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INDIRECT ESTIMATION OF PRE-CENSUS BASELINE IN THE AFTERMATH OF A WAR

Sulaiman M. Bah and Mohammed Mahibur-Rahman

Abstract

Pre-censal estimates help in proper planning for the execution of a census. After the end of a destabilizing war, these pre-censal estimates cannot be easily obtained. The paper proposes how pre-censal estimates can be obtained in the aftermath of a war using indirect estimation techniques. This involves the estimation of probabilities of mortality and of emigration obtained from survival models and multiple decrement life tables.

Key Words

Multiple decrement model, pre-censal estimate, survivorship rate, effect of wars.

1. Introduction

Wars are man-made disasters which bring about demographic crises. Other events leading to demographic crises include epidemics, famines, droughts and environmental catastrophes such as major earthquakes, floods etc. These disasters may be interrelated or one may precipitate the other. In some cases, wars serve as primary disasters which precipitate other secondary disasters such as famines and droughts. These disasters, particularly wars, produce drastic effects on all components of population change; fertility, mortality and migration. Over the past decade, the demography of droughts and famines has received considerable attention (Caldwell and Caldwell, 1992; Dyson,1991a and 1991b; Janetta, 1992; Watkins and Watkins, 1985; Razzaque *et al.*, 1990; Seaman, 1992; Ashton *et al.*, 1984 and Pederson, 1995). On the other hand, the demography of wars has received little attention (Méng-Try, 1981; Hammel, 1992).

The similarities between famines and wars include increased mortality, reduced fertility and high emigration to safer areas. One must caution that there are several differences between famines and wars. In wars, facilities which help to support the health of the society get destroyed. These facilities include hospitals, roads, power plants, water supplies and sewage systems. The absence/breakdown of these facilities may also lead to additional deaths. In the case of famines, however, these facilities may still remain intact. Another difference is that in famines, considerable mortality which occur remain invincible in censuses and surveys which follow them. This was the case in the census carried out in 1976 in Mauritania and Senegal and in 1977 in Niger. In those censuses, there was no evidence of the Sahelian drought in the age structure (Caldwell and Caldwell, 1992). The same was found in the case of the Malian censuses of 1976 and 1987. In those censuses again, no effect of the droughts of 1973 and 1984 were found (Pederson, 1995). In the case of wars, on the other hand, the age structure of the population may change drastically.

Perhaps the single most distinguishing feature of wars is the increased mortality associated with them; both in magnitude and in differential effect. Literature shows that during wars, there is usually higher mortality among children and aged than among younger adults. In general, the highest mortality is for the adults who are engaged in combat. Of the non-combatant population, there is higher mortality among those who cannot bear the hardships of war or who are weak. These include the aged, the women and the children. In a recent work on childhood mortality in Beirut (Lebanon) during wartime, it was pointed out that even though the war was likely to have had a significant impact on male adult mortality, the military events did not disrupt the health services delivered to children. As such, the war did not reverse the trend in the decline in childhood mortality but definitely slowed it down (Deeb *et al.*, 1997). Wars are also associated with reduced fertility. This is a result of a combination of factors including: shift in the incidence of marriage, shift of incidence of first births and increases in divorce and of separation of spouses due to several reasons. In the study of Kampuchea, Ming-Try (1981:217) noted the following: 'the decline in births in the years 1975-1978 was due above all to excess male mortality, to excess work, to the separation of couples during evacuation, and to the mobilization of the young to the front and into production.' The highest fertility during the war period will be in the first year of war (largely for women pregnant before the onset of the war) after which fertility reduces with the duration of the war. Also associated with wars is increased emigration and outflow of refugees. The demography of refugees has already been studied by Huyck and Bouvier (1983). One can generalize that during war, there is very high emigration of the non-combatant population. This is highest for the non-combatant youths and adults, followed by women, then children and least for the aged.

Conceptual framework

Any meaningful post-war population estimation has to incorporate the effects of war on all the components of population change; mortality, fertility and migration. During this post war period, the effect of all these destablizing forces is reflected in a distorted age structure of the population. This is shown in the conceptual framework in Figure 1. The figure shows the time frame divided into three segments: pre-war, war period and post war. During pre-war, the three components of population growth are considered normal. During the war period, the conditions become abnormal and this results in high mortality, high emigration. Fertility becomes low as a result of combination of high mortality, high migration, marital disruption and general reduced interest in childbearing in the resident surviving non-migrants. During the post war, the effect of all these destablizing forces is reflected in a distorted age structure of the population.

