Indirect Technique for Estimating Life Expectancy from Limited Data Set of BRAC Female Members

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Abstract

This paper aims to construct the complete life table (LT) from limited data set of the female members of BRAC village organizations (VO) using the INDEPTH (International Network for the continuous Demographic Evaluation of Population and Their Health in developing countries) model life tables (MLT), and to justify the validity of the estimated results. The MLT technique was used to estimate the life expectancy of BRAC VO members because the data were available for women ranging from 18 - 55 years only. As a service to VO members, BRAC provides them insurance coverage against death. Secondary data set of BRAC female VO members was collected from the MIS of BRAC area level offices (sub-district level) and the insurance claims formed the main sources of data for this study. With a sample size of 186,379 women including 391 dead, the sampling design used was as follows: 12 of 45 BRAC district-level regions were randomly selected and 32 areas were again randomly selected from the selected regions. Using the INDEPTH MLT, a complete life table of BRAC female members was generated. The pattern of life expectancy curve of BRAC female VO members is similar to both the Matlab (a sub-district) and the national female population of Bangladesh. The closeness of life expectancy curves indicates that the technique used provided valid estimates. The life expectancy at birth of BRAC female members was estimated at 64 years in 1998, which was higher compared to national female population (61 years). The higher life expectancy among BRAC VO female members indicates that BRAC development interventions can be a catalytic agent in increasing the life expectancy among poor women in rural Bangladesh. Therefore, this demographic technique could be used for the indirect estimation of life table in developing countries of Asia and Africa.

Introduction

Life table provides the most complete description of mortality in any population. Its main principal advantage over other methods of measuring mortality, e.g., the crude death rate, is that it does not reflect the effect of age and does not require the adoption of a standard population for comparative purposes. The construction of a life table requires reliable data on the age specific death rates calculated from information on deaths by age and sex (from vital registration system) and population by age and sex (from population censuses).

To calculate life tables in the late 1990s the complete national data were available only for about one-quarter deaths of the world estimated from about 75 countries (5). In rest of the world, especially in Africa, some parts of Asia and Latin America, the basic data either do not exist due to lack of functioning vital registration systems, or are unusable because of incompleteness of coverage or errors in reporting (6).

Model life tables are important demographic tools for populations that lack accurate and complete demographic data. In the study of mortality, model life tables provide the basis for indirect techniques to estimate mortality rates from survey data. They are also extensively used to smoothing data from partial registration of deaths and for estimating mortality from age distributions (1-8). In practice, these techniques are predicted on the observed similarities in the age-patterns of mortality for different populations, and may range from the simple adoption of the mortality pattern of a neighbouring population with similar socio-biological characteristics, to the use of sophisticated demographic models (6).

The best known model life tables are UN Model Life Tables, Coale-Demeny Model Life Tables, UN Model Life Tables for Developing countries, Ledermann System of Model Life Tables, and Brass Logit System. The substantial evidences, however, have documented that some serious technical issues that complicate the use of existing empirical models in describing mortality patterns in contemporary developing countries (6,7). Principally, the restricted nature of original sample of life tables that trigger these models has always been a major disadvantage. In this regard, the Brass Logit system offers considerable advantages by being essentially independent of historical data. Such flexibility could be harnessed in extending its application to situations of extreme data poverty, e.g. in Africa and some parts of South-East Asia (6). A new INDEPTH (International Network for the continuous Demographic Evaluation of Population and

Their Health in developing countries) system of model life tables technique based on the Brass-type formula had recently been developed by the INDEPTH Network (9). This technique mainly generates a complete life table from the information of under-five mortality, adult mortality or a certain age-specific mortality, and a corresponding standard life table from the INDEPTH demographic surveillance system (DSS) sites. In this paper, we estimate the life expectancy of the female members of BRAC village organizations (VO) using the INDEPTH system of model life tables (MLT), because the data were available for BRAC female VO ranging from 18-54 years only. We justified the validity of the estimated results.

