Chapter III

ESTIMATION OF CHILD MORTALITY FROM INFORMATION ON CHILDREN EVER BORN AND CHILDREN SURVIVING

A. BACKGROUND OF METHODS

1. *Use of data on child survivorship*

It is well known that the proportions of children ever born who have died are indicators of child mortality and can yield robust estimates of childhood mortality. The births to a group of women follow some distribution over time, and the time since birth is the length of exposure to the risk of dying of each person. The proportion dead among the children ever borne by a group of women will therefore depend upon the distribution of the children by length of exposure to the risk of dying (that is, upon the distribution in time of the births) and upon the mortality risks themselves. By allowing for the effects of the distribution of the births in time, such a proportion of dead children can be converted into a conventional mortality measure expressing their average experience. Specifically, the proportions of children dead classified by the mother's five-year age group or duration of marriage can provide estimates of the probabilities of dying between birth and various childhood ages. In certain cultures, women appear to be more likely to state duration of marriage correctly than to give correct information about their age, so the estimation procedure based on data classified by duration of marriage may be preferred. However, the use of data classified by duration is not recommended in countries where consensual unions are frequent and relatively unstable.

Brass[1] was the first to develop a procedure for converting proportions dead of children ever born reported by women in age groups 15-19, 20-24, etc. into estimates of the probability of dying before attaining certain exact childhood ages. Following the notation in the literature and using the symbol $D(i)$ to denote the proportion dead among children ever born to women in successive five-year age groups (where $i = 1$ signifies age group 15-19; $i = 2$ denotes 20-24; etc.), Brass developed a procedure to convert $D(i)$ values into estimates of $q(x)$, where $q(x) = 1.0 - l(x)$, the probability of dying between birth and exact age x. The basic form of the estimation equation proposed by Brass is

$$q(x) = k(i)\,D(i) \qquad \text{(A.1)}$$

where the multiplier $k(i)$ is meant to adjust for non-mortality factors determining the value of $D(i)$.

Brass found that the relation between the proportion of children dead, $D(i)$, and a life-table mortality measure, $q(x)$, is primarily influenced by the age pattern of fertility, because it is this pattern that determines the distribution of the children of a group of women by length of exposure to the risk of dying. He developed a set of multipliers to convert observed values of $D(i)$ into estimates of $q(x)$, the multipliers being selected according to the value of $P(1)/P(2)$—a good indicator of fertility conditions at younger ages—where $P(i)$ is the average parity or average number of children ever born reported by women in age group i. Brass estimated the $k(i)$ multipliers by using a third-degree polynomial of fixed shape but variable age location to represent fertility,[2] the logit system generated by the general standard (see chapter I, subsection B.4) to provide the mortality element, and a growth rate of 2 per cent per annum to generate a stable age distribution for females.

An important assumption made in the development of this method is that the risk of dying of a child is a function only of the age of the child and not of other factors, such as mother's age or the child's birth order. In practice, it appears that children of young mothers experience mortality risks well above average. For this reason, the estimate of the infant mortality rate $q(1)$ (the probability of dying before age 1) that can be derived from reports of women aged 15-19 frequently suggests heavier child mortality than estimates derived from reports of older women. Therefore, mortality estimates based on the reports of women aged 15-19 are generally disregarded, in part for this reason and in part because the numbers of children born and dead are usually small.

Trying to increase the flexibility of Brass' original method, Sullivan[3] computed another set of multipliers by using least-squares regression to fit equation (A.1) to data generated from observed fertility schedules and the Coale-Demeny life tables.[4] Trussell[5] estimated a third set of multipliers by the same means but using data generated from the model fertility schedules developed by

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1 William Brass, "Uses of census or survey data for the estimation of vital rates" (E/CN.14/CAS.4/V57), paper prepared for the African Seminar on Vital Statistics, Addis Ababa, 14-19 December 1964.

2 William Brass, *Methods for Estimating Fertility and Mortality from Limited and Defective Data* (Chapel Hill, North Carolina, Carolina Population Center, Laboratories for Population Statistics, 1975).

3 Jeremiah M. Sullivan, "Models for the estimation of the probability of dying between birth and exact ages of early childhood", *Population Studies*, vol. XXVI, No. 1 (March 1972), pp. 79-97.

4 Ansley J. Coale and Paul Demeny, *Regional Model Life Tables and Stable Populations* (Princeton, New Jersey, Princeton University Press, 1966).

5 T. James Trussell, "A re-estimation of the multiplying factors for the Brass technique for determining childhood survivorship rates", *Population Studies*, vol. XXIX, No. 1 (March 1975), pp. 97-108.

Coale and Trussell.[6] The general theory on which these methods are based is essentially the same, but they arrive at somewhat different multipliers because the data bases used in each case are different. Since the Sullivan variant has no obvious advantages over that proposed by Trussell, whereas the latter is based on a wider range of cases, the Trussell procedure is described here. It must be mentioned, however, that the multipliers presented are a more recent and more satisfactory version of those originally proposed by Trussell in 1975.

It is important to take note that this method of estimation is based on the assumption that fertility and childhood mortality have remained constant in the recent past. If, for example, fertility has been changing, the ratios of average parities obtained from a cross-sectional survey will not replicate accurately the experience of any cohort of women and will not provide a good index of the distribution in time of the births to the women of each age group.

The problems caused by declining fertility can be avoided when data for true cohorts are available (from censuses or surveys taken five or 10 years apart). In this case, an estimation method specifically designed for cohorts experiencing fertility change should be used.[7]

Preston and Palloni[8] propose an alternative approach to estimate the time location of births, which circumvents all the problems associated with changing fertility. This approach is closely related to the "own-children" procedure for estimating fertility from an age distribution (see chapter VIII, section C). If it is possible to link, within households, the records of mothers and their surviving children, it becomes possible to tabulate surviving children according both to their own age and to that of their mothers. Given an age pattern of mortality, say, from one of the Coale-Demeny regional model life tables, the combination of the proportion of children dead and the age distribution of the surviving children of women from some particular age group uniquely determines a level of mortality. The age distribution of surviving children is used to define the age distribution of children ever born without recourse to fertility models. In an actual application, the choice between the age distribution of surviving children and the ratio of consecutive parities to estimate the real distribution of births over time, depends upon data availability and upon a rough assessment of the likelihood each approach has of yielding the best possible estimate. In cases where age-reporting is good and most children live with their mothers, the approach suggested by Preston and Palloni may be the better, particularly if fertility is changing. In cases where age-reporting or completeness of enumeration is poor, or where a sizeable proportion of children do not live with their mothers or cannot be properly linked to them because of poor information, the parity-ratio approach is very likely to be better. A detailed description of the Preston-Palloni method is not included here, in part because in most cases where mortality needs to be estimated indirectly, age distributions are at best only moderately reliable, and in part because the data required for its application are not as widely available as the proportions of children dead. However, the user who has access to the former data for cases where biases due to fertility change may be a problem is encouraged to consider the application of this method.

Probably a more widespread problem is posed by declining mortality. The procedures outlined above all assume that a constant pattern and level of mortality have prevailed in the recent past of the population under study. In most countries, however, mortality has been declining.

Feeney[9] was the first to examine the effects of changing mortality on the performance of the child-mortality estimation procedure. Using infant mortality as an index of mortality level in a one-parameter logit life-table system, he calculated the proportions of children dead that would be observed if infant mortality were changing linearly through time. On the basis of these simulated cases, he showed that for plausible annual rates of change in infant mortality, the $q(1)$ values estimated from data on children ever born and surviving for different age groups of mother could be matched with the $q(1)$ values prevalent during a set of years before the survey; and that this set of years was, for all practical purposes, invariant with respect to the rate of mortality change. Using this empirical finding, Feeney developed an estimation procedure to establish the set of years to which infant mortality rates estimated from data on children ever born and children surviving refer. This procedure was developed from data generated by using a one-parameter logit life-table system derived from the general standard (see chapter I, subsection B.4) and the Brass fertility polynomial.[10] The use of $q(1)$, infant mortality, as an indicator of mortality level and as the estimated parameter makes the underlying age pattern of mortality important to the results, since similar overall levels of mortality (life tables with the same expectation of life at birth, for example) can be associated with markedly different infant mortality rates. As a result, the Feeney method is likely to yield biased $q(1)$ estimates when the mortality pattern in early childhood of the population under study does not resemble that embodied by the general standard. For this reason, Feeney's original method is not described in detail.

It is fairly straightforward to apply Feeney's approach to data generated with other mortality models. Coale

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[6] Ansley J. Coale and T. James Trussell, "Model fertility schedules: variations in the age structure of childbearing in human populations", *Population Index*, vol. 40, No. 2 (April 1974), pp. 185-258.

[7] This method is presented in section E and it uses the estimation equations and coefficients given in tables 70-71.

[8] Samuel H. Preston and Alberto Palloni, "Fine-tuning Brass-type mortality estimates with data on ages of surviving children", *Population Bulletin of the United Nations, No. 10-1977* (United Nations publication, Sales No. E.78.XIII.6), pp. 72-87.

[9] Griffith Feeney, "Estimating infant mortality rates from child survivorship data by age of mother", *Asian and Pacific Census Newsletter*, vol. 3, No. 2 (November 1976), pp. 12-16; and Griffith Feeney, "Estimating infant mortality trends from child survivorship data", *Population Studies*, vol. XXXIV, No. 1 (March 1980), pp. 109-128.

[10] W. Brass, *Methods for Estimating Fertility and Mortality from Limited and Defective Data.*

and Trussell[11] carried out this exercise by assuming that period mortality changes can be modelled as movements through successively higher (or lower) levels of a set of model life tables, so that cohort life tables may be obtained by chaining together the mortality rates experienced by true cohorts living through the different periods. In this case, it can also be shown empirically that the child mortality estimate of the Brass type obtained from data for women in age group i, for example, is equal to the corresponding value prevalent during some particular period $t(x)$ years before the survey, and that this period is, for most practical purposes, invariant with respect to the speed of mortality change, so long as the rate of change is roughly constant over time. Because these time-location estimates have been derived in a manner that is consistent with that used in deriving the Trussell multiplying factors employed in estimating child mortality in this chapter, this timing procedure is described here.

An alternative solution to the problem of declining mortality is possible if data on children ever born and surviving are available from two surveys taken five or 10 years apart. It arises, once again, from the use of a hypothetical cohort representing the intersurvey experience; and it provides mortality estimates that refer to the intersurvey period. This estimation approach is not sensitive to the exact shape of mortality changes, but changes in the completeness of reporting of dead children from one survey to the next or population changes that are selective for the number of dead children may seriously affect the results.

To conclude these preliminary remarks on the methods presented in this chapter, it should be pointed out that for several of them two variants are presented: one variant to be applied when data on children ever born and surviving are classified by age of mother; and another when they are classified by duration of first marriage. The variants based on data classified by duration of marriage are, strictly speaking, based on the assumption that women, once married, stay married until age 50 (the assumed upper limit of the potential reproductive life of a woman). Therefore, the duration-based methods should strictly be applied only to data from currently married women still in their first union. However, in practice, no serious biases will arise when they are applied to data pertaining to all ever-married women, as long as their marriage duration is calculated as the time elapsed since first marriage.

As a last word of caution, it must be said that the performance of the duration variants of these methods can be rather poor when "duration" is not accurately measured. Problems in the measurement of this variable have been described in chapter II, subsection A.2, and are only briefly cited now. Duration of marriage is defined as the time elapsed since first union, regardless of whether that union is legal. Data on duration of marriage will be less than ideal when only legal unions are considered; when the time elapsed is not measured from the beginning of the first union, but rather from that of the current union; or when, as in some Muslim cultures, the entrance into a legal marriage predates the initiation of cohabitation. In populations where these problems are likely to arise, the duration variant should not be used.

2. *Organization of this chapter*

All the estimation procedures presented in this chapter have one characteristic in common: they use data on children ever born and surviving. However, the methods can be separated into categories according to the exact type of data they require (whether classified by age or by duration of marriage, for example), or according to the practical constraints that their assumptions impose (whether fertility is assumed to be constant or not). Sections B-E are devoted to the different categories. To aid the user in selecting that most suited for a particular application, brief descriptions of each section follow (see also table 46):

Section B. Estimation of child mortality using data classified by age. In this section, the most recent version of the original Brass estimation procedure is presented (Trussell's method). Estimates of $q(2)$, $q(3)$, $q(5)$, $q(10)$, $q(15)$ and $q(20)$, as well as of the periods to which they refer in cases where a smooth change in mortality can be assumed, are obtained from data on children ever born and surviving classified by age of mother. Fertility patterns are assumed to remain constant;

Section C. Estimation of child mortality using data classified by duration of marriage. In this section, a variant of the original Brass method that may be applied to data classified by duration of first marriage is presented. Estimates of $q(2)$, $q(3)$, $q(5)$, $q(10)$, $q(15)$, $q(20)$ and $q(25)$, as well as of the periods to which they refer in cases where a smooth change in mortality can be assumed, are obtained from data on children ever born and surviving classified by the mother's marriage duration. Marital fertility patterns are assumed to remain constant;

Section D. Estimation of intersurvey child mortality using data for a hypothetical intersurvey cohort. In this section, data from two censuses or surveys five years apart are used to estimate average intersurvey child mortality. The use of hypothetical cohorts circumvents the necessity of assuming that fertility and mortality have remained constant. Therefore, if the data at the two points in time considered are similar in quality and moderately reliable, intersurvey estimates are to be preferred over those derived by other means;

Section E. Estimation of child mortality when the fertility experience of true cohorts is known. In this section, data from two censuses or surveys five or 10 years apart are used to determine the parity ratios for true cohorts; and these ratios, in turn, are employed in estimating child mortality from data collected by the second census or survey. Both an age and a duration variant are described in subsection E.2. The time location of the child mortality estimates obtained is also estimated and constant fertility is not assumed.