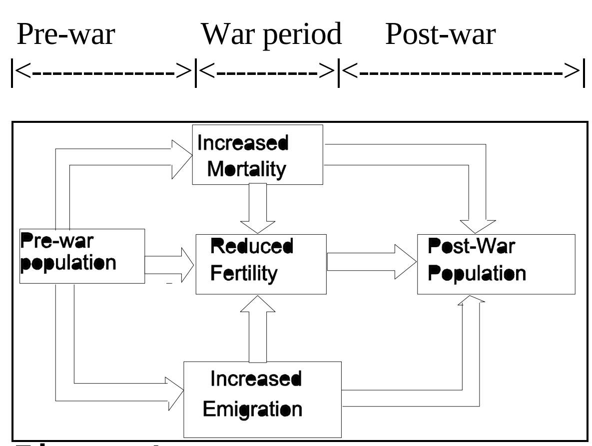

Figure 1

2. Methodology

The analysis is restricted to a ten-year period, covering a pre-war era, war era and a post-war era. It is assumed that a census took place at time *t*, five years later, at time *t+5*, the war started and ended five years later at time *t+10*. At the end of the war, it is required to obtain pre-censal estimate for the census which will be carried in the year *t+10*. Our main task is to obtain plausible mortality and migration rates (during the war period, *t+5* to *t+10*) to be used to estimate the population which remains after decimation by the war.

In the demographic literature, there are several models for describing age-specific mortality rates, age-specific fertility rates and age-specific migration rates. While these are very convenient for modeling purposes and do have practical uses elsewhere, we do not find basis for employing them in this study (Coale and Trussel, 1974; Brass 1978; Rogers *et al.*, 1978; Heligman and Pollard, 1980; Zaba, 1989). Those models are deterministic in nature and are applicable more to peace-time population rather than war-time population. Similarly, we do not find basis for employing the random distribution models which are found in the statistical literature (Hagerstrand, 1957; Stillwell and Congdon, 1991). Our reading of the literature on the demographic effects of war lead us to believe that wars act differentially on the population; as explained earlier, their effect is not random. For this purpose, we choose instead to use the method outlined below.

The basic strategy of this paper is to obtain model migration rates and model mortality rates and use them in multiple decrement model. Since we are considering a war of five years duration, we choose not to model fertility except for adjusting the population aged 0-4 who were born during the war. In a double decrement environment, we define the single decrement probabilities: ${}_tp^{/(d)}$ [${}_tp^{/(e)}$] as the probability that death [emigration] will not occur prior to age $x+t$; the double decrement probabilities (without the superscript slash): ${}_tp^{(d)}$ [${}_tp^{(e)}$] as the probability of not dying [not emigrating] between ages *x* and *x+t* in the presence of emigration with ${}_tq^{(d)}$ [${}_tq^{(e)}$] as the complement of these probabilities and the total survival probability: ${}_tp^{\tau}{}_x$ as the probability of neither dying nor emigrating prior to age *x+t* given alive and resident at age *x* . Following the approach of London (1988), we have that for the random event of death, there exists forces of mortality, $\mu^{(d)}{}_{x+t}$ and of emigration, $\mu^{(e)}{}_{x+t}$ at age *x+t* such that

$$ {}_t p_x^{/(d)} = \exp[-\int_0^t \mu_{x+u}^{(d)}\ du] \qquad (1) $$

and

$$ {}_t p_x^{/(e)} = \exp[-\int_0^t \mu_{x+u}^{(e)}\ du] \qquad (2) $$

If the random events of death and emigration are independent, then ${}_tp = {}_tp^{(d)} * {}_tp^{(e)}$. Hence the density function for death is given by:

$$ = \int_0^t \{\exp[-\int_0^t \mu_{x+u}^{(d)}\ du] * \exp[-\int_0^t \mu_{x+u}^{(e)}\ du] * \mu_{x+u}^{(d)}\}\ du \qquad (3) $$

Assuming constant force as $\mu^{(d)}{}_{x+t} = \mu^{(d)}$, we have

$$ {}_t q_x^{(d)} = \int_0^t \{\exp[-\int_0^t \mu^{(d)} du] * \exp[-\int_0^t \mu^{(e)} du] * \mu^{(d)}\}\ du $$

which simplifies to

$$ {}_t q_x^{(d)} = \frac{\mu^{(d)}}{\mu^{(d)} + \mu^{(e)}} * [1 - \exp(-t * (\mu^{(d)} + \mu^{(e)})] \qquad (4) $$

Let $\delta = \mu^{(d)}/\mu^{(e)}$ be the ratio of the two forces of decrement. Now the expression (4) becomes, in terms of δ

$$ {}_t q_x^{(d)} = \frac{\delta}{\delta + 1} * [1 - \exp(-t * \mu^{(d)}(1 + \frac{1}{\delta}))] = \frac{\delta}{\delta + 1} * F_{\mu,\delta} \qquad (5) $$

where $F_{\mu,\delta}$ is a function of $\mu^{(d)}$ and δ.