Profile of BRAC

BRAC, a national private development organization, was established as a relief and rehabilitation organisation in 1972 after the Bangladesh Liberation. Over the years BRAC has gradually evolved into a large and multifaceted development organisation with the twin objectives of alleviation of poverty and empowerment of the poor. BRAC organizes poor rural women into village organizations (VO)—the nucleus of all development interventions of BRAC. As a service to VO members, BRAC provides insurance coverage to the members against death, and the insurance claims formed the main source of data for this study.

The Brass Logit Life Table System

The Brass Logit life table system (2) belongs to a category of mortality models called relational models. This relational system of life tables was built up from the observed structural relationship of survival curves among life tables. This system provides a greater degree of flexibility than the empirical models discussed above. It rests on the assumption that two distinct age patterns of mortality can be related to each other by a linear relationship between the logit of their respective survivorship probabilities. Thus for any two observed series of survivorship values, l_x and l^s_x, where the latter is the standard, it is possible to find constants α and β as follows:

$$\log it(l_x) = \alpha + \beta \log it(l^s_x)$$

$$if \ \log it(l_x) = 0.5 \ln\left[\frac{(1.0 - l_x)}{l_x}\right]$$

Then

$$0.5 \ln\left[\frac{(1.0 - l_x)}{l_x}\right] = \alpha + 0.5\beta \ln\left[\frac{(1.0 - l^s_x)}{l^s_x}\right]$$

for all age x between 1 and ω. If the above equation holds for every pair of life tables, then any life table can be generated from a single standard life table by changing the pairs of (α,β) values used. In reality, the assumption of linearity is only approximately satisfied by pairs of actual life tables. However, the approximation is close enough to warrant the use of the model to study and fit observed mortality schedules. The parameter α varies the mortality *level* of the standard, while β varies the *slope* of the standard, i.e., it governs the relationship between the mortality in children and adults. As β decreases, there is higher survival in the older ages relative to the standard, and vice versa. Higher values of α at a fixed β lead to lower survival relative to the standard (7).

Methodology

The INDEPTH MLTs technique was used in this study to provide the indirect estimation of life table from limited data set of BRAC female members. The life table of Matlab (a sub-district of Bangladesh) comparison area was used as standard life table for this estimation. For observing the fitness of INDEPTH MLTs, life expectancy curve of BRAC female members was compared with that of female population of Matlab comparison area and general female population of Bangladesh. In mid 1998, there were 2.54 million female members in the village organizations, and according to official records, a total of 3,879 female VO members aged 18–54 years had died. Twelve out of 45 district-level BRAC regions were randomly selected. Of the 12 regions, 32 BRAC areas (sub-district level) were randomly selected. Thus, the sample size was 186,379, and 391 of them died. Secondary data of BRAC female VO members were collected from the MIS of BRAC area level offices. The nearest relatives of all the deceased members' households (who died in 1998) were interviewed. Data were collected during May 2000.

INDEPTH System of Model Life Tables

The INDEPTH MLT is based on the assumption of Brass logit system that two distinct age-patterns of mortality can be related to each other by a linear transformation of the logit of their respective survivorship probabilities. Thus, for any two given series of survivorship values, $l^F{}_x$ and $l^{S,F}{}_x$, where the latter is the standard, it can be possible to write according to the following relationship:

$$l_x^F = \frac{1}{1+e^{2\alpha+\beta\ln\left[\frac{(1-l_x^S)}{l_x^S}\right]}} \qquad \text{.................................... (I)}$$

The values of α and β are obtained by running a linear regression of logit of the empirical values of l^F_x on those of the corresponding standard values. This procedure produces a new set of α and β which is used to generate the final estimates of l^F_x using the Brass-type formula (Brass, 1971).

The following steps are used to generate a complete life table from the limited data set of BRAC female members aged 18-54 years:

1. Computing the survivorship values l_{30} to l_{55+} by assuming $l_{25} = 1$ for both the observed and standard using the following formula:

$$_nl_x = 1 - {}_nq_x, \ \& \ \ {}_nq_x = \frac{n\,{}_nM_x}{1+n(1-{}_na_x)\,{}_nM_x} \qquad \text{(Table 1, col. 7 \& 9)}$$

