2
5 - 9	5	58.8	61.2	57.0	64.2	57.7	62.0
10 - 14	10	55.3	56.9	52.9	59.5	53.0	57.4
15 - 19	15	50.8	52.4	48.4	54.8	48.5	52.6
20 - 24	20	46.3	48.0	44.0	50.0	44.0	48.1
25 - 29	25	42.0	43.5	39.7	45.4	39.2	43.4
30 - 34	30	37.6	39.1	35.5	40.7	34.8	38.6
35 - 39	35	33.0	34.9	31.2	36.2	30.6	34.1
40 - 44	40	29.0	30.5	27.3	31.7	26.6	29.7
45 - 59	45	24.4	26.6	23.6	27.7	22.5	25.7
50 - 54	50	20.4	22.3	20.0	23.4	18.7	21.3
55 - 59	55	17.0	18.7	16.6	19.0	15.5	17.4
60 - 64	60	13.5	15.2	13.6	15.2	12.8	13.6
65 - 79	65	10.4	11.5	10.2	11.4	9.9	9.8
70+	70	7.6	8.7	7.1	6.9	7.1	6.0

Table 8. Expectation of life at different age in ***Mizoram*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)					
		1997		2001		2011	
		Male	Female	Male	Female	Male	Female
0 - 1	0	64.9	71.8	65.0	71.1	68.9	72.6
1 - 4	1	65.7	71.0	65.3	71.2	70.1	74.3
5 - 9	5	63.0	67.0	62.1	67.9	67.1	71.8
10 - 14	10	58.5	62.1	57.5	63.3	62.4	67.1
15 - 19	15	54.0	57.4	52.7	58.3	57.5	62.1
20 - 24	20	49.9	52.6	48.2	53.6	52.9	57.2
25 - 29	25	46.0	48.0	43.8	49.2	48.4	52.5
30 - 34	30	41.7	43.2	39.5	44.8	44.1	47.6
35 - 39	35	37.3	38.7	34.7	40.2	39.7	42.8
40 - 44	40	32.4	33.8	30.5	35.5	35.5	38.1
45 - 59	45	28.1	29.0	26.7	30.9	31.2	33.1
50 - 54	50	24.0	24.2	22.5	26.3	27.2	28.5
55 - 59	55	19.5	20.2	18.2	21.6	23.0	24.2
60 - 64	60	15.1	16.6	13.7	17.5	19.0	20.0
65 - 79	65	11.0	12.4	9.5	13.7	15.2	15.6
70++	70	7.3	8.1	6.1	9.6	12.0	12.2

Table 9. Expectation of life at different age in ***Nagaland*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)					
		1991		2004		2011	
		Male	Female	Male	Female	Male	Female
0 - 1	0	72.8	69.5	67.8	72.1	70.6	72.1
1 - 4	1	72.7	68.6	68.0	72.2	70.7	73.0
5 - 9	5	69.3	64.8	64.9	69.1	67.4	69.9
10 - 14	10	64.6	60.1	60.8	64.5	62.7	64.9
15 - 19	15	59.9	55.7	56.1	59.8	57.8	60.1
20 - 24	20	55.4	50.9	51.6	55.0	53.1	55.1
25 - 29	25	50.9	46.2	47.2	50.4	48.6	50.4
30 - 34	30	46.1	41.5	43.0	45.7	43.9	45.9
35 - 39	35	41.4	36.6	38.5	41.4	39.3	41.1
40 - 44	40	36.6	32.2	34.7	36.9	35.0	36.3
45 - 59	45	32.2	28.0	30.3	32.1	31.0	31.3
50 - 54	50	28.3	23.4	26.2	27.6	26.7	26.9
55 - 59	55	24.3	19.2	21.9	23.1	23.1	22.4
60 - 64	60	20.0	15.3	18.0	18.9	18.8	17.6
65 - 79	65	15.8	10.8	14.8	15.1	14.9	13.1
70+	70	12.2	6.4	10.8	12.2	11.2	8.7

Table 10. Expectation of life at different age in ***Sikkim*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)					
		1991		2001		2011	
		Male	Female	Male	Female	Male	Female
0 - 1	0	62.0	60.3	65.2	67.8	64.4	69.7
1 - 4	1	63.9	62.8	66.1	68.7	64.9	70.8
5 - 9	5	61.8	60.7	63.1	65.7	61.9	67.9
10 - 14	10	57.8	56.5	58.2	60.9	57.3	63.0
15 - 19	15	53.2	52.2	53.4	56.1	52.6	58.3
20 - 24	20	48.7	47.6	48.6	51.5	48.3	53.6
25 - 29	25	44.5	43.2	44.4	47.0	43.8	49.0
30 - 34	30	39.7	39.1	39.8	42.4	39.4	44.4
35 - 39	35	35.1	34.8	35.1	38.0	35.1	39.7
40 - 44	40	30.9	30.7	31.0	33.6	31.1	35.3
45 - 59	45	26.8	26.4	26.7	29.4	27.4	30.9
50 - 54	50	22.8	22.7	22.6	25.5	23.2	26.6
55 - 59	55	18.6	18.7	19.2	21.1	19.3	22.5
60 - 64	60	15.4	15.4	15.4	17.5	15.4	18.7
65 - 79	65	12.0	11.9	11.8	13.4	11.6	15.5
70+	70	9.7	9.0	8.7	10.2	7.7	12.6