In a manner parallel to the above, for emigration, we also obtain the following:

$$ {}_t q_x^{(e)} = \frac{1}{\delta + 1} * [1 - \exp(-t * \mu^{(d)}(1 + \frac{1}{\delta}))] = (1 - \frac{\delta}{\delta + 1}) * F_{\mu,\delta} = F_{\mu,\delta} - {}_t q_x^{(d)} \qquad (6) $$

Note that, for known value of ${}_t q^{(d)}$, ${}_t q^{(e)}$ is computable. From here, we would introduce the concept of the 'Intensity Parameter' *I*, reflecting the intensity of the war. No doubt, *I* > 1. The parameter *I* could be made constant or varying. In this paper, we assume that *I* is constant for all age groups, so that $\mu^{(d)} = I * \tilde{\mu}^{(d)}$, where $\tilde{\mu}^{(d)}$ is the pre-war force of mortality. Substituting for $\mu^{(d)}$ in equation (5), we have

$$ {}_t q_x^{(d)} = \frac{\delta}{\delta + 1} * [1 - \exp(-t * I * \tilde{\mu}^{(d)}(1 + \frac{1}{\delta}))] \qquad (7) $$

In this way, if we have base values of $\tilde{\mu}^{(d)}$, we can set values for *I* and δ to obtain different probabilities. Under the constant force assumption, we know that the force of mortality equals to the life-table central death rate, i.e. $\tilde{\mu}^{(d)} = {}_n m_x$.

3 Results

Using a FORTRAN program, results were obtained showing how these probabilities change with different parameter values. Tables 1 and 2 have been extracted from those outputs. In Table 1, the base values are given. *I* and δ are initially set equal to one and subsequently the *I* values are increased at increments of 0.25 up to 2.00. At each value of *I*, δ is set from 1.0 to 2.0 with increments of 0.5. The findings show that if *I* is kept constant and δ is increased, the probability of dying increase while that of emigrating decrease. On the other hand, if *I* is increased while keeping δ fixed, both probabilities increase at all ages. Note that, the probabilities of emigrating have not been reported as it is easily obtained from probabilities of dying through the expression (6).

These values in Table 1 are used to obtain the total survivorship rates using ${}_n d_x^{(d)} = l_x * {}_n q_x^{(d)}$ and ${}_n d_x^{(e)} = l_x * {}_n q_x^{(e)}$. Since in a double decrement life table the l_x values are additive, we have, $l_{x+n} = l_x * {}_n d_x^{(d)} * {}_n d_x^{(e)}$. Having obtained l_x values (which now incorporates the two decrements), it is straight forward to obtain $_nL_x$ values and hence the survivorship rates $_nS_x$. These values have been obtained using another program and the results are shown in Table 2. Having obtained the survivorship probabilities, one can apply them on the pre-war population to obtain an estimate of pre-censal population.

4 Application and Discussion

Let us take a country which had census in 1980. During the period 1980-1985, the mortality pattern can be adequately described by the UN general model with life expectancy at birth of 55.0 years. In 1985, war broke out and peace was achieved in 1990 when a census was also due to be held. Assuming that the intensity of the war I=1.5 and the ratio of the force of mortality to that of emigration δ was 2.0, we estimate the pre-censal female population. Table 3 shows the results of the application of the model.

The results indicate that during the pre-war period, the population increased by about 1.2% from 485495 to 515581. When the war set in and the births reduced to a quarter and under the assumed model, the population actually declined to 467638. The result looks realistic even though it was actually the constant *I* method that was used. However, in line with the substantive findings on the differentials in mortality and emigration, the varying *I* method would be more realistic. Further research is needed to develop this option and to guide analysts on how to determine the two main parameters in the model. It is hoped that this model will be of some use in determining pre-censal population estimates in the aftermath of war.