2. Regressing the values of logit of observed l_x on the logit of Matlab l_x and obtain the regression coefficients (Figure 1), $\alpha = 0.4254$ and $\beta = 0.7699$.
3. Computing the estimated l^F_x corresponding to the above α and β, using the equation (I).
4. Picking up the values of gamma, γ_x for pattern 1 (females) and for $\beta = 0.8$ provided INDEPTH MLTs (Annex Table 1).
5. Dividing the estimated l^F_x by the corresponding values of γ_x and we get the corrected l_x.
6. Regressing the logit of the corrected values of l_x on the logit of the standard l_x and obtain the new values of $\alpha = -0.0283$ and $\beta = 0.9845$ (Figure 2).
7. Using the new values of α, β and standard l_x's in the equation (I) and obtain the final l_x (Table 2).

Table 1 Estimation of α and β for the estimated l_x (number of survivors)

Age (years)	${}_nD_x$	${}_nMP_x$	${}_nM_x$	${}_na_x$	Obs ${}_nq_x$	Obs l_x	MC ${}_nq_x$	MC l_x	Logit (Obs l_x)	Logit (MC l_x)
25	63	38580	0.0016	0.5	0.00813	1	0.0049	1		
30	54	36717	0.0015	0.5	0.00733	0.9919	0.0115	0.9951	-2.401913	-2.652522
35	53	33548	0.0016	0.5	0.00787	0.9846	0.0089	0.9836	-2.078977	-2.046928
40	53	24416	0.0022	0.5	0.01079	0.9769	0.0175	0.9749	-1.871267	-1.828826
45	36	13792	0.0026	0.5	0.01297	0.9663	0.0078	0.9578	-1.678131	-1.561225
50	36	6896	0.0052	0.5	0.02577	0.9538	0.0371	0.9503	-1.513507	-1.475314
55+	68	6896	0.0099	0.5	0.04812	0.9292	0.0347	0.915	-1.287269	-1.188145

Note: nDx, observed deaths between ages x and x+n; nMPx, mid-year population between ages x and x+n; ${}_nM_x$, observed mortality rate for ages x to x+n; ${}_na_x$, percentage of the age interval x, x+n; ${}_nq_x$, probability of dying between ages x and x+n; l_x, number of survivors at age x in the life table population; Obs= Observed, MC= Matlab Comprision area.

Figure 1 Regression of logit(Obs lx) on logit(MC lx)

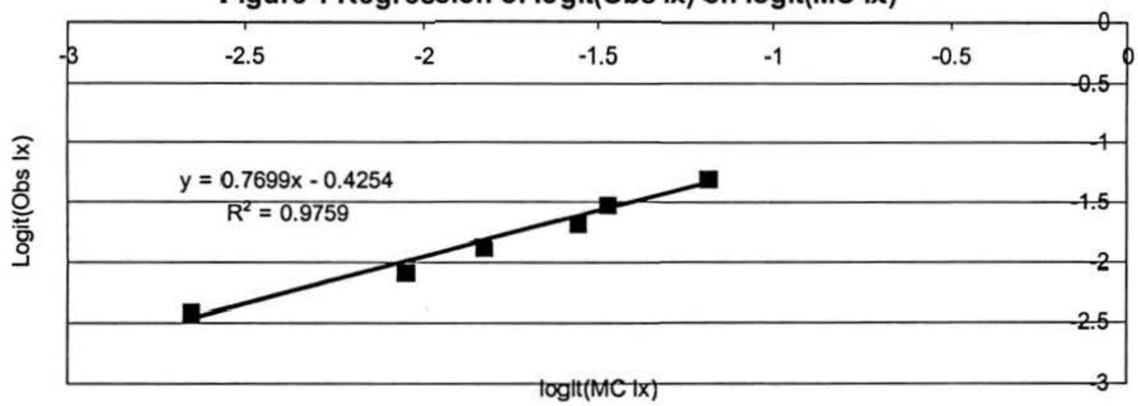


Figure 2 Regression of logit(Stand lx) on logit(corr lx)

