The Own-Children Method of Fertility Estimation

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CHAPTER I

Introduction

In most nations birth registration is incomplete and conventional measurement of fertility from vital statistics is difficult or impossible. Many of these nations, however, have for some time routinely conducted population censuses and surveys. By applying indirect demographic estimation techniques, demographers have been able to use census and survey data to fill many of the gaps in our knowledge of fertility levels and trends. Some of these techniques, including the own-children method, have the additional capability of producing fertility estimates by social and economic characteristics asked about in censuses or surveys. This feature makes the indirect methods useful even in situations in which vital registration is virtually complete, since information on social and economic characteristics is not usually recorded on birth certificates. Consequently, many of the indirect estimation techniques originally developed for situations in which vital registration was seriously deficient will remain useful even as vital registration improves.

The own-children method in brief

The own-children method of fertility estimation is a reverse-survival technique for estimating age-specific birth rates for years previous to a census or household survey. From the basic household records, on computer tape or in other machine-readable form, enumerated children are first matched to mothers within households, usually on the basis of answers to questions on age, sex, marital status, number of living children, and relation to head of household. Sometimes matching is facilitated by a special census question on line number (in the household listing) of mother, if present. In either case, a computer algorithm is used for matching. The matched (i.e., own) children, classified by their own ages and mother's age, are then reverse-survived to estimate numbers of births by age of mother in previous years. Reverse-survival is similarly used to estimate numbers of women by age in previous years. After adjustments are made for misenumeration (mainly undercount and age misreporting) and unmatched (i.e., non-own) children, age-specific birth rates are calculated by dividing the number of reverse-survived births by the number of reverse-survived women. Estimates are normally computed for each of the fifteen years or groups of years before the census. Estimates are not usually computed further back than fifteen years because births must then be based on children aged 15 or more at enumeration, a large proportion of whom do not reside in the same household as their mother and hence cannot be matched. (If marriage is late and households are stable, however, twenty years of estimates are sometimes possible.) All calculations are done initially by single years of age and time. Estimates for grouped ages or calendar years are obtained by appropriately aggregating single-year numerators (births) and denominators (women) and then dividing the aggregated numerator by the aggregated denominator. Such aggregation is often useful for minimizing the distorting effects of age misreporting on the fertility estimates.

The basic logic of the procedure is illustrated by the simplified reverse-survival diagram in Figure 1.1. We suppose a census in 1970. $C_{3,27}$ denotes the number of children aged 3 who are matched to women aged 27 at the time of the census; we imagine that $C_{3,27}$ is already adjusted for undercount, age misreporting, and the presence of non-own (unmatched) children. W_{27} denotes the number of women aged 27 enumerated in the census; we similarly imagine that W_{27} is already adjusted for undercount and age misreporting. Three years ago the children, $C_{3,27}$, were births, B_{24}, to women aged 24, W_{24}. Because of intervening deaths, B_{24} is somewhat larger than $C_{3,27}$, and W_{24} is somewhat larger than W_{27}. The age-specific birth rate three years ago, F_{24}, is calculated as B_{24}/W_{24}.

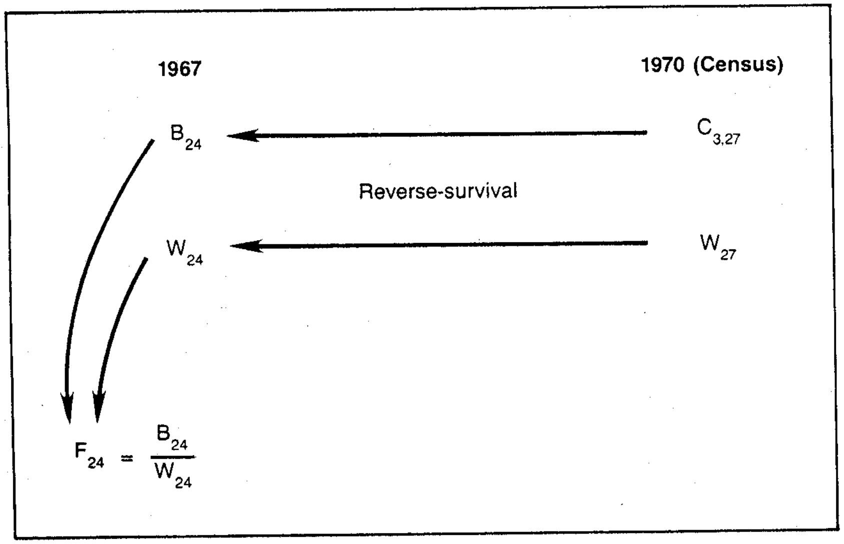

Figure 1.1. Reverse-survival diagram for own-children analysis

Starting from this simple logic, the own-children method has undergone many refinements and elaborations over more than two decades of applications, described and summarized in the chapters that follow.

Historical development

The own-children method of fertility estimation originated in a series of special tabulations of young children by age of mother from the 1910 and 1940 censuses of the United States (U.S. Bureau of the Census 1947), which were used to generate estimates of differential fertility. Employing such tabulations, Wilson H. Grabill and Lee-Jay Cho developed the basic ideas of the method in the early 1960s (Grabill and Cho 1965). Further work occurred in a study of differential fertility in the United States (Cho, Grabill, and Bogue 1970). Cho (1971c) subsequently refined the approach to obtain annual fertility estimates for each of the ten years immediately preceding a census. The 1970 round of censuses ushered in applications of the method in countries around the world, including Bolivia, Brazil, Colombia, Costa Rica, Guatemala, Hungary, Indonesia, Japan, the Republic of Korea, Malaysia, Pakistan, Paraguay, the Philippines, and Thailand. (References to these studies are included in the bibliography at the end of this book.)

As the method was applied to more censuses, further refinements were made to handle problems such as age misreporting and changes in mortality levels during the past. For application in countries lacking reliable information on mortality from vital registration, the Brass method of estimating infant and child mortality (Brass 1975) and Feeney's extension of Brass's method, allowing for changing mortality (Feeney 1980) were incorporated into the procedure. A package of computer programs in three stages was developed.

More recent extensions of the own-children method include estimation of age–parity-specific birth rates (Retherford and Cho 1978), age-specific birth rates for currently married women (Ratnayake, Retherford, and Sivasubramaniam 1984), birth rates by age and duration since first marriage for ever-married women (Cho and Retherford 1978; Retherford, Cho, and Kim 1984), and age-specific birth rates for men (Retherford and Sewell 1986).

A promising new development, now being tested, involves the reconstruction of birth histories from data on own children. A woman and her own children represent a partial birth history. Omitted are deceased children, children living elsewhere, and children of ages 15 and older. The total number of births excluded equals the number of children ever born to the woman less the number of her own children. By considering the age of the woman, the birth dates of her own children, the number of excluded births, and the shape of the aggregate age-specific fertility schedule, it is possible to impute the birth dates of the excluded children and hence to arrive at a complete, reconstructed (though partially estimated) birth history for every woman. Although these reconstructed histories generally are not accurate at the individual level, preliminary tests indicate that the imputation can be carried out in such a way that they produce fertility statistics that are reasonably accurate at the aggregate level. When mortality is low and families are intact, the proportion of births that need to be imputed is quite small, so that even a rather crude imputation procedure should provide good results. Birth history data are essential for many kinds of fertility analysis, but they have thus far been available only from relatively small fertility surveys. The ability to reconstruct statistically valid birth history data from censuses and large-scale household surveys promises to open vast new areas for fertility research.

Strengths and limitations

The own-children method has several strengths. First, the method is useful in less developed countries where vital registration often is seriously deficient. In these countries, censuses as well as vital registration tend to suffer from undercount; but censuses, to which the own-children method can be applied, tend to be more accurate. Moreover, if omissions in censuses tend to be of entire households, then age-specific child–woman ratios tend to be biased comparatively little by undercount. Then own-children estimates of age-specific birth rates, which can be viewed as mortality-adjusted, age-specific child–woman ratios, also tend to be biased comparatively little by undercount.

A second strength is that own-children estimates of fertility can be tabulated by whatever characteristics are recorded in the census or household survey. This makes it possible, for example, to tabulate fertility estimates by such variables as education, occupation, language, and religion. Since vital registration systems do not normally collect information on these variables, fertility estimates derived from vital registration cannot be so tabulated. This feature of the own-children method makes it attractive in more developed as well as in less developed countries (see, for example, Cho, Grabill, and Bogue 1970; Rindfuss and Sweet 1977; Sweet and Rindfuss 1983).

A third strength is that the own-children method ordinarily requires no new data collection and is therefore inexpensive to apply. The typical application is to a census or household survey already undertaken for other purposes. Examples of suitable household surveys are labor force surveys and income and expenditure surveys. The only requirements are that the census or survey be of households, so that children may be matched to mothers within the same household, and that basic information on age and sex of respondents be asked. Ideally, additional information on marital status, number of children ever born or still living, and relationship to head of household should also be present, to facilitate matching, but in most instances satisfactory if slightly less accurate results can be obtained even when this supplemental information is missing.

A fourth strength relates to the large size of the census or household survey samples to which the own-children method is typically applied, relative to the small sample size of the typical fertility survey. Fertility surveys that collect maternity histories are usually based on a few thousand interviews and do not offer much potential for detailed cross-tabulation of fertility estimates for geographic subdivisions and by socioeconomic characteristics. In contrast, the census samples to which the own-children method is typically applied often contain upward of one million individuals, thereby providing a great deal of potential for cross-tabulation.

A fifth strength is that the own-children estimates of age-specific birth rates derived for each year during the fifteen-year estimation period immediately preceding the census or survey do not suffer from age truncation. This advantage stems from the fact that the initial matching of children to mothers is done for women up to age 65 at the time of enumeration. Fifteen years previous to enumeration these 65-year-old women were 50 years old. Therefore, age-specific birth rates can be calculated up to age 50 for each calendar year back to the fifteenth year before enumeration. Fertility estimates derived from maternity histories, on the other hand, suffer from age truncation. Typically, maternity histories are collected only from ever-married women aged 15–49. This means, for example, that age-specific birth rates can be calculated up to age 45 for the fifth year preceding the survey, age 40 for the tenth year preceding the survey, and age 35 for the fifteenth year preceding the survey. Thus maternity history data do not ordinarily allow a complete reconstruction of age-specific fertility in previous years.

The major limitation of the own-children method is that both the age pattern of fertility and the estimated trend of fertility can be severely distorted by age misreporting. Such distortions can be lessened but usually not eliminated by aggregating estimates over several calendar years. However, if the method is applied to two or more successive censuses, the estimated fertility trends for single calendar years partly overlap, since each census yields estimates for a fifteen-year period. For example, own-children fertility estimates derived from two censuses ten years apart yield trends that overlap during the first five years preceding the first census. The degree to which these two trends coincide during this five-year period may indicate the nature of systematic biases due to age misreporting, and the trend accordingly adjusted. Of course, sensitivity to age misreporting also characterizes fertility estimates derived from maternity histories. But, as we shall see later, the distortions due to age misreporting tend to be less pronounced in maternity histories because of differences in the way that data are collected.

A second limitation is that the own-children estimates may be biased by migration, although this is not usually much of a problem since migrants are normally a small proportion of a population. If migration rates are high, however, and if migrants are a highly selected group by virtue of their age-specific fertility behavior, then bias in the fertility estimates from this source can also be serious. For example, in instances of high rates of rural-to-urban migration, own-children estimates of fertility for urban areas in years before the survey tend to be too high because many of the urbanites interviewed at the time of the census lived a few years before in rural areas, where their fertility was much higher. On the other hand, if, in a particular geographic area, in-migrants have the same age-specific birth rates as nonmigrants, there is no bias from in-migration, unless some of the in-migrants leave their children with relatives in other geographic areas for long periods of time before becoming permanently resettled in the geographic area under consideration. Rather similar remarks pertain to potential biases introduced by out-migration. Fertility estimates derived from maternity histories also suffer from migration bias, although not in precisely the same way.

A third limitation is that the own-children method in its current state of development does not yield birth interval statistics. This deficiency exists because the household roster of surviving children who are matched to a particular woman does not yield a complete birth history. Given the ages of the surviving children matched to a woman, one can infer birth dates, yielding a partial birth history that omits births of children who later died or moved out of the household before being enumerated in the census. As mentioned earlier, however, it is possible to use probability models to impute the birth dates of the missing children and thereby reconstruct the complete birth history, provided that the census includes questions on number of children ever born and number of children still living. Preliminary tests indicate that aggregate-level birth interval statistics from birth histories reconstructed in this way compare quite well with those derived from maternity histories. This extension of the own-children method, which is still under development, clarifies why age misreporting and, to a lesser extent, migration tend to bias fertility estimates derived from own children and maternity histories in much the same way. Indeed, fertility estimates derived from own children can be viewed as fertility estimates derived from incomplete maternity histories.

A fourth limitation is that matching errors and misallocation of nonown children may introduce bias. But bias from these sources tends to be small compared with bias from age misreporting.

Purpose and organization of this book

The purpose of this book is twofold. The first is to provide a concise summary of the own-children methodology and problems of application. The second is to spell out step-by-step procedures for applying the methodology.

Chapter 2 outlines the basic methodology. Chapter 3 discusses major methodological extensions. Chapter 4 deals with evaluation and analysis of errors. Chapter 5 contains illustrative analyses for the Republic of Korea and Pakistan. Chapter 6 analyzes fertility trends estimated alternatively from birth histories and own-children data. Chapter 7 outlines step-by-step procedures for application, with illustrative examples. The appendices discuss specialized aspects of the method and selected computer programs.

CHAPTER 2

Basic Methodology

This chapter explains the core methodology for estimating age-specific birth rates. Although the methodology can be applied to household surveys as well as to censuses, in the interest of concision we discuss only censuses. The explanation of methodology is framed first in terms of continuous functions, then more realistically in terms of discrete functions.

Continuous formulation

The logic of the own-children method is most easily explained if age-specific birth rates, age distributions, and life table variables are viewed as continuous functions (Retherford, Cho, and Kim 1984). Let

$f_a(t)$: Instantaneous age-specific birth rate for women aged a at time t

$C_{x,a}$: Number of own children aged x of mothers aged a enumerated in the census

$B_a(t)$: Number of births to women aged a at time t

$W_a(t)$: Number of women aged a at time t

ℓ_y : Probability of surviving from birth to age y

ℓ^f_y : Probability of surviving from birth to age y for females.

The values of ℓ_y and ℓ^f_y are obtained from appropriate life tables for the population. In the continuous formulation, ages and times are conceptualized as exact ages and times rather than single-year age groups or time periods. (Note that, strictly speaking, $C_{x,a}$, $B_a(t)$, and $W_a(t)$ are density functions, defined as the number of persons per year of age or time.)

For simplicity we consider that numbers of women and children at the time of the census have already been adjusted for underenumeration, age misreporting, and the presence of unmatched (non-own) children, and that mortality has been constant over the estimation period. Then, with t denoting the time of the census,

$$B_{a-x}(t-x) = C_{x,a}\,(\ell_0/\ell_x) \tag{2.1}$$

$$W_{a-x}(t-x) = W_a(t)\,(\ell^f_{a-x}/\ell^f_a) \tag{2.2}$$

$$f_{a-x}(t-x) = B_{a-x}(t-x)/W_{a-x}(t-x). \tag{2.3}$$

Formula (2.1) reverse-survives children aged x of mothers aged a at time t to births of mothers aged $a-x$ at time $t-x$. Formula (2.2) reverse-survives women aged a at time t to women aged $a-x$ at time $t-x$.

Note that the age associated with an own-children estimate of an age-specific birth rate is the age obtaining at the time of childbirth, not at the time of the census. When the own-children estimates of fertility are tabulated by other characteristics such as education, however, these other characteristics normally pertain to the time of the census.

Discrete formulation

The actual computation of own-children fertility estimates is done with discrete age and time intervals. The base calculations are all done by single years of age and time (Retherford and Cho 1978:569–70). We have the following definitions:

$F_a(t)$: Single-year central age-specific birth rate for women aged a to $a+1$ during calendar year t to $t+1$

C_x : Number of children aged x to $x+1$ enumerated in the census

$C_{x,a}$: Number of own children aged x to $x+1$ of mothers aged a to $a+1$ enumerated in the census

$B_a(t)$: Births during the period t to $t+1$ to women aged a to $a+1$ at time t

$W_a(t)$: Number of women aged a to $a+1$ at time t

U^c_x : Adjustment factor for underenumeration and age misreporting of children aged x to $x+1$

$U^c_{x,a}$: Adjustment factor for underenumeration and age misreporting of children aged x to $x+1$ of mothers aged a to $a+1$

U^w_a : Adjustment factor for underenumeration and age misreporting of women aged a to $a + 1$

V_x : Adjustment factor for non-own (unmatched) children, computed as the reciprocal of the proportion of children aged x to $x + 1$ at the time of the census who are matched to mothers

$R_{a \leftarrow b}$: Reverse-survival factor, from age group b to $b + 1$ to age group a to $a + 1$, for both sexes. If mortality has been constant over the estimation period, $R_{a \leftarrow b} = L_a/L_b$, where L_a denotes life table person-years lived between exact ages a and $a + 1$. If mortality has been changing, then

$$R_{a \leftarrow b} = \prod_{u=1}^{b-a} [L_{b-u}(t-u)/L_{b-u+1}(t-u)], \text{ where } L(t) \text{ is}$$

taken from the period life table for year t to $t + 1$. $R^f_{a \leftarrow b}$ denotes the reverse-survival factor for females only.

$r_{a \leftarrow b}$: Reverse-survival factor, from age group b to $b + 1$ to exact age a, for both sexes. If mortality has been constant over the estimation period, $r_{a \leftarrow b} = \ell_a/L_b$, where ℓ_a denotes the life table probability of surviving from birth to exact age a. If mortality has been changing, then

$$r_{a \leftarrow b} = [\ell_a(t-b+a-1)/L_a(t-b+a-1)]$$

$$\prod_{u=1}^{b-a} [L_{b-u}(t-u)/L_{b-u+1}(t-u)] \text{ if } a<b,$$

and $r_{a \leftarrow b} = \ell_a(t-1)/L_a(t-1)$ if $a = b$.

The calculation of central age-specific birth rates is illustrated in Figure 2.1. (Central, or age–period, rates pertain to squares or rectangles in the Lexis diagram shown in the figure.) Variable mortality and adjustments for underenumeration and age misreporting and for non-own children are now taken explicitly into account. For census enumeration at time t we have first that

$$B_a(t-x-1) = C_{x,a+x+1}\, U^c_{x,a+x+1}\, V_x\, r_{0 \leftarrow x}, \tag{2.4}$$

corresponding to events in parallelogram CD, and that

$$W_a(t-x-1) = W_{a+x+1}(t)\, U^w_{a+x+1}\, R^f_{a \leftarrow a+x+1}, \tag{2.5}$$

corresponding to the left edge of square BC. Then, by the logic of Figure 2.1,

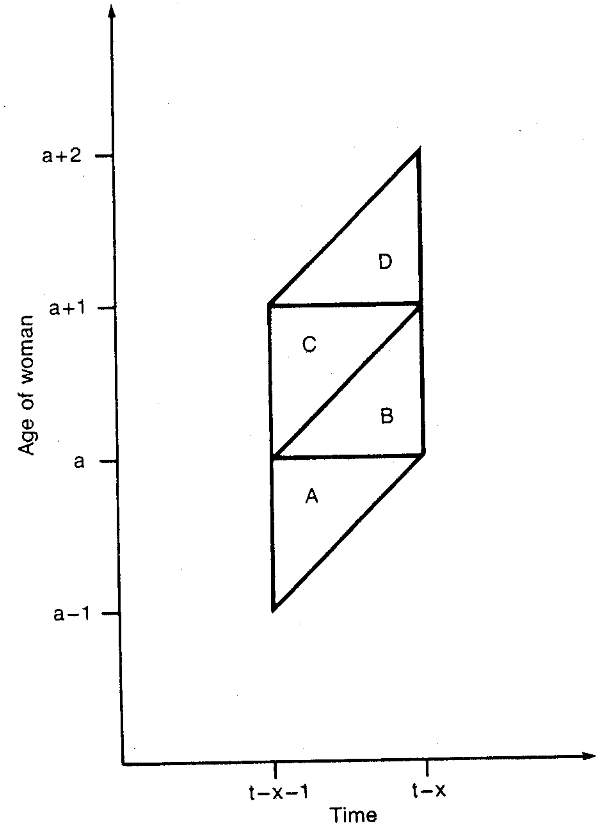

Figure 2.1. Lexis diagram for visualizing the calculation of $F_a(t-x-1)$

Source: Retherford and Cho (1978:570).

Note: Births in the square BC are obtained by adding half of the births in AB to half of the births in CD. The midyear population in BC is likewise obtained by averaging the population at the beginning and end of the year, as represented by the left and right edges of the square BC. The symbol t denotes the time of the census and x denotes child's age.

$$F_a(t-x-1) = [B_{a-1}(t-x-1) + B_a(t-x-1)]/[W_a(t-x-1) + W_a(t-x)]. \tag{2.6}$$

This rate corresponds to births in square BC divided by the midyear number of women in square BC. On the right-hand side of (2.6), numerator and denominator are each obtained by an averaging procedure, as indicated in Figure 2.1. Multiplicative factors of 0.5 in the numerator and denominator cancel in the quotient and are not shown. Age-specific birth rates in five-year age groups over one or more calendar years are easily obtained from the single-year rates by dividing the appropriate sum of numerators (births) by the appropriate sum of denominators (women) from the right-hand side of equation (2.6). Such aggregation is particularly useful for minimizing errors from age misreporting in applications where the reporting of ages is inaccurate.