11 Ansley J. Coale and James Trussell, "Estimating the time to which Brass estimates apply", annex I to Samuel H. Preston and Alberto Palloni, "Fine-tuning Brass-type mortality estimates with data on ages of surviving children", *Population Bulletin of the United Nations, No. 10-1977*, pp. 87-89.

TABLE 46. SCHEMATIC GUIDE TO CONTENTS OF CHAPTER III

Section	Type of input data	Estimated parameters
B. Estimation of child mortality rates using data classified by age (one survey)	Children ever born classified by five-year age group of mother Children surviving (or dead) classified by five-year age group of mother Women classified by five-year age group	$q(2)$, $q(3)$, $q(5)$, $q(10)$, $q(15)$ and $q(20)$ Reference period for each $q(x)$ estimate
C. Estimation of child mortality using data classified by duration of marriage (one survey)	Children ever born classified by five-year duration of marriage group of mother Children surviving (or dead) classified by five-year duration of marriage group of mother Ever-married women classified by five-year duration of marriage group	$q(2)$, $q(3)$, $q(5)$, $q(10)$, $q(15)$, $q(20)$ and $q(25)$ Reference period for each $q(x)$ estimate
D. Estimation of intersurvey child mortality using data for a hypothetical intersurvey cohort (data by age from two surveys five years apart)	Children ever born classified by five-year age group of mother from two surveys or censuses five years apart Children surviving (or dead) classified by five-year age group of mother from two surveys or censuses five years apart Women classified by five-year age group from two surveys or censuses five years apart	Intersurvey estimates of $q(2)$, $q(3)$, $q(5)$, $q(10)$, $q(15)$ and $q(20)$
E. Estimation of child mortality when the fertility experience of true cohorts is known	Children ever born classified by five-year age (duration) group of mother from surveys or censuses five or 10 years apart Children surviving (or dead) classified by five-year age (duration) group of mother from the second survey or census Women (ever-married women) classified by five-year age (duration) group	$q(2)$, $q(3)$, $q(5)$ and $q(10)$, and their time reference periods when data are classified by age and surveys are five years apart $q(3)$, $q(5)$ and $q(10)$ with reference periods when data are classified by age and surveys are 10 years apart $q(3)$, $q(5)$ and $q(10)$ with reference periods when data are classified by duration and surveys are five years apart $q(5)$ and $q(10)$ with reference periods when data are classified by duration and surveys are 10 years apart

B. ESTIMATION OF CHILD MORTALITY RATES USING DATA CLASSIFIED BY AGE

1. *Data required*

The data required for this method are listed below:

(*a*) The number of children ever born, classified by sex (see note) and by five-year age group of mother;

(*b*) The number of children surviving (or the number dead), classified by sex (see note) and by five-year age group of mother;

(*c*) The total number of women (irrespective of marital status), classified by five-year age group. Note that all women, not merely ever-married women, must be considered.

Note should be taken also that classification by sex for children ever born and surviving is desirable, not essential. If it is available, child mortality for each sex can be estimated separately; whereas if it is not available, estimates for each sex can only be obtained by assuming that the sex differentials in the population being studied are the same as those embodied by model life tables whose mortality level is consistent with the estimated child mortality of both sexes, or by making some other assumption about the relationship between male and female child mortality.

When data on children ever born are classified by sex, their consistency may be ascertained by computing the sex ratios (defined as the average number of male children per female child) of children ever born by age of mother. Ideally, these sex ratios should not vary systematically with age and their values should be between

1.02 and 1.07. Studies made in countries where birth registration is fairly complete have shown that the sex ratio at birth is remarkably constant and that its usual value is around 1.05 males per female. In populations originating in Africa south of the Sahara, this value appears to be closer to 1.03. In either case, however, its constancy and the fact that women are supposed to declare all the children they have ever borne alive, whether these children survived or not, allows a simple consistency check. In populations other than those originating in sub-Saharan Africa, sex ratios higher than 1.07 or lower than 1.02 suggest differential omission of females or males, respectively, or misreporting of the sex of the reported children.

2. *Computational procedure*

The steps of the computational procedure are described below.

Step 1: calculation of average parity per woman. Parity $P(1)$ refers to age group 15-19, $P(2)$ to 20-24 and $P(3)$ to 25-29. In general,

$$P(i) = CEB(i)/FP(i) \qquad \text{(B.1)}$$

where $CEB(i)$ denotes the number of children ever borne by women in age group i; and $FP(i)$ is the total number of women in age group i, irrespective of their marital status. Recall that, following the usual convention, variable i refers to the different five-year age groups considered. Thus, the value $i = 1$ represents age group 15-19, $i = 2$ group 20-24 and so on. The treatment of women whose parity is not stated is discussed in chapter II, subsection A.2, and annex II. In general, if the El-Badry technique for estimating true non-response cannot be applied, women of unstated parity should be included in the female population denominator when calculating average parity, since childless women are often misclassified as cases of non-response.

Step 2: calculation of proportion of children dead for each age group of mother. The proportion of children dead, $D(i)$, is defined as the ratio of reported children dead to reported children ever born, that is,

$$D(i) = CD(i)/CEB(i) \qquad \text{(B.2)}$$

where $CEB(i)$ is defined as in step 1; and $CD(i)$ is the number of children dead reported by women in age group i.

Step 3: calculation of multipliers. Table 47 presents the estimation equations and the necessary coefficients to estimate the multipliers, $k(i)$, according to the Trussell variant of the original Brass method. A different set of

TABLE 47. COEFFICIENTS FOR ESTIMATION OF CHILD MORTALITY MULTIPLIERS, TRUSSELL VARIANT, WHEN DATA ARE CLASSIFIED BY AGE OF MOTHER

Mortality model (1)	Age group (2)	Index i (3)	Mortality ratio[a] $q(x)/D(i)$ (4)	Coefficients $a(i)$ (5)	$b(i)$ (6)	$c(i)$ (7)
North	15-19	1	$q(1)/D(1)$	1.1119	−2.9287	0.8507
	20-24	2	$q(2)/D(2)$	1.2390	−0.6865	−0.2745
	25-29	3	$q(3)/D(3)$	1.1884	0.0421	−0.5156
	30-34	4	$q(5)/D(4)$	1.2046	0.3037	−0.5656
	35-39	5	$q(10)/D(5)$	1.2586	0.4236	−0.5898
	40-44	6	$q(15)/D(6)$	1.2240	0.4222	−0.5456
	45-49	7	$q(20)/D(7)$	1.1772	0.3486	−0.4624
South	15-19	1	$q(1)/D(1)$	1.0819	−3.0005	0.8689
	20-24	2	$q(2)/D(2)$	1.2846	−0.6181	−0.3024
	25-29	3	$q(3)/D(3)$	1.2223	0.0851	−0.4704
	30-34	4	$q(5)/D(4)$	1.1905	0.2631	−0.4487
	35-39	5	$q(10)/D(5)$	1.1911	0.3152	−0.4291
	40-44	6	$q(15)/D(6)$	1.1564	0.3017	−0.3958
	45-49	7	$q(20)/D(7)$	1.1307	0.2596	−0.3538
East	15-19	1	$q(1)/D(1)$	1.1461	−2.2536	0.6259
	20-24	2	$q(2)/D(2)$	1.2231	−0.4301	−0.2245
	25-29	3	$q(3)/D(3)$	1.1593	0.0581	−0.3479
	30-34	4	$q(5)/D(4)$	1.1404	0.1991	−0.3487
	35-39	5	$q(10)/D(5)$	1.1540	0.2511	−0.3506
	40-44	6	$q(15)/D(6)$	1.1336	0.2556	−0.3428
	45-49	7	$q(20)/D(7)$	1.1201	0.2362	−0.3268
West	15-19	1	$q(1)/D(1)$	1.1415	−2.7070	0.7663
	20-24	2	$q(2)/D(2)$	1.2563	−0.5381	−0.2637
	25-29	3	$q(3)/D(3)$	1.1851	0.0633	−0.4177
	30-34	4	$q(5)/D(4)$	1.1720	0.2341	−0.4272
	35-39	5	$q(10)/D(5)$	1.1865	0.3080	−0.4452
	40-44	6	$q(15)/D(6)$	1.1746	0.3314	−0.4537
	45-49	7	$q(20)/D(7)$	1.1639	0.3190	−0.4435

Estimation equations:

$$k(i) = a(i) + b(i)\,(P(1)/P(2)) + c(i)\,(P(2)/P(3))$$

$$q(x) = k(i)\,D(i)$$

[a] Ratio of probability of dying to proportion of children dead. This ratio is set equal to the multiplier $k(i)$.

coefficients is provided for each of the four different families of model life tables in the Coale-Demeny system.

Step 4: calculation of probabilities of dying and of surviving. Estimates of the probability of dying, $q(x)$, are obtained for different values of exact age x as the product of the reported proportions dead, $D(i)$, and the corresponding multipliers, $k(i)$. Note that the value of x is not generally equal to that of i, because x is related, in broad terms, to the average age of the children of women in age group i.

Once $q(x)$ is estimated, its complement $l(x)$, the probability of surviving from birth to exact age x, is readily obtained as $l(x)= 1.0-q(x)$.

Step 5: calculation of reference period. As explained earlier, when mortality is changing smoothly, the reference period, $t(x)$, is an estimate of the number of years before the survey date to which the child mortality estimates, $q(x)$, obtained in the previous step refer. The value of $t(x)$ is also estimated by means of an equation whose coefficients were estimated from simulated cases by using linear regression. The equation used in this case is presented in table 48 together with a set of values for its coefficients.

3. *A detailed example*

The data shown in table 49 were gathered by a survey carried out in Panama between August and October 1976. They are used to illustrate the method just described. However, before proceeding with the estimation of child mortality, a quick check of the consistency

TABLE 48. COEFFICIENTS FOR ESTIMATION OF THE REFERENCE PERIOD, $t(x)$,[a] TO WHICH THE VALUES OF $q(x)$ ESTIMATED FROM DATA CLASSIFIED BY AGE REFER

Mortality model (1)	*Age group* (2)	*Index* i (3)	*Age* x (4)	*Parameter estimate* (5)	*Coefficients* $a(i)$ (6)	$b(i)$ (7)	$c(i)$ (8)
North	15-19	1	1	$q(1)$	1.0921	5.4732	−1.9672
	20-24	2	2	$q(2)$	1.3207	5.3751	0.2133
	25-29	3	3	$q(3)$	1.5996	2.6268	4.3701
	30-34	4	5	$q(5)$	2.0779	−1.7908	9.4126
	35-39	5	10	$q(10)$	2.7705	−7.3403	14.9352
	40-44	6	15	$q(15)$	4.1520	−12.2448	19.2349
	45-49	7	20	$q(20)$	6.9650	−13.9160	19.9542
South	15-19	1	1	$q(1)$	1.0900	5.4443	−1.9721
	20-24	2	2	$q(2)$	1.3079	5.5568	0.2021
	25-29	3	3	$q(3)$	1.5173	2.6755	4.7471
	30-34	4	5	$q(5)$	1.9399	−2.2739	10.3876
	35-39	5	10	$q(10)$	2.6157	−8.4819	16.5153
	40-44	6	15	$q(15)$	4.0794	−13.8308	21.1866
	45-49	7	20	$q(20)$	7.1796	−15.3880	21.7892
East	15-19	1	1	$q(1)$	1.0959	5.5864	−1.9949
	20-24	2	2	$q(2)$	1.2921	5.5897	0.3631
	25-29	3	3	$q(3)$	1.5021	2.4692	5.0927
	30-34	4	5	$q(5)$	1.9347	−2.6419	10.8533
	35-39	5	10	$q(10)$	2.6197	−8.9693	17.0981
	40-44	6	15	$q(15)$	4.1317	−14.3550	21.8247
	45-49	7	20	$q(20)$	7.3657	−15.8083	22.3005
West	15-19	1	1	$q(1)$	1.0970	5.5628	−1.9956
	20-24	2	2	$q(2)$	1.3062	5.5677	0.2962
	25-29	3	3	$q(3)$	1.5305	2.5528	4.8962
	30-34	4	5	$q(5)$	1.9991	−2.4261	10.4282
	35-39	5	10	$q(10)$	2.7632	−8.4065	16.1787
	40-44	6	15	$q(15)$	4.3468	−13.2436	20.1990
	45-49	7	20	$q(20)$	7.5242	−14.2013	20.0162

Estimation equation:

$$t(x)=a(i)+b(i)(P(1)/P(2))+c(i)(P(2)/P(3))$$

[a] Number of years prior to the survey.

TABLE 49. CHILDREN EVER BORN AND CHILDREN SURVIVING, BY SEX AND AGE OF MOTHER, PANAMA, 1976

Age group (1)	*Total number of women* (2)	*Male children* *Ever born* (3)	*Dead* (4)	*Female children* *Ever born* (5)	*Dead* (6)	*Sex ratio of children ever born* (7)
15-19	2 695	278	24	279	16	0.9964
20-24	2 095	1 380	77	1 253	53	1.1014
25-29	1 828	2 395	172	2 362	140	1.0140
30-34	1 605	3 097	236	2 988	199	1.0365
35-39	1 362	3 444	348	3 278	288	1.0506
40-44	1 128	3 274	394	3 093	292	1.0585
45-49	930	2 682	354	2 594	335	1.0339
TOTAL	11 643	16 550	1 605	15 847	1 323	1.0444

of the data presented is carried out by computing the sex ratios of the number of children ever born. Column (7) of table 49 shows these ratios. They are computed by dividing the number of male children ever born by the corresponding number of female children. As an example, for age group 20-24, the sex ratio is

$$1{,}380/1{,}253 = 1.1014,$$

and the overall sex ratio is

$$16{,}550/15{,}847 = 1.0444.$$

The sex ratios given in column (7) of table 49 fluctuate somewhat by age of mother but show no systematic trend, and the overall sex ratio is acceptably close to the expected value of 1.05. Furthermore, since some variation of the sex ratios by age is expected because of the relatively small sample being considered, it is concluded that this test shows no clear deficiency in the data.

