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ESTIMATION OF EARLY CHILDHOOD MORTALITY FROM CHILDREN EVER BORN AND SURVIVING

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Résumé — Parmi les problèmes associés à l'usage des données de maternité pour l'estimation de la mortalité infantile, la question de naissances vivantes qui sont décédées avant l'enquête sans une année de naissance ou un âge connus au moment du décès a été l'objet de peu ou de nulle attention.

Comme une solution possible, cette étude a développé une technique de table de mortalité l'estimation de mortalité infantile précoce utilisant des données sur les enfants déjà nés et survivants. Des données (provenant de cette enquête) sur la fécondité, sur la famille et sur la planification de la famille au sud-ouest de la Nigérie (1971), provenant de cette enquête ont été utilisées pour illustrer la mécanique opérationelle de la technique. Les estimation dérivées de e_x^0 pour les âges 0-4 et 5-9 se rapprochent assez près des estimations correspondantes avec les mêmes données et utilisant l'approche "Brass logit Function".

Abstract — Among the problems associated with the use of maternity history data for the estimation of child mortality, the issue of livebirths who died before survey without a known year of birth or age at death has received little or no attention. As a possible solution, this study develops a life table technique for estimating early childhood mortality using data on children ever born and surviving. Data from the survey on fertility, family and family planning in South-western Nigeria (1971) are used to illustrate the operational mechanics of the technique. The derived estimates of e_x^0 for the ages 0 - 4 and 5 - 9 approximate fairly closely corresponding estimates with the same data using the Brass logit function approach.

Key Words—**childhood mortality, estimation**

Introduction

In the absence of data from fairly reliable periodic censuses and a national vital registration system, there are two broad approaches for estimating fertility or mortality in a given population. One of these, the direct approach, consists of three alternatives: a sample vital registration system, multiple-round surveys, or the dual record system; the second approach, indirect, is the use of maternity histories (Brass, 1973).

The application of each of these techniques varies considerably because every country presents special and different opportunities as well as problems. In particular, from a recent evaluation of each of the three procedures under the direct approach, it appears that the prospects of obtaining vital rates of adequate accuracy at an acceptable cost from these direct sources are not encouraging, at least in the immediate future (Brass, 1973). Accordingly the indirect method of estimating the two critical components of population growth has been given considerable attention in recent years (Bogue and Bogue, 1970; Brass, 1971, 1973, 1975, 1977; Potter, 1975).

With respect to mortality, although these indirect estimation methods have focused mainly on child and adult mortality, greater success has been achieved in the case of child mortality estimation. Since the development of a technique by Brass (1968) for deriving probabilities of dying by age *(q_i)* where $i = 1, 2, 3, 5, 10, 15$ and 20, there have been two refinements by Sullivan (1972) and Trussell (1975). Available evidence from applying all three methods indicates that there is little to choose from the estimates based on the Sullivan and Trussell refinements of the Brass original methodology. Several examples in the application of all three estimation procedures can be cited to substantiate this point. For instance, using data from the 1971 survey of fertility, family and family planning in South-western Nigeria, Ekanem and Farooq (1977) showed that the Brass and Sullivan approaches yielded a q_2 value of .125 and .132 respectively for all Southern Nigeria (1971). The corresponding values for q_3 were .148 and .147 and for q_5, .208 and .194.

Concern in the present study is focused not on a further refinement of either of these earlier estimation methods but on the development of a new methodology for estimating early childhood mortality on the basis of children ever born and surviving by age of mother. Specifically the method is to aid the estimation of the life expectancy at birth for children in the age groups 0-4 and 5-9. The implied q_i values can then be compared with those derived from the earlier methods by Brass, Sullivan and/or Trussell.

It will be recalled that in the case of inferring fertility trends from data on maternity histories, the basic data of concern are the date and order of birth of each liveborn child (aged 0-34) for a sample of women in the reproductive period, (15-49), according to the current age of the women (i.e. age at survey date). The sample of women, separated into seven five-year classes determined by age at survey, is assumed to be representative of the female population of childbearing age. The total livebirths for each cohort of women (15-19, 20-24, . . . , 40-44, 45-49) are allocated to different periods preceding the survey date. Reading along the rows of such a schema, gives the births to the cohorts of women in different periods preceding the survey while the columns give the births to different cohorts of women over different ranges in the same time interval preceding the survey. If the periods preceding the survey cover five-year intervals (0-4, 5-9, . . . , -24, 30-34), the diagonal entries from the left should show the births to women from different cohorts over the same ages. In sum, if the basic data are reported accurately, a reliable picture of the current fertility situation and variations over time among groups may be obtained from such a schema assuming that women in the reproductive ages in a given past period are represented by those living. With slight modifications the same schema can be used to estimate levels and trends in mortality.

