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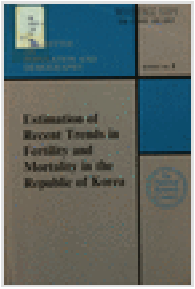

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COMMITTEE ON
POPULATION AND DEMOGRAPHY Report No. 1

Estimation of Recent Trends in Fertility and Mortality in the Republic of Korea

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Committee on Population and Demography
Assembly of Behavioral and Social Sciences
National Research Council

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Preface

The Committee on Population and Demography was established in April 1977 by the National Research Council, in response to a request by the Agency for International Development (AID) of the U.S. Department of State. It was widely felt by those concerned that the time was ripe for a detailed review of levels and recent trends of fertility and mortality in the developing world. Although most people in the demographic community agree that mortality has declined in almost all developing countries during the last 30 years, there is uncertainty about more recent changes in mortality in some countries, about current levels of fertility, and about the existence and extent of recent changes in fertility.

In 1963, a Panel on Population Problems of the Committee on Science and Public Policy of the National Academy of Sciences published a report entitled *The Growth of World Population*. The appointment of that panel and the publication of its report were expressions of the concern then felt by scientists, as well as by other informed persons in many countries, about the implications of population trends. At that time, the most consequential trend was the pronounced and long-continued acceleration in the rate of increase of the population of the world, and especially of the population of the poorer countries. It was estimated in 1963 that the annual rate of increase of the global population had reached 2 percent, a rate that, if continued, would cause the total to double every 35 years. The disproportionate contribution of low-income areas to that acceleration was caused by rapid declines in mortality combined with high fertility that remained almost unchanged: the birth rate was nearly fixed or declined more modestly than the death rate.

Since the earlier report, however, the peak rate of growth in the world's population has apparently been passed. A dramatic decline in the birth rate in almost all the more developed countries has lowered their aggregate annual rate of increase to well below 1 percent, and the peak rate of increase has also apparently been passed in the less-developed parts of the world as a whole. A sharp decline in fertility in many low-income areas has more than offset the generally continued reduction in the death rate, although the rate of population increase remains high in almost all less-developed countries.

The causes of the reductions in fertility—whether they are the effect primarily of such general changes as lowered infant mortality, increasing education, urban rather than rural residence, and improving status of women or of such particular changes as spreading knowledge of and access to efficient methods of contraception or abortion—are strongly debated. There are also divergent views of the appropriate national and international policies on population in the face of these changing trends. The differences in opinion extend to different beliefs and assertions about what the population trends really are in many of the less-developed countries. Because births and deaths are recorded very incompletely in much of Africa, Asia, and Latin America, levels and trends of fertility and mortality must be estimated, and disagreement has arisen in some instances about the most reliable estimates of those levels and trends.

It was to examine these questions that the Committee on Population and Demography was established within the Assembly of Behavioral and Social Sciences of the National Research Council. It was funded for a period of three years by AID under Contract No. AID/pha-C-1161. The Committee has undertaken three major tasks:

1. To evaluate available evidence and prepare estimates of levels and trends of fertility and mortality in selected developing nations;
2. To improve the technologies for estimating fertility and mortality when only incomplete or inadequate data exist (including techniques of data collection);
3. To evaluate the factors determining the changes in birth rates in less-developed nations.

Given the magnitude of these tasks, the Committee decided to concentrate its initial efforts on the first two tasks; it initiated work on the third task in 1979.

The Committee approaches the first task through careful assessment, by internal and external comparison, and through analysis, by application of the most reliable methods known, of all the data sources available. Each of the country studies therefore consists of the application of a range of methods to a number of data sets. Best estimates of levels and recent trends are then developed on the grounds of their consistency and plausibility and the robustness of the individual methods from which they were derived.

The Committee's second task, refinement of methodology, is seen as a by-product of achieving the first. The application of particular methods to many different data sets from different countries and referring to different time periods will inevitably provide valuable information about the practical functioning of the methods themselves. Particular data sets might also require the development of new methodology or the refinement of existing techniques.

The Committee set three criteria for identifying countries to study in detail: that the country have a population large enough to be important in a world view; that there be some uncertainty about levels and recent trends of fertility or mortality; and that sufficient demographic data be available to warrant a detailed study. After a country has been selected for detailed study, the usual procedure is to set up a panel or working group of experts, both nationals of the country and others knowledgeable about the demography and demographic statistics of the country. The role of these panels and working groups, which generally include at least one Committee member, is to carry out the comparisons and analyses required. A small staff assists the Committee, panels, and working groups in their work.