Table 11. Expectation of life at different age in ***Tripura*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)					
		1991		2001		2011	
		Male	Female	Male	Female	Male	Female
0 - 1	0	69.7	62.8	66.0	69.4	68.1	70.8
1 - 4	1	70.8	65.1	67.5	70.6	69.1	71.9
5 - 9	5	67.9	63.1	64.9	67.7	66.1	69.0
10 - 14	10	63.0	59.0	60.2	62.9	61.2	64.2
15 - 19	15	58.3	54.5	55.3	58.1	56.4	59.4
20 - 24	20	53.6	49.8	50.7	53.5	51.8	54.7
25 - 29	25	49.0	45.4	45.8	49.0	47.0	50.0
30 - 34	30	44.4	40.8	41.3	44.2	42.4	45.2
35 - 39	35	39.7	36.2	36.6	39.5	37.6	40.4
40 - 44	40	35.3	31.8	32.0	34.8	33.0	35.6
45 - 59	45	30.9	27.6	27.6	30.2	28.5	30.8
50 - 54	50	26.6	23.2	23.4	25.7	24.2	26.4
55 - 59	55	22.5	19.2	19.6	21.4	20.2	22.1
60 - 64	60	18.7	15.1	15.8	17.4	16.3	17.7
65 - 79	65	15.5	11.2	12.6	13.8	12.5	13.7
70+	70	12.6	7.7	9.8	10.5	9.3	9.6

Table 12. Projected Expectation of life at different age in ***India*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)							
		2021		2031		2041		2051	
		Male	Female	Male	Female	Male	Female	Male	Female
0 - 1	0	66.0	68.8	67.6	71.4	69.2	72.8	70.4	74.6
1 - 4	1	67.0	70.2	68.1	72.2	69.3	73.3	70.1	74.5
5 - 9	5	63.7	67.2	64.7	68.9	65.8	70.0	66.4	71.0
10 - 14	10	58.9	62.5	59.8	64.0	60.9	65.1	61.5	66.0
15 - 19	15	54.0	57.6	54.9	59.1	55.9	60.2	56.5	61.0
20 - 24	20	49.3	52.9	50.2	54.3	51.1	55.3	51.6	56.2
25 - 29	25	44.6	48.2	45.5	49.5	46.4	50.4	46.9	51.3
30 - 34	30	40.0	43.4	40.8	44.6	41.7	45.6	42.2	46.4
35 - 39	35	35.5	38.8	36.3	39.9	37.1	40.7	37.6	41.5
40 - 44	40	31.1	34.1	31.9	35.1	32.7	35.9	33.1	36.6
45 - 59	45	26.9	29.4	27.6	30.4	28.4	31.1	28.8	31.8
50 - 54	50	22.7	24.9	23.4	25.7	24.1	26.4	24.4	27.1
55 - 59	55	18.6	20.4	19.2	21.2	19.9	21.8	20.1	22.4
60 - 64	60	14.8	16.1	15.4	16.8	15.8	17.3	15.9	17.8
65 - 79	65	10.9	12.0	11.3	12.5	11.7	12.8	11.6	13.2
70+	70	7.4	8.2	7.6	8.5	7.8	8.6	7.4	9.0

Table 13. Projected Expectation of life at different age in ***Arunachal P*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)							
		2021		2031		2041		2051	
		Male	Female	Male	Female	Male	Female	Male	Female
0 - 1	0	67.3	66.0	68.2	69.5	69.6	70.8	70.8	72.3
1 - 4	1	67.5	66.9	68.1	69.9	69.2	70.9	70.0	71.9
5 - 9	5	64.2	64.2	64.9	66.7	65.6	67.4	66.2	68.1
10 - 14	10	59.4	61.4	60.0	62.4	60.7	62.7	61.2	63.2
15 - 19	15	54.8	56.9	55.2	57.7	55.8	58.1	56.3	58.4
20 - 24	20	50.0	52.0	50.3	52.8	50.9	53.1	51.3	53.4
25 - 29	25	45.5	47.6	45.8	48.5	46.0	48.8	46.4	49.1
30 - 34	30	40.8	42.8	41.0	43.6	41.1	43.9	41.5	44.2
35 - 39	35	36.4	38.1	36.6	38.8	36.7	39.0	37.0	39.3
40 - 44	40	31.6	33.4	31.7	34.0	31.8	34.2	32.1	34.4
45 - 59	45	27.6	28.8	27.7	29.3	27.8	29.4	28.1	29.5
50 - 54	50	23.3	24.1	23.3	24.5	23.3	24.6	23.6	24.6
55 - 59	55	19.5	19.5	19.6	19.8	19.5	19.7	19.8	19.7
60 - 64	60	15.8	15.6	15.8	15.5	15.7	15.3	15.9	15.2
65 - 79	65	11.9	11.8	11.5	11.0	11.1	10.7	11.2	10.5
70+	70	7.8	7.6	7.2	6.6	6.6	6.1	6.6	5.8

Table 14. Projected Expectation of life at different age in ***Assam*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)							
		2021		2031		2041		2051	
		Male	Female	Male	Female	Male	Female	Male	Female
0 - 1	0	61.1	62.9	63.5	65.6	65.0	68.0	66.4	69.5
1 - 4	1	63.0	65.2	64.9	67.5	65.9	69.5	66.9	70.6
5 - 9	5	61.8	64.8	62.7	66.4	63.3	67.5	64.0	68.3
10 - 14	10	57.0	60.0	57.8	61.4	58.4	62.6	59.0	63.3
15 - 19	15	52.1	55.1	52.9	56.5	53.5	57.6	54.0	58.3
20 - 24	20	47.4	50.4	48.1	51.7	48.7	52.7	49.2	53.4
25 - 29	25	42.7	45.7	43.3	46.9	43.8	47.9	44.3	48.5
30 - 34	30	38.2	41.0	38.8	42.1	39.4	43.0	39.9	43.6
35 - 39	35	33.6	36.4	34.2	37.4	34.6	38.2	35.0	38.7
40 - 44	40	29.2	31.7	29.7	32.6	30.1	33.4	30.5	33.8
45 - 59	45	24.9	27.1	25.3	27.9	25.6	28.6	25.9	28.9
50 - 54	50	20.8	23.0	21.2	23.8	21.5	24.5	21.8	24.8
55 - 59	55	16.4	18.9	16.7	19.7	16.8	20.3	17.0	20.6
60 - 64	60	13.2	15.0	13.2	15.5	13.3	15.9	13.3	16.2
65 - 79	65	9.4	10.8	9.2	11.1	9.1	11.3	9.0	11.5
70+	70	5.8	7.4	5.3	7.4	4.9	7.4	4.7	7.4