Step 1: calculation of average parity per woman. Average parities $P(1)$, $P(2)$ and $P(3)$ are calculated by dividing the number of children ever born of each sex (appearing in columns (3) and (5) of table 49) by the total number of women (column (2) of that table). Thus, for example, $P_m(1)$, the mean number of male children ever borne by women aged 15-19 is

$$P_m(1) = 278/2{,}695 = 0.1032.$$

The complete sets of $P_m(i)$ and $P_f(i)$ values are shown in columns (3) and (4) of table 50.

Note that the values of $P(i)$ for both sexes combined are just the sum of $P_m(i)$ and $P_f(i)$, the mean number of male and female children, respectively, born to women of age group i.

TABLE 50. AVERAGE PARITY PER WOMAN, BY SEX OF CHILD AND AGE OF MOTHER, PANAMA, 1976

Age group *(1)*	*Index* i *(2)*	*Average parity per woman* *Males* $P_m(i)$ *(3)*	*Females* $P_f(i)$ *(4)*	*Both sexes* $P_t(i)$ *(5)*
15-19	1	0.1032	0.1035	0.2067
20-24	2	0.6587	0.5981	1.2568
25-29	3	1.3100	1.2920	2.6020
30-34	4	1.9300	1.8620	3.7920
35-39	5	2.5286	2.4068	4.9354
40-44	6	2.9025	2.7420	5.6445
45-49	7	2.8839	2.7892	5.6731

Step 2: calculation of proportion of children dead, for each age group of mother. The values of this proportion, $D(i)$, are computed from table 49 by dividing the number of children dead of each sex, given in columns (4) and (6), by the children ever born of the corresponding sex, shown in columns (3) and (5). Thus, $D_m(1)$, the proportion of male children dead among those ever born to women aged 15-19 is

$$D_m(1) = 24/278 = 0.0863.$$

To calculate the $D(i)$ values for both sexes combined, the deaths have to be added and then divided by the total number of children ever born (sum of males and females). Hence, $D_t(1)$ for both sexes would be

$$D_t(1) = (24+16)/(278+279) = 0.0718.$$

Table 51 shows a complete set of the proportions of children dead.

TABLE 51. PROPORTIONS OF CHILDREN DEAD, BY SEX OF CHILDREN AND AGE OF MOTHER, PANAMA, 1976

Age group *(1)*	*Index* i *(2)*	*Proportion of children dead* *Males* $D_m(i)$ *(3)*	*Females* $D_f(i)$ *(4)*	*Both sexes* $D_t(i)$ *(5)*
15-19	1	0.0863	0.0574	0.0718
20-24	2	0.0558	0.0423	0.0494
25-29	3	0.0718	0.0593	0.0656
30-34	4	0.0762	0.0666	0.0715
35-39	5	0.1010	0.0879	0.0946
40-44	6	0.1203	0.0944	0.1077
45-49	7	0.1320	0.1291	0.1306

Step 3: calculation of multipliers. The multipliers, $k(i)$, required to adjust the reported proportion dead, $D(i)$, for the effects of the age pattern of childbearing are calculated from the ratios $P(1)/P(2)$ and $P(2)/P(3)$, by using the equation and the coefficients listed in table 47. Thus,

$$k(i) = a(i) + b(i)\,P(1)/P(2) + c(i)\,P(2)/P(3).$$

It is assumed that the West family of model life tables is an adequate representation of mortality in Panama, so values of $a(i)$, $b(i)$ and $c(i)$ are taken from the bottom panel of table 47. Given the values of $P(1)$, $P(2)$ and $P(3)$ shown in table 50, values of $k(i)$ can be calculated for each sex and for both sexes combined. The full set of $k(i)$ values is shown in table 52. As an example, the multiplier for the male children of women aged 20-24 ($i = 2$) is

$$\begin{aligned} k_m(2) &= 1.2563 + (-0.5381)(0.1032/0.6587) \\ &\quad + (-0.2637)(0.6587/1.3100) \\ &= 1.0394. \end{aligned}$$

TABLE 52. TRUSSELL'S MULTIPLIERS FOR CHILD MORTALITY ESTIMATION, WEST MODEL; PANAMA, 1976

Age group *(1)*	*Index* i *(2)*	*Multipliers k(i) for:* *Males* *(3)*	*Females* *(4)*	*Both sexes* *(5)*
15-19	1	1.1026	1.0279	1.0663
20-24	2	1.0394	1.0411	1.0404
25-29	3	0.9850	1.0027	0.9938
30-34	4	0.9939	1.0147	1.0042
35-39	5	1.0109	1.0337	1.0221
40-44	6	0.9984	1.0219	1.0100
45-49	7	0.9909	1.0138	1.0022
$P(1)/P(2)$		0.1567	0.1730	0.1645
$P(2)/P(3)$		0.5028	0.4629	0.4830

Step 4: calculation of probabilities of dying and of surviv-

TABLE 53. ESTIMATES OF PROBABILITIES OF DYING AND OF SURVIVING, BY SEX, DERIVED FROM CHILD SURVIVAL DATA CLASSIFIED BY AGE OF MOTHER, WEST MODEL: PANAMA, 1976

Age group (1)	Age (x) (2)	Males $q(x)$ (3)	Males $l(x)$ (4)	Females $q(x)$ (5)	Females $l(x)$ (6)	Both sexes $q(x)$ (7)	Both sexes $l(x)$ (8)
15-19	1	0.0952	0.9048	0.0590	0.9410	0.0766	0.9234
20-24	2	0.0580	0.9420	0.0440	0.9560	0.0514	0.9486
25-29	3	0.0707	0.9293	0.0595	0.9405	0.0652	0.9348
30-34	5	0.0757	0.9243	0.0676	0.9324	0.0718	0.9282
35-39	10	0.1021	0.8979	0.0909	0.9091	0.0967	0.9033
40-44	15	0.1201	0.8799	0.0965	0.9035	0.1088	0.8912
45-49	20	0.1308	0.8692	0.1309	0.8691	0.1309	0.8691

ing. The estimated values of the probabilities of dying, $q(x)$, are now calculated by multiplying the $k(i)$ values appearing in table 52 by the corresponding proportions dead, $D(i)$, given in table 51. A complete set of $q(x)$ estimates is shown in table 53. As an example, the value of $q_f(5)$ is obtained as follows:

$$q_f(5) = k_f(4)D_f(4) = (1.0147)(0.0666) = 0.0676.$$

Since every $q(x)$ value is the probabilistic complement of the probability of surviving, $l(x)$, the latter value can be obtained by subtracting the former from 1.0. Thus,

$$l_f(5) = 1.0 - 0.0676 = 0.9324.$$

In table 53, every $q(x)$ value is accompanied by its corresponding $l(x)$ value.

Step 5: calculation of reference period. Since mortality is not likely to have remained constant in Panama until 1976, it is useful to know the reference period, $t(x)$, of each $q(x)$ estimate. The values of the ratios $P(1)/P(2)$ and $P(2)/P(3)$ that are needed to estimate $t(x)$ have already been computed in step 3. The form of the estimation equation and the values of the coefficients needed to estimate $t(x)$ are obtained from table 48, again assuming a West mortality pattern. The value of $t_f(3)$ is calculated here as an example:

$$t_f(3) = 1.5305 + (2.5528)(0.1730)$$
$$+ (4.8962)(0.4629) = 4.24.$$

Thus, the estimated $q_f(3)$ value of 0.0595 is similar to that corresponding to the period life table in operation 4.24 years before the date of the survey, which may itself be regarded as the average date of interview. Since the survey took place between August and October 1976, in rough terms $q_f(3)$ refers to mid-1972. The complete set of estimated $t(x)$ values is presented in table 54.

Note that the $t(x)$ values imply that the estimates of $q(1)$, $q(2)$, $q(3)$ and $q(5)$ obtained above refer to mortality conditions prevalent approximately one year, two and one-half years, four and one-half years and six and one-half years before the survey, respectively; thereafter, the estimated values of $t(x)$ increase by some two and one-half to three years per age group. These values appear to be quite consistent with the notion that because the estimate of $q(2)$, for example, is based mainly on information corresponding to women aged 20-24, whose childbearing experience is relatively recent, the $q(2)$ estimate should also refer to the recent experience of the population. The plausibility and consistency of the values of $t(x)$ is reassuring. They provide important information for the study of child mortality trends over time.

4. *Comments on the detailed example*

The calculation of the sex ratios of children ever born by age group of mother did not reveal any irregularities that could not be explained by the small numbers involved in most cases. Another way to assess the quality of the data on children ever born is by examining the behaviour of the average parities reported by women of each age group. Unless fertility rose at some time in the past, average parities should increase with age up to age group 45-49. According to this rough test, data for Panama again appear to be satisfactory, although the very small increase in parity from ages 40-44 to ages 45-49 is somewhat suspicious (the average number of male children actually declines slightly). It is of interest to examine the parities because any omission of children

TABLE 54. ESTIMATES OF THE REFERENCE PERIOD[a] TO WHICH THE ESTIMATED PROBABILITIES OF DYING REFER, WEST MODEL: PANAMA, 1976

Age group (1)	Age (x) (2)	Parameter estimate (3)	Reference period, $t(x)$[a] Males (4)	Females (5)	Both sexes (6)
15-19	1	$q(1)$	0.97	1.14	1.05
20-24	2	$q(2)$	2.33	2.41	2.37
25-29	3	$q(3)$	4.39	4.24	4.32
30-34	5	$q(5)$	6.86	6.41	6.64
35-39	10	$q(10)$	9.58	8.80	9.19
40-44	15	$q(15)$	12.43	11.41	11.92
45-49	20	$q(20)$	15.36	14.33	14.86

[a] Number of years prior to the survey.

ever born might be made up disproportionately of dead children, thus greatly affecting the proportion dead. In the case in hand, the parity data show no clear evidence of omission. The proportions of dead children increase rapidly with age of mother, especially above age 35, if one ignores the value for women aged 15-19 (this value is almost always out of line with subsequent values, probably because the children of young women are, in fact, subject to higher mortality risks); these proportions thus give no indication of increasing omission of dead children as age rises. The very rapid increase in the proportions dead with age of mother suggests that a combination of effects is in operation: an increasingly longer average exposure to the risk of dying of the children and considerably higher child mortality from 10 to 15 years before the survey.

One simple way of exploring the consistency of the mortality estimates obtained by this method is to convert them into mortality levels in the Coale-Demeny system, in order to compare the age pattern of the estimates obtained with that of the models. When estimates are available by sex, it is worth calculating the mortality levels associated with the $q(x)$ estimates for each sex. Table 55 shows the levels, as derived from the West model life tables by interpolating between the values of tables 236 and 237 (see annex VIII); levels for both sexes are not shown, since, being effectively averages of the levels for the two sexes individually, they would not contribute any more information.

TABLE 55. MORTALITY LEVELS IN THE WEST MODEL LIFE TABLES CONSISTENT WITH THE CHILDHOOD MORTALITY ESTIMATES, $q(x)$, PANAMA, 1976

	Males		Females	
Age x (1)	West mortality level (2)	Reference date (3)	West mortality level (4)	Reference date (5)
1	16.3	1975.7	18.1	1975.6
2	20.0	1974.4	20.2	1974.3
3	19.4	1972.3	19.2	1972.5
5	19.4	1969.8	19.0	1970.3
10	18.4	1967.1	18.1	1967.9
15	17.8	1964.3	18.1	1965.3
20	17.8	1961.3	17.0	1962.4

As an example, the level consistent with the estimated $q(2)$ for females is calculated here. According to table 53, $q_f(2)$ is equal to 0.0440 and the corresponding $l(2)$ is 0.9560. Since only $l(x)$ values are tabulated in table 236 in annex VIII (females, model West), this last value is used for interpolation purposes. In the column labelled "$l(2)$" in table 236, the two values that enclose the observed $l(2)$ are $l_{20}(2)=0.95392$ and $l_{21}(2)=0.96559$ (the $l(2)$ values at levels 20 and 21, respectively). Therefore, the interpolation factor θ is

$$\theta=(0.9560-0.95392)/(0.96559-0.95392)=0.178,$$

and because the distance between levels 20 and 21 is just one, the level consistent with $q_f(2)$ is 20.178 or 20.2 when rounded. All other values shown in table 55 are obtained in a similar way. For a detailed explanation of the procedure for linear interpolation, see annex IV.

An examination of the levels displayed in table 55 shows that, as mentioned above, the estimates of $q(1)$ imply relatively high mortality (they are associated with relatively low levels in the Coale-Demeny models) and should not be considered. Making some allowance for the random variation inherent in any measure derived from probability samples, the remaining estimates of level decline steadily as age of mother rises, strongly suggesting that child mortality has been falling. Furthermore, the estimates of level are fairly consistent for the two sexes, indicating that child mortality differentials by sex in Panama are rather similar to those embodied in the West model life tables. Note that in table 55, reference-date estimates calculated by subtracting the $t(x)$ estimates given in table 54 from 1976.7 (the average date of the survey) are also shown. These estimates, in conjunction with the mortality levels, can be used to determine the trend of child mortality through time, especially because neither the data nor the results of their analysis reveal any obvious problems.