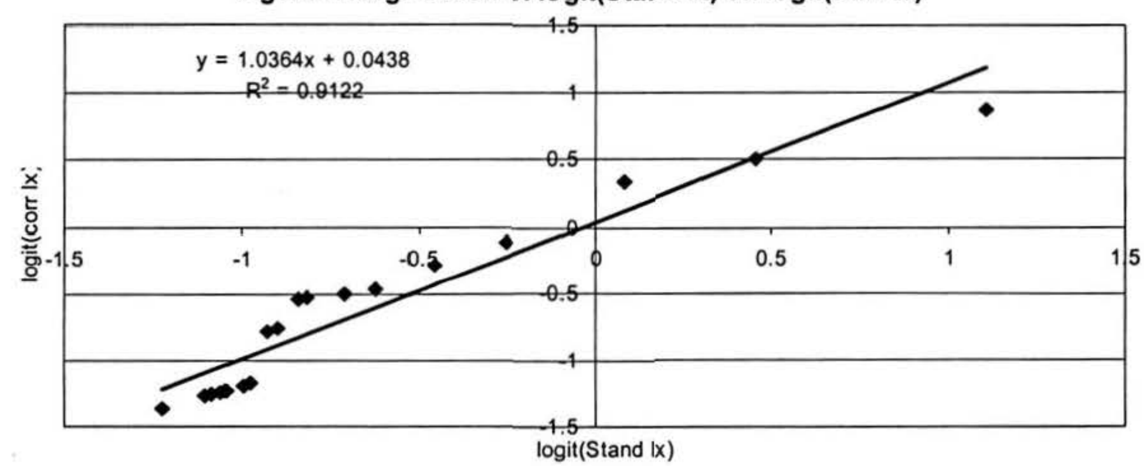


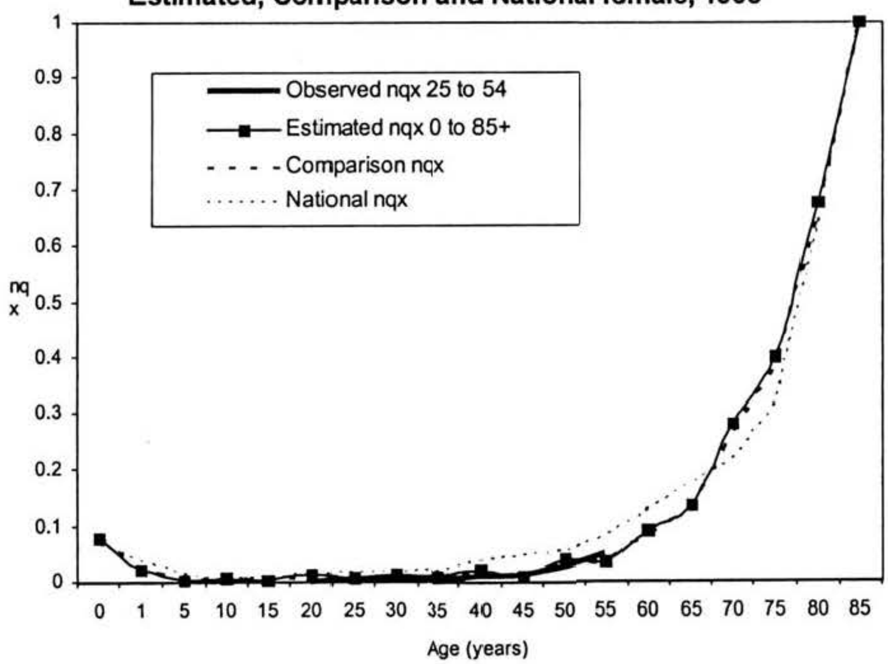
Table 2 Estimation of Final l_x (number of survivors)