TABLE 1: Distribution of Probability of dying ($_tq^{d)}$) between ages x and x+t for different *I* and δ

Age x - x+t	$\tilde{\mu}^{(d)}$	I=1.00 δ=1.0	I = 1.25 δ = 1.0	I = 1.25 δ = 1.5	I = 1.25 δ = 2.0	I = 1.50 δ = 1.0	I = 1.50 δ = 1.5	I = 1.50 δ = 2.0	I = 1.75 δ = 1.0	I = 1.75 δ = 1.5	I = 1.75 δ = 2.0	I = 2.00 δ = 1.0	I = 2.00 δ = 1.5	I = 2.00 δ = 2.0
0- 1	0.0956	0.0870	0.1063	0.1084	0.1094	0.1247	0.1276	0.1291	0.1422	0.1460	0.1480	0.1589	0.1638	0.1663
1- 4	0.0141	0.0533	0.0658	0.0665	0.0669	0.0778	0.0789	0.0795	0.0896	0.0910	0.0917	0.1010	0.1028	0.1038
5- 9	0.0033	0.0163	0.0203	0.0203	0.0204	0.0242	0.0243	0.0244	0.0281	0.0283	0.0283	0.0320	0.0322	0.0323
10-14	0.0020	0.0098	0.0122	0.0122	0.0123	0.0146	0.0147	0.0147	0.0170	0.0171	0.0171	0.0194	0.0195	0.0195
15-19	0.0030	0.0149	0.0185	0.0186	0.0186	0.0221	0.0222	0.0223	0.0257	0.0259	0.0259	0.0293	0.0295	0.0295
20-24	0.0042	0.0204	0.0253	0.0254	0.0255	0.0302	0.0304	0.0305	0.0351	0.0353	0.0354	0.0399	0.0402	0.0403
25-29	0.0049	0.0239	0.0296	0.0298	0.0299	0.0354	0.0356	0.0357	0.0410	0.0413	0.0414	0.0466	0.0470	0.0471
30-34	0.0058	0.0280	0.0348	0.0350	0.0351	0.0415	0.0418	0.0419	0.0480	0.0484	0.0486	0.0545	0.0550	0.0553
35-39	0.0067	0.0326	0.0404	0.0407	0.0408	0.0481	0.0485	0.0487	0.0556	0.0562	0.0564	0.0631	0.0638	0.0641
40-44	0.0079	0.0382	0.0472	0.0476	0.0478	0.0561	0.0567	0.0570	0.0649	0.0656	0.0660	0.0734	0.0744	0.0749
45-49	0.0101	0.0479	0.0591	0.0597	0.0601	0.0701	0.0710	0.0714	0.0808	0.0819	0.0825	0.0912	0.0927	0.0935
50-54	0.0138	0.0645	0.0792	0.0803	0.0809	0.0935	0.0951	0.0959	0.1073	0.1094	0.1104	0.1206	0.1233	0.1247
55-59	0.0198	0.0897	0.1095	0.1117	0.1128	0.1284	0.1314	0.1330	0.1463	0.1503	0.1524	0.1634	0.1685	0.1712
60-64	0.0290	0.1259	0.1521	0.1565	0.1588	0.1765	0.1825	0.1857	0.1991	0.2070	0.2112	0.2202	0.2301	0.2353
65-69	0.0434	0.1762	0.2095	0.2184	0.2230	0.2394	0.2514	0.2577	0.2662	0.2816	0.2897	0.2903	0.3091	0.3192
70-74	0.0658	0.2410	0.2803	0.2976	0.3069	0.3136	0.3364	0.3486	0.3419	0.3701	0.3855	0.3659	0.3996	0.4182
75-79	0.0988	0.3137	0.3545	0.3855	0.4025	0.3863	0.4254	0.4472	0.4112	0.4579	0.4843	0.4306	0.4843	0.5151
80-84	0.1438	0.3813	0.4171	0.4658	0.4935	0.4422	0.5006	0.5344	0.4596	0.5263	0.5657	0.4718	0.5454	0.5896
85-89	0.2271	0.4484	0.4707	0.5437	0.5874	0.4834	0.5649	0.6149	0.4906	0.5781	0.6328	0.4947	0.5864	0.6446

TABLE 2: Distribution of Total Survivorship rates ($_nS_x$) between ages (x , x+4) and (x+5 , x+9) for different *I* and δ

