19 ESTIMATING MORTALITY FROM CHILD SURVIVORSHIP DATA: A REVIEW

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The Papua New Guinea censuses of 1966, 1971, and 1980-81 each obtained information on numbers of children ever born to women and numbers of children surviving at the time of the census. The use of this information to estimate mortality was pioneered by William Brass just over 30 years ago, and much work has been done subsequently, both in the development of estimation techniques and in their application. This chapter introduces the essential ideas of child survivorship estimation and presents a number of lessons drawn from experience with various applications.

CHILD SURVIVORSHIP ESTIMATION

Child survivorship estimation began with Brass's discovery that the proportions of deceased children among all children ever born to women in standard five-year age groups closely approximate suitably chosen values of q(x), the life table probability of death between age zero and age x. The age groups and corresponding q(x) values are shown in table 19.1, illustrated with 1971 census data for the whole of Papua New Guinea (McDevitt 1981:11). Thus, for example, the census data show that among all children ever born to women aged 25-29, a proportion 0.184 were deceased at the time of the census.

This proportion approximates q(x) for x = 3, so we estimate q(3) = 0.184.

Table 19.1 Mortality Statistics Estimated from Child Survivorship Data by Age of Mother

Age group	Proportion of deceased children among all children ever born to women in this age group	Approximate life table q(x) value	Approximate time, years prior to census
15-19	-	q(1)	1.3
20-24	0.161	q(2)	2.9
25-29	0.184	q(3)	4.5
30-34	0.205	q(5)	6.9
35-39	0.228	q(10)	10.0
40-44	0.258	q(15)	12.1
45-49	0.283	q(20)	15.3
50-54	-	q(25)	18.8
55-59	-	q(30)	21.7
60-64	-	q(35)	23.9

Note: See text for explanation.

The correspondence between the proportions of deceased children and the q(x) values is only approximate, and much effort has been devoted to correcting for the difference, which depends on the history of fertility and mortality in the population. The usual way to adjust for the difference is to multiply the proportions of deceased children by suitably calculated "multipliers."[1] In most applications, however, the multipliers are fairly close to one, and rough estimates may be made simply by ignoring them and using the observed proportions of deceased children as estimates of q(x).

The usefulness of the q(x) estimates is increased greatly by the recognition that any q(x) value may be translated into any other life table statistic using a model life table family.[2] One simply locates the model life table with the given q(x) value and then reads off the desired life table statistic. The advantage of this translation lies

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[1]The first multipliers seem to have been given in Brass (1961). These were followed by those given in Brass and Coale (1968), which are reproduced in United Nations, Department of Economic and Social Affairs (1967:125) and Brass (1975:55) and have been widely used. See also Retherford (1979). The multiplier idea has been elaborated and refined in various ways. See for example Sullivan (1972), Trussell (1975), Preston and Palloni (1978), and Feeney (1982).

A different approach to the use of child survivorship data is given by Preston (1980). This approach uses information on numbers of surviving children only and produces an estimate of adult female mortality. It responds differently to errors in the data, and this may prove useful in analysis. There has been little experience with the technique as yet, however.

[2]The most commonly used model life table families are the Brass logit system and the Coale-Demeny regional tables. On the former see Brass (1971a, 1975), Carrier and Hobcraft (1971:chapter 2 and appendix 1), and Hill and Trussell (1977:314-317). On the latter see Coale and Demeny (1966).

in the possibility of bringing the estimates from the various age groups to a common standard so that they may be compared. For example, the q(x) values in table 19.1 are found to correspond, using the Brass general model life table, to q(5) values of 194, 201, 205, 210, 226 and 228 per thousand, respectively. Thus, we see that the data for all age groups indicates about the same level of mortality, corresponding to a probability of death by age 5 of about 20 percent. We also see that the estimated mortality level increases with the age group of the women.

This observation leads to a third development, the dating of child survivorship estimates. The original Brass method assumed constant mortality. In many applications, however, translating the q(x) estimates to a common standard indicates higher mortality among the children of older women. Declining mortality is a natural explanation for this pattern, since the children of older women were born longer ago and would, if mortality were declining, have experienced higher mortality than the children of younger women.