The adjustment factors require additional explanation (Retherford, Choe, and Wanglee 1978). The factors U^c_x and U^w_a are normally obtained from an indpendent source, such as a postenumeration survey. The factor $U^c_{x,a}$ is derived in the following way: First, because we adjust the number of women aged a to $a + 1$ by the factor U^w_a, we adjust the number of own children aged x to $x + 1$ who are matched to these women, $C_{x,a}$, by the same factor. At the same time we adjust the total number of children aged x to $x + 1$, C_x, by the factor U^c_x. These two requirements together imply that the overall adjustment factor, $U^c_{x,a}$, for own children, $C_{x,a}$, should be proportional to both U^w_a and U^c_x.

These considerations can be summarized by two equations,

$$U^c_{x,a} = k_x\, U^w_a\, U^c_x \tag{2.7}$$

$$U^c_x\, C_x = \Sigma_a(U^c_{x,a}\, V_x\, C_{x,a}), \tag{2.8}$$

where k_x is a proportionality factor, shown below to be a function of x, and V_x is the adjustment factor for non-own children. Substituting the expression for $U^c_{x,a}$ from equation (2.7) into equation (2.8) and solving for k_x, we obtain

$$k_x = C_x/[V_x\Sigma_a(U^w_a\, C_{x,a})], \tag{2.9}$$

which establishes that k_x is indeed a function of x. Substituting this expression for k_x back into equation (2.7) we obtain

$$U^c_{x,a} = (U^w_a\, U^c_x\, C_x)/[V_x\Sigma_a(U^w_a\, C_{x,a})]. \tag{2.10}$$

Since $C_x = \Sigma_a(V_x\, C_{x,a})$, equation (2.10) may be rewritten as

$$U^c_{x,a} = (U^w_a\, U^c_x\, \Sigma_a\, C_{x,a})/(\Sigma_a\, U^w_a\, C_{x,a}). \tag{2.11}$$

Values of $U^c_{x,a}$ are derived in practice from equation (2.11). In many instances, of course, no postenumeration survey is available. Then equation (2.11) cannot be applied, and $U^c_{x,a}$ and U^w_a are simply set to one.

In applications of the own-children method, years previous to the census are demarcated in twelve-month intervals starting with the census date. For example, for a census taken with a reference date of 1 November 1980, the year before the census extends from 1 November 1979 to 31 October 1980, which is not a normal calendar year starting on 1 January. The convention for labeling these offset calendar years is the following: Since, in this example, more than half of the year before the census occurs in calendar year 1980, the year before the census is labeled 1980. Had the census been taken on 1 April instead of 1 November 1980, then more than half of the year before the census would fall in calendar year 1979 and the year before the census would then have been labeled 1979. If desired, rates for offset calendar years can be interpolated linearly to standard calendar years extending from 1 January to 1 January. Normally this is done only when one wishes to compare precisely fertility estimates derived by the own-children method with estimates derived from vital registration. Henceforth we shall refer frequently to years of time as calendar years, even when they do not run from 1 January to 1 January.

Illustrative results for Sri Lanka

Figure 2.2 provides a simple illustration of one of the graphical formats in which final estimates are typically presented. In this case the application was to the 1981 Census of Sri Lanka (Ratnayake, Retherford, and Sivasubramaniam 1984). The data consisted of a 10 percent sample, including approximately 1.4 million individuals, created by selecting systematically every tenth census block from the full count. The large sample size allowed detailed cross-tabulations of the fertility estimates, illustrated in Figure 2.2 with a cross-tabulation of trends in total fertility by education and urban–rural residence. In this case, the detailed own-children estimates of age-specific birth rates by education and residence were aggregated to total fertility rates (TFRs), calculated by summing age-specific birth rates in five-year age groups and multiplying the sum by five. Summary measures such as the TFR are useful for reducing the mass of detailed age-specific fertility estimates to readable proportions.

Supplementary options

Period-cohort rates. In most applications of the own-children method, age–period (or central) age-specific birth rates are calculated, corresponding in the single-year case to squares in the Lexis diagram. It is also possible to calculate what have come to be called period–cohort rates, pertaining to parallelograms such as parallelogram CD in the Lexis diagram in Figure 2.1. Denoting period–cohort rates by $F^*_a(t)$, we have that

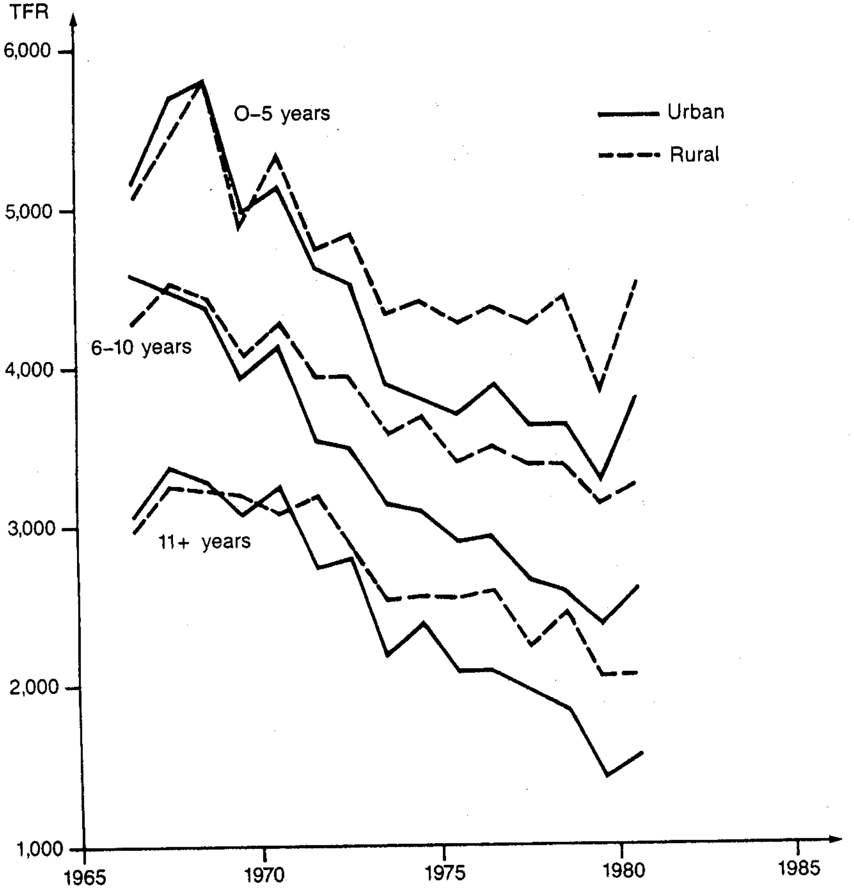

Figure 2.2. Own-children estimates of total fertility rates, by completed years of education and urban–rural residence, derived from the 1981 Census: Sri Lanka, 1966–80

Source: Ratnayake, Retherford, and Sivasubramaniam (1984:24).

Note: Throughout this book, rates and probabilities are expressed on a per-thousand basis.

$$F_a^*(t-x-1) = B_a(t-x-1)/\{.5[W_a(t-x-1) + W_{a+1}(t-x)]\} \qquad (2.12)$$

where the B's and W's on the right-hand side of (2.12) are obtained from equations (2.4) and (2.5). The age subscript and the time argument of F^* in (2.14) denote age and time at the earliest time point in the parallelogram. Thus $F_a^*(t)$ pertains to fertility during the period t to $t+1$ for women aged a to $a+1$ at the beginning of the period.

If the own-children method is applied to a series of censuses, the period–cohort age-specific birth rates may be chained together along cohort corridors in the Lexis diagram to reconstruct the entire age-specific fertility experience of real cohorts.

Interpolation of life tables. The reverse-survival procedure assumes that complete life tables by sex and single years of age are available for each of the fifteen years preceding the census. Often this is not the case. Typically life tables are available only for some years (usually census years) and are abridged to age groups 0, 1–4, 5–9, 10–14, etc. In this situation the available period life tables must be interpolated to single years of time and age. First, linear interpolation (and, if necessary, extrapolation) of the initial abridged period life tables is performed on the ${}_nq_x$ (life table probability of dying between ages x and $x+n$) values of these tables to yield interpolated ${}_nq_x$ values for the midpoints of other calendar years or groups of calendar years within the estimation period. Period life table values of ℓ_x (survivors) at abridged ages are then computed for each of these other calendar years as $\ell_{x+n} = \ell_x(1 - {}_nq_x)$. Values of L_0 and L_{85+} (person-years of exposure at age 0 and at ages 85 and over) are also linearly interpolated for these other years.

The precise procedure for interpolation or extrapolation from initial period life tables for calendar years t_1 and t_2 is as follows: Suppose the quantity to be interpolated is ${}_nq_x$. Assume that the ${}_nq_x$ changes linearly over time. Then for any time t,

$${}_nq_x(t) = {}_nq_x(t_1) + [(t-t_1)/(t_2-t_1)][{}_nq_x(t_2) - {}_nq_x(t_1)]. \qquad (2.13)$$

Although linear interpolation is adequate to obtain abridged life tables for other calendar years, it is inadequate to graduate these abridged life tables to single years of age. Nonlinear interpolation procedures must be used instead. Interpolation of the ℓ_x values in each abridged life table to single years of age is accomplished by means of a regression approach (Coale and Demeny 1966:20–23) for ages 1–4 and a matrix approach to polynomial interpolation (Feeney 1974) for subsequent five-year age groups. The end result is a set of ℓ_x values by single years of age for each intermediate calendar year. Single-year values of L_x (person-years of exposure) for ages 1–84 are obtained from the single-year values of ℓ_x using the formula $L_x = .5(\ell_x + \ell_{x+1})$. The interpolation of abridged ℓ_x values to single years of age is described in more detail in Appendix A (see also Retherford 1978). A computer subprogram is available for carrying out the various interpolations.

Estimation of infant and child mortality. When life tables for years near the census are not available, the Brass method of estimating infant and child mortality (Brass 1975) or Feeney's extension of Brass's method (Feeney 1980) can be applied to census data on number of children ever born and number of children still living. From these data Brass's method provides estimates of child mortality levels prevailing before the census, and Feeney's extension of Brass's method provides estimates of both child mortality levels and trends. Brass's and Feeney's methods are convenient because they can be used to estimate child mortality from the same data set from which the own-children fertility estimates are derived.

Brass's and Feeney's methods of estimating infant and child mortality require the same data on proportions of surviving children among all children ever born to women of ages 15 to 64, classified by woman's age in five-year age groups. The infant and child mortality estimates generated from these data can be matched to model life tables such as one of the model life tables developed by Coale and Demeny (1966, 1983) or Brass (1975). In this way complete life tables spanning all ages are obtained. A computer subprogram is available for computing the infant and child mortality estimates and matching them to complete life tables.

Sampling variability of own-children fertility estimates. A rough estimate of the standard error of ${}_5F_a(t - x - 1)$, denoted below simply as F, is

$$s_F = k\{[(1 - f)F(1 - F)]/(\tilde{W} - 1)\}^{.5}, \qquad (2.14)$$

where $k = r_{0\leftarrow x}/{}_5R^f_{a\leftarrow a+x+.5}$, f is the sampling function, and $\tilde{W} = {}_5W_a \, {}_5U^w_a$. A rough estimate of the standard error of the TFR is

$$s_{TFR} = 5(\Sigma_i s^2_{F_i})^{.5}. \qquad (2.15)$$

A more extended discussion of sampling variability, including derivations of the above formulae, is contained in Appendix B.

Data collection requirements

One of the great advantages of the own-children method is that it can be applied to existing censuses and household surveys, so that no new data collection is required. If an application of the own-children method is anticipated, however, it is desirable to design the census or survey to facilitate the application. Each respondent should be identified with a household identifier, so that persons within the same household can be treated as a block. (This is necessary for matching children to mothers within the same household.) Age, sex, and marital status are basic questions that should always be asked. Age should be coded in single years. Questions on number of children ever born and number of children still living facilitate both the matching of children to mothers and the derivation of mortality estimates. Matching may be further facilitated and made more accurate by coding the line number (or person number, as it is sometimes called) or mother (if present) in the household listing, for each person below the age of 15 (or 20) in the household. Alternatively, if matching is based primarily on relationship information, sufficiently detailed relationship codes should be used to enable an accurate match in almost all cases. If, for example, adoption is prevalent in the population, then one of the relationship codes should be "adopted child of household head," since otherwise adopted children will be erroneously matched and treated as own children. Normally, if relationship to the head is to be ascertained anyway, an extra question on the mother's line number is not needed unless households are large and complex, with many ambiguous matches, as in certain Pacific island populations. A slight, further improvement in the estimates can be realized if it is ascertained whether the mother of each child under age 15 is alive or dead, but this improvement may not be large enough to justify an additional item in a questionnaire usually crowded with other, more essential items.

Two extensions of the basic own-children method involve estimation of age–duration-specific birth rates (with duration measured since first marriage) and age–parity-specific birth rates. A question on year of or age at first marriage is necessary to calculate age–duration-specific birth rates, and a question on number of children ever born (parity) is necessary to calculate age–parity-specific birth rates. A question on birth order of each child under age 15 is needed to calculate age–parity-specific birth rates for years further back than the first year before the census.

CHAPTER 4

Evaluation and Analysis of Errors

The effect of matching errors on own-children fertility estimates

A common but usually unimportant source of bias in own-children estimates of fertility arises from matching errors, of which there are three major types: (1) mismatch, (2) misallocation of unmatched children, and (3) failure to record the existence of some children because they are living in a geographic area other than the study area in which the mother lives.

Mismatch error may occur from overmatching, whereby more children are matched to a woman than actually are hers biologically. A frequent source of overmatching is insufficient precision in the codes for relation to head of household, which are used in the computer algorithm for matching children to mothers. This algorithm checks for configurations of codes that constitute an admissable match. For example, if, for a given household, an adult male is reported as the head of household and there is a woman reported as wife of head and a child reported as child of head, the algorithm will respond to that particular configuration of codes by matching the child to the wife.

An example of insufficiently precise relationship codes is provided by the 1974 Census of American Samoa, in which the relationship codes were as follows:

1. head
2. wife of head
3. son, daughter, nephew, or niece of head
4. grandchild of head
5. brother, sister, brother-in-law, or sister-in-law of head
6. father, mother, father-in-law, or mother-in-law of head
7. other relative

8. no relation
9. unknown

With this set of relationship codes, various kinds of matching errors can arise. For example, because sons and daughters cannot be distinguished from nephews and nieces, it is possible to match erroneously a woman's niece or nephew to her.

Another instance of mismatch concerns adoption. Relationship codes in the censuses of the United States, for example, do not distinguish biological children from adopted children. Therefore, adopted children tend to be matched erroneously to adoptive mothers instead of being treated as non-own (unmatched) and allocated by means of the non-own adjustment factor.

The matching algorithm makes use of questions on age, marital status, and number of children ever born or still living, in addition to the question on relation to household head. The algorithm will not match children to mothers who are out of range on age. That is, the difference between a mother's age and a child's age must fall within the 15–50 range. The algorithm also will not match children to women who have never married, although this requirement can be relaxed if consensual unions are prevalent. And the algorithm will not match more children to a woman than the number she says are still living (or were ever born, if the question on number still living was not asked). The algorithm then attempts to match children to mothers, starting at the top of the household listing and working down. As many children as possible are matched to the first eligible mother before the algorithm proceeds to the next. Although age and marital status are always asked on censuses, number of children ever born and number of children still living are not always asked. In such cases the probability of overmatching is increased.

Mismatch may stem also from undermatching. This can occur when a relationship is wrongly reported or, less commonly, miscoded. In either case, a child may not be matched to its biological mother even when both are in the same household. This can happen, for example, if the household head refers affectionately to a child as a grandchild when in reality the relation is less direct. Undermatching can occur also as a consequence of underreporting of children ever born or children surviving; this form of undermatching is thought to be uncommon, however, since omitted children tend to be either dead or living elsewhere. As will be seen shortly, tests of alternative matching procedures suggest that undermatching is more common than overmatching, contrary to expectations.

If mismatch is statistically independent of mother's age, it will not distort the own-children estimates of age-specific birth rates because the children in question are taken into account one way or the other; i.e., they are either matched and included as own children, or they are classified as non-own and allocated. We shall see shortly, however, that mismatch occurs more frequently at some ages than at others, with the result that the age pattern of fertility is systematically distorted. But the overall level of fertility, as measured by the total fertility rate, tends to be affected very little.

The second type of matching error involves misallocation of unmatched, or non-own, children. If, for example, younger women are more likely than older women to be separated temporarily from their young children (owing, say, to labor migration of young women who leave children temporarily in the care of relatives), the distribution of non-own children of a given age by age of mother will be more concentrated at younger ages of mothers than is true of the distribution of own children of the same age by age of mother. In applying the own-children method in this situation, we do not know the ages of the mothers of the non-own children. We simply assume that non-own children of a given age are distributed by age of mother in the same way as own children of the same age. But this assumption introduces bias, because the non-own adjustment factor then effectively reallocates a certain proportion of non-own children from younger mothers to older mothers. As a consequence, the estimated age pattern of fertility is too low at the younger reproductive ages and too high at the older reproductive ages.

Misallocation of non-own children can occur not only across ages but also across other characteristics. For example, the distribution of non-own children of a given age by education of mother may be more concentrated at lower levels of education, where mortality and the risk of orphanhood are higher, than is true of the distribution of own children of the same age by education of mother. Non-own adjustment factors can be tabulated no more by education of mother than by age of mother, since the mothers of non-own children are unidentified. Thus the non-own adjustment is the same, regardless of education of mother. Fertility estimates by education are biased if the true adjustments for non-own children (as opposed to the estimated adjustments) differ by education of mother. Misallocation of non-own children has little impact on the fertility estimates if the non-own adjustment factors are small. But these factors are occasionally as high as 1.3 or 1.4 for older children. Then the potential for bias is greater.

The third type of matching error involves failure to record the existence of some children because they are living in a geographic area other than the study area in which the mother lives. In the case of large-scale in-migration to the study area, for example, women may leave children temporarily in the care of relatives at the point of origin until they become resettled at the destination. In this situation the own-children estimates of fertility in the destination area are downwardly biased. Bias from this source is probably very small, because migrants who are separated from their young children usually constitute a very small proportion of the population.

Illustrative analysis of the effect of mismatch on own-children fertility estimates for American Samoa and Indonesia. Not all of the matching errors discussed above have been studied empirically to assess directly the magnitude of their impact on own-children estimates of fertility. Mismatch errors have received the most attention, and they have been investigated for American Samoa with data from the 1974 Census, and for East Java with data from the 1976 Indonesian Intercensal Population Survey, also known as SUPAS II (Levin and Retherford 1982).

The American Samoan analysis was based on a virtually complete population count of 29,100 individuals, and the East Java analysis on a sample of 35,822 individuals. In each case the census included a special census question on mother's person number or line number in the household listing, completed for each child whose biological mother was in the same household. It was anticipated that the direct match based on mother's person number (MPN matching) would match fewer children than the indirect match based on relation to head of household (RHH matching), since there is, in the former case, less ambiguity about the mother–child relationship and therefore a reduced probability of erroneously matching the child when the biological mother is actually absent. The data allowed a test of this hypothesis, as well as an assessment of the effect of erroneous matches on the own-children estimates of fertility.

Although the American Samoa and East Java data sets are similar in that both allow MPN matching, they differ in some other respects. In American Samoa, adoption is common, households are generally large and complex, and the frequency of in- and out-migration (mainly to the United States) is very high, leading to frequent temporary separations of family members. Under these conditions the likelihood of mismatch was expected to be considerably higher for RHH matching than for MPN matching. In East Java, on the other hand, households are simpler and smaller and the population is less migratory; under these conditions the likelihood of mismatch was expected to be low for both types of matching.

The relationship codes in Indonesia are also more elaborate than in American Samoa, allowing more precise RHH matching. The relationship codes for American Samoa were given earlier (pages 36–37). The codes for Indonesia are as follows:

1. head
2. wife of head
3. own child of head
4. non-own child of head (adopted child or stepchild)
5. grandchild of head
6. parent of head
7. parent of wife of head
8. daughter-in-law or son-in-law of head
9. other family
10. other nonfamily
11. unknown

Because of more complex households, more frequent temporary family separations, and less precise relationship codes in American Samoa than in Indonesia, one expects MPN matching to improve the accuracy of the fertility estimates more for American Samoa than for East Java.

Table 4.1 shows the percentage that non-own children constitute of all children in each single-year age group according to type of match. As expected, the percentage not matched is higher in American Samoa than in East Java. Also expected is the greater divergence between RHH and MPN matching in American Samoa than in East Java. The percentage not matched tends to rise steeply with age of child, mainly because older children are more likely than younger children to live in a household other than their mother's. An unanticipated exception is RHH matching in American Samoa. In this case the percentage not matched is unusually high among younger children, and the typical rise with age in the percentage not matched is largely eliminated. The difference between RHH and MPN matching in American Samoa is especially great for younger children.