The main problems associated with the analysis of maternity history data implicit in the schema outlined above have been discussed at length (Bogue and Bogue, 1970; Brass, 1971, 1973, 1977; Potter, 1975). However, one of these problems which has not received much attention is the issue of livebirths who died before survey without a known year of birth or age at death. Both the dates of birth and age at death are either non-existent or partially available for a sizeable proportion of these dead livebirths reported in most maternity histories from developing countries. Probably this is because mothers remember the ages of children surviving better than the births and death dates of children deceased. Accordingly in developing a method for estimating early childhood mortality using data on maternity histories, the use of surviving as well as all children ever born is suggested. Details of the proposed methodology are set out in the next section.

Estimation Methodology

The data required for the estimation technique consists of total number of children ever born alive by each of the female cohorts and a distribution of the surviving livebirths (at survey) in years before the survey. In Table 1 is presented a schema for the proposed method. The total number of children ever born *(CEB)* is divided into component parts. From the schema adopted, the *CEB* to women 15-19 are *only* in the 0-4 years before survey period as against the 0-4 and

5-9 years before survey period for the women 20-24. Thus for the female cohort aged 15-19 at survey date, ${}_{15}S_0$ of the total number of children ever born $({}_{15}C_0)$ survived. Similarly for the female cohort 25-29 at survey date, out of the N_{25} total number of children ever born, ${}_{25}S_0$ survived out of the ${}_{25}C_0$ born during the 0-4 years before survey while ${}_{25}S_5$ and ${}_{25}S_{10}$ survived out of the ${}_{25}C_5$ and ${}_{25}C_{10}$ born respectively during the 5-9 and 10-14 years before survey.

TABLE 1. A SCHEMA FOR ESTIMATING INFANT AND CHILD MORTALITITY FROM REPORTED AND SURVIVING LIVEBIRTHS

Age of Mother at Survey	Number of Surviving Children by Age (in Years) Before Survey							Total Number of Children Ever Born (CEB)
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	
15 - 19	${}_{15}S_0$							${}_{15}C_0 = N_{15}$
20 - 24	${}_{20}S_0$	${}_{20}S_5$						${}_{20}C_0 + {}_{20}C_5 = N_{20}$
25 - 29	${}_{25}S_0$	${}_{25}S_5$	${}_{25}S_{10}$					${}_{25}C_0 + {}_{25}C_5 + {}_{25}C_{10} = N_{25}$
30 - 34	${}_{30}S_0$	${}_{30}S_5$	${}_{30}S_{10}$	${}_{30}S_{15}$				${}_{30}C_0$ + ---- + ${}_{30}C_{15} = N_{30}$
35 - 39	${}_{35}S_0$	${}_{35}S_5$	${}_{35}S_{10}$	${}_{35}S_{15}$	${}_{35}S_{20}$			${}_{35}C_0$ + ---- + ${}_{35}C_{20} = N_{35}$
40 - 44	${}_{40}S_0$	${}_{40}S_5$	${}_{40}S_{10}$	${}_{40}S_{15}$	${}_{40}S_{20}$	${}_{40}S_{25}$		${}_{40}C_0$ + ---- + ${}_{40}C_{25} = N_{40}$
45 - 49	${}_{45}S_0$	${}_{45}S_5$	${}_{45}S_{10}$	${}_{45}S_{15}$	${}_{45}S_{20}$	${}_{45}S_{25}$	${}_{45}S_{30}$	${}_{45}C_0$ + ---- + ${}_{45}C_{30} = N_{45}$

Using the schema, it is possible to estimate life table values of the total person-years lived (L_x) by the female cohorts per period before survey. For instance, in the first female cohort (15-19), the ratio of total surviving children $({}_{15}S_0)$ to total number of children ever born $({}_{15}C_0)$ can be equated to the value of ${}_5L_0/5l_0$ in a life table. In symbols

$${}_{15}S_0/{}_{15}C_0 = {}_5L_0/5l_0$$

i.e. $${}_{15}C_0 = {}_{15}S_0(5l_0/{}_5L_0) \qquad (1)$$

where ${}_{15}C_0$ = total livebirths to women 15-19 in the 0-4 years before survey;

${}_{15}C_0$ = number surviving out of ${}_{15}C_0$;

$5l_0$ = 500,000; l_0= 100,000 (radix)

${}_5L_0$ = L_x value in an abridged life table for age 0-4.