This observation led to the discovery that the constant mortality assumption could be dropped and that the q(x) estimates (and any estimates derived from them) could be dated a certain number of years prior to the census.[3] Approximate "years prior to census"

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[3]The effects of changing mortality were noted at the outset by Brass and Coale (1968:115-116). Brass (1975:57) described a technique for taking declining mortality into account assuming a known rate of decline of mortality. My work in this area began with Feeney (1975). The estimation procedure proposed originally by Brass assumed (a) constant mortality during the years prior to the census or survey and (b) an age pattern of mortality conforming to a known

model life table family. I replaced these assumptions by (a) linearly declining infant mortality and (b) at each time prior to the census or survey, a period age schedule of mortality conforming to a given model life table family. I found that the linear infant mortality trends consistent with given proportions of deceased children have, to a very close approximation, a common point of intersection a certain number of years prior to the census or survey. Since constant mortality is one linear trend, this point of intersection provides a time to which estimates based on the assumption of constant mortality apply. The calculation of the consistent trends and their points of intersection is quite laborious, however, and Feeney (1976b) gave a simple approximate procedure. The theory was more fully developed in Feeney (1977a), which also gave applications to 15 data sets (Peninsular Malaysia, 1970; Sarawak, 1960 and 1970; the Philippines, 1970; Thailand, 1970; Albania, 1960; Hungary, 1949 and 1960; American Samoa, 1956 and 1974; Fiji, 1956 and 1966; Costa Rica, 1973; and El Salvador, 1971). See also Feeney (1977b). Feeney (1980), a revision of Feeney (1977a), is recommended for an exposition of the principles of estimation. For the purpose of numerical calculation of estimates, however, see Feeney (1982). A closely related line of work begins with Palloni (1976). Palloni (1979, 1980, and 1981) each develops variations of the basic estimation idea. See also Preston and Palloni (1978) and Coale and Trussell's "Annex I" to same. A simple and very useful overview of the variations is given in Palloni (1979:461, "A Summary of Techniques to Estimate Mortality Trends"). Palloni (1981) is particularly recommended for first reading. It gives a succinct statement of principles, applications to some two dozen countries in Africa, Asia, and Latin America and a useful discussion of errors. One application of child survivorship mortality estimates is the calculation of reverse-survival factors for the estimation of births by reverse-survival of census or survey age distributions. Brass (1979a) gives a procedure that estimates the reverse-survival values directly under conditions of changing mortality. This procedure is by far the simplest for this particular application. See also Kraly and Norris (1978), Sullivan (1974), and Sullivan and Udofia (1979). Brass has developed recently a new and more general approach to the dating of retrospective estimates (Brass n.d.), and Brass and Bamgboye (1981) have applied this approach to child survivorship estimates. The years-prior-to-census values for the age groups 15-19 . . . , 45-49 are, respectively, 1.4, 3.2, 4.9, 7.3, 10.2, 12.1, and 15.4 years. These are somewhat higher than the corresponding values in table 19.1, with a maximum difference (for the 25-29 and 30-34 age groups) of 0.4 years. This is not a large difference in practice, and I concur with Brass's suggestion that "the search for high precision would be unrewarding."

values are given in the far right column in table 19.1. Thus, we find that the q(5) value of 0.205 refers to a time approximately 6.9 years prior to the census, or, the census having been taken on June 30, 1971, to the time, expressed in decimal form, 1964.6.

In summary, child survivorship estimation methods involve several basic elements. First, we estimate life table q(x) values from proportions of deceased children. One estimate is obtained from each age group of women, with different age groups corresponding to different values of x. Second, we may translate these q(x) values to other indicators of the level of mortality, such as the infant mortality rate or the expectation of life at birth, using model life table families. Third, we may estimate the dates, or "time locations," for these estimates of mortality level. Estimates for older age groups of women correspond to earlier dates, as one would expect, since older women had their children longer ago. Finally, we may combine the dating of the estimates with their translation to a common base to provide estimates of mortality trends.

DATA QUALITY

Experience with the application of child survivorship estimation techniques shows that the quality of child survivorship data is extremely variable, ranging from very good to extremely poor.[4] Data

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[4] Data for many countries and time periods are conveniently collected in United Nations (1979).

quality varies between national populations, within national populations over time, and between subgroups of national populations at a given time. Thus, Western Samoa data for the censuses of 1956, 1961, and 1966 appear to be reasonably good, whereas the data for the 1971 and 1976 censuses are, by comparison with earlier data and on the grounds of plausibility, so bad as to be useless for mortality estimation (Banister 1979). Peninsular Malaysia data for 1970 are, by comparison with vital registration data, quite good for Malays and Indians and extremely bad for Chinese.[5]

Cases of really bad data reveal themselves by their own absurdity, but there is only limited comfort in this, for if some data can be so bad as to be obviously useless, it is only reasonable to suppose that other data will be sufficiently bad to mislead and yet not bad enough to betray itself.