Table 4.1. Non-own children as a percentage of all children, by type of matching: American Samoa, 1974, and East Java, 1976

	American Samoa, 1974		*East Java, 1976*	
Age	*RHH*	*MPN*	*RHH*	*MPN*
0	24.8	13.2	2.1	1.2
1	23.2	15.5	3.8	1.5
2	26.2	18.6	4.2	3.1
3	22.4	17.2	6.7	5.2
4	24.6	19.2	6.2	4.4
5	25.0	21.0	6.0	4.5
6	22.2	17.5	7.9	6.5
7	24.1	20.3	9.2	7.1
8	23.5	20.1	10.9	9.0
9	22.8	20.2	8.7	6.5
10	24.5	21.9	12.5	9.5
11	27.0	24.1	13.3	9.3
12	22.4	21.5	15.4	12.6
13	29.0	27.9	15.4	12.4
14	29.5	27.7	17.5	15.6

Source: Levin and Retherford (1982:12).
RHH—relation to head of household.
MPN—mother's person number.

The most startling finding in Table 4.1 is that in both American Samoa and Indonesia the percentage not matched is higher for RHH matching than for MPN matching, the reverse of what was anticipated. Further investigation of the American Samoan case showed that the MPN match produced 815 unmatched, or non-own, children. Of these only eleven were erroneously matched by the RHH match, indicating that overmatching by the RHH algorithm is not a serious problem. Offsetting these eleven children who were overmatched were 107 children who were correctly matched by MPN matching but not matched by RHH matching, owing to errors in relationship codes. These errors appear to consist mainly of respondent errors, not interviewer errors. Quite commonly, for example, the household head incorrectly reported a child as grandchild, while correctly reporting the child's mother (identified by MPN matching) as an "other relative" instead of a daughter or daughter-in-law as would be necessary if the child were truly a grandchild. If the household lacked an eligible daughter or daughter-in-law, RHH matching then incorrectly designated the child as non-own. This kind of error was especially common for very young children, for whom the reported grandparent–grandchild relationship evidently often reflects an affectionate social tie rather than a biological tie.

The results in Table 4.1 suggest that fertility estimates based alternatively on RHH and MPN matching should coincide approximately for East Java but diverge slightly for American Samoa, particularly in the years just previous to enumeration, for which fertility estimates are based on reverse survival of very young children. Figures 4.1 and 4.2 confirm this expectation. In the case of East Java, fertility estimates based alternatively on RHH and MPN matching differ by less than 2 percent, and usually less than 1 percent, over single calendar years between 1962 and 1976. In American Samoa, on the other hand, the discrepancy, though small in years close to 1960, increases for years closer to the census, reaching almost 4 percent in 1974. In American Samoa, estimates of

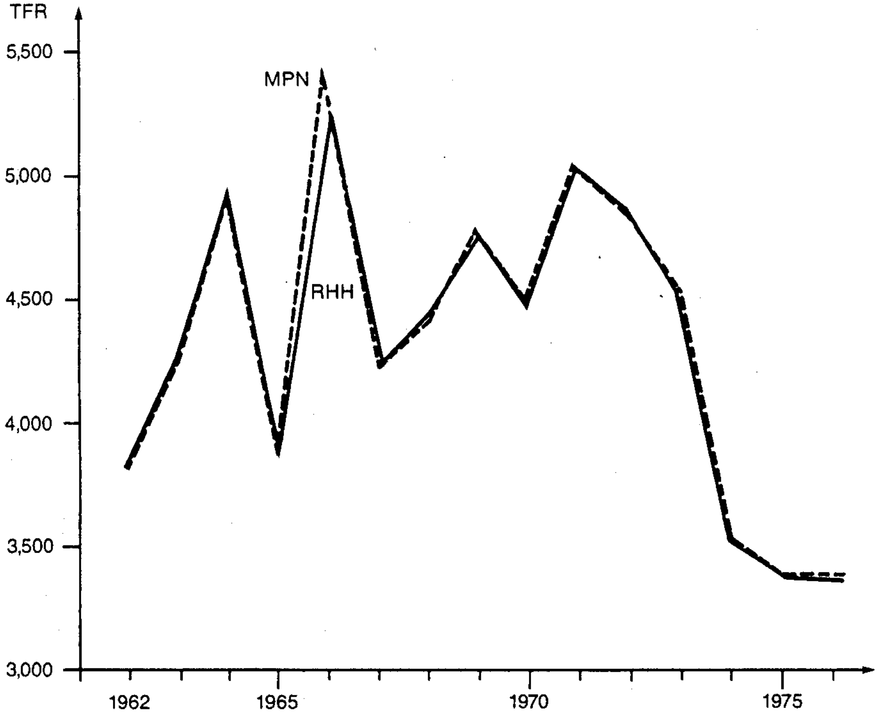

Figure 4.1. Own-children estimates of total fertility rates derived from the 1976 Indonesian Intercensal Population Survey, based alternatively on relationship to household head (RHH) and mother's person number (MPN): East Java, 1962–76

Source: Levin and Retherford (1982:12).

the total fertility rate based on RHH matching are consistently higher than estimates based on MPN matching. In East Java the much smaller discrepancies are in both directions and show no clear pattern. The consistent direction of the discrepancy in American Samoa stems from a systematic distortion in the age pattern of fertility, to which we now turn.

Table 4.2 examines the effects of alternative matching procedures on the age pattern of fertility. Calendar years are grouped into two five-year periods to minimize effects of heaping of children's ages on preferred digits on the fertility estimates. In East Java the difference between the age patterns of fertility estimated alternatively using RHH and MPN matching is inconsequential, consistent with the small differences in matching results and TFR estimates in Table 4.1 and Figure 4.1. In

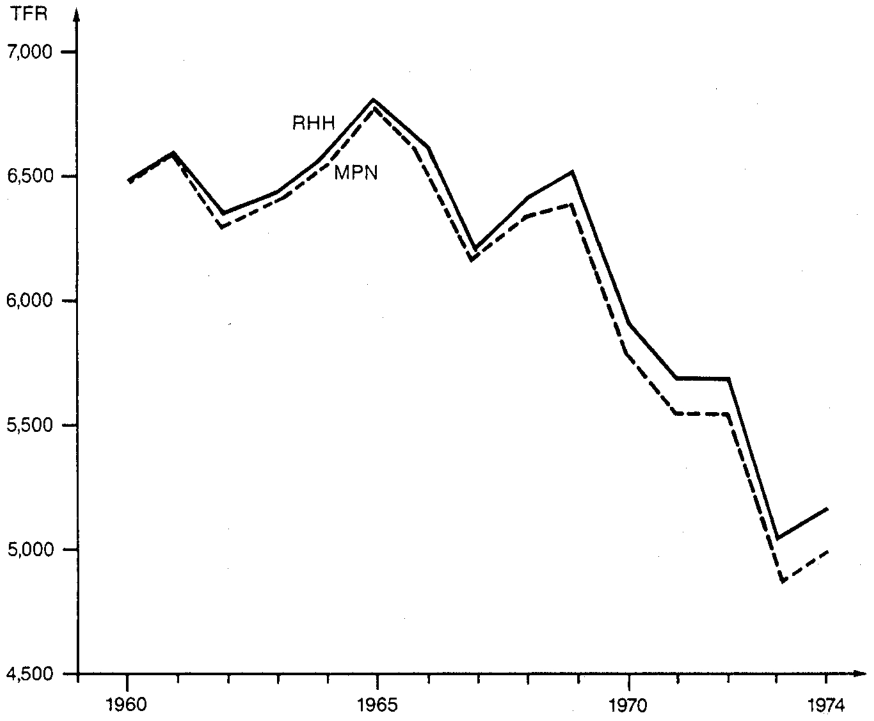

Figure 4.2. Own-children estimates of total fertility rates derived from the 1974 Census, based alternatively on relationship to household head (RHH) and mother's person number (MPN): American Samoa, 1960–74

Source: Levin and Retherford (1982:12).

American Samoa, however, RHH matching results in underestimates of fertility at the younger reproductive ages and overestimates at the older reproductive ages, especially for the second five-year period, 1968–72. This evidently occurs because RHH matching erroneously allocates too many children to older women and not enough to younger women, relative to results based on MPN matching. The likely underlying reasons for this misallocation have already been discussed.

Because the number of women in each five-year age group decreases with age, the shift of children from younger women to older women increases birth rates at the older reproductive ages more than it decreases birth rates at the younger reproductive ages. This effect probably explains why the TFR computed from age-specific birth rates based on

Table 4.2. Own-children estimates of age-specific birth rates and total fertility rates, by type of matching: American Samoa, 1963–72, and East Java, 1965–74

Country, period, and type of matching	Age group 15–19	20–24	25–29	30–34	35–39	40–44	45–49	TFR
American Samoa								
1963–67								
RHH	43	233	321	312	241	123	29	6,519
MPN	47	242	320	311	232	117	25	6,470
RHH/MPN	.923	.964	1.003	1.005	1.037	1.053	1.178	1.007
1968–72								
RHH	43	222	287	270	230	110	39	6,000
MPN	47	239	293	260	215	98	27	5,995
RHH/MPN	.925	.927	.979	1.037	1.067	1.126	1.435	1.001
East Java								
1965–69								
RHH	135	226	206	168	108	48	14	4,532
MPN	134	225	205	167	107	48	15	4,511
RHH/MPN	1.007	1.005	1.005	1.010	1.004	.996	.953	1.005
1970–74								
RHH	124	230	207	162	100	51	14	4,435
MPN	125	231	206	162	101	51	15	4,448
RHH/MPN	.989	.995	1.003	1.004	.997	1.007	.925	.997

Source: Levin and Retherford (1982:13).

RHH matching slightly but consistently exceeds the TFR computed from birth rates based on MPN matching.

Proportional errors in age-specific rates based on RHH matching for American Samoa are as much as 8 percent too low at ages 15–19 and 44 percent too high at ages 44–49. Absolute errors in these rates are, of course, much smaller than the percentage errors suggest, because fertility in these extreme age groups is very low. Moreover, the errors are largely offsetting. Hence the errors in the TFR are quite small.

Illustrative analysis of the effect of mismatch on own-children fertility estimates for the United States. Mismatch also biases own-children estimates of fertility for the United States (Retherford and Cho 1978). Table 4.3 compares estimates of age-specific birth rates and TFRs derived from vital registration with parallel estimates derived by applying the own-children method to the 1970 Census. The comparison ratios in the last line of the table show a systematic age bias in the results. The own-children estimates of age-specific birth rates are too low for the 15–19 age group, about right for age groups 20–24, 25–29, and 30–34, too high beyond age 35, and increasingly so with advancing age. Overall, the bias is quite small, the comparison ratio for the total fertility rate being very close to unity.

Table 4.3. Age-specific birth rates derived alternatively from vital statistics and by applying the own-children method to the 1970 Census: United States, 1969

Derivation	Age group 15–19	20–24	25–29	30–34	35–39	40–44	45–49	TFR
Vital statistics (VS)	65.4	166.4	143.5	73.9	33.0	8.6	0.5	2,456.5
Own children (OC)	52.3	164.1	151.5	77.8	37.5	10.7	2.2	2,481.1
VS/OC	1.25	1.01	0.95	0.95	0.88	0.80	0.23	0.99

Source: Retherford and Cho (1978:573).
Note: All rates are central rates and relate to the year prior to the 1970 Census, 1 April 1969 to 1 April 1970. VS rates were obtained by weighting published rates for calendar years 1969 and 1970 by 0.75 and 0.25 respectively.

The systematic age bias in Table 4.3 probably is due mainly to the transfer of illegitimate children of young unmarried mothers to older women with few or no children, through adoption. This is likely for two reasons. First, illegitimate births constituted nearly one-third of total births in the 15–19 age group in 1969, indicative of a high potential for adoption. Second, adopted children appear unavoidably as own children in the census, because the relationship codes do not include a separate category for adopted children.

The effect of mortality estimation errors on own-children fertility estimates

The effect of mortality estimation errors on own-children estimates of fertility has been investigated for the Republic of Korea and Thailand.

Cho (1971) employed alternative model life tables separated by five years of life expectancy to generate own-children fertility estimates for Korea, based on the 1966 Census. This work indicated that an error of five years in life expectancy introduces less than a 5 percent error in the fertility estimates, indicating a rather low level of sensitivity to mortality estimation errors.

The question of sensitivity to mortality estimation errors was subsequently investigated in more depth in an application of the own-children method to the 1970 Census of Thailand (Retherford, Chamratrithirong, and Wanglee 1980). Table 4.4 presents selected results from the analysis. Two mortality assumptions were employed: first, that mortality was the same across education categories, and second, that mortality was variable across education categories. In the first case, mortality estimates for the whole country were used. In the second case, mortality estimates by education were derived from child survivorship data (children ever born and children surviving) in the 1970 Census. The precise manner in which the mortality estimates were derived is described in the original article.

Table 4.4 shows that the maximum difference in life expectancy between education categories is about sixteen years. Life expectancy for the more educated groups is very high and may be overestimated, but such inaccuracies need not concern us here. The point to be noted is that the error in the own-children estimates of TFRs by education caused by using overall mortality in place of education-specific mortality varies between 2 percent and 8 percent, as shown in the third panel of the table. The error is smallest for those with little education, since they constitute most of the population.

Under the assumption of similar mortality across education groups, fertility differentials by education tend to be underestimated, for the following reasons: The groups with lower fertility tend also to have lower mortality. If mortality for these groups is overestimated by assuming the same mortality for all groups, then births are inflated too much by reverse survival and fertility is overestimated. Similarly, the groups with higher fertility tend also to have higher mortality. If mortality for these groups is underestimated by assuming the same mortality for all groups, then births are inflated too little by reverse survival and fertility is underestimated. The net effect is that fertility differentials by education tend to be underestimated when mortality is not specified by education. Absolute errors (the simple difference between true and estimated differential fertility) tend to be small, but relative errors (the simple difference between true and estimated differential fertility as a percentage of true) may be large.

The reason why own-children estimates of fertility tend not to be very sensitive to mortality estimation errors was alluded to in the earlier discussion of sampling variability of own-children estimates of fertility in Chapter 2. An own-children estimate of an age-specific birth rate may be viewed as the product of an age-specific child–woman ratio and a quotient of two reverse-survival ratios, one for children and the other for women. Each of these two reverse-survival ratios tends to be fairly close to one, especially when mortality is low, and the quotient of the two tends to be even closer to one. The range of variability in this quotient across different levels of mortality is rather small.

Table 4.4. Own-children fertility estimates, by women's education, based on alternative mortality assumptions: Thailand, 1965–69

Mortality assumption and ratio comparison	*Education*	*e₀*	*TFR*	*15–19*	*20–24*	*25–29*	*30–34*	*35–39*	*40–44*	*45–49*
				Age group						
Mortality assumption										
Same mortality across education categories	No education	66.5	6,395	143	276	293	263	195	91	18
	Some primary	66.5	6,395	90	280	305	261	213	109	21
	Some secondary	66.5	2,725	16	124	182	109	68	42	4
	Some college	66.5	1,977	1	20	130	149	59	33	5
Variable mortality across education categories	No education	63.0	6,531	146	282	300	269	199	93	18
	Some primary	66.7	6,250	88	273	298	255	208	106	20
	Some secondary	78.8	2,527	14	115	168	101	63	39	4
	Some college	78.8	1,827	1	19	120	137	54	30	4
Ratio comparison (same/variable)	No education	1.06	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
	Some primary	1.00	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
	Some secondary	0.84	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.07
	Some college	0.84	1.08	1.11	1.08	1.08	1.08	1.08	1.08	1.14

Source: Retherford, Chamratrithirong, and Wanglee (1980:8).

The effect of age misreporting on own-children fertility estimates

In most applications, age misreporting is by far the most serious source of bias in own-children estimates of fertility, particularly in less developed countries. In theory, the adjustment factors $U^c_{x,a}$ and U^w_a adjust for age misreporting as well as undercount and other kinds of misenumeration. In practice, reliable estimates of $U^c_{x,a}$ and U^w_a are rarely available. Even when they are derived from postenumeration surveys, these adjustment factors are more effective in adjusting for undercount than for age misreporting because the same kinds of age misreporting found in the original census count tend to be repeated in the postenumeration survey.

Undercount appears to be a much less serious source of error than age misreporting. A large proportion of omissions is of entire households and therefore does not necessarily have much effect on age-specific child–woman ratios, which, when adjusted for mortality, yield own-children estimates of age-specific birth rates. If the omitted households have the same composition by age and other characteristics as the included households, the omissions have no effect whatever on the own-children estimates of fertility.

Although it is probably true, as often claimed, that infants (children below one year of age) are especially prone to undercount, the frequently observed deficiency of infants in the census may stem also from age misreporting in the form of upward rounding of older infants' ages to age 1. But the apparent deficiency of children at age 0 is often less than the apparent deficiency at age 1, a pattern that could be caused by a tendency for upward rounding that is more pronounced at age 1 than at age 0. This seems a more plausible explanation than the alternative explanation that omissions are more common at age 1 than at age 0. Evidence in support of this age exaggeration hypothesis is presented later. Because of the difficulty of disentangling undercount and age misreporting, these effects are usually treated together.

Misreporting of women's ages introduces less error into the own-children estimates of fertility than misreporting of children's ages. For example, if, owing to age heaping, the census shows unusually large numbers of women aged 30, it also shows unusually large numbers of own children of mothers aged 30. Because children are matched to mothers, heaping of mothers' ages on 30, even when severe, does not radically distort corresponding age-specific child–woman ratios, so that women of reported ages 29, 30, and 31 have about the same child–woman ratios as would have been observed had there been no age misreporting at all. As discussed in the next chapter, misreporting of women's ages can still produce systematic distortions in the overall age pattern of fertility, but the effect on the total fertility rate tends to be small.

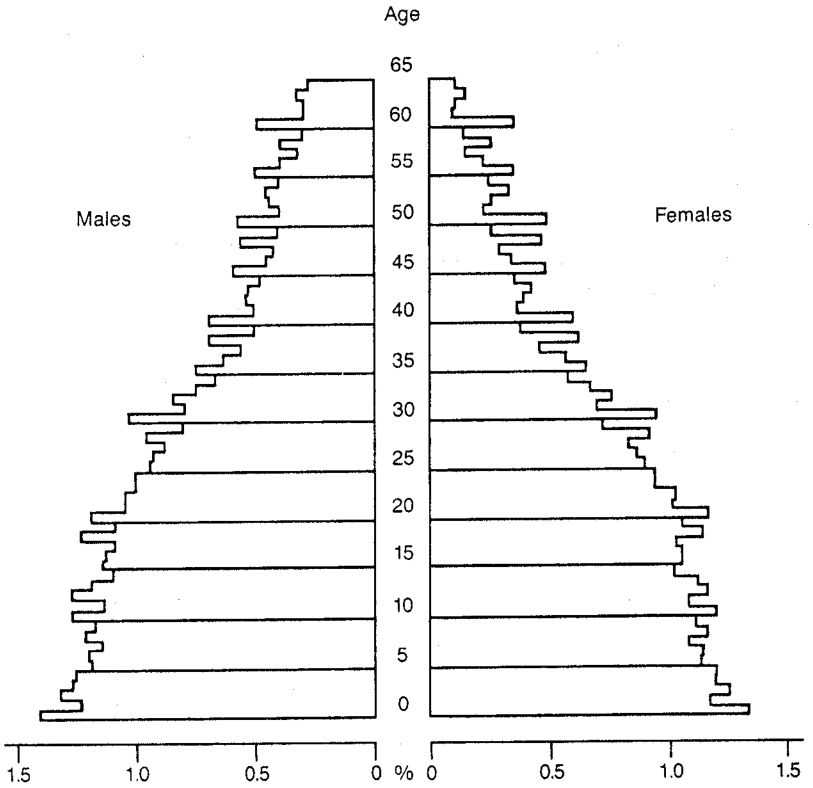

Figure 4.3. Age pyramid derived from the 1981 Census: Sri Lanka

Source: Ratnayake, Retherford, and Sivasubramaniam (1984:4).

Misreporting of children's ages is another matter. It has more serious consequences because it can produce large overestimates of fertility in some calendar years and large underestimates in others. Heaping on age 5, for example, inflates fertility estimates for the sixth year previous to the census, which is the birth year of children aged 5 at the time of the census.

To check for the presence of age misreporting, one should always begin by plotting an age pyramid by single years of age. An illustrative example for Sri Lanka in 1981 is shown in Figure 4.3. The figure shows some evidence of heaping on ages ending in 0 and 5, which helps explain some of the year-to-year fluctuations observed in the derived TFR trend, shown before in Figure 2.2. Myers's index of digit preference (Shryock and Siegel 1973:206ff.) provides a numerical measure of age heaping that is also useful.

Another check involves comparison of fertility estimates derived from own children with fertility estimates derived from vital registration. Fertility estimates derived from vital registration are not affected at all by heaping of children's ages, since births are registered directly, whereas own-children estimates of fertility show peaks and troughs in certain calendar years according to the pattern of heaping of children's ages in the census. Such comparisons therefore tend to reveal the effects of misreporting of children's ages in the census. Figure 4.4 shows such a comparison for Japan, where the agreement between the two sets of estimates is excellent. The agreement would be even better if calendar years lined up more precisely. The midpoint of calendar years is July for the vital statistics estimates and April for the own-children estimates. The discrepancy of three months affects the magnitude of the fertility dip in 1966. This fertility dip stems from the widespread belief that the Chinese Zodiacal Year of the Fire Horse (in this case, 1966) is not propitious for childbearing. The year 1966 from vital statistics coincides precisely with the Year of the Fire Horse, whereas the year 1966 from the own-children analysis includes only nine months of the Year of the Fire Horse, and that is why the fertility dip derived from vital statistics is more pronounced than the dip derived by the own-children method.