Similarly for the female cohort 20-24, the total livebirths born to the women (N_{20}) can be divided into two components corresponding to the periods 0-4 and 5-9 years before the survey. Again in symbols:

$$N_{20} = {}_{20}C_0 + {}_{20}C_5$$
$$= {}_{20}S_0(5l_0/{}_5L_0) + {}_{20}S_5\,(5l_0/{}_5L_5) \qquad (2)$$

where

${}_{20}S_0$ = number surviving out of ${}_{20}C_0$ total livebirths;

${}_{20}S_5$ = number surviving out of ${}_{20}C_5$ total livebirths;

In general,

$$N_j = \sum_{i=0}^{k} {}_jC_i$$

$$= \sum_{i=o}^{k} =0\ {}_jS_i\ (5l_0/{}_5L_i) \qquad (3)$$

where k = i = 0, 5, 10, 15, 20, 25, 30;
j = 15, 20, 25, 30, 35, 40, 45;
N_j = total livebirths in the j^{th} age group of mother;
${}_jC_i$ = total livebirths in the j^{th} age group of mother in the i^{th} year period (child) before survey;
${}_jS_i$ = surviving children in the j^{th} age group of mother in the i^{th} year period (child) before survey.

Having derived the ${}_jC_i$ values corresponding to all the ${}_jS_i$ values, the suggested procedure for deriving life table values of L_X for each of the periods before survey is to begin with a first guess of the mortality level that yields a value of ${}_5L_0/5l_0$ as close as possible to the observed ${}_{15}S_0/{}_{15}C_0$ (in the case of the female cohort 15-19) and then to proceed to other levels in the spirit of trial and error. In illustrating the operational mechanics of the technique the data used derives from the South-western phase of the 1971-1973 National Survey of Fertility Family and Family Planning in Nigeria (Table 2). The survey under reference was undertaken by the former Institute of Population and Manpower Studies (University of Ife, Nigeria) and funded by the Population Council (New York). A total of three thousand and thirteen households and three thousand, four hundred and fifteen married women aged 15-49 were covered in the South-western phase (1971) of the Survey (Acsadi et al, 1972, chap. 5).

TABLE 2. DISTRIBUTION OF REPORTED NUMBER OF SURVIVING LIVEBIRTHS BY AGE OF MOTHER AND YEARS BEFORE THE SURVEY AND OF TOTAL LIVEBIRTHS BY AGE OF MOTHER IN SOUTH-WESTERN NIGERIA, 1971

Age of Mother at Survey	Number of Surviving Livebirths by Age (In Years) Before Survey							Surviving Livebirths	Total Live Births (CEB)	Proportion Surviving
	0-4	5-9	10-14	15-19	20-24	25-29	30-34			
15 - 19	125							125	129	.969
20 - 24	822	204						1026	1149	.893
25 - 29	1171	737	195					2103	2416	.870
30 - 34	720	672	383	107				1892	2299	.823
35 - 39	407	474	430	256	52			1619	1975	.820
40 - 44	174	238	246	211	127	30		1026	1326	.774
45 - 49	61	113	137	125	104	55	16	611	803	.761
15 - 49	3480	2438	1401	699	283	85	16	8402	10097	.832

Empirical Test of Technique

Consider the female age group 15-19. Using Equation (1) and the values in Table 2.

$$_5L_0/5l_0 = 125/129 = .969 \qquad (4)$$

From the North model female life table in the Coale-Demeny system (1966), mortality level 21 yields a value of .963 for $_5L_0/5l_0$; the corresponding value for level 22 is .973. The use of the North model life table is consistent with conventional practice among mortality analysts to use the South model for analysing mortality data for countries in the North African subregion while the North model is used for countries in subsaharan Africa (Clairin, 1968; pp. 199-213; Ekanem and Som, 1981). In particular the North model has one feature that is unique to African populations namely a high childhood mortality relative to infant mortality (Brass et al, 1968; pp. 122-124).

The observed value of $_{15}S_0/_{15}C_0$ implies a female mortality that lies between levels 21 and 22. By linear interpolation, an appropriate $_5L_0$ value is derived. In this case it equals 484423.0. The same procedure is followed in obtaining the components of N_{20} in terms of the periods 0-4 and 5-9 years before survey. Thus at mortality level 15,

$$_5L_0/5l_0 = .893 \qquad (5)$$

and $$_5L_5/5l_0 = .847$$

Using (2) and (5),

$$N_{20} = 822\,/\,.893 + 204/.847$$
$$= 920 + 241 = 1161$$

The corresponding results from level 16 are

$$N_{20} = 822/.906 + 204/.867$$
$$= 1142$$

Thus the observed N_{20} (1149) lies between levels 15 and 16. By using the same interpolation procedure as for the age group 15-19,

$$_5L_0 = 450680.3 \qquad (6)$$
$$_5L_5 = 429897.7$$

For the purposes of checking on the procedure, the derived $_jC_i$ and $_5L_X$ values for all the seven female cohorts are reproduced in Tables 3 and 4 as well as the associated mean life expectancies by age (e_X^0) corresponding to the $_5L_X$ values.