Having said the worst, it should be emphasized that the situation is not nearly so bad as the worst suggests it could be. Reasonably good data seem to be more common than very bad data, and in most situations there will be sufficient information available to test data quality and so guard against misleading conclusions.

ESTIMATION VERSUS DIAGNOSIS

There is nothing remarkable in calling attention to the need to consider errors in demographic data. Indeed, this is a truism. But

[5]The 1970 Peninsular Malaysia data on children surviving have never been published, but have been made available to researchers.

it is frequently suggested, more by implication and example than by direct statement, that the calculation of estimates should not be undertaken until the quality of the data on which they are based has been assessed. The correct sequence is in fact precisely the opposite. The first step is to calculate estimates. The second step is to analyze the estimates, comparing them with other sources of information. The calculation of estimates comes first because the transformation of the data into estimates is by far the best way we have to assess data quality.

The practical conclusion is that the "estimation" techniques are tools for diagnosis as well as for estimation. We calculate estimates first to diagnose data quality, and then proceed to conclusions about levels, trends, and differentials in mortality, using the results of the diagnosis stage to establish margins of error.

LESSONS OF EXPERIENCE

The mechanical application of estimation methods to data is ultimately a fairly trivial matter, though considerable effort is required to master the relevant literature. What matters most in practice is the ability to use the methods to analyze data. How are the techniques used to analyze data? How do we diagnose data quality? How do we evaluate the validity of the assumptions? What is the net effect on the estimates? How much can we conclude, and how reliably, about demographic reality from the available data? These are matters of judgment in which experience as well as knowledge of the particular method used plays a key role. We have a good deal of experience with applications for scores of populations, and a number of lessons stand out.

Calculate Estimates from Data for All Age Groups

It is widely believed that reports of numbers of children born and surviving are unreliable for women past middle reproductive ages. Thus, Sullivan (1972) provides multipliers only for age groups 15-19, 20-24, and 25-29, forcing the user to ignore data for women over age 30. The reason given for this belief is that mean values of children ever born decline with advancing age beyond a certain age. This is sometimes considered to reflect memory lapse among older women. If reporting of children born and children surviving decline, however, the effects will partially cancel out in the calculation of proportions of deceased children. In any event, numerous applications show that data for women up to and even over age 50 give reasonably good estimates (Feeney 1977a).

At the same time, other applications show that data for young women may be very bad, a phenomenon that presumably cannot be explained by memory lapse (Cho and Feeney 1976). In view of these facts, the sensible rule is to abandon preconceptions and let the data speak for itself. Calculate estimates for all available age groups, scrutinize the results carefully, making the comparisons indicated below, and only then decide what should be believed and what should be discounted or discarded.

Compare Estimates for Subpopulations

Peninsular Malaysia provides a good example of the value of this rule. The estimates obtained for the total population from the 1970 census data are substantially low by comparison with vital registration data that is reasonably complete. When estimates are calculated for community groups, however, the estimates for Malays and Indians are found to be quite good, and the estimates for Chinese extremely bad. The errors in the total population estimates are thus largely because of the bad data for the Chinese subpopulation. Incidentally, this indicates that the data problems in this instance lie with the respondents rather than with the census operation.

Compare Estimates from Successive Censuses

American Samoa, Fiji, Gilbert and Ellice Islands, and Hungary provide examples in which estimates from two successive censuses provide evidence in favor of both data quality and the validity of the assumptions used (Feeney 1976b and 1977a). The East Malaysian state of Sabah provides an example of how such comparisons can generate a warning that something is seriously wrong (Feeney 1977a). Korea provides an example showing that consistency does not prove correctness, for three successive censuses yield reasonably consistent estimates, all of which are seriously low (Cho and Feeney 1976).

Compare Estimates with Vital Registration Data

The Philippines provides an example showing that this comparison can be very useful even if the vital registration data are substantially incomplete (Feeney 1977a). The infant mortality rates estimated from Philippines child survivorship data are substantially lower than rates calculated from vital statistics, which are almost certainly below the true values. The conclusion is that the child survivorship data is seriously flawed and probably useless for mortality estimation.