Of course, as the above example illustrates, the discrepancies revealed by such comparisons may indicate errors other than age misreporting. Another example is the previous comparison in Table 4.3, which revealed mismatch of adopted children. Another difficulty is that populations with severe age misreporting in censuses tend also to have deficient vital registration. In such cases comparisons of fertility estimates derived from own-children data with fertility estimates derived from vital registration may test the completeness of vital registration more than they test the accuracy of the own-children estimates of fertility. In applications of the own-children method in island populations in the South Pacific, for example, it has been found that fertility estimates derived from own-children data almost invariably exceed fertility estimates derived from vital registration. The discrepancies suggest underregistration of births (Levin and Retherford 1986).

In other types of demographic analysis, smoothing techniques are often used to eliminate or reduce the effects of age misreporting. These must be used cautiously in own-children analysis because age misreporting causes not only annual fluctuations in the own-children estimates of fertility but also systematic distortions in the long-term trend and overall age pattern of fertility. Smoothing techniques tend to eliminate year-to-year fluctuations, but they are usually ineffective in eliminating bias in long-term trends and overall age patterns. In practice, the detailed, unsmoothed estimates may provide useful clues about how age misreporting biases the long-term trends and overall age patterns of estimated

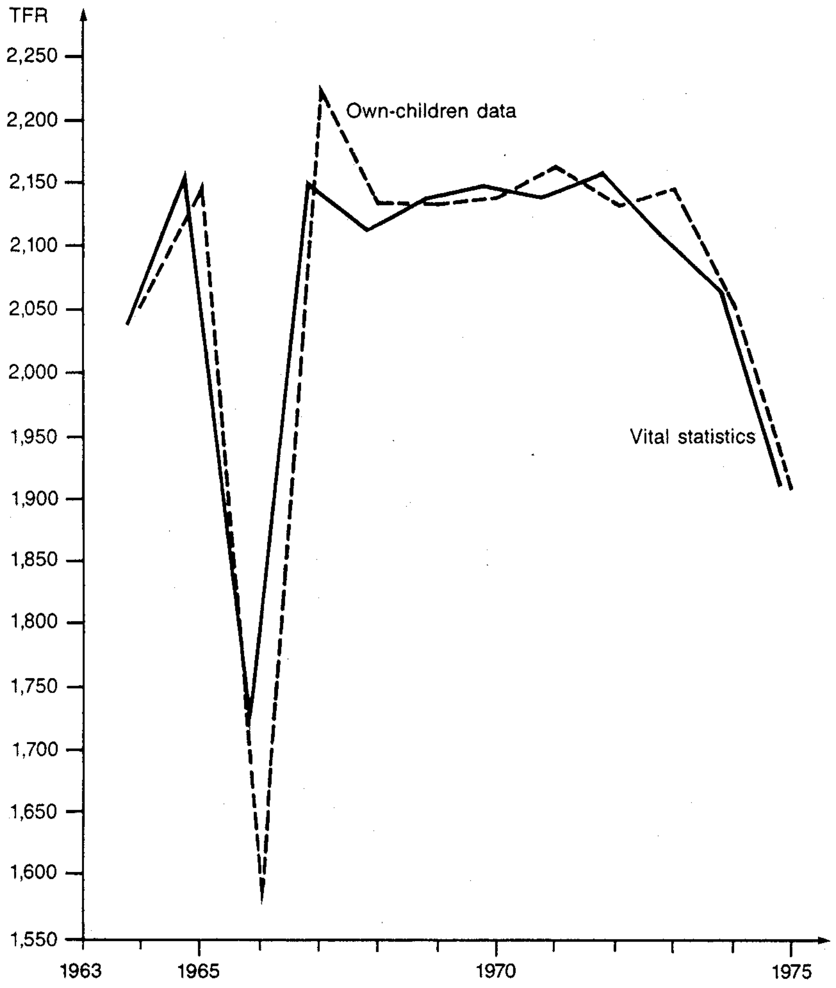

Figure 4.4. Estimated total fertility rates derived alternatively from census data on own children and vital registration data: Japan, 1964–75

Source: Itoh (1981).

fertility. Premature smoothing of the data eliminates these clues and restricts possibilities of analysis of errors. To the extent that smoothing is attempted, it should be done only after an initial examination of the detailed unsmoothed estimates. The preferred method of smoothing is simple aggregation for groups of ages (typically five-year age groups) and groups of calendar years, as described in previous chapters.

Experience in applying the own-children method in many populations suggests that a sufficient level of initial detail in the tabulations of own-children estimates of fertility is five-year age groups and one-year time periods. The age-specific birth rates in five-year age groups and the TFR should each be graphed against time in single calendar years, as in Figure 4.5, which is an illustrative graph of the TFR trend in Pakistan, based on the 1973 Housing, Economic, and Demographic Survey (HED). In this case, the plot by single calendar years shows clear evidence of age misreporting. Figure 4.5 shows major fertility peaks in the ninth, eleventh, and thirteenth years before the survey, corresponding to children of ages 8, 10, and 12 at the time of the survey. Since Pakistan censuses and surveys are noted for major heaping on ages 8, 10, and 12, one suspects that the trend in the TFR is severely biased by age misreporting.

Figure 4.5. Own-children estimates of total fertility rates derived from the 1973 Housing, Economic, and Demographic Survey: Pakistan, 1959–73

Source: Retherford et al. (1985:19).

When results from just one census or survey are available, it is very difficult to distinguish spurious trends and age patterns of fertility from real trends and age patterns. Results from two or more censuses enable a more definitive analysis. For example, if own-children estimates of fertility are available from two censuses taken ten years apart, each census yields a fifteen-year fertility trend, and the two trends overlap during the five years immediately preceding the first of the two censuses. If each trend is spuriously distorted in the same way by age misreporting (and perhaps other sources of systematic bias as well), the two trends will overlap poorly, and each will show the same pattern of distortion. The spurious aspects of the trend will be apparent, and it may be possible to discern approximately the true trend from the comparison. An extended example of this kind of analysis, focusing on Pakistan, is presented in Chapter 5.

If own-children estimates of fertility are available from several successive censuses, own-children estimates of cohort fertility can be checked against reported numbers of children ever born. Suppose, for example, that the own-children method has been applied to censuses taken in 1960, 1970, and 1980, yielding a set of age-specific birth rates for every year between 1945 and 1979. Recall from Chapter 2 that the own-children method yields period–cohort age-specific birth rates as well as central (age–period) age-specific birth rates, and that the period–cohort age-specific birth rates can be chained together along cohort corridors in the Lexis diagram to estimate age-specific fertility for real cohorts. For a given cohort, these period–cohort age-specific birth rates can be cumulated to estimate mean numbers of children ever born at specified ages of women, and these own-children estimates of children ever born at a specified age can be compared with children ever born for the same cohort of women at the same age as reported directly in a particular census. Such comparisons can be distorted by in- and out-migration, so that this test is a global test for many kinds of errors, not just age misreporting.

Figure 4.6 shows an example for the state of Wisconsin in the United States (Retherford and Sewell 1986). Period–cohort rates for the real cohort of ages 28–31 in 1970 and ages 38–41 in 1980 were reconstructed by applying the own-children method to the 1970 and 1980 censuses. The cohort's average age was, to a close approximation, exactly 30 in 1970 and exactly 40 in 1980, and we view the cohort as concentrated at these two ages at these two dates. Three age-specific birth rates (ASBRs) for this cohort can be derived from the 1970 Census: an ASBR at 15–19 for 1955–59, an ASBR at 20–24 for 1960–64, and an ASBR at 25–29 for 1965–69. Likewise, three age-specific birth rates can be derived from the 1980 Census: an ASBR at 25–29 for 1965–69, an ASBR at 30–34 for 1970–74,and as ASBR at 35–39 for 1975–79. The calculations are all done initially by single years of age, with numerators and denominators aggregated separately over age and time before they are divided to get period–cohort age-specific rates in five-year age groups over five-year time periods. The ASBRs at 25–29 for 1965–69 overlap, and in general they will not agree. (Note the discontinuity at 25–29 in Figure 4.6; the discontinuity is large in Panel A and negligible in Panel B.) The final estimate of the ASBR at 25–29 for 1965–69 may be taken as the average of the two.

If the final set of ASBRs for 15–19, 20–24, . . ., 35–39 is totaled and the sum multiplied by five, the result is an estimate of cumulative fertility per woman at exact age 40 in 1980. This estimate can be compared with the mean number of reported children even born at exact age 40 in 1980. An estimate of the mean number of children ever born at exact age 40 is obtained by averaging the reported number of children ever born at ages 38, 39, 40, and 41. The own-children estimate of cumulative fertility and the estimated mean number of children ever born should agree. In the case of high school dropouts in Figure 4.6, the respective values of cumulative fertility and children ever born at exact age 40 are 3.39 and 3.46, which agree to within 2.0 percent (with children ever born taken as the base). In the case of high school graduates (those with twelve completed years of education), the respective values of cumulative fertility and children ever born at exact age 40 are 3.15 and 2.99, which agree to within 5.3 percent.

Errors in fertility estimates by characteristics that change over the adult life cycle

As mentioned earlier, one strength of the own-children method that enhances its usefulness in more developed as well as less developed countries is that it allows tabulation of fertility estimates by socioeconomic characteristics such as education. It is important to note, however, that the method treats demographic characteristics such as age, parity, and duration since first marriage differently than it treats socioeconomic characteristics such as income or labor force activity status. When own-children estimates of fertility are tabulated by age, parity, or duration since first marriage, these characteristics describe women during the year for which fertility is being estimated, some years before the census. But

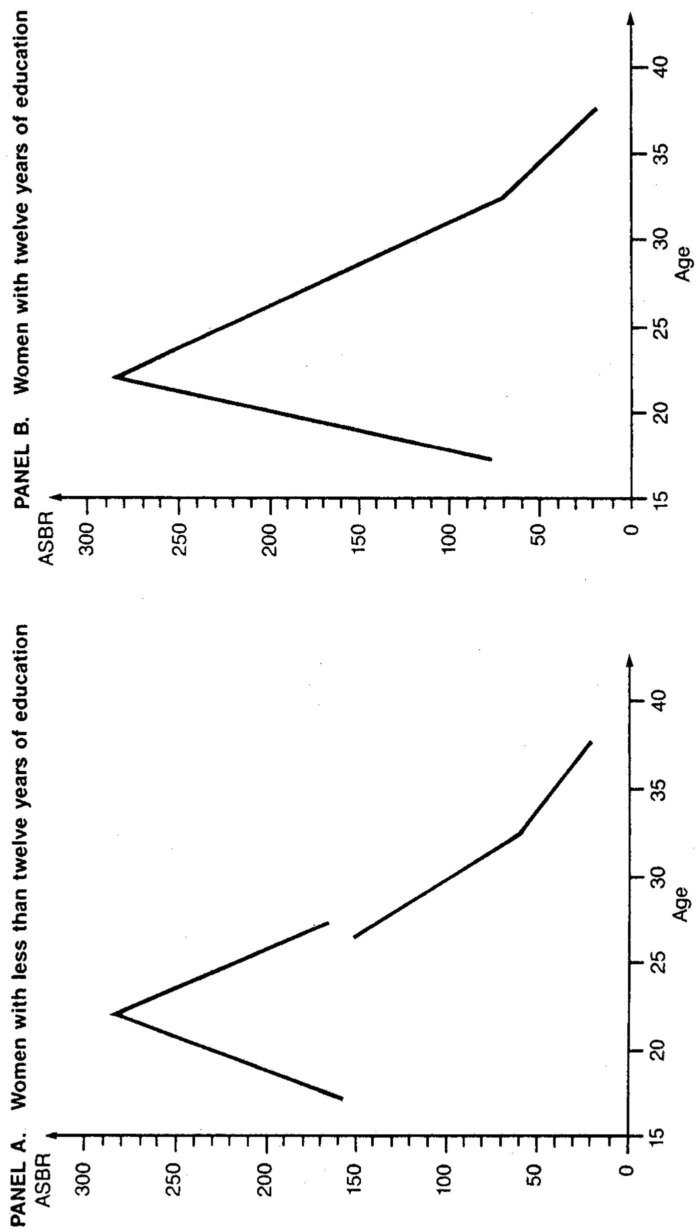

Figure 4.6. Period–cohort age-specific birth rates, by education, for the cohort of women aged 28–31 in the 1970 U.S. Census and 38–41 in the 1980 U.S. Census: Wisconsin

Source: Based on unpublished tabulations from Public Use Sample tapes from the 1970 and 1980 censuses.
Note: Women with more than twelve years of education are not shown.

when the estimates are tabulated by socioeconomic characteristics such as income or labor force activity status, these characteristics describe women at the time of the census, not during the year for which fertility is being estimated.

Problems arise with socioeconomic characteristics such as income and labor force activity status, which tend to change over the adult life cycle. The difficulty is that, say, income may be quite different for an individual at the time of the census from what it was a few years earlier. This means that, for a period several years before a census, the own-children estimates of fertility by income may differ substantially from independently derived estimates of fertility by income where in the latter instance income pertains to the year in question rather than the time of the census. In this situation, the own-children estimates of fertility by income can be misleading.

Own-children fertility estimates by labor force activity status derived from the 1980 Census of Japan (Kawasaki 1985: table 3) provide a dramatic illustration:

Status	*1970*	*1975*	*1980*
Employed	2.115	1.671	0.896
Not employed	2.187	2.237	2.831

They indicate a sharp decline in the fertility of employed women and a sharp increase in the fertility of women who were not employed. These results are highly misleading. Were it possible to tabulate the fertility estimates in this table by activity status at the time the births actually occurred rather than at the time of the census, the results would have been quite different. Only slight changes in fertility by activity status would have been indicated, and they would not necessarily have been even in the same direction, much less at the same level, as the trends shown in the table. The apparent but spurious decline in the TFR of employed women in the table occurs because some women who were employed at the time of the census in 1980, and thus unlikely to be caring for an infant at that time, were not employed five or ten years before the census in 1975 or 1970, when they were more likely to be caring for a baby by virtue of not being employed. Conversely, some of the women who were unemployed and perhaps caring for a baby in 1980, at the time of the census, were employed in 1975 or 1970. Because of these compositional shifts over time within each of the two activity categories in Table 4.5, the TFR falls sharply but spuriously for the employed and rises sharply but spuriously for the unemployed. For further illustration and discussion of effects of this kind, see Rindfuss (1977).

If the own-children method is used to tabulate fertility trends by characteristics that change significantly over the adult life cycle, it is clear that the results must be interpreted cautiously. The estimated trends are of more methodological than substantive interest. Of course, the distinction between characteristics that change and those that do not is not always clear-cut. In the case of education, for example, those who go on for higher education experience changes in educational status for a few years after the beginning of the reproductive period, thereby muddying somewhat the interpretation of fertility trends by education. On the whole, however, educational attainment changes little over the adult life cycle.

Although the estimates of fertility trends by characteristics that change over the adult life cycle may be severely biased, it is still reasonably valid to make fertility comparisons across the categories of such a variable if attention is confined to the first year before the census. If such tabulations are made from more than one census, the results usually yield reliable estimates of trends.

fertility trends to show fertility estimates for single calendar years. In the case of Pakistan, this disaggregation reveals a typical pattern of distortion in the estimated trends that is largely hidden when the estimates are aggregated over five-year time periods. For both countries it is also evident that one more than doubles one's information by having at least two successive censuses or surveys instead of just one. The degree of agreement between overlapping trends is a valuable additional piece of information not available from either source separately. With results based on a single census or survey, one can never be quite sure whether a trend is spurious or real. But if the same suspected biases in estimated trends tend to be repeated in applications to successive censuses or surveys, comparisons of overlapping trends can yield reasonably firm conclusions about the degree of reality of the trend estimated from each source separately.

CHAPTER 6

Comparison of Fertility Trends Estimated Alternatively from Birth Histories and Own Children

It is of interest to compare fertility trends estimated alternatively from birth histories and own-children data because they are susceptible to many of the same kinds of estimation errors. Such comparisons have been made in an eight-country study based on data from the World Fertility Survey (Retherford and Alam 1985). This chapter presents principal findings from that study, and also from China's 1982 National Fertility Survey.

Findings from the World Fertility Survey

It is well known that both birth history analysis and own-children analysis frequently provide distorted estimates of fertility trends. The reasons for such distortions are imperfectly understood, however. In a widely cited article on estimating fertility trends from birth histories, Potter (1977) emphasized the role of event misplacement, which can lead to overestimating a decline in age-specific birth rates. He hypothesized that recent events are recorded fairly accurately but more distant events are misplaced toward the date of interview. The consequence is an artificial bunching of events five to ten years before the survey that results in a spuriously large estimated fertility decline for the ten years or so previous to the survey. Event misplacement tends to be associated with misreporting of children's ages. For example, an erroneous response that a child's age is, say, 11 years may be associated in a very direct way with a parallel erroneous response that the child's date of birth was eleven years previous to the survey.

The principal hypothesis examined here is that fertility trends estimated alternatively from birth histories and own-children data suffer from similar errors in the reporting of women's and children's ages and therefore should show a similar pattern of distortions from this source. It is hypothesized additionally that the distortions are less pronounced in estimates of fertility trends derived from birth histories than in those derived from own-children data. One expects this for several reasons. First, the interviewer has more opportunity to notice and correct internal inconsistencies (for example, implausibly short birth intervals) when collecting birth histories than when collecting own-children data. Second, questions on ages of children are usually more extensive and probing in the birth histories than in the household surveys. Third, reporting by surrogates is absent in birth histories, where mothers invariably report for themselves and their children, but frequent in household surveys, where the household head often responds for the entire household. It should be borne in mind that various methods of collecting birth histories were employed in the World Fertility Survey (Jemai and Singh 1984), a fact that affects the interpretation of findings presented here.

These hypotheses about similar sources of distortions in fertility estimates derived from birth histories and own-children data are tested on World Fertility Survey (WFS) data from the Dominican Republic, Indonesia, Kenya, Republic of Korea, Nepal, Pakistan, Sri Lanka, and Syria. Each of those country surveys covered a sample of either ever-married women or, in the cases of the Dominican Republic and Kenya, both ever-married and single women, from whom birth histories were collected. The sample, called the individual sample, was embedded in a larger sample of complete households, called the household sample. In the study reported here, the fertility trend is estimated alternatively from birth histories from the individual sample and from own-children data from the household sample. The two estimated trends are then compared for each of the eight countries.

Methodology. In the birth history approach, age-specific totals of births to ever-married women are reconstructed from the birth histories for each year previous to the survey. Person-years of exposure to risk for ever-married women are similarly reconstructed. Except for the Dominican Republic and Kenya, where the individual sample included both ever-married and single women, person-years at risk for all women, regardless of their marital status, are estimated by dividing appropriate age-specific categories of person-years at risk for ever-married women by appropriate age-specific proportions ever married at the time of the survey. These proportions ever married are usually determined from the WFS household samples; thus the birth history analysis is usually not based entirely on the individual sample. In these computations, base calculations are done in century months, which are then aggregated to years or groups of years as desired. The birth history approach ordinarily assumes that all births previous to the survey occurred to women who had ever been married at the time of the survey and that none occurred to women still single (never married). It also assumes that women who died during the estimation period previous to the survey had, while they were alive, age-specific birth rates identical to those of women who survived. More detailed discussions of birth history analysis are found in numerous WFS publications (see, for example, Goldman, Coale, and Weinstein 1979).

In the present instance, the WFS computer program package, FERTRATE, was used to generate fertility estimates from birth histories. The time periods for which estimates were calculated were counted backward in twelve-month intervals starting from the time of the survey rather than from 1 January of the year of the survey, so that the estimates are comparable to those generated by the own-children method. The twelve-month intervals are labeled by the calendar year that encompasses most of the interval; for example, the period June 1978 to May 1979 would be labeled 1978, since more than half of the period fell in 1978.

The second approach to estimation utilizes the own-children method, which has already been described in earlier chapters. In this method, enumerated children are first matched to mothers within households, ordinarily on the basis of answers to questions on age, sex, marital status, number of children still living, and relation to head of household. WFS household surveys, however, contained a special code directly linking children to their mothers, so that matching was accomplished quite simply.

The own-children method requires life tables, from which reverse-survival ratios are computed. For the Dominican Republic, Republic of Korea, and Syria, constant mortality over time was assumed; and life tables were calculated by matching child mortality estimates, obtained by applying Brass's (1975) method to child survivorship data (numbers of children ever born and still living by age of mother) from the WFS survey itself, to the appropriate Coale–Demeny model West life table (Coale and Demeny 1966). For Indonesia we assumed changing mortality. Estimates of life expectancy for 1960 and 1978 were obtained from the United Nations 1976 and 1981 Demographic Yearbooks and were matched to Coale–Demeny model West life tables. These life tables were interpolated to single years of age and time by procedures described in Chapter 2 and Appendix A. A similar procedure was used for Kenya, except that the starting estimates for life expectancy were for 1969 and 1978. For Nepal we began with life expectancy estimates of 37.5 years for 1960 and 42.5 years for 1975 and then used the same procedure followed for Indonesia and Kenya. For Pakistan we assumed constant mortality and used the life table derived from the Population Growth Estimation (PGE) Survey of

1962–65 (Afzal 1974: 22). For Sri Lanka we assumed constant mortality and used published life tables for 1970–72 (Sri Lanka Department of Census and Statistics 1978).