C. ESTIMATION OF CHILD MORTALITY USING DATA CLASSIFIED BY DURATION OF MARRIAGE

1. *Data required*

The data required for this method are given below:

(*a*) The number of children ever born classified by sex (see the note below) and by the mother's five-year duration-of-marriage group. Duration of marriage is defined as the time elapsed since entry into first union, regardless of whether this union is legal;

(*b*) The number of children dead classified by sex (see the note given below) and by the mother's five-year duration-of-marriage group;

(*c*) The total number of ever-married women in each five-year marriage-duration group. (The term "ever-married" means, in this instance, having entered into at least one union.)

As in the case of data classified by mother's age, note should be taken that the classification of children ever born and children surviving by sex is desirable, but not necessary. If it is available, child mortality for each sex can be estimated separately; otherwise, estimates by sex may be imputed by assuming that a certain mortality model represents the mortality pattern of the population being studied. When a classification by sex is available, sex ratios may be used to ascertain the consistency of the data.

2. *Computational procedure*

The steps of the computational procedure are described below.

Step 1: calculation of average parity per woman. Parity $P(1)$ refers to women whose first union has lasted between 0 and 5 exact years (that is, the 0-4 duration group), $P(2)$ to women in the 5-9 duration category and $P(3)$ to those in category 10-14. In general,

$$P(i) = CEB(i)/MFP(i) \qquad \text{(C.1)}$$

where $CEB(i)$ is the number of children ever born reported by women belonging to duration group i and $MFP(i)$ is the total number of ever-married women in duration group i. Note that in this case the index i represents duration groups and not age groups. The value $i = 1$ is associated with the first duration group (of length 0-4), $i = 2$ with the second (5-9), and so on.

Step 2: calculation of proportion of children dead for each duration group of mother. This proportion, $D(i)$, is again defined as

$$D(i) = CD(i)/CEB(i) \qquad \text{(C.2)}$$

where $CD(i)$ is the total number of children dead reported by women in duration group i and $CEB(i)$ is the number of children ever born declared by those women.

Step 3: calculation of multipliers. The multipliers, $k(i)$, are obtained by substituting into equation (C.3) the appropriate average parity ratios calculated by using the average parities derived in step 1 and the coefficients shown in table 56. The equation for obtaining $k(i)$ is

$$k(i) = a(i) + b(i)(P(1)/P(2)) + c(i)(P(2)/P(3)). \qquad \text{(C.3)}$$

Note should be taken that table 56 lists coefficients for duration-of-marriage groups up to 30-34 years in length. In practice, data are often only tabulated for groups up to 15-19 or 20-24 years; coefficients for longer duration periods have been included for the sake of completeness, even though they may not be used very often. It should also be noted that in all cases, the duration categories used must span exactly five years. Data referring to an open-ended duration interval, such as 20+ (20 years or more), should not be used to estimate child mortality.

Step 4: calculation of probabilities of dying and of surviving. Each probability of dying before exact age x, denoted by $q(x)$, is calculated as the product of the proportion of children dead among the ever born, $D(i)$, and the corresponding multiplier $k(i)$ obtained in step 3. Thus,

$$q(x) = k(i)D(i) \qquad \text{(C.4)}$$

TABLE 56. COEFFICIENTS FOR ESTIMATION OF CHILD MORTALITY MULTIPLIERS, TRUSSELL VARIANT, WHEN DATA ARE CLASSIFIED BY DURATION OF MARRIAGE

Model (1)	Duration group (2)	Index i (3)	Mortality ratio[a] $q(x)/D(i)$ (4)	Coefficients: $a(i)$ (5)	$b(i)$ (6)	$c(i)$ (7)
North	0-4	1	$q(2)/D(1)$	1.2615	−0.5340	0.1252
	5-9	2	$q(3)/D(2)$	1.1957	−0.4103	−0.0930
	10-14	3	$q(5)/D(3)$	1.3067	−0.0103	−0.4618
	15-19	4	$q(10)/D(4)$	1.4701	0.1763	−0.7268
	20-24	5	$q(15)/D(5)$	1.5039	0.0039	−0.7071
	25-29	6	$q(20)/D(6)$	1.4798	−0.2487	−0.5582
	30-34	7	$q(25)/D(7)$	1.4373	−0.2317	−0.5047
South	0-4	1	$q(2)/D(1)$	1.3103	−0.5856	0.1367
	5-9	2	$q(3)/D(2)$	1.2309	−0.3463	−0.1073
	10-14	3	$q(5)/D(3)$	1.2774	0.0336	−0.3987
	15-19	4	$q(10)/D(4)$	1.3493	0.1366	−0.5403
	20-24	5	$q(15)/D(5)$	1.3592	−0.0315	−0.4944
	25-29	6	$q(20)/D(6)$	1.3532	−0.1978	−0.4099
	30-34	7	$q(25)/D(7)$	1.3498	−0.1663	−0.4131
East	0-4	1	$q(2)/D(1)$	1.2299	−0.3998	0.0910
	5-9	2	$q(3)/D(2)$	1.1611	−0.2451	−0.0797
	10-14	3	$q(5)/D(3)$	1.2036	0.0171	−0.2992
	15-19	4	$q(10)/D(4)$	1.2773	0.1015	−0.4276
	20-24	5	$q(15)/D(5)$	1.3014	−0.0219	−0.4195
	25-29	6	$q(20)/D(6)$	1.3160	−0.1630	−0.3751
	30-34	7	$q(25)/D(7)$	1.3287	−0.1523	−0.3925
West	0-4	1	$q(2)/D(1)$	1.2584	−0.4683	0.1080
	5-9	2	$q(3)/D(2)$	1.1841	−0.3006	−0.0892
	10-14	3	$q(5)/D(3)$	1.2446	0.0131	−0.3555
	15-19	4	$q(10)/D(4)$	1.3353	0.1157	−0.5245
	20-24	5	$q(15)/D(5)$	1.3875	−0.0193	−0.5472
	25-29	6	$q(20)/D(6)$	1.4227	−0.1954	−0.5127
	30-34	7	$q(25)/D(7)$	1.4432	−0.1977	−0.5339

Estimation equations:

$k(i) = a(i) + b(i)(P(1)/P(2)) + c(i)(P(2)/P(3))$

$g(x) = k(i)D(i)$

[a] Ratio of probability of dying to proportion of children dead. This ratio is set equal to the multiplier $k(i)$.

for some pair (x, i) defined in table 56, from which the coefficients needed to calculate $k(i)$ were obtained. From the $q(x)$ values, their probabilistic complements, $l(x)$ (the probability of surviving from birth to exact age x) are easily obtained by subtraction from one, that is,

$$l(x) = 1.0 - q(x).$$

Step 5: calculation of reference period. As before, $t(x)$ is an estimate of the number of years before the survey to which the estimates of childhood mortality obtained in step 4 refer when mortality has been changing. The $t(x)$ values are obtained by using an equation whose form and coefficients for the case in which data are classified by marriage duration are presented in table 57.

3. *A detailed example*

Data on the number of children ever born and children surviving obtained during a survey carried out in Panama between August and October 1976 were tabulated not only by age of mother but by the time elapsed since her first union. The data classified by duration are summarized in table 58.

These data are used to illustrate the duration-based procedure for estimating mortality in childhood. Only data for the first five duration groups are given in table 58; data for longer duration groups, spanning five years each, are not available. Once again, as a consistency check, the sex ratios of the reported number of children ever born are examined. Just as in the case in which these data are classified by age, the values of these sex ratios for different marriage durations are expected to be reasonably stable and to be close to 1.05 (although some allowance must be made for the random variability inherent in the small numbers considered). The sex ratios are shown in column (7) of table 58. They were obtained by dividing the number of male children ever born by the corresponding number of female children. The sex ratio values shown in table 58 are not exactly constant, but, except for that referring to duration group 0-4, they all fall acceptably close to the expected figure. The large deviation shown by the sex ratio of the children born to women married only a few years (duration group 0-4) is probably due to the relatively small number of cases considered. Survival probabilities estimated from the data corresponding to this duration group may well be subject to similar biases and should be treated with reserve.

The steps of the computational procedure are given below.

Step 1: calculation of average parity per woman. Average parities are computed in a way very similar to step 1 of the age version: each of the entries in columns (3) and (5) (male and female children ever born, respectively) of

TABLE 57. COEFFICIENTS FOR ESTIMATION OF THE REFERENCE PERIOD, $t(x)$,[a] TO WHICH THE VALUES OF $q(x)$ ESTIMATED FROM DATA CLASSIFIED BY DURATION OF MARRIAGE REFER

Mortality model *(1)*	*Duration group* *(2)*	*Index* *i* *(3)*	*Age* *x* *(4)*	*Parameter estimate* *(5)*	*Coefficients* *a(i)* *(6)*	*b(i)* *(7)*	*c(i)* *(8)*
North	0-4	1	2	$q(2)$	1.0311	1.3149	−0.3282
	5-9	2	3	$q(3)$	1.6964	4.2147	−0.0160
	10-14	3	5	$q(5)$	1.4285	3.2687	4.4073
	15-19	4	10	$q(10)$	−0.0753	−1.0800	12.9281
	20-24	5	15	$q(15)$	−1.9749	−3.4773	21.3318
	25-29	6	20	$q(20)$	−2.1888	0.6124	23.9376
	30-34	7	25	$q(25)$	0.9613	4.4416	21.4661
South	0-4	1	2	$q(2)$	1.0202	1.3064	−0.3297
	5-9	2	3	$q(3)$	1.6601	4.5105	−0.0335
	10-14	3	5	$q(5)$	1.2146	3.4684	4.9524
	15-19	4	10	$q(10)$	−0.6454	−1.6045	14.6773
	20-24	5	15	$q(15)$	−2.9104	−4.1352	24.0072
	25-29	6	20	$q(20)$	−3.1641	1.2106	26.3515
	30-34	7	25	$q(25)$	0.4456	5.6384	23.2565
East	0-4	1	2	$q(2)$	1.0380	1.4213	−0.3545
	5-9	2	3	$q(3)$	1.6441	4.7042	0.0642
	10-14	3	5	$q(5)$	1.1068	3.3032	5.4464
	15-19	4	10	$q(10)$	−0.8678	−1.9683	15.5187
	20-24	5	15	$q(15)$	−3.2154	−4.1123	24.8624
	25-29	6	20	$q(20)$	−3.3885	1.6746	26.9798
	30-34	7	25	$q(25)$	0.4716	5.8775	23.7246
West	0-4	1	2	$q(2)$	1.0349	1.3714	−0.3390
	5-9	2	3	$q(3)$	1.6654	4.5855	0.0233
	10-14	3	5	$q(5)$	1.2109	3.3291	5.1402
	15-19	4	10	$q(10)$	−0.5370	−1.7679	14.6370
	20-24	5	15	$q(15)$	−2.4694	−3.9194	23.0999
	25-29	6	20	$q(20)$	−2.2107	1.3059	24.4479
	30-34	7	25	$q(25)$	1.7815	5.0415	20.6725

Estimation equation:

$$t(x) = a(i) + b(i)\,(P(1)/P(2)) + c(i)\,(P(2)/P(3))$$

[a] Number of years prior to the survey.

TABLE 58. CHILDREN EVER BORN AND CHILDREN SURVIVING, BY SEX OF CHILD AND MARRIAGE DURATION OF MOTHER, PANAMA, 1976

Duration group (1)	Ever-married women (2)	Male children: Ever born (3)	Male children: Dead (4)	Female children: Ever born (5)	Female children: Dead (6)	Sex ratio of children ever born (7)
0-4	1 523	836	35	862	24	0.9698
5-9	1 717	2 303	124	2 204	110	1.0449
10-14	1 362	2 827	217	2 647	149	1.0680
15-19	1 225	3 103	251	3 003	220	1.0340
20-24	1 069	3 206	387	3 052	292	1.0505
TOTAL	6 896	12 275	1 014	11 768	795	1.0431

table 58 is divided by the corresponding entry in column (2), the number of ever-married women. Thus, for example, $P_m(1)$ for male children is

$$P_m(1) = 836/1{,}523 = 0.5489.$$

The average parities corresponding to all births (shown in table 59 under the label "Both sexes") can be obtained in the same way; or, alternatively, they can be obtained simply by summing the average numbers of male and female children ($P_m(i)$ and $P_f(i)$).

Thus, for both sexes, $P_t(2)$ would be

$$P_t(2) = (2{,}303+2{,}204)/1{,}717 = 2.6249$$

or, simply

$$P_t(2) = 1.3413+1.2836 = 2.6249.$$

Other values of the average parities are shown in table 59.

TABLE 59. AVERAGE PARITIES, BY SEX OF CHILDREN AND MARRIAGE DURATION OF MOTHER, PANAMA, 1976

Duration group (1)	Index i (2)	Average parity per woman: Males $P_m(i)$ (3)	Females $P_f(i)$ (4)	Both sexes $P_t(i)$ (5)
0-4	1	0.5489	0.5660	1.1149
5-9	2	1.3413	1.2836	2.6249
10-14	3	2.0756	1.9435	4.0191
15-19	4	2.5331	2.4514	4.9845
20-24	5	2.9991	2.8550	5.8541

Step 2: calculation of proportion of children dead for each duration group of mother. This proportion, $D(i)$, is computed from table 58 by dividing the number of children dead (column (4) for males, column (6) for females) by the number of children ever born (column (3) for males, column (5) for females). When both sexes are considered, the number of male and female dead children has to be calculated by adding the figures in columns (4) and (6) and then dividing by the sum of male and female children ever born (columns (3) and (5)). The calculation of $D(2)$ for all cases is shown below:

$$D_m(2) = 124/2{,}303 = 0.0538$$

$$D_f(2) = 110/2{,}204 = 0.0499$$

$$D_t(2) = (124+110)/(2{,}303+2{,}204) = 0.0519$$

where the subindices indicate whether the value of $D(2)$ is for males (m), females (f) or both sexes combined (t). All values of $D(i)$ are given in table 60.