Table 15. Projected Expectation of life at different age in ***Manipur*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)							
		2021		2031		2041		2051	
		Male	Female	Male	Female	Male	Female	Male	Female
0 - 1	0	70.5	73.9	71.6	74.9	72.4	75.8	73.3	76.6
1 - 4	1	69.9	73.6	70.9	74.5	71.7	75.2	72.4	75.9
5 - 9	5	66.3	70.2	67.1	70.8	67.8	71.4	68.5	72.1
10 - 14	10	61.4	65.3	62.1	65.8	62.8	66.5	63.5	67.1
15 - 19	15	56.5	60.4	57.2	60.9	57.8	61.5	58.5	62.2
20 - 24	20	51.6	55.5	52.3	56.0	52.9	56.6	53.5	57.2
25 - 29	25	46.8	50.6	47.4	51.1	48.0	51.6	48.5	52.2
30 - 34	30	42.2	45.7	42.7	46.2	43.2	46.7	43.7	47.3
35 - 39	35	37.7	40.8	38.0	41.2	38.4	41.7	38.9	42.3
40 - 44	40	33.6	36.0	34.1	36.3	34.5	36.8	35.0	37.3
45 - 59	45	29.1	31.2	29.6	31.5	30.2	31.9	30.7	32.4
50 - 54	50	24.7	26.4	25.2	26.7	25.7	27.0	26.1	27.5
55 - 59	55	20.5	21.8	20.9	21.9	21.3	22.2	21.6	22.6
60 - 64	60	16.0	17.0	16.3	17.1	16.5	17.3	16.8	17.7
65 - 79	65	11.6	12.4	11.7	12.4	11.9	12.6	12.1	12.8
70+	70	7.0	8.0	7.0	7.8	7.1	7.8	7.3	8.0

Table 16. Projected Expectation of life at different age in ***Meghalaya*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)							
		2021		2031		2041		2051	
		Male	Female	Male	Female	Male	Female	Male	Female
0 - 1	0	58.5	62.3	57.8	62.5	57.2	62.7	56.4	61.7
1 - 4	1	60.3	65.1	59.3	65.6	58.4	66.2	57.3	65.7
5 - 9	5	57.5	63.1	56.5	63.6	55.5	64.2	54.4	64.4
10 - 14	10	52.8	58.7	51.6	59.1	50.6	59.6	49.5	59.8
15 - 19	15	48.3	54.2	47.1	54.5	45.9	54.9	44.7	55.0
20 - 24	20	43.9	49.4	42.9	49.7	41.8	50.1	40.8	50.2
25 - 29	25	39.3	44.7	38.1	44.8	37.0	45.2	35.9	45.2
30 - 34	30	34.9	40.2	33.7	40.4	32.6	40.6	31.5	40.9
35 - 39	35	30.7	35.9	29.6	36.0	28.5	36.3	27.5	36.5
40 - 44	40	26.7	31.6	25.5	31.7	24.6	32.0	23.6	32.2
45 - 59	45	22.7	27.2	21.4	27.2	20.5	27.3	19.5	27.4
50 - 54	50	19.3	23.0	18.5	23.0	17.8	23.1	16.8	23.2
55 - 59	55	16.2	18.7	15.4	18.6	14.8	18.6	13.9	18.6
60 - 64	60	13.5	14.8	13.1	14.6	12.8	14.5	12.2	14.4
65 - 79	65	9.8	11.0	9.5	10.7	9.1	10.4	8.7	10.3
70+	70	5.5	7.0	5.3	6.5	5.0	6.1	4.7	5.8

Table 17. Projected Expectation of life at different age in ***Mizoram*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)							
		2021		2031		2041		2051	
		Male	Female	Male	Female	Male	Female	Male	Female
0 - 1	0	67.8	69.1	89.1	68.0	90.2	66.0	68.9	63.9
1 - 4	1	69.6	72.3	92.7	73.0	94.7	73.2	70.1	73.1
5 - 9	5	67.0	70.5	91.0	71.2	92.6	71.4	67.1	71.3
10 - 14	10	62.3	65.7	86.3	66.3	87.8	66.5	62.4	66.3
15 - 19	15	57.3	60.7	81.3	61.6	82.8	62.2	57.5	62.7
20 - 24	20	52.5	55.8	76.4	56.6	77.9	57.2	52.9	57.7
25 - 29	25	47.8	50.9	71.7	51.7	73.1	52.3	48.4	52.7
30 - 34	30	43.3	46.1	67.3	46.9	68.5	47.4	44.1	47.8
35 - 39	35	39.3	41.2	64.3	41.9	65.8	42.4	39.7	42.8
40 - 44	40	35.4	36.8	62.4	37.8	65.8	38.6	35.5	39.2
45 - 59	45	31.0	32.1	58.4	32.9	61.7	33.6	31.2	34.3
50 - 54	50	27.3	27.9	56.7	28.9	61.0	30.0	27.2	30.9
55 - 59	55	22.9	23.5	52.8	24.5	57.0	25.5	23.0	26.3
60 - 64	60	19.1	18.9	50.4	19.7	54.7	20.6	19.0	21.4
65 - 79	65	15.2	14.4	48.7	15.0	53.3	15.9	15.2	16.6
70+	70	11.2	10.8	46.1	11.6	50.0	12.8	12.0	13.8