As of mid-1979, 106 population specialists around the world were members of one or more panels or working groups. This number includes 66 specialists from developing nations. The Committee, the Assembly, and the National Research Council are grateful for the unpaid time and effort these experts have been willing to give.

Each country being studied has a different mix of data sources and different problems with data errors. Therefore, there is no standard pattern for all the reports. However, each report includes a summary of the main findings regarding estimates of fertility and mortality, a description of the data sources available, and a presentation of the analyses that were carried out, classified by type of data analyzed; detailed methodological descriptions are included where necessary in appendixes.

In some of the reports the estimates of fertility and mortality are presented as ranges. The use of a range is deliberate. It indicates that the panel and the Committee are confident that the range includes the true value, but have concluded that the evidence does not warrant selecting a

Summary of Findings

This section presents a summary of the principal results of the estimation of fertility and mortality trends in the Republic of Korea. The numerical results are accompanied by a brief discussion of the validity and significance of the estimates; a technical description of how the estimates were constructed is presented in later sections.

The principal results regarding the trend in fertility in Korea from 1955 to 1975 show an increase in fertility during the late 1950s to a high point in 1960, a steep decline for 6 or 7 years, a temporary slackening of the rate of decline in the late 1960s, and a resumption of the steep decline in the first half of the 1970s (see Tables 1 and 2). Table 1 includes three standard measures of fertility: the crude birth rate or births per thousand population; the general fertility rate, or births per thousand women aged 15–49; and the total fertility rate, the number of children that would be born per woman reaching age 50 if women were subject to the age-specific fertility rates of the year in question. Table 2 shows the age-specific fertility schedules at the dates of the five censuses from 1955 to 1975.

The basis for the estimates is the so-called own-children procedure. It involves calculation of the number of births that must have occurred each year to account (after due allowance for mortality) for the number of young persons (i.e., those under age 21 in 1975 to estimate births since 1955) enumerated by age in the censuses of 1966, 1970, and 1975. Ages of childbearing used in calculating age-specific fertility schedules are derived from census information on the ages of the mothers of children living in the households at the time of the censuses. The estimates were calculated

TABLE 1 Corrected Numbers of Female Births, Numbers of Females 15-49, Crude Birth Rates (CBR), General Fertility Rates (GFR), and Total Fertility Rates (TFR), 1955-1975: Republic of Korea

Year	Female Births (in thousands)	Midyear Female Population 15-49 (in thousands)	CBR[a]	GFR[b]	TFR[c]
1955	413[d]	5,227	39.5	164	5.46[e]
1956	413	5,362	38.2	160	5.33[e]
1957	430	5,501	38.4	162	5.40
1958	484	5,629	41.9	178	5.94
1959	496	5,735	41.8	179	5.93
1960	512	5,834	42.1	182	5.98
1961	492	5,939	39.6	172	5.62
1962	486	6,072	38.1	166	5.41
1963	494	6,223	37.6	165	5.35
1964	459	6,368	34.0	150	4.86
1965	444	6,505	32.2	142	4.61
1966	451	6,629	31.9	141	4.59
1967	438	6,780	30.3	134	4.34
1968	459	6,957	31.2	137	4.42
1969	463	7,150	30.8	134	4.39
1970	458	7,386	29.8	129	4.27
1971	469[f]	7,626	29.8	128	4.26
1972	469[f]	7,858	29.3	124	4.18
1973	445[f]	8,118	27.3	114	3.86
1974	431[f]	8,407	25.9	107	3.62
1975	388[f]	8,710	22.8	92	3.14

[a]The crude birth rate is calculated as the general fertility rate times the quantity (midyear female population 15-49 ÷ midyear total population) taken from uncorrected census data.
[b]GFR = (2,075 × female births) ÷ female population 15-49.
[c]Calculation of TFRs is based on the following reported own-children schedules: 1957-1958 from Cho (1971), 1959-1970 from Cho (1974a), and 1971-1975 from unpublished data from the 1975 census.
[d]Average of births 1954-1956.
[e]TFRs for 1955 and 1956 estimated from trend in GFRs 1955-1957.
[f]Based on average of 1966 and 1970 undercounts in ages 0-4. The conspicuously low value of fertility for 1975 could be caused by a particularly serious undercount of children under 1 year of age in 1975 relative to earlier censuses.

after adjustment of the three censuses for relative understatement and overstatement of the number of persons at individual ages.