Age	*Stand lx*	*Estimated lx*	*Gamma*	*Corr lx*	*logit(Corr lx)*	*logit(Stand lx)*	*Final lx*
0	1	1	1	1			1
1	0.92014	0.938927	1	0.939	-1.3663327	-1.222149216	0.920244
5	0.90023	0.927194	1	0.927	-1.2721857	-1.099864506	0.899547
10	0.89713	0.92541	1	0.925	-1.2591161	-1.08288878	0.896322
15	0.8926	0.922811	1	0.923	-1.2405803	-1.058813217	0.891592
20	0.88933	0.92094	1	0.921	-1.2275947	-1.041946567	0.888166
25	0.87944	0.915341	1	0.915	-1.1903319	-0.993547108	0.877807
30	0.87509	0.912901	1	0.913	-1.1747924	-0.973363292	0.873248
35	0.86501	0.907285	1.1	0.825	-0.7746231	-0.928776464	0.862661
40	0.85732	0.903035	1.1	0.821	-0.7613661	-0.896613563	0.85457
45	0.84233	0.894816	1.2	0.746	-0.5378512	-0.837839114	0.838766
50	0.83572	0.891216	1.2	0.743	-0.529972	-0.813365884	0.831787
55	0.80468	0.874446	1.2	0.729	-0.4940302	-0.707917	0.798954
60	0.77678	0.859467	1.2	0.716	-0.4629003	-0.623503471	0.769377
65	0.71275	0.82498	1.3	0.635	-0.2760009	-0.454382429	0.701457
70	0.62269	0.774955	1.4	0.554	-0.1074902	-0.250488748	0.606259
75	0.45906	0.673585	2	0.337	0.33880994	0.082058272	0.435932
80	0.28619	0.536723	2	0.268	0.50147603	0.456970889	0.262153
85+	0.09896	0.299486	2	0.15	0.86830821	1.104393144	0.08496

Probability of dying

Figure 3 shows that the probability of dying ($_nq_x$) curve of the estimated result using the INDEPTH MLTs is quite consistent with that of observed values of 25-55 years of BRAC members. The estimated J-shaped curve also follows the usual mortality patterns and quantum and the trend in probability of dying for BRAC members are comparable with those found by the Bangladesh Demographic and Health Survey (National female) and the Demographic Surveillance System of ICDDR,B (female population of Matlab comparison area). Moreover, the probability of dying curve for BRAC members is lower for ages from 25 to 70 years compared to national female population of Bangladesh (Figure 3). But the reverse situation appears in the Figure 3 for ages 70 years and above; and the gap between the curves gradually decreases with increase in age.

Figure 3 Probability of dying curve for Observed, Estimated, Comparison and National female, 1998