Table 18. Projected Expectation of life at different age in ***Sikkim*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)							
		2021		2031		2041		2051	
		Male	Female	Male	Female	Male	Female	Male	Female
0 - 1	0	65.1	70.5	64.9	72.8	64.6	75.9	64.1	77.8
1 - 4	1	65.5	71.1	64.9	73.2	64.4	76.2	63.8	78.0
5 - 9	5	62.4	67.8	61.4	69.8	60.7	72.6	60.0	74.4
10 - 14	10	57.7	63.0	56.6	64.9	55.7	67.6	55.0	69.4
15 - 19	15	52.8	58.4	51.7	60.4	50.8	63.1	50.0	64.8
20 - 24	20	48.4	53.8	47.5	55.8	46.6	58.4	46.0	60.1
25 - 29	25	44.0	49.3	43.0	51.1	42.1	53.7	41.4	55.4
30 - 34	30	39.7	44.6	38.7	46.4	38.0	48.9	37.3	50.5
35 - 39	35	35.3	40.0	34.5	41.7	33.7	44.2	33.2	45.7
40 - 44	40	31.1	35.3	30.4	36.9	29.8	39.3	29.5	40.8
45 - 59	45	27.2	31.0	26.7	32.6	26.4	35.1	26.3	36.5
50 - 54	50	23.1	26.5	22.7	28.1	22.5	30.5	22.5	31.9
55 - 59	55	19.1	22.2	18.6	23.7	18.4	26.0	18.5	27.3
60 - 64	60	14.8	18.4	14.2	19.9	13.8	22.2	13.8	23.4
65 - 79	65	10.7	14.8	10.0	16.3	9.6	18.7	9.4	19.8
70+	70	6.7	11.8	5.8	13.4	5.2	16.0	4.9	17.2

Table 19. Projected Expectation of life at different age in ***Tripura*** (through Life table).

Age Group	Age *x*	Expectation of life at age x (e_x^0)							
		2021		2031		2041		2051	
		Male	Female	Male	Female	Male	Female	Male	Female
0 - 1	0	69.5	73.3	68.7	75.9	74.7	78.2	76.2	74.6
1 - 4	1	70.0	73.8	68.8	76.0	74.6	78.0	75.8	74.2
5 - 9	5	67.0	70.9	65.4	72.8	70.9	74.5	72.0	70.5
10 - 14	10	62.3	66.1	60.6	67.9	66.1	69.5	67.1	65.5
15 - 19	15	57.6	61.2	55.8	63.0	61.2	64.6	62.2	60.6
20 - 24	20	53.0	56.4	51.1	58.1	56.6	59.7	57.7	55.6
25 - 29	25	48.2	51.7	46.3	53.3	51.7	54.9	52.8	50.8
30 - 34	30	43.6	46.9	41.7	48.5	47.2	50.0	48.3	45.8
35 - 39	35	38.9	42.1	36.9	43.6	42.4	45.1	43.6	40.9
40 - 44	40	34.5	37.3	32.6	38.8	38.3	40.2	39.6	36.0
45 - 59	45	30.0	32.5	28.0	33.9	33.7	35.3	34.9	31.1
50 - 54	50	25.7	28.0	23.6	29.5	29.3	30.9	30.5	26.6
55 - 59	55	21.6	23.5	19.2	24.9	25.0	26.2	26.1	21.8
60 - 64	60	17.6	19.2	14.8	20.5	20.4	21.7	21.8	17.1
65 - 79	65	13.8	15.0	10.6	16.1	16.2	17.3	17.2	12.5
70+	70	10.9	11.2	7.0	12.1	13.5	13.3	14.6	8.1

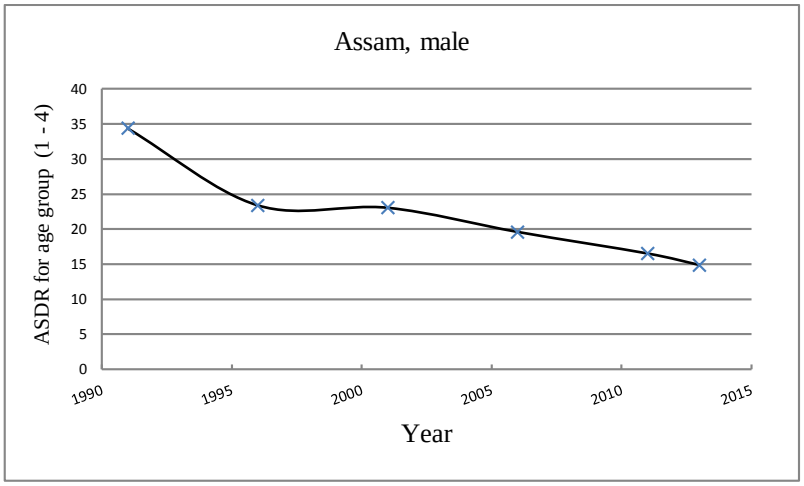
Expectation of life for various ages by through Life table techniques from extrapolated data.

As mention in the methodology, the other objective of this paper is also to compute the expectation of life by the use of life table for future years in all the states of North east of the country. As the methodology is explained in the previous section, where by the existing data is tested against the distribution most of them follow by age group and existing years for both males and females. The data shows that upto certain degree of test of goodness of fit and level of significance, most of the distribution follows exponential trend. Utilising this pattern, the data sets are extrapolated using the same distribution upto the year 2051 for states except for the state of Nagaland where the existing data cannot be fitted by standard distribution. In this way ASDR data can be generated for both males and females and for the seven states for the years 2021, 2031,2041 and 2051 and this served as inputs for the life tables by which expectation of life for various age group can be evaluated.

Table 12 to Table 19 depicts the required information of the last column of the life tables for India and all the eight North eastern states computed arbitrary for the years 2021, 2031,2041 and 2051.