Age x - x+t	I = 1.25 δ = 1.0	I = 1.25 δ = 1.5	I = 1.25 δ = 2.0	I = 1.50 δ = 1.0	I = 1.50 δ = 1.5	I = 1.50 δ = 2.0	I = 1.75 δ = 1.0	I = 1.75 δ = 1.5	I = 1.75 δ = 2.0	I = 2.00 δ = 1.0	I = 2.00 δ = 1.5	I = 2.00 δ = 2.0
0- 4	0.90887	0.90921	0.90965	0.89123	0.89150	0.89217	0.87358	0.87403	0.87501	0.85615	0.85673	0.85788
5- 9	0.95940	0.95950	0.95950	0.95160	0.95160	0.95170	0.94380	0.94380	0.94400	0.93600	0.93600	0.93620
10-14	0.97560	0.97560	0.97560	0.97080	0.97070	0.97080	0.96600	0.96590	0.96600	0.96120	0.96120	0.96130
15-19	0.96300	0.96300	0.96300	0.95580	0.95580	0.95580	0.94860	0.94850	0.94870	0.94140	0.94140	0.94160
20-24	0.94940	0.94940	0.94950	0.93960	0.93960	0.93970	0.92980	0.92990	0.93010	0.92020	0.92030	0.92060
25-29	0.94080	0.94080	0.94090	0.92920	0.92940	0.92960	0.91800	0.91810	0.91840	0.90680	0.90700	0.90740
30-34	0.93040	0.93050	0.93070	0.91700	0.91720	0.91750	0.90400	0.90420	0.90460	0.89100	0.89130	0.89170
35-39	0.91920	0.91930	0.91960	0.90380	0.90400	0.90440	0.88880	0.88900	0.88950	0.87380	0.87420	0.87490
40-44	0.90560	0.90570	0.90610	0.88780	0.88800	0.88850	0.87020	0.87060	0.87130	0.85320	0.85360	0.85440
45-49	0.88180	0.88210	0.88250	0.85980	0.86020	0.86100	0.83840	0.83900	0.84010	0.81760	0.81830	0.81960
50-54	0.84160	0.84210	0.84310	0.81300	0.81370	0.81510	0.78540	0.78640	0.78830	0.75880	0.76000	0.76230
55-59	0.78100	0.78200	0.78390	0.74320	0.74470	0.74730	0.70740	0.70920	0.71260	0.67320	0.67550	0.67960
60-64	0.69580	0.69770	0.70130	0.64700	0.64960	0.65450	0.60180	0.60500	0.61110	0.55960	0.56350	0.57090
65-69	0.58100	0.58450	0.59130	0.52120	0.52570	0.53440	0.46760	0.47310	0.48350	0.41940	0.42590	0.43800
70-74	0.43940	0.44550	0.45690	0.37280	0.38010	0.39390	0.31620	0.32480	0.34040	0.26820	0.27760	0.29480
75+	0.39625	0.40375	0.41702	0.32286	0.33330	0.35156	0.25215	0.26526	0.28797	0.18786	0.20277	0.22849

TABLE 3: Application of the model

Age x-x+n	Base Population $_5P1_x$, 1980	Survivorship Rates ($_nS_x$) 1980-1985	Estimated Population $_5P2_x$, 1985	Survivorship Rates ($_nS_x$) 1985-1990	Estimated Population $_5P3_x$, 1990
0-4	55185	.9592	56070[a]	.89217	11361[b]
5-9	51668	.9868	52933	.95170	50024
10-14	46676	.9880	50986	.97080	50376
15-19	56294	.9821	46116	.95580	49868
20-24	52223	.9775	55286	.93970	44078
25-29	44677	.9738	51048	.92960	51952
30-34	38678	.9693	43506	.91750	47454
35-39	27827	.9642	37491	.90440	39917
40-44	20512	.9564	26831	.88850	33907
45-49	19550	.9428	19618	.86100	23839
50-54	16039	.9205	18432	.81510	16891
55-59	17517	.8866	14764	.74730	15024
60-64	12705	.8365	15531	.65450	11033
65-69	10001	.7640	10628	.53440	10165
70-74	7044	.6660	7641	.39390	5680
75-79	4579	.5491	4691	.35156[d]	3010
80+	4067	.3677[c]	2514		3059
85+			1495		
Total	485495		515581		467638

[a] The life table survivorship, $_5S_0$ is given as .89 and assuming that the five-years births are 63,000.

[b] The life table survivorship, $_5S_0$ .81148 (not shown in Table 3) and assuming that during the war, births gets reduced to a quarter of pre-war births.

[c] This refers to the survivorship from 80+ to 85+

[d] This refers to the survivorship from 75+ to 80+

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