Discussion

The data in Table 4 indicate that in South-western Nigeria, life expectancies at birth of children of mothers aged 45-49 at the time of the survey (1971) increased from 51.2 to 56.5 for children of women aged 20-24. This improvement is probably an over-estimate because younger mothers tend to have children nearer to the older age boundary of any age group, while older mothers have them nearer the younger boundary. Thus children of younger mothers are exposed to a higher mortality risk after the survey than children of older mothers. This influence is probably strongest with mothers aged 15-19 and much of the further improvement to a life expectancy of 71.5 years estimated from this age group is probably spurious. Accordingly considering the L_0 and L_5 estimates from the female age groups 20-24 to 45-49, the mean life expectancy at birth for children aged 0-4 in South-western Nigeria (1971) was probably 54 as against 57 for children aged 5-9. When both of these estimates are compared with corresponding estimates of 51 and 53 using the same data but Brass's estimation procedure (Ekanem and Farooq, 1977), then the assertion noted earlier that the North model life table has a tendency to over-estimate childhood mortality becomes more obvious.

TABLE 3. DISTRIBUTION OF ESTIMATED NUMBER OF CHILDREN EVER BORN BY AGE OF MOTHER AND YEARS BEFORE SURVEY FOR SOUTH-WESTERN NIGERIAN WOMEN (1971) USING NORTH MODEL

Age of Mother at Survey	Estimated Number of Children Ever Born By Years Before Survey							All Reported CEB
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	
15 - 19	129							129
20 - 24	912	237						1149
25 - 29	1311	870	235					2416
30 - 34	829	831	500	139				2299
35 - 39	465	577	538	327	68			1975
40 - 44	203	302	322	282	175	42		1326
45 - 49	71	143	179	167	142	78	23	803
15 - 49	3920	2960	1774	915	385	120	23	10097

Ideally the application of the method developed here would be more appropriate and could yield more realistic results if the data on children ever born and those surviving were tabulated by sex. Probably the fluctuations in the estimates of L_0 and L_5 with the data used here in illustrating the method could be sequel to the lumping together of the data for both sexes. However, this does not distract from the efficacy of the general methodology as described.

Conclusion

The method developed in this paper is certainly useful in terms of estimating early childhood mortality from a one-shot retrospective survey data relative to other existing methods. The only data needed is a tabulation of the children (by sex) that survived to the survey date by age of mother (and child) as well as the total reported livebirths per cohort of the women (15-19) interviewed during the survey. If the derived estimates are fairly consistent with those obtained on the basis of methods by Brass (1968), Sullivan (1972) or Trussell (1975), the confidence of the analyst should increase considerably.

Admittedly there is no claim here that the method is foolproof in terms of giving an error-free estimate of early childhood mortality. The problem of omitted livebirths still remains unsolved and is likely to affect the estimate of early childhood mortality. However, on the assumption that the omitted events are not very serious, the method does yield some plausible results as long as the analyst is cautious against this probable source of error in the estimates. There is the additional problem that within the limits imposed by the difference between the number of children ever born and those surviving, the childhood mortality pattern within each mother's age cohort may be different from that of the North model.

TABLE 4. DERIVED L_x—VALUES FOR THE FERTILITY DATA REPORTED BY THE FEMALE COHORTS IN SOUTH-WESTERN NIGERIA, 1971 (USING NORTH MODEL)

Cohort	Range of North mortality level	Derived L_x - values	Associated $\overset{o}{e}_x$ values
15-19	21-22	L_0 = 484423.0	71.5
20-24	15-16	L_0 = 450680.3	56.5
		L_5 = 429897.7	59.8
25-29	15-16	L_0 = 447790.8	57.1
		L_5 = 423769.1	58.9
		L_{10}= 414809.0	55.4
30-34	13-14	L_0 = 434249.0	53.0
		L_5 = 404453.4	56.2
		L_{10}= 393231.8	53.2
		L_{15}= 385067.6	49.2
35-39	13-14	L_0 = 437960.8	54.1
		L_5 = 410208.0	56.9
		L_{10}= 399651.9	53.8
		L_{15}= 391864.3	49.8
		L_{20}= 383057.6	45.6
40-44	12-13	L_0 = 427850.3	51.1
		L_5 = 394722.6	54.9
		L_{10}= 382446.8	52.1
		L_{15}= 373730.3	48.3
		L_{20}= 364098.4	44.4
		L_{25}= 353167.8	40.5
45-49	12-13	L_0 = 428166.1	51.2
		L_5 = 395199.2	55.0
		L_{10}= 382973.5	52.2
		L_{15}= 374282.4	48.3
		L_{20}= 364671.8	44.4
		L_{25}= 353762.6	40.6
		L_{30}= 341546.4	36.8

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