Compare Estimates with Birth History Data

There seems to be little doubt that, short of a fully developed vital registration system, birth histories from a well-conducted fertility survey provide the best estimates of infant and child mortality, at a substantial cost, of course, and for relatively little data, as the numbers will be too small to allow much disaggregation by areas or characteristics. Birth history data probably provides the best information on the appropriate model life table specification. An analysis of data for Nepal illustrating this lesson is given in Thapa and Retherford (1982).

Discount Estimates from the 15-19 Age Group

Children born to women aged 15-19 were obviously born to mothers less than age 20 at the time of birth, and births to young women experience relatively high mortality. This biases the mortality estimates from this age group upward. The bias shows clearly in one application after another and is confirmed by direct data on infant mortality rates by age of mother (Feeney 1980). Data for women aged 20-24 are slightly biased as well. Ewbank (1982) has recently suggested a method of adjusting for this bias and has applied it to data for Bangladesh. It appears to work well in this case, but the magnitude of this particular bias in Bangladesh is fairly small and it remains to be seen how well the method will work in other applications.

Beware of Model Life Table Specification

Model life table families enter into the calculation of child survivorship estimates at several points, but certain calculations are more vulnerable than others to departures of the actual, unobserved pattern of mortality from the assumed model pattern. The use of proportions of deceased children to estimate q(x) values is of course independent of any model life table specification. The multipliers used to refine these estimates do depend on model life table specification, but the multipliers are relatively insensitive to the model life table family chosen (Brass and Coale 1968:112-114). The real danger in model life table specification comes in the translation of the q(x) values to a common value and in the attempt to estimate trends. The Coale-Demeny (1966) regional model life tables provide a simple way to get a bearing on the errors involved. There are four models, labeled "West," "North," "East," and "South," each of which may be used to translate any q(x) value into any other life table value. Suppose for example that we have estimated a q(5) value of 0.2 from child survivorship data. The West model life table with q(5) = 0.2 has a q(1) value of 0.130. The North model with this value of q(5) has a q(1) value of 0.115, about 10 percent lower, and the East model with this value of q(5) has a q(1) value of 0.145, about 10 percent higher. These figures are obtained by interpolation in the model life tables given in Coale and Demeny (1966). Thus, if the translation of a q(5) to a q(1) value is based on a West model table, an error of about 10 percent will be incurred if the true pattern of mortality conforms to the North or East model. This example is broadly representative, but two points should be made. First, the translation to q(1) is particularly sensitive to model life table specification. Translation from q(10) or q(15) to q(5), for example, incurs errors of about five percent. Second, translations over long age spans can give errors up to 20 percent and, in a few extreme cases, even larger errors. Thapa and Retherford (1982) have shown how extreme a range of trends can result from letting the model life table family vary arbitrarily.

DATA COLLECTION AND PROCESSING

In the matter of child survivorship data, the purpose of the census or survey schedule is to obtain for each woman the number of children this woman has ever born alive in her lifetime and the number of these children who are surviving at the time of the census. The obvious and most common approach is to ask for this information directly. Various alternatives have been suggested, however, with the idea of improving the response. It has been suggested, for example, that completeness of reporting will be improved by asking about "children ever born now living in this household," "children ever born now living elsewhere," and "children ever born now deceased," the idea being that this will reduce underreporting of deceased children. Numbers of surviving children are then obtained as the sum of the first two responses and numbers of children ever born as the sum of all three responses. Other variations have involved questions on stillborn children and adoption.[6]

There has been little research on the effects of these variations in the form of the questions on the quality of the data collected. Blacker (1974) and Blacker and Brass (1979) report significant improvements in the results for several African censuses. Banister (1979), on the other hand, reports that innovations made in the 1971 and 1976 censuses of Western Samoa reduced the quality of reporting so seriously that the resulting data are useless for the purpose of estimating mortality.

In view of these mixed results, innovations in the form of the questions should be approached with caution, recognizing the risk that they may impair rather than improve the results. Innovations probably should not be made unless pretest results can be carried through to tabulation and analysis, for it is only at the analysis stage that one can assess the results. The need for pretesting is a truism, of course, but pretesting is limited frequently to

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[6]Cho (no date) is useful in providing copies of census schedules for a number of countries with English translation of contents. See page 129 for a copy of the 1970 Malaysia schedule, which asks for children born in four categories: living here, living elsewhere, dead, and born dead. This detail was dropped in the 1980 census schedule, which asks "Have you ever given birth to any child?" and, in the event of a positive response, "How many children in total have ever been born alive to you?" and "How many are still living?"

operational issues that provide important but very incomplete evidence on data quality.