The above tables reveal that for India, e_0^0 steadily increases to reach 70.4 years for males and 74.6 years for females in 2051. A similar trend continues in the state of Assam, where e_0^0 steadily increases to

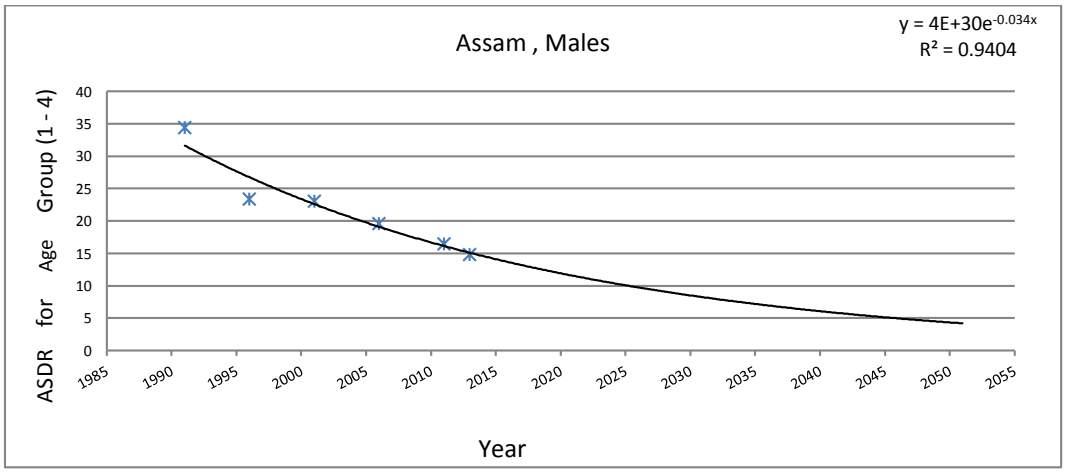
Figure 1. Fitting best fit distribution to ASDR age (1 – 4) by years for males in Assam.

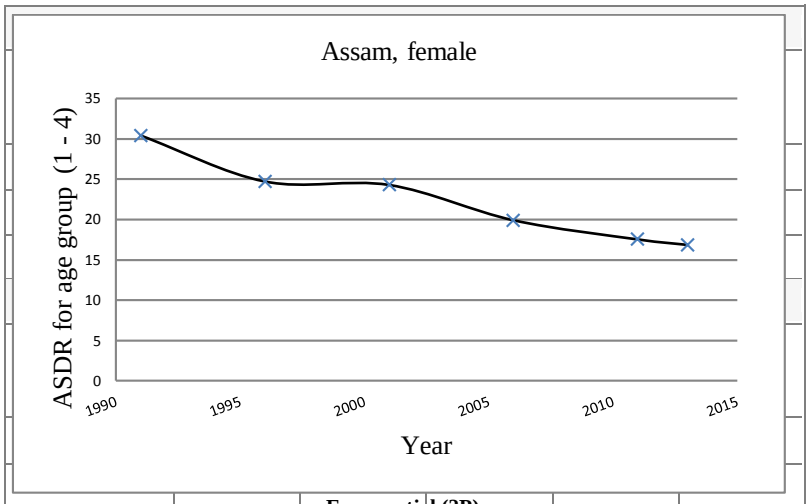


Exponential (2P)

Kolmogorov-Smirnov					
Sample Size Statistic P-Value Rank	6 0.24453 0.79133 31				
α	0.2	0.1	0.05	0.02	0.01
Critical Value	0.41037	0.46799	0.51926	0.57741	0.61661
Reject?	No	No	No	No	No
Anderson-Darling					
Sample Size Statistic Rank	6 1.8692 32				
α	0.2	0.1	0.05	0.02	0.01
Critical Value	1.3749	1.9286	2.5018	3.2892	3.9074
Reject?	**Yes**	No	No	No	No

Figure 2. Extrapolate the best fit distribution to ASDR age (1 – 4) by years for males in Assam.





Exponential (2P)					
Reject?	**Yes**	No	No	No	No
Kolmogorov-Smirnov					
Sample Size Statistic P-Value Rank	6 0.22754 0.85382 33				
α	0.2	0.1	0.05	0.02	0.01
Critical Value	0.41037	0.46799	0.51926	0.57741	0.61661
Reject?	No	No	No	No	No
Anderson-Darling					
Sample Size Statistic Rank	6 1.8187 34				
α	0.2	0.1	0.05	0.02	0.01
Critical Value	1.3749	1.9286	2.5018	3.2892	3.9074
Reject?	**Yes**	No	No	No	No

Figure 3. Fitting the best fit distribution to ASDR age (1 – 4) by years for females in Assam.

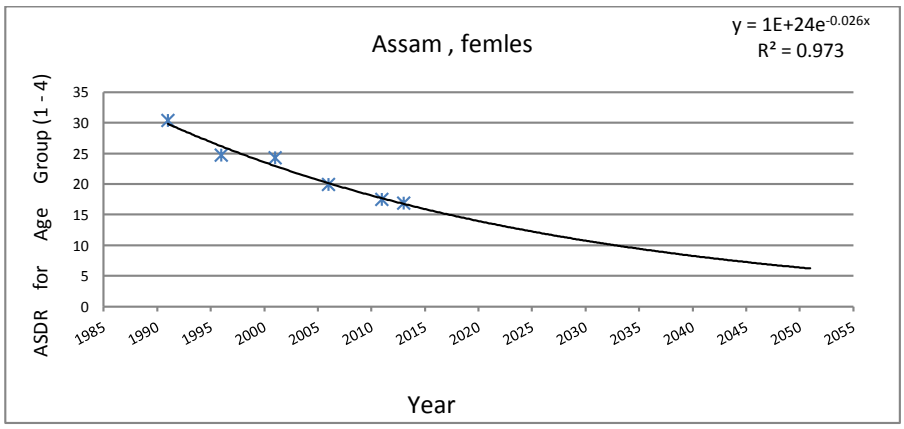


Figure 4. Extrapolate the best fit distribution to ASDR age (1 – 4) by years for females in Assam.