TABLE 60. PROPORTIONS OF CHILDREN DEAD, BY SEX OF CHILD AND MARRIAGE DURATION OF MOTHER, PANAMA, 1976

Duration group (1)	Index i (2)	Proportions of children dead: Males $D_m(i)$ (3)	Females $D_f(i)$ (4)	Both sexes $D_t(i)$ (5)
0-4	1	0.0419	0.0278	0.0348
5-9	2	0.0538	0.0499	0.0519
10-14	3	0.0768	0.0563	0.0669
15-19	4	0.0809	0.0733	0.0771
20-24	5	0.1207	0.0957	0.1085

Step 3: calculation of multipliers. The coefficients needed to compute the multipliers, $k(i)$, are given in table 56. The estimation equation has the form:

$$k(i) = a(i)+b(i)(P(1)/P(2)) + c(i)(P(2)/P(3)) \qquad \text{(C.5)}$$

where the independent variables used are $P(1)/P(2)$ and $P(2)/P(3)$. Once more, the West mortality pattern is selected. Because of the simple form of equation (C.5) the computation of the $k(i)$ multipliers is straightforward. Results are summarized in table 61; as an example, $k_m(3)$ for males is computed as

$$k_m(3) = 1.2446+(0.0131)(0.4092) + (-0.3555)(0.6462) = 1.0202.$$

TABLE 61. MULTIPLIERS FOR THE PROPORTIONS OF CHILDREN DEAD TABULATED BY DURATION OF MARRIAGE, ASSUMING A WEST MORTALITY PATTERN, PANAMA, 1976

Duration group (1)	Index i (2)	Multipliers: Males $k_m(i)$ (3)	Females $k_f(i)$ (4)	Both sexes $k_t(i)$ (5)
0-4	1	1.1366	1.1233	1.1300
5-9	2	1.0035	0.9926	0.9982
10-14	3	1.0202	1.0156	1.0180
15-19	4	1.0437	1.0399	1.0419
20-24	5	1.0260	1.0176	1.0219
$P(1)/P(2)$		0.4092	0.4409	0.4247
$P(2)/P(3)$		0.6462	0.6605	0.6531

Step 4: estimation of probabilities of dying and of surviving. Estimates of $q(x)$, the probability of dying between birth and exact age x, are obtained by multiplying the

proportions dead, $D(i)$, obtained in step 2 by the $k(i)$ multipliers just calculated. Thus, $q(x)=k(i)D(i)$. One must be careful in matching the indices; the value of x corresponding to each i is given in table 56. Table 62 shows the final results for $q(x)$ and for $l(x)$, the probability of surviving.

TABLE 62. ESTIMATES OF PROBABILITIES OF DYING AND OF SURVIVING, BY SEX, DERIVED FROM CHILD SURVIVAL DATA CLASSIFIED BY DURATION OF MARRIAGE, WEST MODEL: PANAMA, 1976

		Probabilities of dying, $q(x)$, and of surviving, $l(x)$					
		Males		Females		Both sexes	
Duration group (1)	Age x (2)	$q(x)$ (3)	$l(x)$ (4)	$q(x)$ (5)	$l(x)$ (6)	$q(x)$ (7)	$l(x)$ (8)
0-4	2	0.0476	0.9524	0.0312	0.9688	0.0393	0.9607
5-9	3	0.0540	0.9460	0.0495	0.9505	0.0518	0.9482
10-14	5	0.0784	0.9216	0.0572	0.9428	0.0681	0.9319
15-19	10	0.0844	0.9156	0.0762	0.9238	0.0803	0.9197
20-24	15	0.1238	0.8762	0.0974	0.9026	0.1109	0.8891

Step 5: calculation of reference period. Since mortality is very likely to have changed recently in Panama, the estimation of the reference period, $t(x)$, is appropriate. For this purpose, one requires the values of $P(1)/P(2)$ and $P(2)/P(3)$, which have already been calculated in step 3 (see table 61). The equation used to estimate $t(x)$ and the appropriate coefficients appear in table 57. The calculation of $t(x)$ is straightforward. As an illustration, $t_m(3)$ for males is computed below:

$$t_m(3) = 1.6654+4.5855(0.4092)+0.0233(0.6462) = 3.56.$$

Values of $t(x)$ are shown in table 63.

4. *Comments on the detailed example*

As in the case of the age-based analysis, the child survival data of the survey conducted in Panama in 1976, when classified by duration of marriage, appear to be of acceptable quality. The sex ratios at birth of children ever born are close to the expected value of 1.05, the average parities increase monotonically with duration of marriage, and the proportions of children dead also increase with marital duration. The consistency of the final mortality estimates, both internal and with respect to the estimates obtained from the age-based method, can be conveniently assessed by finding the mortality level in the Coale-Demeny West family of model life tables consistent with each estimate and then comparing these levels. Table 64 shows the mortality levels implied by the $q(x)$ estimates for each sex. They are obtained by interpolation using the tables referring to the West model in annex VIII.

TABLE 63. ESTIMATES OF THE REFERENCE PERIOD, $t(x)$,[a] TO WHICH THE ESTIMATED PROBABILITIES OF DYING REFER, WEST MODEL, PANAMA, 1976

			Estimates of reference period[a]		
Duration group (1)	Age x (2)	Estimated parameter (3)	Males $t_m(x)$ (4)	Females $t_f(x)$ (5)	Both sexes $t_t(x)$ (6)
0-4	2	$q(2)$	1.38	1.42	1.40
5-9	3	$q(3)$	3.56	3.70	3.63
10-14	5	$q(5)$	5.89	6.07	5.98
15-19	10	$q(10)$	8.20	8.35	8.27
20-24	15	$q(15)$	10.85	11.06	10.95
$P(1)/P(2)$			0.4092	0.4409	0.4247
$P(2)/P(3)$			0.6462	0.6605	0.6531

[a] Number of years prior to the survey.

TABLE 64. MORTALITY LEVELS IN THE WEST MODEL LIFE TABLES CONSISTENT WITH THE DURATION-BASED ESTIMATES OF CHILD MORTALITY, PANAMA, 1976

	Males		Females	
Age x (1)	West mortality level (2)	Reference date (3)	West mortality level (4)	Reference date (5)
2	20.8	1975.3	21.3	1975.3
3	20.5	1973.1	20.0	1973.0
5	19.2	1970.8	19.7	1970.6
10	19.3	1968.5	18.9	1968.3
15	17.6	1965.8	18.1	1965.6

The estimated mortality levels show a fairly coherent trend and reasonable consistency by sex. The average of the duration-based mortality levels is somewhat higher (by about half a level) than that obtained when the data were classified by age, but the reference period of the duration-based estimates is somewhat more recent, for any given value of x. Therefore, although the overall duration-based estimates indicate lower mortality than do the age estimates, their differences are very moderate. Given the instability of marriage in Panama and the resultant danger that the date of first union might be incorrectly reported or that unions may be frequently interrupted, the age-based estimates should probably be preferred in this instance.

D. ESTIMATION OF INTERSURVEY CHILD MORTALITY USING DATA FOR A HYPOTHETICAL INTERSURVEY COHORT

1. *Data required*

The data required for this method are described below:

(*a*) The number of children ever born classified by five-year age group of mother (or by five-year duration group when women can be classified by the time elapsed since their first union) from two censuses or surveys taken five or 10 years apart;

(*b*) The number of children surviving (or its complement, the number of children dead) classified by five-year age or duration group of mother for the same two censuses or surveys;

(*c*) The total number of women in each five-year age group when data are classified by age, or the number of ever-married women belonging to each five-year duration group if data are classified by the time elapsed since the first union, from each of the surveys being considered.

Note that the classification of children by sex is desirable, but not necessary. When data are not classified by sex, sex differentials in childhood mortality may be imputed by using mortality models.

2. *Computational procedure*

The estimation procedure described here differs from those described in sections B and C only in the way in which the proportion of children dead and the average number of children ever born per woman (average parity) are calculated. Once the proportion dead, $D(i)$, and the average parity, $P(i)$, have been obtained, the calculation of multipliers $k(i)$ and the estimation of $q(x)$ (the probability of dying between birth and exact age x) proceed exactly as described in steps 3 and 4 of the computational procedures presented in subsections B.2 and C.2. Therefore, these steps are not described again. Furthermore, since the calculation of proportions of children dead and parities for hypothetical cohorts are essentially the same whether data are classified by age or by duration, the steps needed to perform these calculations are described for the age model only. When data are classified by duration, the same steps can be followed, using ever-married women instead of all women, and bearing in mind that the index i refers to duration groups rather than to age groups.

Note should be taken that, when considering hypothetical cohorts, the value of $t(x)$, the reference period, has no clear meaning and its estimation is unnecessary. In any case, the objective of using data for a hypothetical cohort is to obtain estimates of child mortality referring specifically to the intersurvey period, so there would be no point in estimating the $t(x)$ values.

The steps of the computational procedure are given below.

Step 1: calculation of average parity per woman. As described in step 1 of the computational procedures described in subsections B.2 and C.2, the average parities or average number of children ever born per woman in each age (duration) group are just the quotients of the observed number of children ever born, *CEB*, and the number of women in that age (duration) group, *FP*. In this case, average parities are calculated for each survey separately and the index j is used to indicate the survey to which they refer. Therefore, following the notation used in subsection B.2:

$$P(i,j) = CEB(i,j)/FP(i,j). \qquad \text{(D.1)}$$

Step 2: calculation of average number of children dead per woman. In this step, the average number of children dead per woman in each age group and for each of the surveys being used is calculated. Let $CD(i,j)$ be the number of children dead among those born to women in age group i and reported in survey j, and let $FP(i,j)$ be the total number of women in age group i at survey j. Then, the average number of children dead among women in age group i during survey j, denoted by $ACD(i,j)$, is just the quotient of $CD(i,j)$ and $FP(i,j)$, or

$$ACD(i,j) = CD(i,j)/FP(i,j). \qquad \text{(D.2)}$$

Step 3: estimation of proportion of children dead for a hypothetical cohort of women. Usually, the proportion of children dead is calculated as the number of dead children divided by the number of children ever born. However, when a hypothetical cohort of women is being considered, this proportion is calculated by dividing the average number of children dead by the average number of children ever born per woman of the hypothetical cohort. The average number of births per woman occurring to a true cohort between two surveys is the increment in the average parity of the cohort from one survey to the other, and the average number of children ever born for a hypothetical intersurvey cohort can be constructed by adding such increments (see chapter II, Section C). The average number of dead children for a hypothetical cohort of women can be obtained in a similar way, since the increment in the average number of dead children per woman for a true cohort between two surveys is a measure of the effect of mortality during the intersurvey period. However, when fertility has been changing, the average number of children dead for a hypothetical cohort of women cannot, strictly speaking, be obtained by summing the intersurvey increments of different female cohorts, since the intersurvey deaths include deaths both to children born between the surveys and to children born before the first survey; and the latter (number of children born before the first survey) will not be adequately represented by the parities of the hypothetical cohort which reflect the intersurvey fertility change. A procedure to estimate the appropriate average number of children dead for a hypothetical cohort under conditions of changing fertility is available.[12] Yet

[12] Hania Zlotnik and Kenneth H. Hill, "The use of hypothetical cohorts in estimating demographic parameters under conditions of changing fertility and mortality", *Demography*, vol. 18, No. 1 (February 1981), pp. 103-122.

unless fertility is falling unprecedently fast, the error introduced by using the simpler procedure described here is very small. Therefore, the former procedure is not described.

Thus, if mortality is changing but fertility has remained constant, the proportions of children dead for a hypothetical intersurvey cohort of women can be calculated by summing the intersurvey increments observed both in the average number of children dead and in average parities, and then dividing the sum of the former by the sum of the latter. In such a case, mortality estimates for the intersurvey period can be obtained by the procedures described in subsection B.2 (or subsection C.2 when the data are classified by duration of first marriage).

A detailed description of the calculation of the average parities and average numbers of children dead for a hypothetical cohort follows. If the length of the intersurvey period is n five-year intervals, the average number of children ever borne by women of age group i in the hypothetical cohort exposed to intersurvey fertility rates and denoted by $P(i,s)$ is

$$P(i,s)=P(i,2)-P(i-n,1)+P(i-n,s). \quad \text{(D.3)}$$

Similarly, the average number of children dead per woman of age group i in the hypothetical cohort, denoted by $ACD(i,s)$, is

$$ACD(i,s)=ACD(i,2)-ACD(i-n,1) +ACD(i-n,s). \quad \text{(D.4)}$$

Note that in both equations (D.3) and (D.4), if i is smaller than or equal to n, the hypothetical-cohort value is assumed to be equal to the value observed at the second survey. For estimation of child mortality, the hypothetical-cohort approach is of little value if the surveys are more than 10 years apart, since with a 15-year interval, the proportions of children dead for women under age 30 are estimated as equal to the reported proportions of children dead from the second survey; therefore, the estimates of $q(1)$, $q(2)$, and $q(3)$ will not reflect the complete intersurvey experience.

The hypothetical-cohort proportions dead, $D(i,s)$, are then obtained by dividing the average number of children dead obtained from equation (D.4) by the average parities obtained from equation (D.3), that is,

$$D(i,s)=ACD(i,s)/P(i,s). \quad \text{(D.5)}$$

Note that, since the calculations use average numbers per woman, it is not important, except because of the effects of sampling errors, whether the two data sets come both from censuses, both from surveys or one from each type of source.

Step 4: estimation of probability of dying. As stated earlier, the estimation of $q(x)$ here corresponds to steps 3 and 4 of the computational procedures described in subsections B.2 and C.2 (age and duration versions, respectively). Their application is exactly the same as given before, using the parities for the hypothetical cohort of women, $P(i,s)$, and the proportions dead, $D(i,s)$, also corresponding to the hypothetical cohort.