Because of the unusual accuracy of the reporting of age in the Korean censuses, the occurrence of a peak total fertility rate in 1960 and the subsequent large decline can be accepted as genuine. Specifically, the increase in fertility in the late 1950s is confirmed by the recorded differences in the number of children at the appropriate ages in 1966, 1970,

TABLE 2 Estimated Age-Specific Fertility Rates (per thousand women) for Census Years: Republic of Korea

Year	Age Group 15-19	20-24	25-29	30-34	35-39	40-44	45-49	Mean Age of Childbearing
1955[a]	39	240	288	245	184	82	14	30.2
1960	35	249	323	273	204	96	16	30.5
1966	19	193	290	207	131	61	17	30.2
1970	13	174	298	207	111	43	8	29.8
1975	12	153	256	131	55	18	3	28.7

[a] The schedule for 1955 is based on the reported pattern of fertility for 1957 and the corrected TFR for 1955.
SOURCE: Age patterns of fertility are the reported own-children schedules for 1957-1975 (see footnote c of Table 1).

and 1975. Only an increase of fertility between 1956 and 1960 could account for the large number of children at age 6 relative to the number at age 10 in 1966, the large number at age 10 relative to the number at age 14 in 1970, and the large number at age 15 relative to the number at age 19 in 1975. The time sequence of aggregate fertility presented in Table 1 and the changing patterns of age-specific fertility rates presented in Table 2 are confirmed by evidence from independent sources, and they are also consistent with recorded changes of behavior within the Korean population.

The most precise corroboration of the principal estimates is an independent confirmation of the average level and the average age pattern of fertility during the five-year period from 1971 to 1975. This confirmation is provided by calculations based on registered births adjusted for incomplete registration. The average value of the total fertility rate, 1971–1975, in Table 1 is 3.81; the corresponding figure from corrected registered births is 3.80. The virtually identical average age-specific fertility schedules for 1971–1975 calculated from these independent sources are shown in Figure 1. The registration of births is wholly independent of the enumeration of young children in the 1975 census—the source of the estimates of fertility from 1971 to 1975 in Table 1. The adjustment for underregistration is derived from the number of children ever borne by women at each age as recorded in the 1970 and 1975 censuses, so that the correction for underregistration is also independent of the reported age distribution of young children.

Additional features of the estimates presented in Tables 1 and 2 find confirmation (although not so exact) from other independent evidence, namely the births reported in two large-scale sample surveys in which

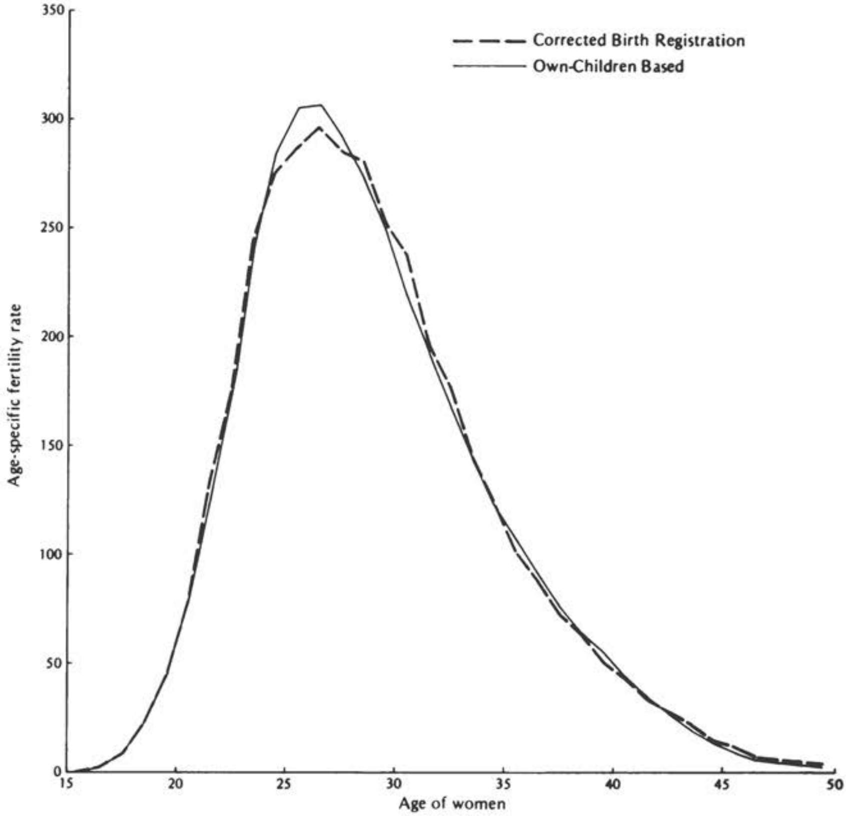


FIGURE 1 Age-specific fertility rates (per thousand women), 1971–1975, calculated from corrected birth registration and from own-children estimates: Republic of Korea.