As noted earlier, the own-children estimates are rather insensitive to errors in the mortality estimates because such errors cause only very small changes in reverse-survival ratios, which under modern mortality conditions are always rather close to 1. For the countries examined here, errors in the fertility estimates due to mortality estimation errors are much smaller than the errors stemming from age misporting. Moreover, the method of mortality estimation guarantees an absence of fluctuations over time in estimated mortality during the estimation period. Thus there is no danger whatever that year-to-year distortions in the estimated fertility trends, examined in the section of this chapter on results of the comparison, could be due to mortality estimation errors. Of course, our smoothing of mortality trends may have introduced some year-to-year distortions in the fertility estimates.

No adjustments for incorrect enumeration (age-selective sampling bias or age misreporting) were made, either in the birth history analysis or in the own-children analysis, since the effects of misenumeration, especially age misreporting, are of observational interest.

As mentioned, the own-children data include information on women up to 65 years of age. In the birth histories, however, only women below age 50 were queried. This means that, for the fifteen-year estimation period previous to the survey, annual estimates of complete age-specific fertility schedules covering the entire reproductive age range of 15–49 could be computed from the own-children data but not from the birth history data, which suffer from truncation as soon as one considers time periods previous to the survey. For example, if one wishes to compute age-specific birth rates for the fifth year previous to the survey from the birth histories, one is restricted to women aged 15–44 at that time instead of the full range of 15–49. For the full fifteen-year estimation period the range is restricted to ages 15–34. This has meant that the most desirable fertility measure, the total fertility rate, could not be used in comparing fertility trends estimated by the two methods. The cumulative fertility rate at exact age 35, CFR(35), calculated as five times the sum of age-specific birth rates for age groups 15–19 through 30–34, was used instead. Note the similarity to the total fertility rate, which is calculated in the same way but with a higher age cutoff.

The WFS data. The WFS samples were categorized into groups 1, 2, and 3.

In *Group 1,* which is the largest, the household and individual samples are the same, in that every woman in the individual sample belongs to a household in the household sample, and every eligible woman in every household of the household sample belongs to the individual sample (except for those few eligible women who were nonrespondents in the individual survey). Additionally, in the surveys in this group, field operations were carried out at approximately the same time and by the same field staff. Nepal, Pakistan, and Sri Lanka are in this group.

Given the almost simultaneous timing of the individual and household interviews for these countries, one might expect a close correspondence between the two samples in reported ages and birth dates. Preliminary tabulations indicated, however, that this was not always the case. A possible explanation of this lack of agreement hypothesizes the following sequence of events: Ages of all household members were first collected in the household interview. From the household schedule, ever-married women were identified. These women were subsequently questioned, and birth histories collected, in individual interviews. In the process of collecting birth histories, there was intensive questioning about birth intervals and dating of events, which resulted in some cases, by implication, in improved estimates of the respondent's or her children's ages. But these improved estimates are reflected in the household survey results only to the extent that someone, either in the field or in the office, took the trouble to go back to the household schedules and render the reports of women's and children's ages consistent with birth dates recorded in the birth histories. Apparently this was done much more completely in some countries than in others, and in some cases it may not have been done at all (Jemai and Singh 1984).

From published reports there is no way of knowing the extent to which consistency checking and resolving of discrepancies actually occurred, and this uncertainty results in an unknown degree of contamination that obscures the meaning of the comparisons to be made. The results for Pakistan and Nepal, however, suggest that little consistency checking was done, so that the comparisons seem unambiguous. In Sri Lanka, the third country in this group, age reporting is comparatively good, and there seems to be little consequent distortion in the trend estimates derived by either method.

The numbers of ever-married women in the individual sample and of persons in the household sample are 5,940 and 31,971 respectively for Nepal, 4,952 and 32,008 for Pakistan, and 6,810 and 47,914 for Sri Lanka.

In *Group 2* the individual sample is a subsample of the household sample, the latter generally covering three or four times as many households as the former. The two surveys were carried out at approximately the same time and by the same field staff, so that contamination is not

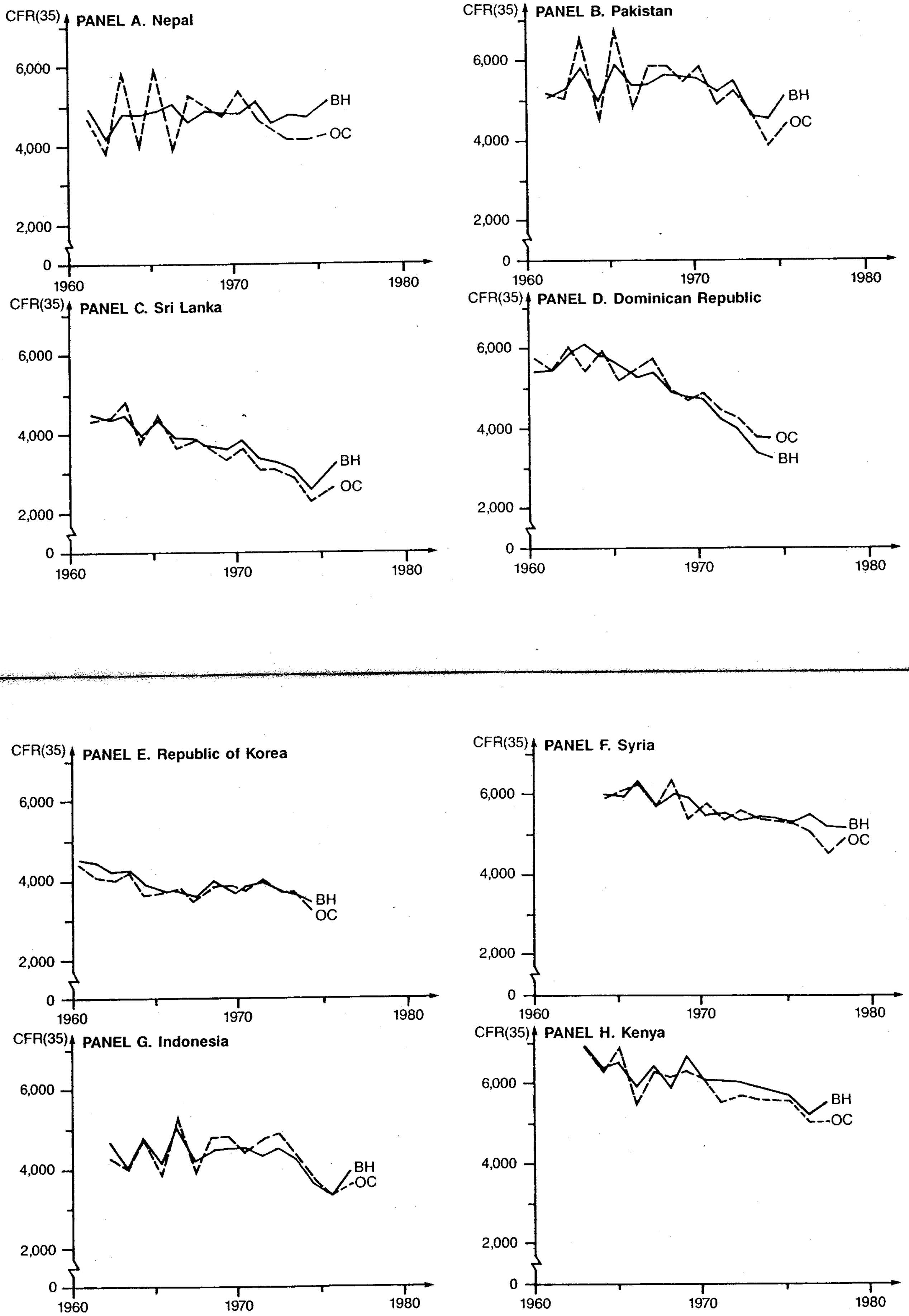

Figure 6.1. Trends in cumulative fertility rates, CFR (35), estimated alternatively by applying the birth history method and the own-children method to the World Fertility Survey: Various countries and periods

Source: Retherford and Alam (1985).

excluded, but it is clearly less serious than in the countries in Group 1 because it can affect only the minority of mothers who were selected for the individual survey. In the present study three countries fall into Group 2: the Dominican Republic, Republic of Korea, and Syria. In the Dominican Republic the women in the individual sample were sampled directly from a list of all the eligible women in the household sample (i.e., there was no process of subsampling households). In Korea and Syria the individual sample consists of all eligible women in a subsample of the households of the household sample.

The numbers of ever-married women in the individual sample and of persons in the household sample are 3,115 and 59,493 for the Dominican Republic, 5,430 and 104,892 for Korea, and 4,487 and 97,310 for Syria.

In *Group 3* the individual and household schedules (the household schedule was very short) were administered in the same interview, so that this case represents the most extreme form of contamination of all three groups. Indonesia and Kenya fall into this category. In the case of Indonesia, however, this difficulty can be largely circumvented because the WFS household survey, known as SUPAS III, was embedded in a much larger survey known as SUPAS II. Thus fertility trends can be estimated by the own-children method from SUPAS II as well as from SUPAS III, both of which we examine here. Because of the large sample size of SUPAS II, the own-children fertility estimates derived from it are relatively free of contamination. No such remedy for contamination was available for Kenya, and the results for Kenya are therefore less instructive than those for the other countries.

The numbers of ever-married women in the individual sample and of persons in the household sample are 9,155 and 50,994 for Indonesia and 8,100 and 46,101 for Kenya. The SUPAS II sample, of which the WFS household sample SUPAS III is a subsample, contains 281,168 persons.

Results of the comparison. Findings are presented in the order of the three groups discussed above. Trends in cumulative fertility rates to age 35, CFR(35), estimated alternatively from birth histories and own-children data, are summarized in Figure 6.1. (Similar graphs for ASBRs are presented in Retherford and Alam 1985.)

Results for Nepal are presented in Panel A of Figure 6.1. The CFR estimates derived by the own-children method (Panel A of Figure 6.1) show a pattern that has been found to be fairly typical for countries of continental South Asia, namely large oscillations during the period ten to fourteen years before the survey and a substantial fertility decline during the eight years or so immediately preceding the survey. Usually the estimates show a fertility upturn in the year just preceding the survey, and this is also evident for Nepal. We have already observed this pattern for Pakistan in chapters 4 and 5.

The large oscillations during the period ten to fourteen years before the survey reflect severe heaping on children's ages of 10 and 12, corresponding to births in the eleventh and thirteenth years before the survey. The comparatively low fertility during the first five years or so immediately preceding the survey may be due mainly to age exaggeration from rounding of children's ages to the next higher age. This pattern resembles that found for Pakistan, as discussed earlier in Chapter 5.

The parallel CFR trend based on birth histories for Nepal (Panel A of Figure 6.1) bears only a slight resemblance to that based on own-children data. On the whole the estimates based on birth histories show little change over time, indicating an absence of fertility decline, and the comparatively minor year-to-year fluctuations do not parallel very closely those derived from own-children data. The results seem either to contradict the hypothesis that fertility trends based alternatively on birth histories and own-children data reflect the same age-reporting errors, or to suggest that the survey takers made exceptional efforts, through probing, to achieve a degree of consistency in the reporting of the timing of birth events in the birth histories that left few traces of age misreporting.

The impressively smooth results from birth histories may have something to do with the Takeshita method of collecting birth histories. This method, which was used in Nepal but not in most other WFS countries, makes special efforts to obtain accurate age data (Jemai and Singh 1984). The smooth results from the birth histories may also be related to extensive imputation of dates of events collected in the birth histories (Chidambaram and Sathar 1984). But imputation cannot be the main reason for the smooth trend derived from the Nepalese birth histories because, as we shall see, this trend is much less smooth in Pakistan, where imputation was just as extensive as in Nepal. If age misreporting is the principal cause of whatever year-to-year distortions remain in the fertility trend estimates for Nepal, then it is apparent that little or no effort was made to render birth dates in the individual sample and ages in the household sample consistent with each other.

The pattern of own-children estimates for Pakistan (Panel B of Figure 6.1) is quite similar to that for Nepal, with pronounced fertility fluctuations early in the estimation period, substantial fertility decline subsequently, and a small upturn in the year immediately preceding the survey; but age misreporting seems more severe, as indicated by more jagged patterns. Again major peaks in the fertility trend occur in the eleventh and thirteenth years previous to the survey, corresponding to heaping on ages 10 and 12. Consonant with our initial hypothesis, the fertility trends estimated by the own-children method are considerably more jagged than those estimated from birth histories, and they show a similar pattern of year-to-year fluctuations. Peaks and troughs in the estimated trends derived by the two methods coincide rather closely. Thus the Pakistan data tend to support the hypothesis that fertility trends estimated alternatively from birth histories and own-children data suffer from similar biases due to similar age-reporting errors in both data sets.

Results for the third country in Group 1, Sri Lanka (Panel C of Figure 6.1), show annual fluctuations in the trends estimated alternatively from birth histories and own children that tend to rise and fall together, and this pattern again supports the hypothesis that the two trends are similarly biased by age-reporting errors. There tend to be peaks in the sixth, ninth, eleventh, and thirteenth years before the survey, corresponding to heaping on ages 5, 8, 10, and 12. The heaping is minor, however, in keeping with the comparatively accurate age reporting that is known to characterize Sri Lanka (Ratnayake, Retherford, and Sivasubramaniam 1984).

In Sri Lanka as well as in Nepal and Pakistan there tends to be a small fertility upturn in the year immediately preceding the survey. Overall, the recurring pattern of fertility peaks corresponding to children's ages 0, 8, 10, and 12 strongly suggests that the observed peaks and troughs in the fertility trends are due primarily to age misreporting and do not reflect real annual fluctuations in fertility. (Note, however, that sampling errors for single-year rates in WFS surveys are large; see Little 1982.)

Next are the Group 2 countries, for which, it will be recalled, the individual sample is embedded in a considerably larger household sample. For the Dominican Republic (Panel D of Figure 6.1) the trends estimated alternatively from birth histories and own-children data coincide reasonably closely, except for the five years immediately preceding the survey, in which fertility is seen to decline more steeply for the birth history estimates than for the own-children estimates. In the estimates derived by the own-children method there appears to be some heaping on ages 4, 7, 10, and 12, corresponding to local peaks in the fertility trend in the fifth, eighth, eleventh, and thirteenth years before the survey. (Nepal, Pakistan, and Sri Lanka also showed heaping on ages 10 and 12.) The trend estimated from birth histories also shows local peaks in the fifth and eighth years before the survey, but not in the eleventh or thirteenth year; instead, it peaks in the twelveth year before the survey. Age reporting errors, described in a previous WFS study (Guzman 1980), are implicated in these patterns, despite their inconsistencies.

Similar graphs of ASBRs (not shown) indicate that the relatively steep fertility decline estimated from birth histories during the five years immediately preceding the Dominican Republic survey is due mainly to discrepancies between the birth history and own-children trends at maternal ages 15–19, much less so to discrepancies at ages 20–24, and hardly at all to discrepancies at ages 25–29 and 30–34. Possibly age-specific proportions ever married from the household sample were underestimated at the younger reproductive ages, resulting in an excessive deflation of birth rates for ever-married women at these ages when these latter rates were effectively multiplied through by age-specific proportions ever married to estimate birth rates for women of all marital statuses combined. Such an error would result in fertility underestimates derived from the birth histories. Given well-known difficulties in assessing the extent of consensual unions (which are especially prevalent at the younger reproductive ages) as opposed to formal unions in many Caribbean countries, this seems a plausible source of error.

The relatively smooth estimated fertility decline since 1965 in the Dominican Republic suggests that age-reporting problems are not severe and that the downward trend in fertility is real. This impression is reinforced by information on contraceptive use rates, which the WFS found to be substantial: Fully 97 percent of eligible women knew of at least one modern contraceptive method, and 26 percent were using one (Hobcraft and Rodriguez 1982).

Results for the Republic of Korea, the second country in Group 2 (Panel E of Figure 6.1) show a CFR decline in the 1960s, a temporary rise in the late 1960s and early 1970s, and a resumption of the decline in the 1970s. The temporary fertility resurgence in the late 1960s and early 1970s has also been observed in fertility trends estimated from other sources (see, for example, Retherford, Cho, and Kim 1983) and seems to be real. The resurgence is most noticeable for age-specific birth rates at ages 20–24 and 25–29, which suggests that the resurgence was due to shifts in the timing of births due to unprecedented prosperity in the late 1960s and early 1970s, rather than to a temporary reversal of the downward trend of completed fertility. Age reporting is known to be very accurate in Korea, and there is no indication in Figure 6.1 that the small annual fluctuations in the two sets of fertility trends based alternatively on birth histories and own-children data reflect common patterns of age misreporting, which is largely absent.

Results for Syria, the third country in Group 2 (Panel F of Figure 6.1) show quite good agreement between the CFR trends estimated alternatively from birth histories and own-children data during all but the most recent three years of the estimation period, in which the trend from the own-children data drops below the trend from birth histories. The peaks and troughs of the fertility trends estimated alternatively from birth histories and own-children data do not coincide very consistently.

As mentioned, the Group 3 countries, Indonesia and Kenya, have the greatest degree of mutual contamination between birth histories and own-children data, since both the individual and the household schedules were administered during the same interview. As anticipated, (Panel G of Figure 6.1) the peaks and troughs of the fertility trends estimated for Indonesia alternatively from birth histories and own-children data coincide rather well, and, as hypothesized, the oscillations over time tend to be more pronounced for the own-children estimates than for the birth history estimates. The pattern of peaks and troughs resembles that for Nepal and Pakistan; that is, the peaks correspond to children's ages 10 and 12, and there is an apparent fertility decline in the five years or so immediately preceding the survey, with a slight upturn in the year just before the survey.

As mentioned earlier, an additional comparison is possible in the case of Indonesia, because the WFS household sample, known as SUPAS III, was embedded in a much larger household survey known as SUPAS II. Figure 6.2 compares own-children estimates of trends in the TFR, covering the entire reproductive age range of 15–49, derived from SUPAS II and SUPAS III. It shows that the pattern of peaks and troughs due to age misreporting is quite similar in the two surveys but tends to be somewhat more pronounced in the WFS SUPAS III than in SUPAS II. This pattern of discrepancies again tends to support the hypothesis that the collection of birth histories results in a good deal of checking for internal consistency that ultimately provides better, or at least more consistent, estimates of women's and children's ages and the timing of birth events. The age–event chart used as an aid in collecting birth histories in Indonesia, as in Nepal, probably contributed to the quality of the age data obtained (Jemai and Singh 1984; Supraptilah 1982).

For the last country in Group 3, Kenya, again the fertility trends indicate severe contamination between the individual and household samples (Panel H of Figure 6.1). As in the case of Indonesia, the CFR(35) trends estimated alternatively from birth histories and own children coincide rather well, although the trend derived from own-children data tends to be somewhat lower than the trend derived from birth histories in the first seven years or so immediately preceding the survey. Again there is some indication of heaping on ages 8, 10, and 12, corresponding to fertility peaks in the ninth, eleventh, and thirteenth years before the survey; a subsequent decline in fertility; and a slight upturn in the year just preceding the survey. As in the other countries, year-to-year fluctuations tend to be larger in the own-children estimates than in the birth history estimates. Again this suggests that even though the household and individual schedules were administered in the same interview, birth dates and ages were not always rendered consistent in the two schedules. The data for Kenya tend also to support the original hypothesis that distortions in fertility trends estimated alternatively from birth histories and own-children data reflect similar age-reporting errors.

Discussion. From the ages of surviving children matched to a woman in the own-children procedure, one can infer birth dates, yielding a partial birth history that omits births of children who later died or moved out of the household before being enumerated in the survey. In effect, the own-children adjustments for mortality and unmatched children compensate for these omissions. Thus, as noted in Chapter 1, the own-chil-

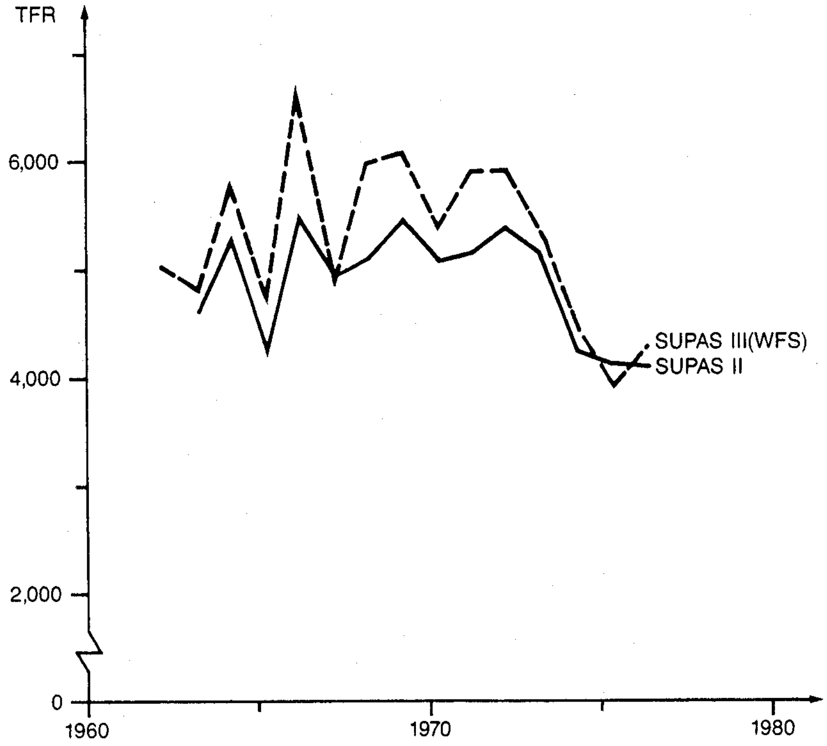

Figure 6.2. Own-children estimates of trends in total fertility rates derived from SUPAS II and SUPAS III: Indonesia, 1962–76

Source: Retherford and Alam (1985).

dren method may be regarded as fertility estimation from incomplete maternity histories.