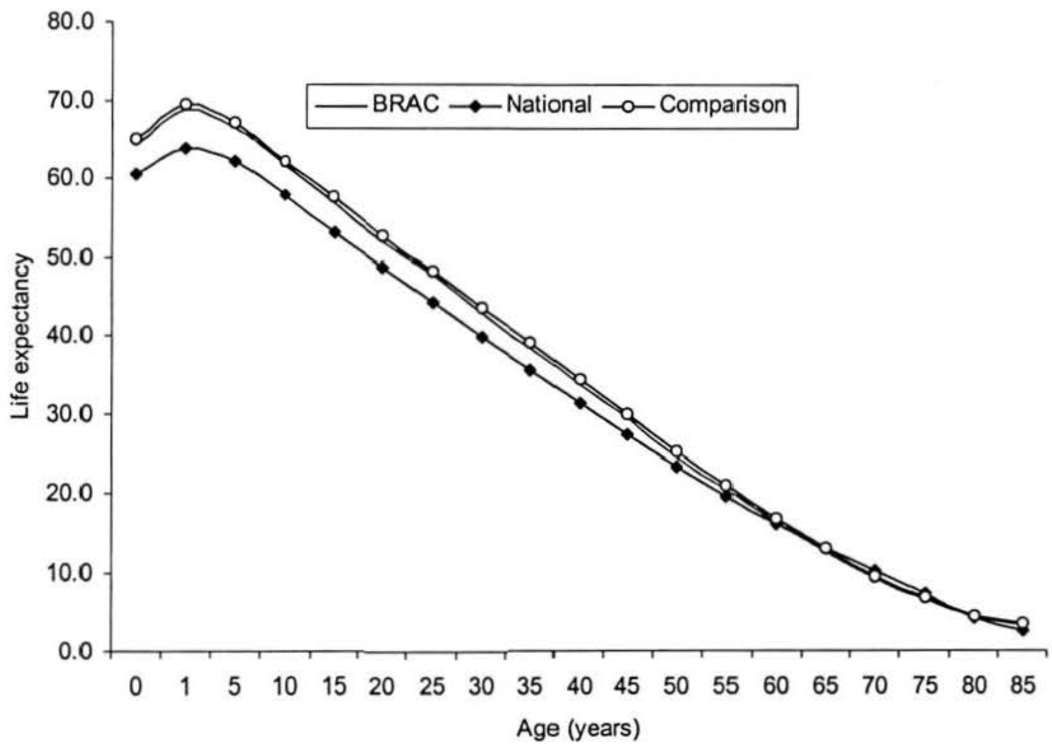


Source: Population and Health in Developing Countries, Volume 1: Population, Health, and Survival at INDEPTH Sites. INDEPTH Network 2002, and Sample Vital Registration System (SVRS), BBS.

Expectancy of life

The life expectancy at birth of BRAC female members was estimated as about 64.3 years which was higher compared to general female population (61 years) and slightly lower than Matlab comparison area (64.9 years) of Bangladesh in 1998 (Figure 4 and Annex Table 2). The pattern of life expectancy curve (LEC) of BRAC female members is similar to both Matlab comparison and general female population of Bangladesh (Figure 4). The gap between LECs of the BRAC and the Matlab female population is trivial. However, the gap between LECs of BRAC and that of national female population is observed for ages between 0 and 60 years. The curves show that the gap increases with decrease in age.

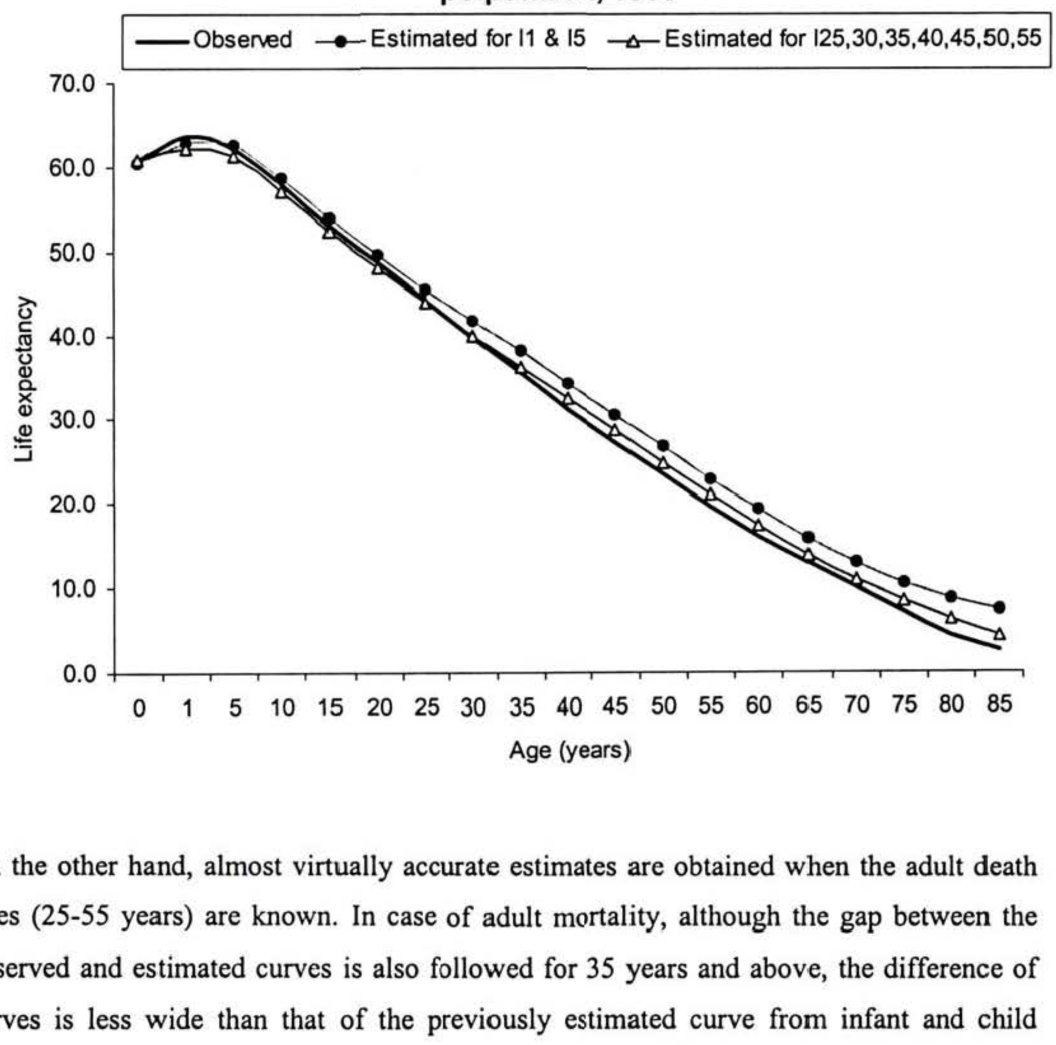
Figure 4: Life expectancy curve for BRAC female members, Comparison and National female population, 1998