Figure 5. Expectation of life at birth(e_0^0) for different NE states, 1991(through Life table).

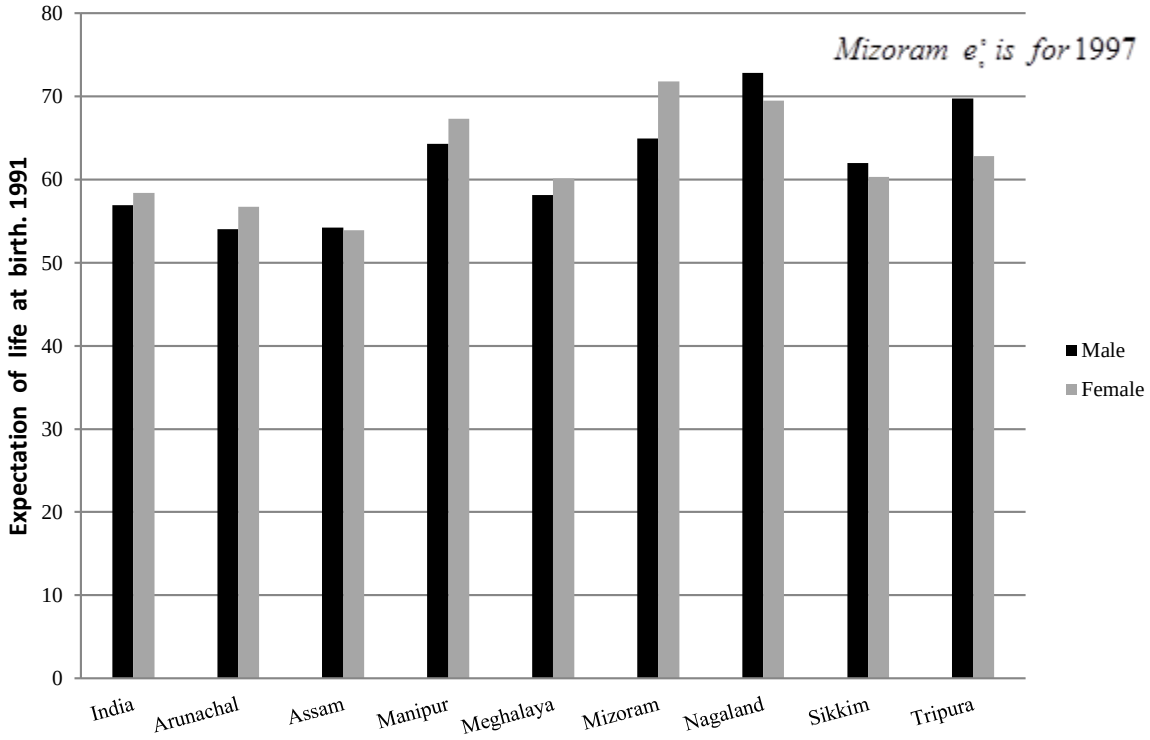


Figure 6. Expectation of life at birth(e_0^0) for different NE states, 2001(through Life table).

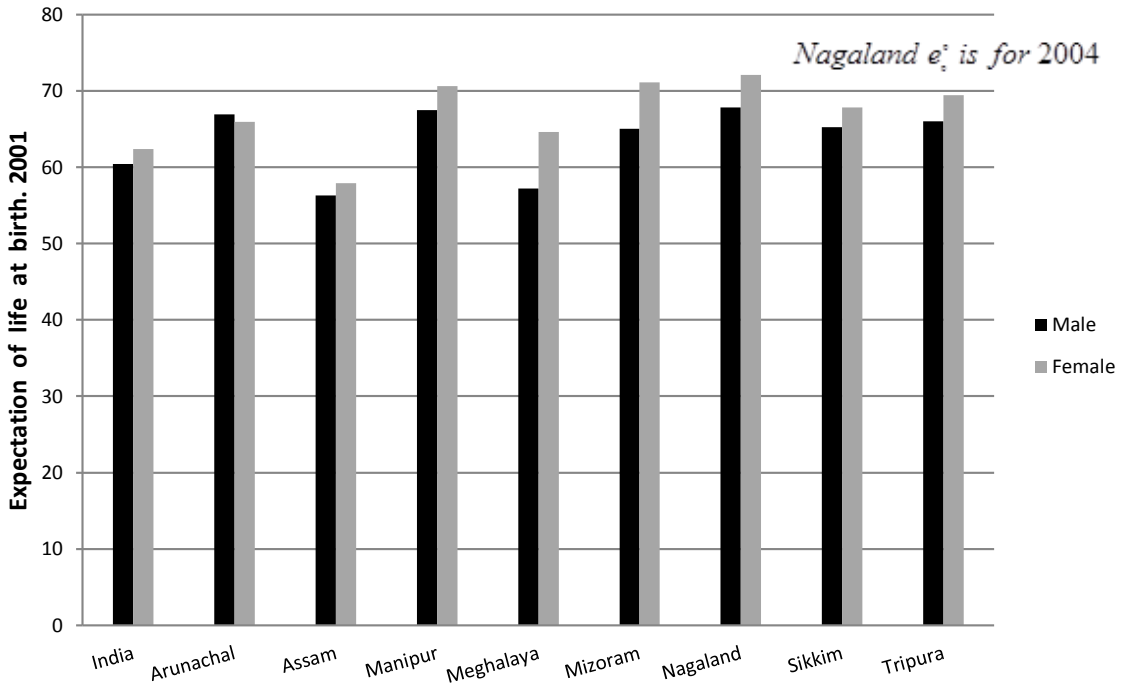


Figure 7. Expectation of life at birth(e_0^0) for different NE states, 2011(through Life table).