Given this similarity between the own-children method and the birth history method, our initial hypothesis, that fertility trends estimated alternatively from birth histories and own children tend to suffer from similar errors in age reporting that should be reflected in roughly coinciding peaks and troughs in the estimated year-to-year fertility trends, is supported fairly strongly by the results for Pakistan, Sri Lanka, Indonesia, and Kenya, but only weakly or not at all by the results for Nepal, the Dominican Republic, Korea, and Syria. Our further hypothesis, that distortions due to age misreporting should be more pronounced in the trend derived from own-children data than in the trend derived from birth histories, which offer more opportunity to detect and correct internal inconsistencies during interviews of respondents, is supported by the results for Nepal, Pakistan, the Dominican Republic, Syria, Indonesia, and Kenya, but weakly or not at all by the reports for Korea and Sri Lanka. In the case of Nepal, it is possible that an extraordinary effort was made to obtain birth histories with a smooth sequence of birth intervals, and that this effort left little trace of the typical South Asian pattern of age misreporting so evident in the own-children estimates. This may have been due partly to use of an age–event chart of the type recommended by Takeshita for the collection of birth histories. In Korea age reporting is known to be quite accurate, and the impact of age misreporting on the estimated fertility trends seems to be minimal. In most cases the agreement between the fertility estimates derived alternatively from own-children data and birth histories is impressive.

None of the countries examined shows much indication of a bunching of births in the birth histories in the vicinity of five to ten years before the survey; fertility ten to fourteen years before the survey tends to be about as high or higher than fertility five to ten years before the survey. Moreover, in at least one case, Pakistan, fertility during the five years immediately preceding the survey seems implausibly low, probably owing to a pattern of age exaggeration stemming from upward rounding of children's ages. Additional evidence in support of this hypothesis, based on overlapping fertility trends estimated from successive censuses or surveys, has already been examined in Chapter 5. This mechanism probably operates in Indonesia as well, although independent evidence indicating a rapid rise in contraceptive use suggests that part of the indicated fertility decline in Indonesia is real. On the whole, Potter's hypothesis about misplacement of events, which assumes bunching of births five to ten years before the survey and accurate reporting of births during the first five years or so immediately preceding the survey, does not receive much support from these data. This finding reinforces previous work by Blacker and Brass (1979), who also found evidence that recent birth dates obtained from birth histories tend to be pushed backward from, rather than toward, the survey date.

Findings from China's 1982 National Fertility Survey

The own-children method has also been applied to China's 1982 National Fertility Survey, which is known to have been extraordinarily accurate (Cho, Han, and Li 1985). The sample size for this survey was very large, amounting to 1,017,574 persons. The sampling fraction was approximately 1/1,000. Like the WFS, this survey used both a household questionnaire and an individual questionnaire. The individual questionnaire was administered to sample women 15–67 years of age, instead of the usual range of 15–49 (Wang and Xiao 1984).

The survey included a simple household questionnaire that was originally intended to aid in the identification of eligible women, to whom the individual questionnaire was administered. The own-children method was later applied to the household data to obtain estimates of fertility for years between 1963 and 1982. The data were of sufficient quality that estimates could be computed for a period up to twenty years before the survey instead of the usual fifteen years before the survey. Life tables for reverse survival were obtained by matching age-specific death rates estimated by Wang (1984) to an appropriate Coale–Demeny model North life table.

The fertility estimates derived alternatively from birth histories and own-children data in the 1982 survey are compared in Figure 6.3. In this case it is possible to examine total fertility rates instead of cumulative fertility rates to age 35 because the birth histories were asked of women aged 15–67 instead of 15–49, thereby eliminating the truncation problem discussed earlier in connection with the WFS surveys. The annual estimates derived by the own-children method overlap calendar years, whereas the annual estimates derived from the birth histories correspond strictly to calendar years (January to December). In Figure 6.3 the estimates derived from birth histories incorporate a one-half year adjustment to facilitate comparison with the estimates derived by the own-children method.

The agreement between the two trends is excellent, especially for the first fifteen years before the survey. The still good agreement for the period sixteen to twenty years before the census is noteworthy because,

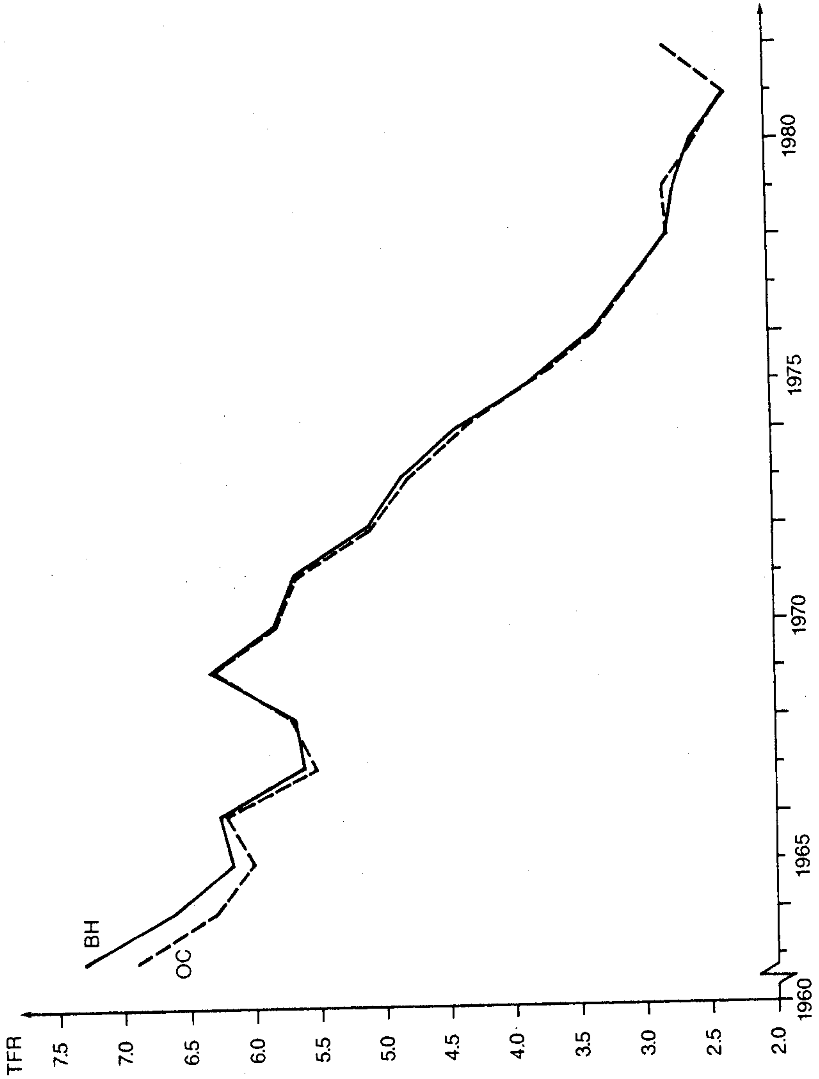

Figure 6.3. Trends in total fertility rates estimated alternatively by applying the birth history method and the own-children method to the 1982 National Fertility Survey: China, 1963–82

Source: Unpublished tabulations.

in the own-children estimates, births for this early period are derived from children aged 15–19, a substantial proportion of whom no longer live in the parental household and therefore cannot be matched to their mothers. Peaks and troughs in the estimated trends coincide rather closely. The deviation between the two trends during the period 1966–81 never exceeds 1.5 percent, except for 1979, when the deviation is slightly larger.

CHAPTER 7

Step-by-Step Procedure with Illustrative Results for Thailand

This chapter presents details of the basic own-children estimation procedure, with emphasis on results from each of three major stages of computer programs.

The three-stage procedure

The computational procedure for the own-children method is organized in three major stages. First, children below age 15 are matched, where possible, to their mothers. Second, from the matched data file obtained in the first stage, women are tabulated by age, own children are tabulated by child's age and mother's age, and non-own children are tabulated by child's age. Third, annual age-specific birth rates and derived fertility measures are computed from the tabulations from the second stage. The results of each stage may be saved on computer tape for use in the next stage or in further analyses. Background tabulations from a study by Arnold, Pejaranonda, and Choe (1986) are used here as a source of illustrative results from stages 2 and 3. These results, presented later in this chapter, are derived from an application of the own-children method to the 1980 Census of Thailand.

Of the three stages, the first is the most data-dependent, in that the stage-1 computer program requires the most modification before it can be adapted from one data set to another. Modifications are necessary to conform to the format of the questionnaire data and to the specification of information used for matching, particularly the coding categories of relationship to head of household. The programs for the other two stages are more standardized. Examples of computer programs are given in Appendix C.

Stage 1: matching

Matching of children to mothers is accomplished by a computerized matching algorithm. The following conditions must be met for matching to be accomplished: (1) the census or survey must be of households; (2) there must be a separate record for each person in the household; (3) the records for individual persons must be grouped by household; (4) separate households must be identified either by a unique household number or by a housing record preceding the records for persons in the household; and (5) each person's record must include data on age, sex, and relationship to head of household. If each woman's record contains information on marital status, this information may be employed to restrict matches to ever-married women. If each woman's record contains information on number of children ever born or number of children surviving, this information is employed so that no more children are matched to a woman than the number she says are still living among those she has ever borne. If the reports on children ever born and still living are classified by sex of child, this information is also employed so that no more boys are matched to a woman than the number of boys she says are still living among those she has ever borne, and likewise for girls.

Because many children begin to live away from their mothers starting at about age 15, matching is usually limited to children younger than 15. This age limit determines the time period for which fertility rates are to be estimated. If the limit is 15, it is possible to estimate fertility rates for each year up to and including the fifteenth year before the census. In the following discussion, age 14 (corresponding to births in the fifteenth year before the census) is assumed to be the upper age limit of children for matching purposes.

The matching algorithm begins by scanning a household, saving information on all women in the age range 15–65 as potential mothers and all children below age 15 as potential own children. Normally, never-married women are not considered to be potential mothers, but this restriction can be relaxed if illegitimate births are common. For each potential mother, considered in the order listed in the household schedule, a search is made of all children in the household who have not yet been matched to a woman. For each of these children, the child's relationship code is compared with the woman's relationship code. When the two codes are compatible with a mother–child match, the ages of the woman and child are compared. If the age difference falls in the range 15–49, the child is matched to that woman.

For a particular woman, the search for her own children stops when the number of children matched to her reaches the reported number of her living children or after all the unmatched children in the household have been scanned. The children below age 15 who are not matched to a woman by the end of the household scan are considered non-own children.

The matching procedure yields a new data file with two record types. The first record type is a woman record. A woman record is created for each woman between the ages of 15 and 65 inclusive, containing the characteristics of the woman and the age and sex of each of her own children below age 15, if any. The second record type is a non-own-children record. A non-own-children record is created for each household with non-own children. The record contains the age and sex of each unmatched child below age 15 in the household.

The following hypothetical example illustrates the procedure. Consider a household of eight persons with the following selected information:

Person number	*Relationship to head of household*	*Sex*	*Marital status*	*Age*	*Number of living children*
1	head	M	M	55	—
2	wife	F	M	53	4
3	son	M	M	30	—
4	daughter-in-law	F	M	28	2
5	daughter	F	D	21	0
6	son	M	N	12	—
7	granddaughter	F	N	5	—
8	grandson	M	N	2	—

The marital status code M denotes currently married, D denotes divorced, and N denotes never married. In this census the information on number of living children was asked of women of ages 15 and older only. For this household the matching algorithm creates the following list of potential mothers:

Person number	*Relationship*	*Marital status*	*Age*	*Number of living children*
2	wife	M	53	4
4	daughter-in-law	M	28	2
5	daughter	D	21	0

It then goes on to create the following list of potential own children:

Person number	*Relationship*	*Sex*	*Age*
6	son	M	12
7	granddaughter	F	5
8	grandson	M	2

For the first potential mother listed, the relationship code is wife. Therefore, among the potential own children only the first child with person number 6 has a relationship code that is consistent with being her child. The age difference is 53 − 12 = 41, which is within the acceptable range. The woman can have up to four children matched to her. To start with, the number matched to her is zero. Thus, the child with person number 6 is determined to be the woman's own child. Similarly, children with person numbers 7 and 8 are matched to the woman with person number 4. No children are matched to the woman with person number 5 because she has no living children. In any case, no children are left to be matched to her. In this household there are no non-own children. Three records corresponding to three potential mothers are generated as follows:

Person number	*Information from woman's record*	*Own-children*					
		Sex	*Age*	*Sex*	*Age*	*Sex*	*Age*
2	wife F M 53 4	M	12	—	—	—	—
4	daughter-in-law F M 28 2	F	5	M	2	—	—
5	daughter F D 21 0	—	—	—	—	—	—

In actual applications, additional information such as geographical area and socioeconomic characteristics is included in the woman records, and age and sex of each child are included in the non-own children records. Each output record has a flag indicating whether the record is a woman record or a non-own-children record.

If mother's person number is collected for each child below age 15, matching is much simpler. In our example the household is then processed on the basis of the following information:

Table 7.1. Women by age, children by own age and mother's age, and

Women's age	No. of women	Children's Age														
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	6,071	34	15	7	0	0	0	0	0	0	0	0	0	0	0	0
16	5,716	93	38	15	8	0	0	0	0	0	0	0	0	0	0	0
17	5,665	212	95	40	16	8	0	0	0	0	0	0	0	0	0	0
18	5,401	337	184	86	42	16	10	0	0	0	0	0	0	0	0	0
19	5,103	465	297	176	94	39	18	11	0	0	0	0	0	0	0	0
20	5,264	639	455	324	217	102	50	28	19	0	0	0	0	0	0	0
21	5,016	636	502	402	301	165	87	39	20	13	0	0	0	0	0	0
22	5,217	729	609	534	459	301	189	95	46	22	15	0	0	0	0	0
23	4,768	756	669	628	583	442	334	192	109	53	29	22	0	0	0	0
24	4,231	714	639	627	625	521	441	310	207	112	55	34	25	0	0	0
25	3,971	661	642	633	659	588	542	415	312	198	105	63	39	29	0	0
26	3,641	595	570	609	621	590	574	482	394	273	169	92	53	33	24	0
27	3,628	578	551	591	654	622	631	571	503	405	279	182	102	51	30	21
28	3,253	483	476	515	573	571	598	564	532	451	354	252	149	89	44	24
29	3,308	468	475	509	579	585	649	619	625	570	480	381	274	171	95	47
30	3,184	414	414	460	540	554	598	625	607	601	547	472	375	280	171	100
31	2,655	332	334	376	432	465	514	534	561	555	528	476	421	320	220	126
32	2,639	305	314	354	416	439	502	526	555	583	560	538	493	421	315	206
33	2,345	250	256	285	358	367	432	457	487	525	538	514	502	443	368	271
34	2,197	218	226	266	315	334	391	419	448	496	512	511	495	476	395	326
35	2,292	207	219	257	306	334	387	424	460	499	533	532	538	520	459	409
36	1,970	167	173	203	251	268	320	349	379	420	449	456	480	475	418	391
37	2,210	177	183	222	256	289	335	383	414	463	497	506	534	531	516	470
38	2,026	152	160	187	228	243	303	328	359	408	440	452	482	497	463	468
39	2,393	160	180	207	259	281	327	382	416	466	522	527	574	597	561	565
40	2,186	123	136	168	205	229	273	307	337	395	413	461	474	509	496	500
41	1,981	110	120	151	184	201	248	285	306	358	391	410	444	463	448	473
42	1,928	89	100	131	161	186	222	241	281	323	352	376	415	437	426	445
43	1,863	68	82	106	143	156	201	226	270	300	331	346	384	413	400	423
44	1,740	51	66	89	115	145	174	198	229	277	299	319	348	373	362	393
45	1,817	35	49	70	97	123	160	185	226	258	294	316	344	372	362	385
46	1,669	25	40	51	80	97	134	162	199	234	259	284	311	339	326	356
47	1,665	21	28	40	59	80	109	140	175	213	241	261	300	319	314	340
48	1,457	13	17	27	40	54	77	107	128	167	195	211	244	271	261	280
49	1,470	11	13	19	28	41	64	86	118	151	174	205	230	252	260	280
50	1,416	9	11	14	20	28	44	59	87	120	138	165	197	218	226	249
51	1,350	10	9	12	15	22	30	46	68	98	123	144	179	213	213	236
52	1,130	6	8	9	12	15	18	27	42	62	78	99	128	153	158	178
53	1,137	7	7	7	7	10	13	17	26	40	53	79	106	125	140	168
54	996	4	5	7	7	8	8	13	16	22	34	49	78	90	105	132
55	914	0	5	6	6	7	9	10	13	18	24	36	50	68	77	101
56	919	0	0	4	5	6	6	6	9	13	17	24	34	49	65	82
57	809	0	0	0	4	4	6	6	9	9	11	15	23	33	44	58
58	788	0	0	0	0	4	5	6	8	8	10	11	17	23	30	45
59	776	0	0	0	0	0	5	5	5	6	7	8	12	14	22	32
60	707	0	0	0	0	0	0	3	4	5	5	8	8	10	12	18
61	642	0	0	0	0	0	0	0	5	5	5	6	8	7	11	12
62	609	0	0	0	0	0	0	0	0	4	5	5	6	6	7	11
63	657	0	0	0	0	0	0	0	0	0	5	4	5	5	7	6
64	524	0	0	0	0	0	0	0	0	0	0	3	4	4	5	5
65	501	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-own children		773	783	794	839	813	877	938	1,034	1,094	1,133	1,192	1,269	1,372	1,419	1,556

Person number	Sex	Marital status	Age	Mother's person number
1	M	M	55	—
2	F	M	53	—
3	M	M	30	—
4	F	M	28	—
5	F	D	21	—
6	M	N	12	2
7	F	N	5	4
8	M	N	2	4

The list of potential mothers is then

Person number	Marital status	Age
2	M	53
4	M	28
5	D	21

And the list of potential own-children is

Person number	Sex	Age	Mother's person number
6	M	12	2
7	F	5	4
8	M	2	4

The first woman on the list of potential mothers has person number 2. The matching algorithm matches children with mother's person number 2 to her. In our example one child is so matched. The second woman has person number 4, and all children with mother's person number 4 are matched to her. In this case two children are matched. No children are matched to the third woman because no children have mother's person number 5.

The procedure based on mother's person number (MPN matching) is simpler and usually results in more accurate matching than the procedure based on relation to household head (RHH matching). To modify our example, suppose that the woman with person number 4 in the above example has one child living away from home, and that the woman with person number 5 is the mother of the child with person number 8. Then the household list will look the same as before, except that the number of living children for person number 5 is changed to 1. For this household, RHH matching produces the same result as before, which is now incorrect. The difficulty is the ambiguity of the relationship of grandson, who can be either daughter's son or daughter-in-law's son. In contrast, MPN matching gives correct results in this modified example.

Most applications of the own-children method use RHH matching because mother's person number is not usually available. It is sometimes asked for in populations where complex households with many potential mothers are common, to improve the accuracy of matching and thereby to facilitate application of the own-children method.

Stage 2: basic tabulation

The second stage of the procedure tabulates data from the matched records from the first stage. The basic tabulation shows numbers of women by age, numbers of own children by child's age and mother's age, and numbers of non-own children by child's age. Table 7.1 is an example of the basic table, based on an application of the own-children method to the 1980 Census of Thailand. Results are shown only for the whole kingdom. A similar table is produced for each geographic subdivision and each category of each socioeconomic variable considered.

Stage 2 also has an option for calculating and printing numbers of children ever born per woman and children surviving per woman by age in five-year age groups. A tabulation of these child survivorship data is again produced for whatever geographic subdivisions and socioeconomic variables are specified. In the case of Thailand, the child survivorship data were tabulated independently by the National Statistical Office and are not shown.