3. *A detailed example*

Data on children ever born and surviving are available for Thailand from a sample of the 1970 census and from two sample surveys held in 1974 and 1975. Weighted averages of the data from the two surveys that approximate those referring to a point exactly five years after the census date were used. All the basic data are shown in table 65.

Steps 1 and 2: calculation of average parity and of average number of children dead per woman. Average numbers of children ever born, $P(i,j)$, and dead, $ACD(i,j)$, per woman are obtained for each age group of women and for each survey by dividing the recorded totals by the relevant number of women. Thus, the average number of children dead per woman aged 25-29 in 1970 is obtained as

$$ACD(3,1)=274{,}526/1{,}141{,}937=0.2404.$$

Table 66 shows the results for all age groups.

Step 3: estimation of proportion of children dead for a hypothetical cohort of women. The interval between the 1970 census and the 1975 blended survey results is five years, so n in equations (D.3) and (D.4) is 1. Thus, for the first age group, 15-19, the average parity and the average number of children dead for the hypothetical

TABLE 65. NUMBER OF WOMEN, CHILDREN EVER BORN AND CHILDREN DEAD, BY AGE GROUP, THAILAND, 1970 AND 1975

	1970[a]			1975[b]		
Age group (1)	Number of women (2)	Children ever born (3)	Children dead (4)	Number of women (5)	Children ever born (6)	Children dead (7)
15-19	1 883 232	245 069	15 223	13 054	1 662	188
20-24	1 359 859	1 367 179	99 316	10 037	8 839	600
25-29	1 141 937	2 795 340	274 526	7 812	16 787	1 329
30-34	1 075 972	4 175 274	504 766	6 508	22 969	2 375
35-39	956 315	4 931 749	732 342	6 244	29 557	3 515
40-44	765 298	4 477 365	829 656	5 454	31 298	4 598
45-49	596 648	3 608 055	821 915	4 388	27 550	4 941

[a] Obtained from an expanded 2 per cent sample.

[b] Weighted average of the 1974 and 1975 rounds of the Survey of Population Change.

TABLE 66. AVERAGE NUMBER OF CHILDREN EVER BORN AND CHILDREN DEAD PER WOMAN, BY AGE GROUP OF MOTHER, THAILAND, 1970 AND 1975

Age group (1)	Index i (2)	1970 Average number of: Children ever born $P(i,1)$ (3)	1970 Average number of: Children dead $ACD(i,1)$ (4)	1975 Average number of: Children ever born $P(i,2)$ (5)	1975 Average number of: Children dead $ACD(i,2)$ (6)
15-19	1	0.1301	0.0081	0.1273	0.0090
20-24	2	1.0054	0.0730	0.8806	0.0598
25-29	3	2.4479	0.2404	2.1489	0.1701
30-34	4	3.8805	0.4691	3.5293	0.3649
35-39	5	5.1570	0.7658	4.7337	0.5629
40-44	6	5.8505	1.0841	5.7385	0.8431
45-49	7	6.0472	1.3776	6.2785	1.1260

cohort of women are put equal to the corresponding values from the second survey:

$$P(1,s)=P(1,2)=0.1273$$

and

$$ACD(1,s)=ACD(1,2)=0.0090.$$

Subsequent values are obtained by adding the cohort increments successively. Thus, for the second age group (20-24):

$$P(2,s)=P(2,2)-P(1,1)+P(1,s)$$

$$=0.8806-0.1301+0.1273$$

$$=0.8778$$

and

$$ACD(2,s)=ACD(2,2)-ACD(1,1)+ACD(1,s)$$

$$=0.0598-0.0081+0.0090$$

$$=0.0607.$$

Table 67 shows the results. (For a more detailed explanation of the procedure used to calculate average parities for a hypothetical cohort, see chapter II, subsection B.4 (c).)

Once the average parities and the average numbers of children dead have been calculated, bearing in mind the caveat about changing fertility, the proportion of children dead for the hypothetical cohort can be obtained using equation (D.5). Thus, according to the values taken from table 67, the proportion of children dead

TABLE 67. AVERAGE NUMBER OF CHILDREN EVER BORN AND CHILDREN DEAD PER WOMAN OF A HYPOTHETICAL INTERSURVEY COHORT, BY AGE OF MOTHER, THAILAND, 1970-1975

Age group (1)	Index i (2)	Average number of: Children ever born $P(i,s)$ (3)	Average number of: Children dead $ACD(i,s)$ (4)	Proportion of children dead $D(i,s)$ (5)
15-19	1	0.1273	0.0090	0.0707
20-24	2	0.8778	0.0607	0.0692
25-29	3	2.0213	0.1578	0.0781
30-34	4	3.1027	0.2823	0.0910
35-39	5	3.9559	0.3761	0.0951
40-44	6	4.5374	0.4534	0.0999
45-49	7	4.9654	0.4953	0.0998

among those ever born to women aged 25-29 years, $D(3,s)$, is calculated as follows:

$$D(3,s)=ACD(3,s)/P(3,s)$$

$$=0.1578/2.0213=0.0781$$

Column (5) of table 67 shows the full set of $D(i,s)$ values.

Step 4: estimation of probability of dying. Estimates of the probability of dying, $q(x)$, between birth and certain exact age x are obtained by using the procedure described in subsection B.2 with the North mortality pattern. The values of the ratios $P(1)/P(2)$ and $P(2)/P(3)$ are needed to estimate the appropriate multipliers, $k(i)$. These ratios are computed by using the parities listed in table 67 as illustrated below:

$$P(1,s)/P(2,s)=0.1273/0.8778=0.1450,$$

$$P(2,s)/P(3,s)=0.8778/2.0213=0.4343.$$

The multipliers, $k(i)$, are then obtained by using the equation appearing at the bottom of table 47 and the coefficients corresponding to the North mortality model, also shown in that table. The value of $k(3)$, for example, is obtained as

$$k(3)=1.1884+(0.0421)(0.1450)$$

$$+(-0.5156)(0.4343)=0.9706.$$

The complete set of multipliers used is shown in column (4) of table 68. The products of these multipliers and the proportions dead, $D(i,s)$, yield estimates of intersurvey child mortality. Thus, $q(5)$, for example, is obtained as

$$q(5)=k(4)D(4,s)=0.0913.$$

All estimates of $q(x)$ are listed in column (6) of table 68. The mortality levels in the North model life tables to which each $q(x)$ estimate corresponds, calculated by assuming a sex ratio at birth of 105 males per 100 females, are shown in column (7). They were computed by interpolating within the values presented in table 242 (see annex IX), corresponding to model North and sex

TABLE 68. CHILD MORTALITY ESTIMATES, THAILAND, PERIOD 1970-1975

Age group of women (1)	Index i (2)	Age x (3)	Multipliers $k(i)$ (4)	Proportion of children dead $D(i, s)$ (5)	Probability of dying $q(x)$ (6)	North mortality level (7)
15-19	1	1	1.0638	0.0707	0.0752	16.7
20-24	2	2	1.0203	0.0692	0.0706	18.4
25-29	3	3	0.9706	0.0781	0.0758	18.6
30-34	4	5	1.0029	0.0910	0.0913	18.5
35-39	5	10	1.0639	0.0951	0.1012	18.5
40-44	6	15	1.0483	0.0999	0.1047	18.7
45-49	7	20	1.0269	0.0998	0.1025	19.3

ratio at birth equal to 1.05. For comparision, table 69 shows the child mortality estimates obtained by using only the 1975 data.

4. *Comments on the detailed example*

The data on children ever born and children surviving from the two surveys conducted in Thailand are not classified by sex of child, so one cannot check whether the reported sex ratios at birth are plausible. However, the availability of data for two points in time more than compensates for this lack, since parameter changes for true cohorts can be examined for plausibility. The average parity of a cohort of women should increase from the first point in time to the second by an amount consistent with the general age pattern of fertility; the average parities corresponding to true cohorts and shown in table 66 do increase in every case and by amounts that look reasonable, so the reporting of children ever born at the two time-points being considered seems consistent. The average number of children dead for true cohorts of women should also increase, whenever migration or selective mortality effects are not in operation; the data given in table 66 also pass this test, although the increases in average numbers of children dead for older women are very small. However, it can be concluded that, so far, these tests reveal no obvious shortcomings of the data.

TABLE 69. CHILD MORTALITY ESTIMATES, THAILAND, 1975

Age group of women (1)	Index i (2)	Age x (3)	Average parity per woman $P(i)$ (4)	Proportion of children dead $D(i)$ (5)	Multipliers $k(i)$[a] (6)	Probability of dying $q(x)$ (7)	Reference period[b] $t(x)$ (8)	North mortality level (9)
15-19	1	1	0.1273	0.0710	1.0370	0.0736	1.1	16.9
20-24	2	2	0.8806	0.0679	1.0272	0.0697	2.2	18.5
25-29	3	3	2.1489	0.0792	0.9832	0.0779	3.8	18.4
30-34	4	5	3.5293	0.1034	1.0167	0.1051	5.7	17.5
35-39	5	10	4.7337	0.1189	1.0782	0.1282	7.8	17.2
40-44	6	15	5.7385	0.1469	1.0615	0.1559	10.3	16.4
45-49	7	20	6.2785	0.1793	1.0381	0.1861	13.1	15.7

[a] Using $P(1)/P(2) = 0.1446$ and $P(2)/P(3) = 0.4098$.

[b] Number of years prior to the survey to which estimates refer.

The behaviour of the proportion dead among children ever born, $D(i, s)$, provides a further test of data quality; these proportions are expected to increase with age of mother, as the average exposure of her children to the risk of dying increases. Although the proportions dead reported at the two points in time being considered rise steadily with age of mother (leaving aside information for women aged 15-19), the proportions dead for the hypothetical cohort actually decline for age group 45-49, suggesting that there is some slight omission of dead children by older women, an omission masked in the original data sets by the effects of declining child mortality.

It is clear from the estimates of mortality level given in table 68 that the child mortality estimate based on information from women under 20 years of age is not reliable, a finding that is fairly common. The estimates for women in the age range from 20 to 44 are highly consistent, indicating that child mortality in Thailand between 1970 and 1975 was approximately equal to that of level 18.5 of the North model. The estimate obtained from data referring to women aged 45-49 indicates somewhat lower child mortality, probably because of the slight omission of dead children already detected. The consistency of the mortality estimates shown in table 68 is in marked contrast with that of the estimates presented in table 69, which show heavier mortality as age of mother rises, presumably because child mortality has been declining.

The intersurvey method of estimation described and illustrated here assumes roughly constant fertility. Fertility in Thailand was falling before 1970, and it continued to fall throughout the intersurvey period. In such circumstances, the estimated intersurvey child deaths exceed those expected on the basis of intersurvey births because they include the child deaths occurring during the intersurvey period to birth cohorts that were larger at the time of the first survey (or census in the case of Thailand) than those constructed for the hypothetical female cohort on the basis of intersurvey fertility. Child mortality will thus be overestimated somewhat by an amount that increases with age of mother, since the ratio of births during the intersurvey period to surviving children at the beginning of the intersurvey period declines with age of mother. Thus, it is surprising to find that the estimated mortality levels given in table 68 tend to increase somewhat with age of mother in spite of the fact that the methodological bias just described would affect them in the opposite direction. Zlotnik and Hill[13] estimated that the magnitude of this bias in the case of Thailand is approximately −0.1 of a mortality level for the estimate derived from age group 25-29, and of about −0.2 of a mortality level for that derived from age group 30-34. The fact that such small biases are counteracted by other, yet undetected, flaws in the data make the average level, 18.5, an acceptable estimate of intersurvey child mortality.

E. Estimation of child mortality when the fertility experience of true cohorts is known

1. *Basis of method and its rationale*

As explained in section A, if fertility has been changing in the recent past, the observed parity ratios used as independent variables when estimating the multipliers, $k(i)$, may not reflect adequately the true experience of cohorts in the population; and, hence, the resulting multipliers may not be suited for mortality estimation purposes. A method proposed to circumvent the problems introduced by declining fertility consists of taking into account the experience of true cohorts when estimating the $k(i)$ multipliers, instead of basing their estimates on ratios of parities referring only to one point in time. This method is described below in detail.

As in the methods presented before, two types of cohorts may be considered: those defined according to age; and those defined according to the duration of first marriage or union. The estimation procedures used to analyze each of these types of data are very similar, so only the case where data are classified by age is described; the variations necessary to apply these procedures to data classified by duration of first marriage are pointed out as the need arises.

2. *Data required*

The following data are required for this method:

(*a*) The number of children ever born classified by five-year age (or duration) group of mother for two surveys five or 10 years apart;

(*b*) The number of children dead (or surviving) classified by five-year age (or duration) group of mother for the most recent survey being considered;

(*c*) The total number of women (or of ever-married women) classified by five-year age (or duration) groups for each one of the surveys being considered.

It is not necessary to have data on the number of children dead for both of the surveys being considered. If these data are available (children dead for both surveys), it is strongly recommended that the method described above in section D be used to estimate intersurvey child mortality, in spite of the fact that it does not make any explicit allowance for the effects of changing fertility.

13 *Ibid.*

As usual, it is helpful to have the data on children ever born and dead classified by sex. When this classification is not available, sex differentials in child mortality can only be imputed by using mortality models.

3. *Computational procedure*

The steps of the computational procedure are given below.