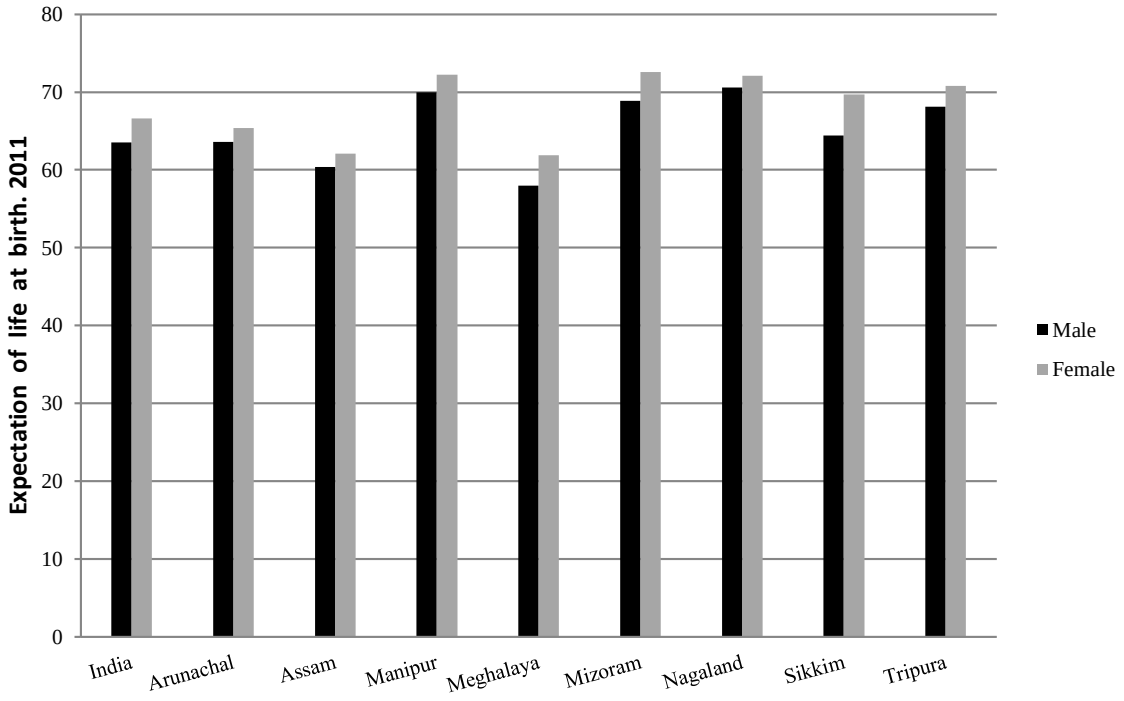


Figure 8 Life expectation at birth by years for NE states for males

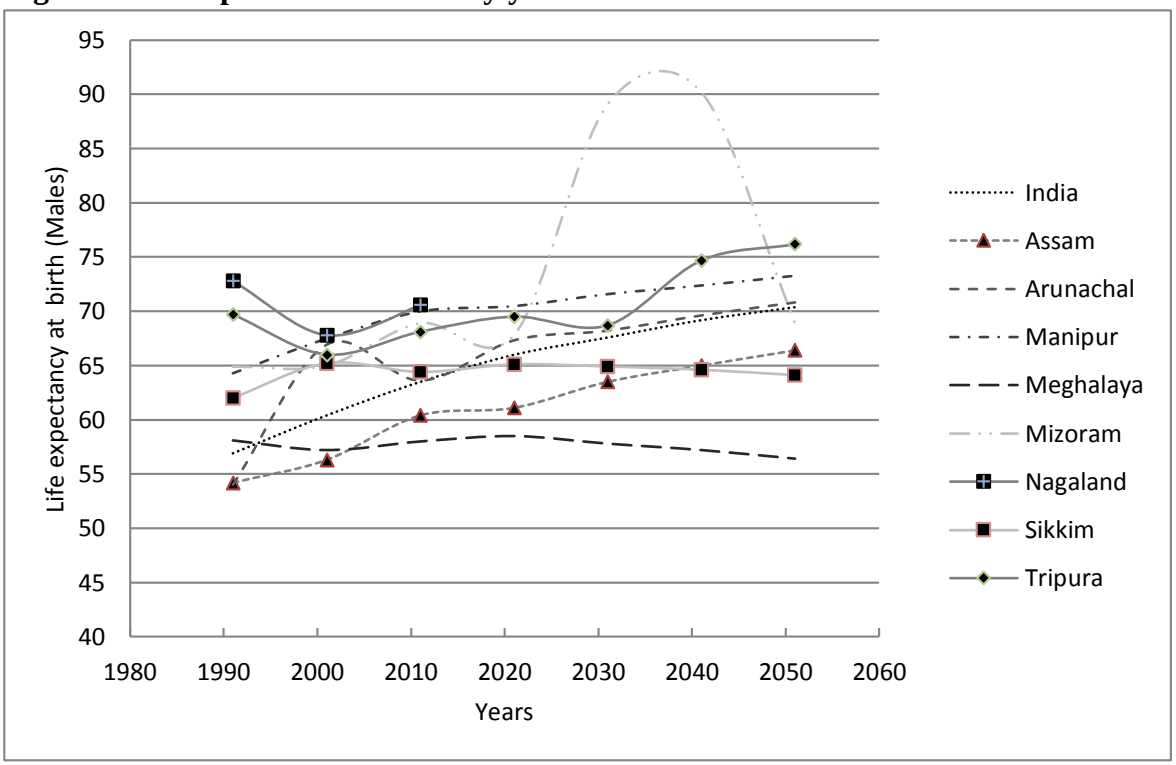
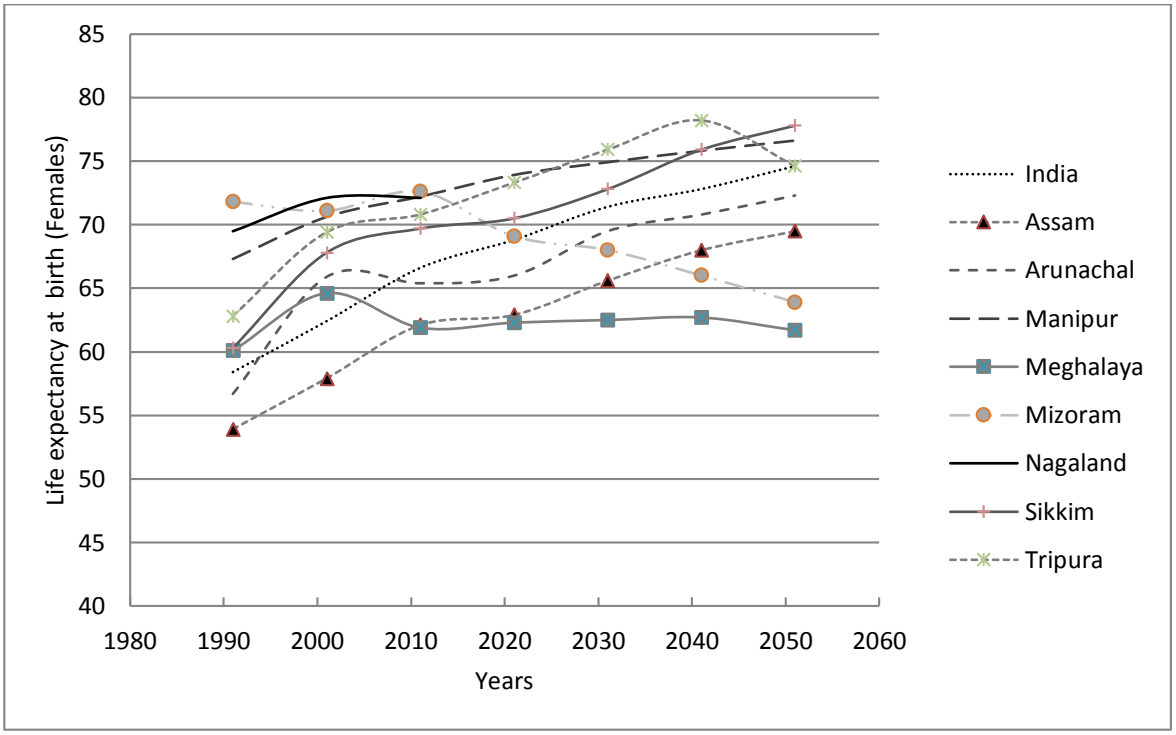