Stage 3: computation of fertility estimates

As a preliminary to stage 3, the child survivorship data just described were used to obtain estimates of infant mortality trends by Feeney's method (Feeney 1980). Infant mortality rate (IMR) estimates for 1974–76 so derived were compared with corresponding estimates from Thailand's 1974–76 Survey of Population Change (SPC). It was found that the estimates derived by Feeney's method were lower than those from the SPC. The ratio of the SPC estimate of the IMR to the estimate of the IMR derived by Feeney's method for 1974–76 was used as an adjustment factor to adjust upward the estimates of the IMRs derived by Feeney's method, regardless of the year to which they pertained. The adjusted IMR for each calendar year was then matched to the appropriate level of the Coale–Demeny North model life table family. In this way a complete abridged life table was obtained for each calendar year during the fifteen-year estimation period preceding the 1980 Census. These abridged life tables were interpolated to single years of age by procedures described in Chapter 2 and Appendix A. The mortality estimates were part of the input to stage 3.

Further input to stage 3 included a set of correction factors for undercount and misenumeration (the factors U_x^c and U_a^w in equations [2.7] to [2.11] in Chapter 2), a set of age-specific proportions married in five-year age groups (for use in computing age-specific marital birth rates for the year before the census), and a standard age distribution in five-year age groups for ages 15–49 (for use in computing age-standardized general fertility rates). The age-specific proportions married were calculated from the census itself, and the standard age distribution was chosen in this case as a Coale–Demeny Model North stable population with a life expectancy at birth for males and females of 60 years (Coale and Demeny 1966). Of course the output from stage 2 was also part of the input for stage 3.

The first results printed by the stage-3 program summarize that part of the input for stage 3 that does not come directly from stage 2. Table 7.2 presents the input correction factors U_x^c and U_a^w, the derivation of which need not concern us here. Table 7.3 presents the proportions married and the standard age distribution. (The results in these two tables are not well labeled in the printed output and have been reformatted here for the reader's convenience.)

The next table printed out by stage 3 is the interpolated single-year life tables for each of the fifteen years immediately preceding the census, by sex. To conserve space, only the person-years (L_x) column of the life table is printed out, since that column is used to construct reverse-survival ratios. In addition, life expectancy at birth is printed out as a summary index of mortality. For brevity, since the computer-printed table is lengthy, Table 7.4 presents only the estimates of life expectancy at birth, by sex, for each of the fifteen years during the estimation period preceding the 1980 Census.

The first major output table from stage 3 is a period–cohort birth matrix and a period–cohort woman matrix, for use in computing period–cohort birth rates. Estimates of these quantities for Thailand are shown in Tables 7.5 and 7.6. Recall from Chapter 2, Figure 2.1, that period–cohort births and women (actually woman-years of exposure) for parallelograms in the Lexis plane are the quantities that flow most naturally from the process of reverse survival. The estimates of period–cohort births and women in Tables 7.5 and 7.6 refer to parallelograms of the type AB and CD in Figure 2.1. Note that Tables 7.5 and 7.6 are tabulated by survey age rather than age at the time the births actually occurred. This means that one can follow real cohorts (defined by survey age) backward in time by reading rightward across rows. A table of period–cohort age-specific birth rates could be produced by term-by-term division of Table 7.5 by Table 7.6. The program does not do this because the single-year rates are not usually of interest. One typically aggregates Tables 7.5 and 7.6 into age groups and time periods with a hand calculator, as desired, before dividing them term-by-term to obtain birth rates. The mode of aggregation is not standard and depends on the application.

Table 7.2. Age-specific correction factors, U_x^c and U_a^w, used in applying the own-children method to the 1980 Census: Thailand

Age	*Correction factor*	*Age*	*Correction factor*
Children		Women *(continued)*	
0	1.085	32	1.000
1	1.085	33	1.000
2	1.085	34	1.000
3	1.085	35	1.000
4	1.085	36	1.000
5	1.085	37	1.000
6	1.085	38	1.000
7	1.085	39	1.000
8	1.085	40	1.000
9	1.085	41	1.000
10	1.085	42	1.000
11	1.085	43	1.000
12	1.085	44	1.000
13	1.085	45	1.000
14	1.085	46	1.000
		47	1.000
Women		48	1.000
15	1.000	49	1.000
16	1.000	50	1.000
17	1.000	51	1.000
18	1.000	52	1.000
19	1.000	53	1.000
20	1.000	54	1.000
21	1.000	55	1.000
22	1.000	56	1.000
23	1.000	57	1.000
24	1.000	58	1.000
25	1.000	59	1.000
26	1.000	60	1.000
27	1.000	61	1.000
28	1.000	62	1.000
29	1.000	63	1.000
30	1.000	64	1.000
31	1.000	65	1.000

Note: For explanation of U_x^c and U_a^w see equations (2.7) to (2.11) in Chapter 2.

Table 7.3. Age-specific proportions married from the 1980 Census and standard age distribution for calculation of age-standardized fertility measures in stage 3 of the own-children fertility estimation procedure: Thailand

Age group	*Proportions currently married*	*Standard population*
15–19	.1559	437,800
20–24	.5295	431,463
25–29	.7432	423,798
30–34	.8201	415,125
35–39	.8438	405,299
40–44	.8325	394,022
45–49	.7989	380,623

Note: The standard age distribution is taken from a Coale-Demeny model West stationary population with a life expectancy for females of 60 years (Coale and Demeny 1966).

Table 7.4. Estimates of life expectancy, by sex, for each of the fifteen years preceding the 1980 Census: Thailand

Year	*Female*	*Male*
1979	65.05	61.37
1978	64.55	60.87
1977	64.05	60.36
1976	63.55	59.86
1975	63.04	59.36
1974	62.54	58.86
1973	62.04	58.36
1972	61.54	57.86
1971	61.04	57.36
1970	60.54	56.87
1969	60.04	56.37
1968	59.54	55.88
1967	59.03	55.38
1966	58.53	54.89
1965	58.03	54.40

Tables 7.7 and 7.8 are similar to Tables 7.5 and 7.6 except that they pertain to age–period, or central, births and women instead of period–cohort births and women. The central births and women pertain to squares in the Lexis plane, again as illustrated by Figure 2.1 in Chapter 2. They are calculated using the averaging procedure described in Chapter 2. In this case the tabulations are by woman's age in previous years rather than her age at the time of the census or survey. Table 7.9, which presents age-specific central birth rates by single years of age for single calendar years, is obtained by term-by-term division of Table 7.7 by Table 7.8.

Although birth rates for single calendar years often are of interest, it is rare that birth rates by single years of age are of interest. Therefore, another basic tabulation routinely printed out is central births and woman-years of exposure, with ages grouped into standard five-year age categories, as shown in Tables 7.10 and 7.11. These tables are obtained directly from Tables 7.7 and 7.8 by aggregation.

Tables 7.12 and 7.13, which provide estimates of central age-specific birth rates and summary measures for five-year age groups, are the main output tables of interest. The first part of Table 7.12 presents age-specific birth rates for single calendar years, obtained by term-by-term division of Table 7.10 by Table 7.11. Also presented are two estimates of the total fertility rate, one pertaining to ages 15–44 and the other to ages 15–49. (Note that TFRs in Table 7.12 are not identical to those in Table 7.9, although the basic data are exactly the same. Discrepancies are introduced because age distributions are not rectangular within five-year age groups.) Four estimates of the general fertility rate (GFR) are given, corresponding to the two age ranges 15–44 and 15–49 and to whether the actual age distribution or the standard age distribution is used. The general fertility rate is calculated as

$$\mathrm{GFR} = (\Sigma_a P^f_a F_a)/(\Sigma_a P^f_a), \qquad (7.1)$$

where P^f_a denotes the number of women aged a to $a + 5$, F_a denotes the central age-specific birth rate for ages a to $a + 5$, and the summations range over either 15–44 or 15–49. If the GFR is standardized, standard instead of observed values of P^f_a are used.

Table 7.13 presents results for aggregated time periods, derived from Tables 7.10 and 7.11. As explained in Chapter 2, numerators and denominators of rates are first aggregated into age groups and time periods by the program before they are divided to get rates. In Table 7.13 the program allows as many as ten time groupings, which are specified by the user.

Women's age	No. of women	Number of years preceding the census and actual year														
		<1 1979	1 1978	2 1977	3 1976	4 1975	5 1974	6 1973	7 1972	8 1971	9 1970	10 1969	11 1968	12 1967	13 1966	14 1965
15	6,071	41	18	8	0	0	0	0	0	0	0	0	0	0	0	0
16	5,716	113	48	19	11	0	0	0	0	0	0	0	0	0	0	0
17	5,665	258	119	51	21	10	0	0	0	0	0	0	0	0	0	0
18	5,401	410	231	109	54	21	13	0	0	0	0	0	0	0	0	0
19	5,103	567	372	224	120	51	24	15	0	0	0	0	0	0	0	0
20	5,264	778	570	411	278	132	65	37	26	0	0	0	0	0	0	0
21	5,016	775	628	510	385	213	113	51	27	18	0	0	0	0	0	0
22	5,217	888	763	677	587	388	246	126	61	30	21	0	0	0	0	0
23	4,768	921	837	796	745	570	435	253	146	72	40	31	0	0	0	0
24	4,231	870	799	794	799	673	574	409	278	151	76	47	35	0	0	0
25	3,971	804	804	803	843	759	705	547	417	267	144	87	55	42	0	0
26	3,641	724	714	773	794	761	747	636	527	370	231	128	74	47	35	0
27	3,628	704	689	750	837	803	822	754	674	548	381	252	143	73	44	32
28	3,253	588	596	653	733	737	778	745	713	609	484	350	209	127	64	36
29	3,308	570	594	645	740	754	845	818	836	770	656	528	385	245	138	70
30	3,184	504	518	584	690	714	778	825	812	813	748	655	527	401	250	149
31	2,655	405	418	476	552	599	669	705	751	750	723	660	592	458	321	189
32	2,639	371	393	449	532	566	653	694	743	788	766	747	692	602	461	308
33	2,345	305	321	362	458	474	562	603	652	710	735	712	705	633	539	405
34	2,197	266	282	337	403	430	509	553	600	671	700	709	695	681	578	489
35	2,292	252	274	325	392	431	503	559	616	675	729	738	756	743	672	613
36	1,970	204	216	258	321	345	417	460	508	569	614	632	675	679	611	585
37	2,210	216	229	281	327	372	436	505	554	626	679	702	750	759	756	705
38	2,026	185	200	237	292	314	394	432	481	552	602	627	676	711	678	701
39	2,393	195	225	262	331	363	426	504	556	631	714	731	806	854	821	846
40	2,186	149	170	213	262	295	355	405	451	535	564	639	666	728	725	749
41	1,982	134	150	192	236	260	323	376	410	485	535	568	624	662	656	709
42	1,928	109	125	166	205	240	290	318	376	437	481	522	583	624	623	666
43	1,863	82	103	134	183	201	262	298	362	405	453	479	540	591	585	634
44	1,740	62	83	113	147	187	226	262	306	375	409	442	489	534	529	589
45	1,817	43	61	89	124	159	208	245	303	349	403	438	484	533	529	577
46	1,669	30	50	65	102	125	175	213	267	316	354	394	436	485	477	533
47	1,665	26	35	50	75	104	142	184	234	288	329	362	422	456	459	509
48	1,457	16	22	34	51	70	100	141	171	225	266	293	343	388	382	420
49	1,470	13	16	24	36	52	83	113	157	205	238	284	324	360	380	419
50	1,416	11	14	18	25	36	57	78	117	162	188	229	277	312	331	374
51	1,351	13	12	15	19	28	39	60	91	133	168	200	251	305	311	354
52	1,130	8	10	11	15	19	24	36	56	83	107	138	180	218	231	267
53	1,137	8	8	8	9	12	17	22	35	54	72	110	149	179	205	251
54	996	5	7	9	9	10	11	17	22	30	47	68	110	129	154	198
55	914	0	6	7	7	9	11	13	18	24	33	50	71	97	113	152
56	919	0	0	5	6	7	8	8	12	17	23	33	48	69	95	123
57	809	0	0	0	5	5	8	8	12	13	15	21	33	47	64	87
58	788	0	0	0	0	5	7	8	11	11	14	15	24	33	44	68
59	776	0	0	0	0	0	6	6	7	8	10	11	16	20	32	48
60	707	0	0	0	0	0	0	4	5	7	7	11	11	14	17	27
61	642	0	0	0	0	0	0	0	6	6	7	8	11	10	16	17
62	609	0	0	0	0	0	0	0	0	5	6	7	8	9	10	17
63	657	0	0	0	0	0	0	0	0	0	7	6	7	8	11	9
64	524	0	0	0	0	0	0	0	0	0	0	4	5	5	7	8
Total	125,312	12,621	11,730	11,947	12,764	12,306	13,066	13,046	13,406	13,792	13,778	13,667	13,887	13,871	12,954	12,935
Non-own factor		1.0746	1.0836	1.0843	1.0840	1.0853	1.0874	1.0949	1.1033	1.1073	1.1125	1.1209	1.1283	1.1414	1.1603	1.1803

Women's age	Number of years preceding the census and actual year															
	<1 1979	1 1978	2 1977	3 1976	4 1975	5 1974	6 1973	7 1972	8 1971	9 1970	10 1969	11 1968	12 1967	13 1966	14 1965	15 1964
15	6,071	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	5,716	5,726	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	5,665	5,675	5,686	0	0	0	0	0	0	0	0	0	0	0	0	0
18	5,401	5,411	5,422	5,432	0	0	0	0	0	0	0	0	0	0	0	0
19	5,103	5,113	5,123	5,134	5,144	0	0	0	0	0	0	0	0	0	0	0
20	5,264	5,276	5,287	5,298	5,309	5,320	0	0	0	0	0	0	0	0	0	0
21	5,016	5,028	5,039	5,050	5,061	5,072	5,083	0	0	0	0	0	0	0	0	0
22	5,217	5,229	5,242	5,254	5,266	5,278	5,290	5,301	0	0	0	0	0	0	0	0
23	4,768	4,780	4,792	4,804	4,816	4,827	4,838	4,849	4,861	0	0	0	0	0	0	0
24	4,231	4,242	4,253	4,264	4,275	4,286	4,296	4,307	4,317	4,327	0	0	0	0	0	0
25	3,971	3,981	3,992	4,003	4,013	4,024	4,034	4,045	4,055	4,065	4,075	0	0	0	0	0
26	3,641	3,651	3,661	3,671	3,681	3,691	3,701	3,711	3,721	3,730	3,740	3,749	0	0	0	0
27	3,628	3,638	3,648	3,659	3,669	3,680	3,690	3,700	3,711	3,720	3,730	3,740	3,750	0	0	0
28	3,253	3,263	3,272	3,282	3,291	3,301	3,311	3,320	3,330	3,339	3,349	3,358	3,367	3,376	0	0
29	3,308	3,318	3,328	3,338	3,348	3,358	3,369	3,379	3,389	3,399	3,409	3,419	3,428	3,438	3,448	0
30	3,184	3,194	3,204	3,214	3,224	3,234	3,244	3,254	3,264	3,274	3,284	3,294	3,304	3,313	3,323	3,332
31	2,655	2,663	2,671	2,680	2,688	2,697	2,706	2,714	2,723	2,732	2,741	2,749	2,758	2,766	2,774	2,783
32	2,639	2,647	2,656	2,665	2,673	2,682	2,691	2,700	2,709	2,718	2,727	2,736	2,745	2,753	2,762	2,770
33	2,345	2,353	2,361	2,369	2,377	2,385	2,393	2,401	2,409	2,417	2,426	2,434	2,442	2,450	2,458	2,466
34	2,197	2,204	2,212	2,219	2,227	2,235	2,242	2,250	2,258	2,266	2,274	2,282	2,290	2,298	2,306	2,313
35	2,292	2,300	2,308	2,316	2,324	2,332	2,341	2,349	2,357	2,366	2,375	2,383	2,392	2,400	2,409	2,417
36	1,970	1,977	1,984	1,991	1,998	2,006	2,013	2,020	2,028	2,036	2,043	2,051	2,058	2,066	2,074	2,081
37	2,210	2,218	2,226	2,234	2,243	2,251	2,259	2,268	2,276	2,285	2,294	2,303	2,311	2,320	2,329	2,338
38	2,026	2,034	2,042	2,049	2,057	2,065	2,073	2,081	2,089	2,097	2,106	2,114	2,122	2,131	2,139	2,147
39	2,393	2,402	2,412	2,421	2,431	2,440	2,450	2,460	2,469	2,479	2,489	2,499	2,509	2,520	2,530	2,540
40	2,186	2,196	2,205	2,214	2,223	2,231	2,241	2,250	2,259	2,268	2,278	2,287	2,296	2,306	2,316	2,325
41	1,981	1,990	1,999	2,007	2,016	2,024	2,033	2,041	2,050	2,058	2,067	2,076	2,085	2,094	2,103	2,112
42	1,928	1,937	1,946	1,955	1,963	1,972	1,980	1,989	1,997	2,006	2,015	2,023	2,032	2,041	2,050	2,059
43	1,863	1,872	1,881	1,890	1,899	1,907	1,916	1,924	1,933	1,941	1,950	1,959	1,968	1,976	1,985	1,994
44	1,740	1,749	1,757	1,766	1,774	1,783	1,791	1,799	1,808	1,816	1,824	1,833	1,841	1,850	1,858	1,867
45	1,817	1,826	1,836	1,845	1,854	1,864	1,873	1,882	1,891	1,900	1,908	1,917	1,927	1,936	1,945	1,954
46	1,669	1,677	1,686	1,695	1,704	1,713	1,722	1,730	1,739	1,747	1,756	1,764	1,773	1,782	1,790	1,799
47	1,665	1,674	1,683	1,692	1,701	1,710	1,719	1,729	1,738	1,746	1,755	1,764	1,773	1,782	1,791	1,799
48	1,457	1,465	1,474	1,482	1,490	1,498	1,507	1,515	1,523	1,531	1,539	1,547	1,555	1,563	1,571	1,579
49	1,470	1,479	1,487	1,496	1,504	1,513	1,522	1,530	1,539	1,547	1,556	1,564	1,573	1,581	1,589	1,598
50	1,416	1,426	1,435	1,443	1,452	1,460	1,469	1,477	1,486	1,495	1,503	1,512	1,520	1,528	1,537	1,545
51	1,350	1,360	1,369	1,378	1,387	1,395	1,404	1,412	1,420	1,429	1,437	1,446	1,454	1,462	1,471	1,479
52	1,130	1,139	1,147	1,155	1,163	1,170	1,177	1,185	1,192	1,199	1,207	1,214	1,221	1,228	1,236	1,243
53	1,137	1,147	1,156	1,164	1,173	1,181	1,188	1,196	1,203	1,211	1,219	1,226	1,234	1,241	1,249	1,256
54	996	1,005	1,013	1,021	1,029	1,037	1,044	1,051	1,057	1,064	1,071	1,078	1,085	1,092	1,099	1,106
55	914	923	931	939	946	954	961	968	974	981	987	994	1,000	1,007	1,013	1,020
56	919	927	936	944	953	961	968	976	983	990	996	1,003	1,010	1,016	1,023	1,030
57	809	817	825	833	841	848	856	863	869	876	882	888	894	900	906	913
58	788	797	805	813	821	829	836	844	851	857	864	870	876	882	889	895
59	776	786	795	803	811	819	827	835	842	849	856	863	869	875	882	888
60	707	716	725	734	742	749	757	764	772	779	785	792	798	804	810	816
61	642	652	660	669	677	684	691	698	705	712	719	725	731	737	743	748
62	609	619	628	636	645	652	660	667	674	681	687	694	700	706	712	717
63	657	668	679	689	699	708	717	725	733	741	749	756	763	770	777	783
64	524	534	543	552	561	569	577	584	591	597	604	610	616	622	628	634
Total	125,312	119,702	114,420	109,161	104,142	99,395	94,457	89,742	84,794	80,273	76,274	72,515	69,071	65,614	62,522	59,347

Table 7.7. Age–period (central) births, by women's age, estimated by applying the own-children method to the 1980 Census: Thailand