Validation of the INDEPTH MLTs

Figure 5 shows the estimated two life expectancy curves for national female population, one of which is estimated from only the values of infant and child mortality, and the other is estimated from the values of adult mortality (25-55 years). Least accurate estimates are obtained when only infant and child mortalities are known. In this case, the pattern of estimated curve is quite consistent with that of empirical curve, but the gap is shown for 5 years and above in between estimated (l1 and l5) and observed LECs. Moreover, the gap of curves shows the increasing trend with increase in age.

Figure 5 Life expectancy curve for National female poipulation, 1998



On the other hand, almost virtually accurate estimates are obtained when the adult death rates (25-55 years) are known. In case of adult mortality, although the gap between the observed and estimated curves is also followed for 35 years and above, the difference of curves is less wide than that of the previously estimated curve from infant and child mortality. In addition, the slight gap between the observed and estimated curves is also visualized for 1-10 years old.

Discussion and Conclusions

This study signified that the construction of life table from limited data set of BRAC female members using the INDEPTH system of MLTs could be possible. Age specific death rates for BRAC female members were available from 25-55 years only. The life table of Matlab comparison area, a DSS site of INDEPTH Network, was taken as standard life table for estimating the full life table. Then applying the INDEPTH system of MLTs technique a full life table has been estimated. Findings of this study revealed that in 1998 the life expectancy at birth of BRAC female members (64 years) was higher compared to national female population (61 years) and slightly lower than that of Matlab comparison area. These may be two reasons for the higher life expectancy among BRAC members. Firstly, a chance factor is involved for the higher denominator of age specific death rates of BRAC members, because there is a tendency to BRAC programme for showing the full coverage of targeted membership status. Secondly, the BRAC development interventions can be a catalytic agent for improving the life style of poor women in rural Bangladesh.

The findings of this study clearly show that the probability of dying curve of the estimated result is quite consistent with that of the observed ages from 25 to 54 years. However, similar patterns of the estimated life expectancy curves and closeness of the curves indicate that the technique used in this study provides valid estimates. This study also justified the predictability of this technique for given different empirical values. For example, when the infant and child mortality (1q0 and 5q0) is known, its prediction is slightly wide from the true value in old age. But for adult mortality (age 25-55), the estimated curve appears as very closure to the true value. As a result, it is clear that the INDEPTH system of MLTs provides the much precise estimates. In addition, for completeness of adequacy test of this technique, further investigation is required to compare the estimated results provided by other MLTs (WHO systems of model life tables, Coale and Demeny models) with the INDEPTH MLTs.

In this type of model life table, several factors are involved in determining the estimated values of survivorship probabilities. The estimated values mainly dependant on the linear relationship between the values of empirical l_x's and standard l_x's. If the relationship is strong, then the predicted value will be more closure to the true value of life table. The closeness of predicted value will also be dependent on the two-parameter (α and β) values. Selection of the appropriate standard life table usually played a very significant role for the better predictability of this mortality model. It is also uncertain how the model life table system would perform in countries with unusual cause specific deaths (e.g. HIV, SARS).

The model life tables have problems (5,6). INDEPTH system of MLTs can generate life tables if the estimates of infant and child mortality are available (Figure 5). This type of model life table is very useful to project future mortality patterns. Therefore, this demographic technique could be used for the indirect estimation of life table in any developing country of Asia and Africa.