Figure 9 Life expectation at birth by years for NE states for females



reach 66.4 years for males and 69.5 years for females in 2051. A significant jump in e_0^0 value for males is seen in Arunachal Pradesh reaching 67.3 years in 2021 from 63.6 in 2011 and this indicator then steadily increases to reach 70.8 years for males and 72.3 years for females in 2051. In Manipur, e_0^0 steadily increases to reach 73.3 years for males and 76.6 years for females in 2051. A point to be noted is that in Meghalaya, e_0^0 steadily decreases to reach 56.4 years for males and the same indicator is almost constant through the projected years and stands at 61.7 years for females in 2051 and these values is well below the corresponding values of the country.

A slightly different pattern of e_0^0 is seen in the state of Mizoram, where by the indicator for males is greater than their counterparts for the year 2031,2041 and 2051 and another point worth noting is the decreases in the indicator value in case of females from 2021 through 2051. The findings also reveals e_0^0 is not increasing for males throughout the years of projection and remains almost constant at around 65 years. The gap in the e_0^0 values is huge between males and females and the indicator value for females increases steadily up to 78.2 years in 2041 and dips to 74.6 in the year 2051. In the state of

Tripura, e_0^0 steadily increases to reach 76.2 years for males and 74.6 years for females in 2051.

Conclusion

The exercises in this paper show that for most of the age groups except few middle ages group, ASDR can be fitted with exponential distribution for most of the states. This distribution when extrapolated provides ASDR for different age groups by sex for all respective NE states, through the year 2051. These predicted ASDR can be used to compute expectation of live for different age groups for the year 2021, 2031, 2041 and 2051 through life table.

The levels and trends of e_0^0 values is increasing gradually for both males and females in the states of Assam, Manipur, Arunachal Pradesh, Tripura in consisting pattern with the National level, although the corresponding values for Assam is lower compared to those with the rest of the NE states. In Sikkim further research evidence is required to investigation the constancy of e_0^0 for males and the huge gender disparity of this indicator with females from 2011 to 2051. In Meghalaya, e_0^0 values is well below the country levels and the findings reveals that the indicator steadily decreases to reach 56.4 years for males from 1991 to 2051 and the levels of the indicator for females is also not encouraging throughout the years of projection. This calls for further research evidence to address this low and un healthy level and trends of life expectancy at birth in the state of Meghalaya. Although the e_0^0 values is high in the state of Mizoram, this indicator falls drastically for males to 68.9 years in 2051 from 90.2 in 2041 and a similar pattern is observed in case of females where by the drop in the value of e_0^0 is 63.9 years in 2051 from 66 years in 2041, a point noted for research investigation.

The states in which e_0^0 (Figure 8 and Figure 9) values greater than 65years in the year 2030 is Arunachal, Tripura and Manipur for males while Meghalaya and Assam are the states in which e_0^0 values is less than 65 years in the year 2030 for females.

Source of funding and conflict of interest

The present work was carried with secondary data, which is freely available from the census of India website and hence no funding is required to prepare the data source for the manuscript. Also as the work is done single-handedly and independently by the author without

copying the methodology from any source, hence the question of conflict of interest does not arise.

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