Step 1: calculation of average parity per woman. To calculate the average parity per woman, $P(i,j)$, let $CEB(i,j)$ be the number of children ever born to women in age (duration) group i at survey j, and let $FP(i,j)$ be the corresponding total number of women (ever-married women if data are classified by duration) of age (duration) group i. Then, as usual, the average number of children ever born per woman of age group i and survey j is calculated as

$$P(i,j) = CEB(i,j)/FP(i,j). \qquad \text{(E.1)}$$

Step 2: calculation of proportion of children dead reported at time of second survey. The values of this proportion, $D(i,2)$, are calculated only for the second survey or census. Thus, denoting the number of children dead to women of age group i from this survey by $CD(i,2)$, one has

$$D(i,2) = CD(i,2)/CEB(i,2). \qquad \text{(E.2)}$$

Step 3: calculation of multipliers. It is in this step that the use of cohort experience becomes relevant. The values of multipliers $k(i)$ are estimated by means of equations fitted to model cases by means of least-squares regression and whose independent variable is a ratio of parities referring to a birth cohort of women at two points in time. Therefore, if the surveys considered are five years apart, these parity ratios have the form $P(i-1,1)/P(i,2)$; while if the surveys are 10 years apart, the corresponding ratios would be $P(i-2,1)/P(i,2)$. The form of the equation to estimate the $k(i)$ multipliers, the values of the fitted coefficients and the form of the corresponding parity ratios are presented in tables 70-73. Tables 70 and 71 are to be used when the data are classified by age, whereas tables 72 and 73 are needed when the data are classified by duration of first marriage. The first table of each set (tables 70 and 72) is to be used when the intersurvey interval is five years, whereas the second table of each set (tables 71 and 73) is needed when the interval is 10 years. After selecting the appropriate table for the case at hand, the calculation of the $k(i)$ multipliers is straightforward, as is shown in the detailed examples.

Step 4: estimation of probability of dying. The estimated values of $q(x)$, the probability of dying between birth and exact age x, are obtained as the products of the observed proportions dead, $D(i,2)$, and the multipliers, $k(i)$, computed in step 3.

Step 5: estimation of reference period. The use of the experience of true cohorts to estimate the multipliers,

TABLE 70. COEFFICIENTS FOR ESTIMATION OF THE MULTIPLIERS, $k(i)$, FROM THE EXPERIENCE OF TRUE COHORTS WHEN DATA ARE CLASSIFIED BY AGE OF MOTHER AND THE INTERSURVEY INTERVAL IS FIVE YEARS

Mortality model (1)	Age group (2)	Index i (3)	Age x (4)	Parity ratios for two successive surveys $P(i-1, 1)/P(i, 2)$ (5)	Coefficients $a(i)$ (6)	$b(i)$ (7)
North	20-24	2	2	$P(1, 1)/P(2, 2)$	1.1635	−1.0530
	25-29	3	3	$P(2, 1)/P(3, 2)$	1.1833	−0.4924
	30-34	4	5	$P(3, 1)/P(4, 2)$	1.3408	−0.5210
	35-39	5	10	$P(4, 1)/P(5, 2)$	1.5425	−0.6137
South	20-24	2	2	$P(1, 1)/P(2, 2)$	1.2015	−1.0218
	25-29	3	3	$P(2, 1)/P(3, 2)$	1.2121	−0.4235
	30-34	4	5	$P(3, 1)/P(4, 2)$	1.2973	−0.4071
	35-39	5	10	$P(4, 1)/P(5, 2)$	1.4205	−0.4515
East	20-24	2	2	$P(1, 1)/P(2, 2)$	1.1614	−0.7298
	25-29	3	3	$P(2, 1)/P(3, 2)$	1.1524	−0.3159
	30-34	4	5	$P(3, 1)/P(4, 2)$	1.2240	−0.3184
	35-39	5	10	$P(4, 1)/P(5, 2)$	1.3253	−0.3682
West	20-24	2	2	$P(1, 1)/P(2, 2)$	1.1838	−0.8901
	25-29	3	3	$P(2, 1)/P(3, 2)$	1.1776	−0.3828
	30-34	4	5	$P(3, 1)/P(4, 2)$	1.2757	−0.3939
	35-39	5	10	$P(4, 1)/P(5, 2)$	1.4017	−0.4662

Estimation equations:

$$k(i) = a(i) + b(i)\, P(i-1, 1)/P(i, 2)$$
$$q(x) = k(i)\, D(i, 2)$$

TABLE 71. COEFFICIENTS FOR ESTIMATION OF THE MULTIPLIERS, $k(i)$, FROM THE EXPERIENCE OF TRUE COHORTS WHEN DATA ARE CLASSIFIED BY AGE OF MOTHER AND THE INTERSURVEY INTERVAL IS 10 YEARS

Mortality model (1)	Age group (2)	Index i (3)	Age x (4)	Parity ratios for two successive surveys $P(i-2, 1)/P(i, 2)$ (5)	Coefficients $a(i)$ (6)	$b(i)$ (7)
North	25-29	3	3	$P(1, 1)/P(3, 2)$	1.0301	−1.1435
	30-34	4	5	$P(2, 1)/P(4, 2)$	1.1163	−0.4176
	35-39	5	10	$P(3, 1)/P(5, 2)$	1.2648	−0.3991
South	25-29	3	3	$P(1, 1)/P(3, 2)$	1.0795	−0.9681
	30-34	4	5	$P(2, 1)/P(4, 2)$	1.1203	−0.3211
	35-39	5	10	$P(3, 1)/P(5, 2)$	1.1972	−0.2918
East	25-29	3	3	$P(1, 1)/P(3, 2)$	1.0535	−0.7242
	30-34	4	5	$P(2, 1)/P(4, 2)$	1.0859	−0.2523
	35-39	5	10	$P(3, 1)/P(5, 2)$	1.1585	−0.2390
West	25-29	3	3	$P(1, 1)/P(3, 2)$	1.0579	−0.8796
	30-34	4	5	$P(2, 1)/P(4, 2)$	1.1054	−0.3139
	35-39	5	10	$P(3, 1)/P(5, 2)$	1.1914	−0.3043

Estimation equations:

$$k(i) = a(i) + b(i)\, P(i-2, 1)/P(i, 2)$$
$$q(x) = k(i)\, D(i, 2)$$

$k(i)$, makes allowance for changes in fertility, but it does nothing with respect to changes in mortality. Therefore, if there is evidence suggesting a mortality decline in the recent past, it is important to ascertain to which time period the $q(x)$ estimates obtained in step 4 really refer. The estimation of the reference period, $t(x)$, the number of years before the second survey to which the corresponding $q(x)$ estimate refers, is carried out by means of equations whose coefficients were estimated by using least-squares regression applied to data generated by model schedules. The estimated values of these coefficients are given in tables 74-77. The order of these tables parallels that used in presenting the tables needed to calculate the $k(i)$ multipliers. The first two tables are used when data are classified by age and the second two when data are classified by marriage duration. Within each set, the first table is used if the intersurvey period is five years and the second if it is 10 years. The use of these tables is illustrated in the next examples.

4. *Detailed examples*

This section presents two examples: that used in the previous section referring to Thailand and illustrating the estimation procedure applied to a five-year intersurvey interval; and the case of Brazil, where data on children ever born and children surviving have been collected by several of its decennial censuses.

(a) *Thailand, 1970-1975*

The basic data available for Thailand for the years

TABLE 72. COEFFICIENTS FOR ESTIMATION OF THE MULTIPLIERS, $k(i)$, FROM THE EXPERIENCE OF TRUE COHORTS WHEN DATA ARE CLASSIFIED BY DURATION OF MARRIAGE AND THE INTERSURVEY INTERVAL IS FIVE YEARS

Mortality model (1)	Duration group (2)	Index i (3)	Age x (4)	Parity ratios for two successive surveys $P(i-1,1)/P(i,2)$ (5)	Coefficients $a(i)$ (6)	$b(i)$ (7)
North	5-9	2	3	$P(1,1)/P(2,2)$	1.2000	−0.5977
	10-14	3	5	$P(2,1)/P(3,2)$	1.3060	−0.4662
	15-19	4	10	$P(3,1)/P(4,2)$	1.4789	−0.5290
South	5-9	2	3	$P(1,1)/P(2,2)$	1.2359	−0.5626
	10-14	3	5	$P(2,1)/P(3,2)$	1.2797	−0.3843
	15-19	4	10	$P(3,1)/P(4,2)$	1.3564	−0.3915
East	5-9	2	3	$P(1,1)/P(2,2)$	1.1648	−0.4057
	10-14	3	5	$P(2,1)/P(3,2)$	1.2047	−0.2919
	15-19	4	10	$P(3,1)/P(4,2)$	1.2823	−0.3120
West	5-9	2	3	$P(1,1)/P(2,2)$	1.1882	−0.4803
	10-14	3	5	$P(2,1)/P(3,2)$	1.2455	−0.3499
	15-19	4	10	$P(3,1)/P(4,2)$	1.3408	−0.3857

Estimation equations:
$k(i)=a(i)+b(i)\,P(i-1,1)/P(i,2)$
$q(x)=k(i)\,D(i,2)$

TABLE 73. COEFFICIENTS FOR ESTIMATION OF THE MULTIPLIERS, $k(i)$, FROM THE EXPERIENCE OF TRUE COHORTS WHEN DATA ARE CLASSIFIED BY DURATION OF MARRIAGE AND THE INTERSURVEY INTERVAL IS 10 YEARS

Mortality model (1)	Duration group (2)	Index i (3)	Age x (4)	Parity ratios for two successive surveys $P(i-2,1)/P(i,2)$ (5)	Coefficients $a(i)$ (6)	$b(i)$ (7)
North	10-14	3	5	$P(1,1)/P(3,2)$	1.1650	−0.7209
	15-19	4	10	$P(2,1)/P(4,2)$	1.2697	−0.4084
South	10-14	3	5	$P(1,1)/P(3,2)$	1.1630	−0.5922
	15-19	4	10	$P(2,1)/P(4,2)$	1.2015	−0.3022
East	10-14	3	5	$P(1,1)/P(3,2)$	1.1162	−0.4502
	15-19	4	10	$P(2,1)/P(4,2)$	1.1589	−0.2409
West	10-14	3	5	$P(1,1)/P(3,2)$	1.1394	−0.5401
	15-19	4	10	$P(2,1)/P(4,2)$	1.1883	−0.2978

Estimation equations:
$k(i)=a(i)+b(i)\,P(i-2,1)/P(i,2)$
$q(x)=k(i)\,D(i,2)$

TABLE 74. COEFFICIENTS NEEDED TO ESTIMATE THE REFERENCE PERIOD, $t(x)$,[a] FROM THE EXPERIENCE OF TRUE COHORTS WHEN DATA ARE CLASSIFIED BY AGE AND THE INTERSURVEY INTERVAL IS FIVE YEARS

Age group (1)	Index i (2)	Age x (3)	Parity ratios for two successive surveys $P(i-1,1)/P(i,2)$ (4)	Coefficients $a(i)$ (5)	$b(i)$ (6)
20-24	2	2	$P(1,1)/P(2,2)$	1.3999	5.9156
25-29	3	3	$P(2,1)/P(3,2)$	1.1637	6.4668
30-34	4	5	$P(3,1)/P(4,2)$	−0.4262	10.1371
35-39	5	10	$P(4,1)/P(5,2)$	−2.7596	14.6371

Estimation equation:
$t(x)=a(i)+b(i)\,P(i-1,1)/P(i,2)$

[a] Number of years prior to the survey to which estimates refer.

1970 and 1975 are presented in table 65. From those data, child mortality is estimated by using only the proportions of children dead reported at the second point in time and the parity changes experienced by the different female birth cohorts.

The steps of the calculations are given below.

Step 1: calculation of average parity per woman. The values of average parities, $P(i,j)$, have already been calculated in step 1 of the detailed example given in subsection D.3 and are given in table 66.

Step 2: calculation of proportion of children dead reported at the time of the second survey. The proportion of children dead at the time of the second survey (1975 in this case), denoted by $D(i,2)$, is calculated directly from the

TABLE 75. COEFFICIENTS NEEDED TO ESTIMATE THE REFERENCE PERIOD, $t(x)$,[a] FROM THE EXPERIENCE OF TRUE COHORTS WHEN DATA ARE CLASSIFIED BY AGE AND THE INTERSURVEY INTERVAL IS 10 YEARS

Age group (1)	Index i (2)	Age x (3)	Parity ratios for two successive surveys $P(i-2,1)/P(i,2)$ (4)	Coefficients $a(i)$ (5)	$b(i)$ (6)
25-29	3	3	$P(1,1)/P(3,2)$	3.2474	14.2086
30-34	4	5	$P(2,1)/P(4,2)$	3.6914	8.9412
35-39	5	10	$P(3,1)/P(5,2)$	3.4605	10.1997

Estimation equation:
$$t(x)=a(i)+b(i)\,P(i-2,1)/P(i,2)$$

[a] See table 74, footnote a.

TABLE 76. COEFFICIENTS NEEDED TO ESTIMATE THE REFERENCE PERIOD, $t(x)$,[a] FROM THE EXPERIENCE OF TRUE COHORTS WHEN DATA ARE CLASSIFIED BY MARRIAGE DURATION AND THE INTERSURVEY INTERVAL IS FIVE YEARS

Duration group (1)	Index i (2)	Age x (3)	Parity ratios for two successive surveys $P(i-1,1)/P(i,2)$ (4)	Coefficients $a(i)$ (5)	$b(i)$ (6)
5-9	2	3	$P(1,1)/P(2,2)$	1.6812	4.5954
10-14	3	5	$P(2,1)/P(3,2)$	1.5051	6.4997
15-19	4	10	$P(3,1)/P(4,2)$	−0.4116	11.1290

Estimation equation:
$$t(x)=a(i)+b(i)\,P(i-1,1)/P(i,2)$$

[a] See table 74, footnote a.