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Annex

Table 1: Standard values of γ_x for females & pattern 1, with β ranging from 0.5 to 1.5

Age	β=0.5	β=0.6	β=0.7	β=0.8	β=0.9	β=1.0	β=1.1	β=1.2	β=1.3	β=1.4	β=1.5
0	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1
30	1	1.1	1	1	1	1	1	0.9	0.9	0.9	0.9
35	1.1	1.1	1.1	1.1	1	1	1	0.9	0.8	0.9	0.9
40	1.1	1.2	1.1	1.1	1.1	1	1	0.9	0.8	0.8	0.8
45	1.2	1.2	1.2	1.1	1.1	1	1	0.8	0.7	0.7	0.8
50	1.2	1.2	1.2	1.2	1.1	1.1	1	0.8	0.7	0.7	0.7
55	1.2	1.3	1.2	1.2	1.1	1.1	1	0.8	0.6	0.6	0.7
60	1.3	1.3	1.2	1.2	1.1	1.1	1	0.7	0.6	0.6	0.6
65	1.3	1.4	1.3	1.2	1.2	1.1	1.1	0.7	0.5	0.5	0.6
70	1.5	1.5	1.4	1.3	1.2	1.1	1	0.6	0.4	0.5	0.5
75	1.7	1.6	2	1.7	1.5	1.2	1.1	0.6	0.3	0.4	0.4
80	2.3	1.8	2	1.7	1.5	1.2	1.1	0.6	0.3	0.3	0.3
85	3.1	2.1	2	1.8	1.6	1.4	1.3	0.5	0.3	0.3	0.2

Table 2: Estimation of the complete life table for BRAC members

Age	*Final* l_x	${}_nq_x$	${}_nd_x$	${}_na_x$	${}_nM_x$	${}_nL_x$	T_x	*Life expectancy*		
								BRAC	National	Matlab
0	1	0.07976	0.0798	0.28	0.08464	0.9423	64.25	64.3	60.5	64.9
1	0.920244	0.02249	0.0207	0.35	0.00571	3.6272	63.31	68.8	63.7	69.5
5	0.899547	0.00358	0.0032	0.5	0.00072	4.4897	59.68	66.3	62.2	67.0
10	0.896322	0.00528	0.0047	0.5	0.00106	4.4698	55.19	61.6	57.9	62.2
15	0.891592	0.00384	0.0034	0.5	0.00077	4.4494	50.72	56.9	53.2	57.5
20	0.888166	0.01166	0.0104	0.5	0.00235	4.4149	46.28	52.1	48.7	52.7
25	0.877807	0.00519	0.0046	0.5	0.00104	4.3776	41.86	47.7	44.2	48.3
30	0.873248	0.01212	0.0106	0.5	0.00244	4.3398	37.48	42.9	39.8	43.5
35	0.862661	0.00938	0.0081	0.5	0.00188	4.2931	33.14	38.4	35.5	39.0
40	0.854570	0.01849	0.0158	0.5	0.00373	4.2333	28.85	33.8	31.2	34.3
45	0.838766	0.00832	0.0070	0.5	0.00167	4.1764	24.62	29.3	27.3	29.9
50	0.831787	0.03947	0.0328	0.5	0.00805	4.0769	20.44	24.6	23.4	25.1
55	0.798954	0.03702	0.0296	0.5	0.00754	3.9208	16.36	20.5	19.6	21.0
60	0.769377	0.08828	0.0679	0.5	0.01847	3.6771	12.44	16.2	16.0	16.6
65	0.701457	0.13571	0.0952	0.5	0.02912	3.2693	8.77	12.5	12.9	12.9
70	0.606259	0.28095	0.1703	0.5	0.06537	2.6055	5.50	9.1	10.1	9.4
75	0.435932	0.39864	0.1738	0.5	0.09957	1.7452	2.89	6.6	7.2	6.9
80	0.262153	0.67591	0.1772	0.5	0.20419	0.8678	1.15	4.4	4.3	4.6
85	0.084960	1	0.0850	0.5	0.30629	0.2774	0.28	3.3	2.6	3.4