In the training of enumerators, the distinction between "no children ever born" and "not applicable" should be made. The importance of such distinctions will be familiar to everyone who has been involved in census or survey work, but it requires specific mention here because it has been shown repeatedly to be problematic with the children-ever-born question. One of the earliest discussions is given by Del Tufo in the report of the 1947 census of (what was then) Malaya.[7] El-Badry (1961) provides further evidence for several diverse countries and also a technique for correction. Questions have arisen recently, however, about the validity of the El-Badry correction.[8]

With respect to editing procedures, it is desirable that any imputations applied to children-born and children-surviving information not affect the ratio between them. A preliminary edit specification for the 1970 census of Malaysia, for example, would have imputed number of surviving children, if not stated, equal to number of children ever born (if stated). This is not an unreasonable specification if the children-surviving information is considered in isolation, for if mortality is low, number of children

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[7] Del Tufo (1947:pars.262-267).

[8] John Blacker (personal communication, August 24, 1982), relating to data for Kenya.

ever born is a reasonably good proxy for number of surviving children. Obviously, it is unacceptable from the point of view of child survivorship estimation, however, for it imputes zero mortality whenever number of surviving children is not stated. This deficiency was recognized and the specification revised.[9]

The standard procedure for tabulating child survivorship information is to provide, for the total population and any desired subgroups, one table of women by age and number of children ever born and one table of women by age and number of children surviving. The women tabulated are restricted in each case to those to whom the questions were addressed (all women over age 10, for example, or all ever-married women over age 12; this varies from case to case). Age is usually given in five-year groups, and this is the information that most estimation procedures require as input. However, it may be useful to provide some tables with age given in single years. For the use of single-year information see the ingenious analysis of Indonesian data given by Hull and Sunaryo (1978).

Tabulated numbers of children ever born will terminate generally with an open-ended group, "15 or more children ever born," for example, and similarly for numbers of children surviving. It is desirable that this value be chosen sufficiently high that only small numbers of women fall in the open-ended category. The reason is that the mortality estimation requires total numbers of children ever born

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[9]This information was supplied in discussions with the staff of the Statistics Department of Malaysia during 1974 and 1975.

and surviving for women in each age group, and these must be calculated from the distributions of the women by number of children ever born or surviving. This poses no difficulty for women of specific parities (though the calculation is a nuisance), for we know that, say, 1,000 women with 5 children ever born have produced a total of 5,000 children ever born. We cannot say exactly how many children have been born to 1,000 women with 15 or more children ever born, however, only that it must be more than 15,000. Therefore, it is necessary to estimate this number, as for example by the procedure given in Saw Swee-Hock (1964:appendix 3). This incurs some error, however, and the effect on the final calculated numbers of children ever born and surviving will be minimized if the open-ended group begins at a high number of children ever born or surviving. Feeney (1977a:section 4.4) shows, using Fiji data for 1966, that truncating at 9+ children ever born or surviving biases infant mortality estimates upward by about 20 percent.

Both the errors created by open-ended groups and the nuisance of the calculations they require may be avoided altogether by tabulating total numbers of children born and surviving to women in each age group. These numbers may be given in a single extra column in the standard tables. This tabulation format was recommended in Feeney (1976a) and has been followed widely in recent years.

CONCLUSION

The single most important conclusion to be drawn from our knowledge and experience to date may be summed up in a simple maxim:

Never trust a single set of data! In those rare cases where no data are available for comparison, little if anything can be concluded. In most situations, however, there will be sufficient information available from other sources to cross-check results. What needs to be emphasized is that these cross-checks must be made. It is never sufficient simply to produce a set of estimates by mechanical application of one or another of the available methods.

A related point concerns data collection. We know that data quality is a critical issue, and we know that in many cases data quality can be affected by appropriate efforts in collection. Yet there is a remarkable lack of systematic, published knowledge in this area, and a readiness to accept speculation and plausibility that contrasts strangely with the theoretical rigor observed in the development of estimation techniques. The explanation is not hard to find. Collection and processing of data and its analysis are by and large carried out by different groups of people, and with a large degree of independence. This is not the way text books say it should happen, but with rare exceptions this is how it does happen. To gain systematic knowledge in this area, however, requires cooperative efforts on the part of both groups. The practical difficulties of securing cooperation should not be underestimated. But the knowledge gained, both of conditions in particular areas and of generally applicable conclusions, might well justify the efforts.

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