TABLE 77. COEFFICIENTS NEEDED TO ESTIMATE THE REFERENCE PERIOD, $t(x)$,[a] FROM THE EXPERIENCE OF TRUE COHORTS WHEN DATA ARE CLASSIFIED BY MARRIAGE DURATION AND THE INTERSURVEY INTERVAL IS 10 YEARS

Duration group (1)	Index i (2)	Age x (3)	Parity ratios for two successive surveys $P(i-2,1)/P(i,2)$ (4)	Coefficients $a(i)$ (5)	$b(i)$ (6)
10-14	3	5	$P(1,1)/P(3,2)$	3.3781	10.5019
15-19	4	10	$P(2,1)/P(4,2)$	3.9324	8.7033

Estimation equation:
$$t(x)=a(i)+b(i)\,P(i-2,1)/P(i,2)$$

[a] See table 74, footnote a.

data given in table 65 by dividing the number of children dead by those ever born for each age group of mother. For example, $D(4,2)$ is calculated as follows:

$$D(4,2)=2{,}375/22{,}969=0.1034.$$

All values of $D(i,2)$ are shown in table 78.

Step 3: calculation of multipliers. The independent variables necessary to estimate the multipliers, $k(i)$, are the ratios of the observed average parities corresponding to true cohorts at the two points in time being considered. These ratios have the form $P(i-1,1)/P(i,2)$, since the intersurvey period is five years. The values of these ratios are shown in column (5) of table 78. For $i=4$, the ratio is

$$P(3,1)/P(4,2)=2.4479/3.5293=0.6936$$

where the values of $P(i-1,1)$ and $P(i,2)$ are obtained from table 66.

Once the necessary parity ratios are computed, the values of $k(i)$ are estimated by using the coefficients presented in table 70. As in the example given in subsection D.3, the mortality pattern selected is North. The

TABLE 78. ESTIMATION OF CHILD MORTALITY FROM 1975 DATA TAKING INTO ACCOUNT THE FERTILITY EXPERIENCE OF COHORTS, THAILAND

Age group (1)	Index i (2)	Age x (3)	Proportion of children dead $D(i,2)$ (4)	Parity ratios for two successive surveys $P(i-1,1)/P(i,2)$ (5)	Multipliers $k(i)$ (6)	Probability of dying $q(x)$ (7)	Reference period $t(x)$ (8)	North mortality level (9)
15-19	1	1	0.0710	-	-	-	-	-
20-24	2	2	0.0679	0.1477	1.0080	0.0684	2.3	18.8
25-29	3	3	0.0792	0.4679	0.9529	0.0755	4.2	18.6
30-34	4	5	0.1034	0.6936	0.9794	0.1013	6.6	17.4
35-39	5	10	0.1189	0.8198	1.0394	0.1236	9.2	16.8

resulting values of $k(i)$ are shown in table 78; $k(4)$ is calculated in detail below:

$$k(4) = 1.3408 + (-0.5210)(0.6936) = 0.9749.$$

Step 4: calculation of probability of dying. Estimates of the probability of dying, $q(x)$, are obtained as the products of the proportion of children dead, $D(i, 2)$, and the $k(i)$ multipliers. Note that this time no estimate of $q(1)$ is possible; consequently, there is no multiplier for $D(1, 2)$. The resulting values of $q(x)$ are shown in column (7) of table 78.

Step 5: calculation of reference period. Using the coefficients presented in table 74 and the parity ratios used in calculating $k(i)$, the values of the reference period, $t(x)$, are obtained by substituting them in the estimation equation shown at the bottom of table 74. For example,

$$t(2) = 1.3999 + (5.9156)(0.1477) = 2.3.$$

This value means that the estimate of $q(2)$ obtained in step 4 refers to approximately 2.3 years before the second survey. So it can be said that $q(2)$ roughly represents the child mortality prevalent in 1973, since the second data set being considered is supposed to represent 1975 experience. The complete set of $t(x)$ values is listed in table 78.

Column (9) of table 78 shows the levels of mortality in the North family of Coale-Demeny life tables consistent with the estimated $q(x)$ values. Once more, these levels suggest that child mortality has been declining. Their values are quite consistent with those shown in table 69, where child mortality estimates were obtained solely from the 1975 data. If anything, the new values suggest that the decline in mortality was more rapid.

(b) *Brazil, 1960-1970*

The data on children ever born and surviving collected for the whole of Brazil during the 1960 and 1970 censuses (both of which have exactly the same reference date, 1 September) are given in table 79. This wealth of data permits the application of most of the methods described in this chapter. Since the detailed application of these methods has already been described in the other examples presented so far, it is not repeated here, but results obtained by using each of them are shown.

TABLE 79. DATA ON CHILDREN EVER BORN AND SURVIVING, BRAZIL, 1960 AND 1970
(*Thousands*)

	1960				1970		
Age group (1)	*Number of women (2)*	*Children ever born (3)*	*Corrected children ever born (4)*	*Children surviving (5)*	*Number of women (6)*	*Children ever born (7)*	*Children surviving (8)*
15-19	3 723	467	453	398	5 306	630	557
20-24	3 244	3 574	3 467	2 984	4 309	4 182	3 653
25-29	2 701	6 864	6 658	5 624	3 264	7 923	6 817
30-34	2 266	8 612	8 354	6 889	2 862	10 808	9 133
35-39	1 993	9 782	9 489	7 607	2 571	12 343	10 229

Before proceeding to apply these methods, it must be pointed out that the question used in the 1960 census to obtain information on children ever born was not phrased properly; consequently, the data collected exhibit a definite bias. Specifically, the question asked of women of reproductive age was: "How many children have you ever had?", instead of "How many children, who have been born alive, have you ever had?" It is therefore likely that the 1960 information on children ever born includes both those born alive and those born dead. So, before the 1960 data are used to estimate child mortality, the number of children ever born have to be corrected for the inclusion of stillbirths. The correction made consists in multiplying the reported numbers of children ever born by 0.97, on the assumption that the incidence of stillbirths among all births is 0.03. In studies of similar data collected during the 1950 census of Brazil, the proportion of stillbirths used for the purpose of correction was 0.05.[14] This estimate was based on the proportion of stillbirths yielded by the 1940 census, during which a definite distinction was made between live births and stillbirths. According to this census, about 7 per cent of all births were stillbirths, but the estimate of 5 per cent was accepted on the grounds that women were not as likely to report all their stillbirths when only a question on children ever born was posed as when two questions, one about live births and another about stillbirths, were asked.

More information about the incidence of stillbirths among all births to the Brazilian population is now available. Two separate questions referring to these events were asked by the 1970 census and by several country-wide sample surveys carried out during the 1970s. All these data reveal that the proportion of reported stillbirths among all births has declined to roughly 0.05 (0.045 may be a more accurate figure); and therefore, a 5 per cent correction for the 1960 data seems too high, especially because of the known tendency among women to underreport the number of children they have ever had. As a compromise, a 3 per cent correction was accepted. The corrected numbers of children ever born by age group of mother for 1960 are shown in column (4) of table 79.

Table 80 shows the results of the steps needed to estimate child mortality from the information gathered in

[14] Giorgio Mortara, "A fecundidade da mulher e a sobrevivencia dos filhos no Brasil, segundo o Censo de 1950", *Contribuções para o Estudo da Demografia do Brasil* (Rio de Janeiro, Fundação Instituto Brasileiro de Geografia e Estatistica, 1970); and J. A. M. Carvalho, "Regional trends of fertility and mortality in Brazil", *Population Studies*, vol. XXVIII, No. 3 (November 1974), pp. 401-421.

TABLE 80. CHILD MORTALITY ESTIMATION USING MULTIPLIERS BASED ON THE WEST MORTALITY PATTERN, BRAZIL, 1960

Age group (1)	Index i (2)	Age x (3)	Average parity per woman $P(i)$[a] (4)	Proportion of children dead $D(i)$ (5)	Multipliers $k(i)$[b] (6)	Probability of dying $q(x)$ (7)	Reference period[c] $t(x)$ (8)	West mortality level (9)
15-19	1	1	0.1217	0.1214	1.1656	0.1415	0.9	12.2
20-24	2	2	1.0686	0.1393	1.0808	0.1506	2.1	13.6
25-29	3	3	2.4650	0.1554	1.0112	0.1571	3.9	13.9
30-34	4	5	3.6865	0.1754	1.0134	0.1778	6.2	13.6

[a] Adjusted to exclude stillbirths.
[b] Based on $P(1)/P(2)=0.1138$ and $P(2)/P(3)=0.4335$.
[c] Number of years prior to the survey to which estimates refer.

TABLE 81. CHILD MORTALITY ESTIMATION USING MULTIPLIERS BASED ON THE WEST MORTALITY PATTERN, BRAZIL, 1970

Age group (1)	Index i (2)	Age x (3)	Average parity per woman $P(i)$ (4)	Proportion of children dead $D(i)$ (5)	Multipliers $k(i)$[a] (6)	Probability of dying $q(x)$ (7)	Reference period[b] $t(x)$ (8)	West mortality level (9)
15-19	1	1	0.1187	0.1159	1.1168	0.1294	1.0	13.0
20-24	2	2	0.9705	0.1265	1.0850	0.1373	2.1	14.3
25-29	3	3	2.4274	0.1396	1.0258	0.1432	3.8	14.6
30-34	4	5	3.7764	0.1550	1.0298	0.1596	5.9	14.5

[a] Based on $P(1)/P(2)=0.1223$ and $P(2)/P(3)=0.3998$
[b] See table 80, footnote c.

1960 (see subsection B.2). Note that the levels of mortality implied by the $q(x)$ estimates are fairly similar, except for that associated with $q(1)$, which is clearly out of line with the rest, probably because child mortality is not independent of mother's age (see subsection A.1).

Note that the raw data (table 79) provide the number of children surviving rather than the number dead. The latter, of course, are obtained by subtraction.

Table 81 shows the estimates of childhood mortality obtained solely from the 1970 information (see subsection B.2). Once more, the estimate of $q(1)$ is not consistent with the others. In general, the level of child mortality seems to have improved between 1960 and 1970.

It is worth remarking that when child mortality is estimated from a single data set, the estimated values of $q(1)$, $q(2)$, $q(3)$ and $q(5)$ refer approximately to one, two, four and six years before the census being considered. Reference dates for the usual child mortality estimates always display this pattern.

Tables 82 and 83 illustrate the steps necessary to obtain intercensal estimates of child mortality (see section D). The average number of children dead is obtained in this case by subtracting the number of children surviving from the total number of children ever born and dividing the result by the number of women in the relevant age group. Thus, for example,

$$ACD(3, 1)=(6{,}658-5{,}624)/2{,}701=0.3828;$$

$$ACD(2, 2)=(4{,}182-3{,}653)/4{,}309=0.1228.$$

Final results are shown in table 83. Note that the

TABLE 82. CHILD MORTALITY ESTIMATION FOR THE INTERCENSAL PERIOD 1960-1970, WITH 1960 DATA ON CHILDREN EVER BORN CORRECTED FOR INCLUSION OF STILLBIRTHS, BRAZIL

		Average number of children ever born		Average number of children dead		
Age group (1)	Index i (2)	1960 $P(i, 1)$[a] (3)	1970 $P(i, 2)$ (4)	1960 $ACD(i, 1)$ (5)	1970 $ACD(i, 2)$ (6)	Intercensal period $ACD(i, s)$ (7)
15-19	1	0.1217	0.1187	0.0148	0.0138	0.0138
20-24	2	1.0686	0.9705	0.1488	0.1228	0.1228
25-29	3	2.4650	2.4274	0.3828	0.3388	0.3378
30-34	4	3.6865	3.7764	0.6464	0.5853	0.5593
35-39	5	4.7610	4.8009	0.9441	0.8222	0.7771

[a] Adjusted to exclude stillbirths.

TABLE 83. INTERCENSAL ESTIMATES OF CHILD MORTALITY, BRAZIL, 1960-1970

Age group (1)	Index i (2)	Age x (3)	Average parity per woman $P(i, s)$ (4)	Proportion of children dead $D(i, s)$ (5)	Multipliers $k(i)$[a] (6)	Probability of dying $q(x)$ (7)	West mortality level (8)
15-19	1	1	0.1187	0.1163	1.1172	0.1299	12.9
20-24	2	2	0.9705	0.1265	1.0849	0.1372	14.4
25-29	3	3	2.4244	0.1393	1.0256	0.1429	14.7
30-34	4	5	3.6783	0.1521	1.0296	0.1566	14.6
35-39	5	10	4.7927	0.1621	1.0460	0.1696	14.6

[a] Based on $P(1)/P(2)=0.1223$ and $P(2)/P(3)=0.4003$.

TABLE 84. CHILD MORTALITY ESTIMATION TAKING INTO ACCOUNT THE EXPERIENCE OF TRUE COHORTS, BRAZIL, 1970

Age group (1)	Index i (2)	Age x (3)	Parity ratios for two successive censuses $P(i-2,1)/P(i,2)$ (4)	Multipliers $k(i)$ (5)	Probability of dying $q(x)$ (6)	Reference period[a] $t(x)$ (7)	West mortality level (8)
25-29	3	3	0.0501	1.0138	0.1415	4.0	14.7
30-34	4	5	0.2830	1.0166	0.1576	6.2	14.6
35-39	5	10	0.5134	1.0352	0.1773	8.7	14.3

[a] Number of years prior to the survey to which estimates refer.

mortality levels prevalent during the intercensal period almost coincide with those obtained solely from the 1970 data; and, excluding $q(1)$, they are fairly consistent.

Lastly, when estimates for 1970 are obtained by taking into account the fertility experience of true cohorts, almost the same mortality levels are obtained (see table 84). Such consistency is reassuring. It permits one to conclude that the average West mortality level prevalent during the period 1960-1970, as measured by child mortality, was approximately 14.5.

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