Women's age	*Number of years preceding the census and actual year*													
	<1 1979	1 1978	2 1977	3 1976	4 1975	5 1974	6 1973	7 1972	8 1971	9 1970	10 1969	11 1968	12 1967	13 1966	14 1965
15	77	83	80	87	91	89	88	104	111	110	107	109	100	101	110
16	185	175	166	199	173	179	189	212	209	187	190	176	186	194	169
17	334	301	317	332	301	340	331	347	318	306	301	297	323	285	248
18	488	471	460	486	479	505	478	472	459	432	439	456	429	391	357
19	672	599	593	666	621	640	592	601	579	570	592	559	530	500	447
20	776	695	736	772	716	726	695	693	690	702	657	642	617	559	551
21	831	800	795	821	760	784	749	774	791	735	703	699	657	625	599
22	904	818	799	819	782	800	781	824	781	745	729	700	712	641	645
23	895	802	788	816	770	811	821	781	769	751	711	726	711	683	703
24	837	759	761	785	746	811	765	747	749	718	723	715	719	717	774
25	764	701	702	737	734	724	699	697	690	714	685	712	735	749	798
26	714	643	649	715	657	661	649	626	673	671	667	713	782	773	729
27	646	595	615	621	583	608	578	608	622	646	664	741	791	691	688
28	579	556	530	542	520	535	556	562	597	640	679	736	695	639	650
29	537	468	463	495	452	506	509	531	589	658	685	645	643	604	611
30	455	406	406	431	431	460	483	518	592	639	604	603	607	557	583
31	388	357	350	398	388	426	469	519	583	550	545	561	562	529	555
32	338	301	331	356	359	415	468	504	510	508	501	514	533	503	521
33	285	278	292	324	343	410	454	430	461	467	461	486	509	468	464
34	259	245	270	309	338	391	390	393	421	431	440	460	471	420	419
35	228	223	259	311	329	339	347	369	390	406	416	429	422	381	396
36	210	215	250	297	278	306	308	334	362	378	378	382	374	356	364
37	200	213	238	249	250	276	280	305	333	341	327	333	336	321	311
38	190	197	202	221	220	244	253	285	302	298	288	301	308	271	259
39	172	160	179	194	194	217	229	250	257	252	256	264	262	218	224
40	142	138	150	165	173	191	199	202	215	213	214	215	198	179	175
41	121	114	123	136	142	158	163	164	183	178	169	164	154	134	138
42	96	93	101	113	114	121	127	137	147	138	124	130	113	104	105
43	72	72	77	89	87	92	95	104	108	90	89	90	83	80	77
44	53	55	57	63	61	70	69	74	69	59	59	59	58	54	58
45	37	42	42	44	44	48	48	46	42	40	42	40	40	38	38
46	28	28	29	31	32	32	29	29	27	28	27	28	26	24	22
47	21	19	21	22	24	20	20	20	20	19	18	20	17	16	17
48	14	15	16	17	16	14	15	15	15	14	13	14	12	13	13
49	12	13	13	12	11	11	11	12	12	12	11	11	9	11	9
50	12	11	10	9	10	10	8	11	10	9	10	9	8	9	9
51	10	9	9	8	8	8	8	9	7	7	8	8	7	7	7
52	8	7	8	7	6	7	7	6	6	7	7	6	6	6	6
53	7	6	6	6	5	6	5	5	6	7	5	5	5	5	5
54	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7.8. Central woman-years of exposure, by women's age, estimated by applying the own-children method to the 1980 Census: Thailand

Women's age	Number of years preceding the census and actual year													
	<1	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1968	1967	1966	1965
15	5,899	5,706	5,559	5,288	5,232	5,201	5,192	5,081	4,594	4,201	3,912	3,750	3,563	3,412	3,390
16	5,696	5,548	5,278	5,221	5,191	5,181	5,070	4,583	4,191	3,902	3,740	3,554	3,403	3,380	3,053
17	5,538	5,267	5,211	5,180	5,170	5,058	4,572	4,181	3,893	3,730	3,544	3,393	3,371	3,044	2,772
18	5,257	5,200	5,168	5,158	5,047	4,562	4,170	3,883	3,721	3,535	3,384	3,361	3,035	2,764	2,614
19	5,189	5,157	5,147	5,035	4,551	4,160	3,873	3,711	3,525	3,374	3,352	3,026	2,756	2,606	2,386
20	5,146	5,135	5,023	4,540	4,150	3,863	3,701	3,515	3,365	3,342	3,017	2,747	2,597	2,378	2,362
21	5,123	5,011	4,528	4,139	3,852	3,691	3,505	3,355	3,332	3,007	2,738	2,589	2,370	2,353	2,245
22	4,998	4,517	4,128	3,842	3,680	3,495	3,345	3,321	2,998	2,729	2,580	2,362	2,345	2,237	2,206
23	4,505	4,117	3,831	3,670	3,485	3,335	3,311	2,988	2,720	2,572	2,354	2,337	2,229	2,198	2,238
24	4,106	3,821	3,660	3,475	3,325	3,301	2,979	2,712	2,563	2,346	2,329	2,221	2,189	2,230	2,339
25	3,811	3,649	3,465	3,315	3,291	2,970	2,703	2,554	2,338	2,320	2,213	2,181	2,221	2,330	2,427
26	3,639	3,455	3,305	3,281	2,960	2,694	2,546	2,329	2,312	2,205	2,173	2,212	2,321	2,418	2,214
27	3,445	3,295	3,271	2,951	2,685	2,537	2,321	2,304	2,196	2,165	2,204	2,312	2,408	2,204	2,081
28	3,286	3,261	2,942	2,676	2,529	2,313	2,296	2,188	2,157	2,195	2,302	2,398	2,195	2,072	2,022
29	3,251	2,933	2,668	2,521	2,306	2,288	2,181	2,148	2,187	2,293	2,388	2,186	2,063	2,013	1,926
30	2,924	2,659	2,512	2,298	2,280	2,173	2,140	2,179	2,284	2,378	2,177	2,054	2,004	1,917	1,906
31	2,651	2,504	2,290	2,272	2,165	2,133	2,170	2,275	2,369	2,168	2,045	1,996	1,909	1,897	1,872
32	2,496	2,282	2,264	2,157	2,125	2,162	2,266	2,359	2,159	2,037	1,987	1,900	1,888	1,863	1,795
33	2,275	2,256	2,150	2,117	2,154	2,258	2,350	2,150	2,028	1,978	1,891	1,880	1,854	1,786	1,685
34	2,248	2,142	2,109	2,146	2,249	2,340	2,141	2,019	1,969	1,883	1,871	1,845	1,777	1,676	1,584
35	2,135	2,102	2,138	2,240	2,331	2,132	2,011	1,961	1,874	1,862	1,836	1,769	1,668	1,576	1,567
36	2,094	2,130	2,232	2,322	2,123	2,002	1,952	1,866	1,854	1,828	1,760	1,660	1,568	1,559	1,508
37	2,122	2,223	2,313	2,115	1,994	1,944	1,858	1,845	1,819	1,751	1,651	1,560	1,550	1,499	1,357
38	2,214	2,303	2,106	1,985	1,935	1,849	1,836	1,810	1,743	1,643	1,552	1,542	1,491	1,349	1,246
39	2,294	2,097	1,977	1,927	1,841	1,828	1,802	1,734	1,634	1,544	1,534	1,483	1,341	1,239	1,177
40	2,088	1,968	1,918	1,832	1,819	1,793	1,725	1,626	1,535	1,525	1,475	1,334	1,231	1,170	1,059
41	1,959	1,909	1,823	1,810	1,784	1,716	1,617	1,527	1,517	1,466	1,326	1,224	1,163	1,053	1,022
42	1,900	1,815	1,801	1,774	1,707	1,608	1,518	1,508	1,458	1,318	1,216	1,156	1,046	1,015	968
43	1,806	1,792	1,765	1,698	1,600	1,510	1,500	1,449	1,310	1,209	1,148	1,039	1,008	961	901
44	1,783	1,756	1,689	1,591	1,501	1,491	1,440	1,302	1,201	1,141	1,032	1,002	955	894	888
45	1,747	1,680	1,582	1,493	1,482	1,432	1,294	1,194	1,134	1,026	995	948	888	882	849
46	1,671	1,574	1,485	1,474	1,424	1,286	1,187	1,127	1,019	989	942	882	876	843	779
47	1,565	1,476	1,465	1,415	1,279	1,179	1,120	1,013	982	936	876	870	837	773	730
48	1,468	1,457	1,407	1,271	1,172	1,112	1,006	975	929	870	863	830	767	724	748
49	1,448	1,398	1,262	1,164	1,105	999	968	922	863	857	824	761	719	741	705
50	1,388	1,254	1,156	1,097	992	961	915	857	850	817	755	713	735	699	0
51	1,245	1,147	1,089	984	954	908	850	843	810	749	706	729	693	0	0
52	1,138	1,080	976	946	901	842	836	803	742	700	722	686	0	0	0
53	1,071	968	938	893	835	828	796	735	693	715	679	0	0	0	0
54	959	929	885	827	820	788	728	686	707	672	0	0	0	0	0
55	921	876	819	812	780	720	679	700	665	0	0	0	0	0	0
56	868	811	804	772	713	672	692	658	0	0	0	0	0	0	0
57	803	796	764	705	664	685	650	0	0	0	0	0	0	0	0
58	787	755	697	657	676	642	0	0	0	0	0	0	0	0	0
59	746	688	648	668	634	0	0	0	0	0	0	0	0	0	0
60	679	640	659	625	0	0	0	0	0	0	0	0	0	0	0
61	630	649	616	0	0	0	0	0	0	0	0	0	0	0	0
62	639	606	0	0	0	0	0	0	0	0	0	0	0	0	0
63	595	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7.10. Central births, by women's age in five-year age groups, estimated by applying the own-children method to the 1980 Census: Thailand

Women's age	*Number of years preceding the census and actual year*														
	<1 *1979*	*1* *1978*	*2* *1977*	*3* *1976*	*4* *1975*	*5* *1974*	*6* *1973*	*7* *1972*	*8* *1971*	*9* *1970*	*10* *1969*	*11* *1968*	*12* *1967*	*13* *1966*	*14* *1965*
15–19	1,757	1,629	1,617	1,770	1,666	1,753	1,678	1,736	1,677	1,605	1,629	1,597	1,568	1,472	1,331
20–24	4,244	3,874	3,879	4,012	3,772	3,933	3,811	3,820	3,781	3,651	3,524	3,482	3,417	3,225	3,271
25–29	3,241	2,963	2,958	3,110	2,946	3,034	2,992	3,024	3,171	3,330	3,379	3,548	3,646	3,456	3,477
30–34	1,724	1,587	1,648	1,818	1,859	2,102	2,265	2,363	2,566	2,594	2,550	2,625	2,683	2,478	2,543
35–39	1,000	1,008	1,127	1,272	1,271	1,382	1,417	1,543	1,643	1,675	1,666	1,710	1,702	1,547	1,554
40–44	484	471	508	566	577	633	653	681	722	678	656	659	607	551	553
45–49	111	118	121	125	127	125	122	122	116	113	111	113	105	102	98

Table 7.11. Central woman-years of exposure, by women's age in five-year age groups, estimated by applying the own-children method to the 1980 Census: Thailand

Women's age	*Number of years preceding the census and actual year*														
	<1 *1979*	*1* *1978*	*2* *1977*	*3* *1976*	*4* *1975*	*5* *1974*	*6* *1973*	*7* *1972*	*8* *1971*	*9* *1970*	*10* *1969*	*11* *1968*	*12* *1967*	*13* *1966*	*14* *1965*
15–19	27,578	26,879	26,362	25,882	25,189	24,162	22,877	21,438	19,923	18,742	17,932	17,084	16,127	15,206	14,215
20–24	23,878	22,600	21,170	19,665	18,492	17,684	16,841	15,891	14,978	13,996	13,018	12,255	11,731	11,395	11,390
25–29	17,432	16,593	15,650	14,744	13,771	12,802	12,046	11,525	11,190	11,178	11,280	11,289	11,208	11,037	10,670
30–34	12,594	11,844	11,325	10,989	10,972	11,065	11,068	10,982	10,809	10,444	9,971	9,674	9,433	9,140	8,842
35–39	10,859	10,855	10,765	10,589	10,224	9,755	9,459	9,216	8,924	8,627	8,333	8,013	7,619	7,222	6,855
40–44	9,536	9,240	8,997	8,706	8,411	8,118	7,801	7,412	7,021	6,659	6,197	5,754	5,403	5,094	4,838
45–49	7,899	7,584	7,201	6,817	6,461	6,009	5,574	5,231	4,927	4,677	4,500	4,292	4,087	3,964	3,811

Table 7.9. Central age-specific birth rates, by women's age, estimated by applying the own-children method to the 1980 Census: Thailand

Women's age	Number of years preceding the census and actual year													
	<1 1979	1 1978	2 1977	3 1976	4 1975	5 1974	6 1973	7 1972	8 1971	9 1970	10 1969	11 1968	12 1967	13 1966	14 1965
15	13.1	14.6	14.4	16.5	17.5	17.2	17.0	20.4	24.2	26.1	27.4	28.9	28.1	29.6	32.3
16	32.6	31.5	31.5	38.1	33.3	34.6	37.3	46.3	49.9	48.0	50.8	49.5	54.7	57.4	55.4
17	60.3	57.2	60.9	64.0	58.2	67.3	72.3	83.1	81.8	82.0	84.9	87.6	95.8	93.8	89.6
18	92.9	90.5	89.0	94.3	95.0	110.6	114.6	121.7	123.4	122.3	129.8	135.7	141.4	141.6	136.5
19	129.5	116.1	115.2	132.3	136.6	153.8	152.8	161.9	164.2	168.9	176.5	184.9	192.2	191.9	187.5
20	150.8	135.4	146.6	170.1	172.5	187.9	187.7	197.2	205.0	210.2	217.9	233.7	237.7	234.9	233.2
21	162.2	159.6	175.6	198.3	197.2	212.5	213.8	230.8	237.6	244.6	256.8	269.8	277.2	265.6	266.8
22	180.9	181.1	193.5	213.1	212.4	228.9	233.6	248.1	260.6	272.8	282.7	296.3	303.6	286.7	292.5
23	198.7	194.7	205.6	222.2	220.9	243.3	248.0	261.5	282.7	292.0	302.0	310.5	319.1	311.0	314.1
24	203.8	198.6	208.0	225.8	224.2	245.8	256.8	275.3	292.3	305.9	310.7	322.2	328.6	321.4	330.7
25	200.6	192.2	202.5	222.2	223.1	243.7	258.8	273.0	295.4	307.9	309.5	326.6	331.0	321.6	328.7
26	196.2	186.0	196.4	218.0	221.9	245.5	254.9	268.7	290.9	304.5	306.9	322.4	337.1	319.8	329.5
27	187.5	180.6	187.9	210.5	217.1	239.5	249.0	263.9	283.0	298.6	301.4	320.7	328.5	313.4	330.5
28	176.2	170.5	180.2	202.5	205.7	231.4	242.1	256.8	277.0	291.7	294.8	307.0	316.6	308.6	321.5
29	165.3	159.6	173.5	196.4	196.1	221.2	233.7	247.2	269.5	286.8	286.8	295.0	311.7	299.9	317.5
30	155.5	152.6	161.5	187.5	188.9	211.7	225.5	237.6	259.0	268.7	277.3	293.7	303.0	290.4	305.8
31	146.3	142.6	152.7	175.0	179.3	199.9	216.1	227.9	246.0	253.6	266.4	281.3	294.6	278.9	296.5
32	135.4	132.1	146.4	165.1	168.9	191.9	206.6	213.5	236.0	249.5	251.9	270.7	282.4	270.1	290.4
33	125.4	123.2	135.7	153.1	159.3	181.6	193.4	200.2	227.2	235.9	243.6	258.7	274.5	262.0	275.6
34	115.0	114.3	127.8	144.2	150.4	166.9	182.4	194.5	213.9	228.9	235.2	249.3	264.9	250.8	264.6
35	106.6	106.0	121.3	139.0	141.2	159.1	172.6	188.0	208.1	218.0	226.5	242.6	253.0	241.9	252.9
36	100.1	100.9	111.9	127.8	130.7	153.0	157.7	179.0	195.2	206.9	214.7	230.4	238.4	228.3	241.4
37	94.4	95.6	102.7	117.8	125.2	141.9	150.6	165.1	182.9	195.0	198.3	213.8	216.6	214.2	228.9
38	85.9	85.7	96.0	111.1	113.9	131.9	137.9	157.4	173.4	181.1	185.7	194.9	206.8	200.8	207.9
39	75.1	76.4	90.4	100.9	105.4	118.6	127.1	144.3	157.0	163.4	167.2	178.2	195.1	175.8	190.7
40	67.8	69.9	78.1	90.2	95.0	106.7	115.2	124.4	140.0	139.8	145.4	161.6	161.2	153.3	165.0
41	62.0	59.7	67.7	74.9	79.6	92.4	100.7	107.5	120.7	121.4	127.3	134.4	132.3	126.9	134.8
42	50.3	51.1	56.0	63.6	66.9	75.3	83.7	91.0	101.0	104.4	102.0	112.2	108.1	102.8	108.8
43	40.1	40.1	43.4	52.2	54.3	60.7	63.6	71.9	82.6	74.3	77.6	87.0	82.6	82.8	86.0
44	29.5	31.5	34.0	39.7	40.8	47.0	48.0	56.5	57.2	52.1	57.3	59.2	60.9	60.4	65.2
45	21.0	25.2	26.5	29.2	29.7	33.7	37.3	38.2	37.1	38.8	41.9	42.4	44.8	42.9	44.2
46	16.7	18.1	19.4	20.8	22.5	24.6	24.5	25.4	26.4	28.3	28.7	32.0	30.1	28.9	28.4
47	13.2	12.9	14.3	15.6	18.4	17.2	17.4	19.8	20.8	20.0	20.5	22.9	20.3	21.3	23.6
48	9.8	10.6	11.6	13.3	13.3	12.3	14.9	15.5	16.0	16.3	15.1	16.5	15.6	18.2	17.5
49	8.2	9.3	10.1	10.3	10.2	10.9	11.0	13.2	13.6	14.1	13.6	14.3	13.2	14.2	12.1
50	8.4	8.5	8.3	8.3	9.7	10.1	8.9	13.3	11.4	10.5	12.7	13.3	11.5	12.7	0.0
51	8.2	7.8	7.8	8.3	8.5	8.8	9.2	10.5	9.3	9.5	10.7	10.5	9.6	0.0	0.0
52	6.9	6.9	8.2	7.0	6.7	8.5	8.4	7.4	8.6	9.7	9.1	9.2	0.0	0.0	0.0
53	6.2	6.5	6.8	6.4	6.0	7.8	6.5	7.4	8.1	9.2	7.3	0.0	0.0	0.0	0.0
54	2.7	3.2	3.1	3.3	3.1	3.9	2.6	4.4	3.6	5.2	0.0	0.0	0.0	0.0	0.0
55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TFR	3,641.5	3,559.2	3,822.5	4,289.0	4,359.6	4,859.5	5,094.3	5,469.9	5,892.6	6,116.9	6,274.8	6,619.9	6,822.6	6,574.7	6,806.4

Table 7.12. Age-specific central birth rates in five-year age groups, total fertility rates, and general fertility rates, estimated by applying the own-children method to the 1980 Census: Thailand

Rate and Women's age	Number of years preceding the census and actual year													
	<1 1979	1 1978	2 1977	3 1976	4 1975	5 1974	6 1973	7 1972	8 1971	9 1970	10 1969	11 1968	12 1967	13 1966	14 1965
ASBR															
15–19	63.7	60.6	61.3	68.4	66.1	72.6	73.4	81.0	84.2	85.7	90.8	93.5	97.2	96.8	93.7
20–24	177.7	171.4	183.2	204.0	204.0	222.4	226.3	240.4	252.4	260.9	270.7	284.1	291.3	283.0	287.2
25–29	185.9	178.6	189.0	211.0	214.0	237.0	248.3	262.4	283.4	297.9	299.6	314.3	325.3	313.2	325.8
30–34	136.9	134.0	145.5	165.4	169.4	189.9	204.6	215.2	237.4	248.4	255.7	271.4	284.4	271.1	287.6
35–39	92.1	92.9	104.7	120.1	124.3	141.6	149.8	167.4	184.1	194.2	199.9	213.4	223.3	214.2	226.7
40–44	50.7	51.0	56.5	65.0	68.6	77.9	83.8	91.9	102.9	101.8	105.8	114.6	112.3	108.2	114.3
45–49	14.1	15.6	16.8	18.4	19.6	20.8	22.0	23.2	23.5	24.1	24.7	26.3	25.6	25.8	25.8
TFR															
15–49	3,606.1	3,520.4	3,785.5	4,261.4	4,330.0	4,811.3	5,040.9	5,407.4	5,839.9	6,065.0	6,236.1	6,587.5	6,797.5	6,561.1	6,805.9
15–44	3,535.6	3,442.4	3,701.7	4,169.6	4,232.1	4,707.5	4,931.1	5,291.2	5,722.2	5,944.5	6,112.8	6,455.9	6,669.5	6,432.0	6,676.8
GFR															
15–49	114.4	110.3	116.9	130.1	130.6	144.7	151.0	162.7	175.9	183.6	189.7	200.9	209.2	203.5	211.6
15–44	122.2	117.7	124.5	138.5	138.9	153.6	160.0	172.2	186.2	194.3	200.9	212.6	221.4	215.4	224.1
STD															
15–49	104.9	102.3	109.9	123.7	125.6	139.6	146.1	156.7	169.2	175.7	180.7	190.8	196.9	190.1	197.1
15–44	118.7	115.5	124.1	139.7	141.7	157.6	165.0	177.0	191.3	198.7	204.3	215.7	222.9	215.0	223.1

Note: STD denotes age-standardized GFR.

Table 7.13. Age-specific central birth rates and total fertility rates for aggregated time periods, estimated by applying the own-children method to the 1980 Census: Thailand

Women's age	Summary rates						
	1965–69	1970–74	1975–79	1967–69	1970–73	1974–76	1977–79
15–19	94.3	78.9	64.0	93.7	80.7	69.0	61.9
20–24	283.0	239.3	187.0	281.7	244.1	209.8	177.3
25–29	315.5	264.8	194.6	313.1	272.5	220.0	184.4
30–34	273.7	218.7	149.6	270.2	226.0	175.0	138.7
35–39	215.0	166.6	106.6	211.9	173.3	128.4	96.5
40–44	110.9	91.0	58.1	110.7	94.7	70.3	52.7
45–49	25.6	22.6	16.7	25.5	23.2	19.5	15.4
TFR (15–49)	6,589.8	5,409.0	3,882.8	6,533.9	5,572.4	4,460.4	3,635.3