respondents supplied detailed histories of their lifetime childbearing. The aggregate level of overall fertility in the two five-year time intervals prior to these surveys is closely, though not perfectly, consistent with the estimates presented in Table 1; the age pattern in each case is very close to that given in Table 2. The total fertility rate from each survey for the five years prior to the survey is 4 percent higher than our estimates. Age-specific fertility rates by five-year age groups from the surveys and from our estimates are compared in Figure 2.

The time sequence of total fertility rates from 1960 to 1974 presented in Table 1 is compared in Figure 3 with estimates derived from two sets of data in the Korean National Fertility Survey of 1974: own-children estimates from the household census of the surveyed population, and

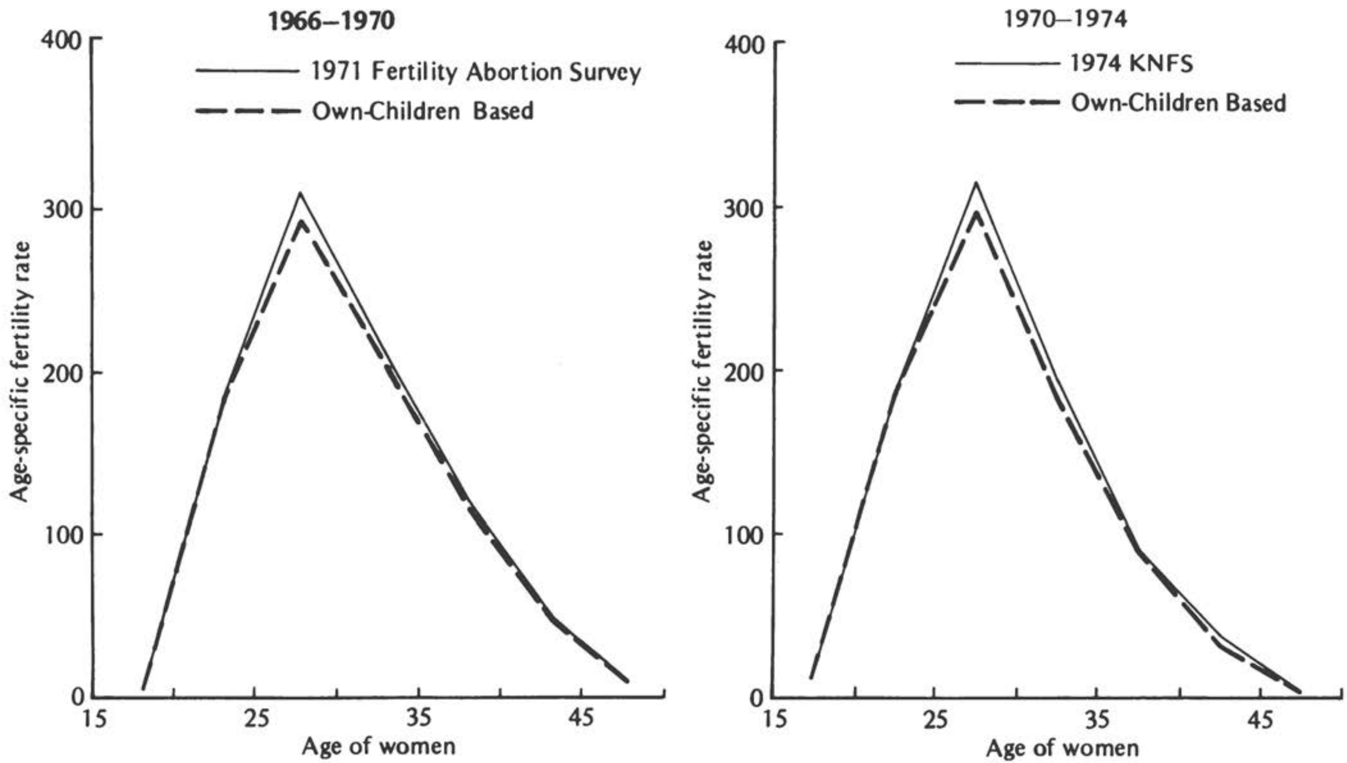


FIGURE 2 Average age-specific fertility rates (per thousand women) for 1966–1970 and 1970–1974 derived from survey pregnancy histories and from adjusted own-children estimates: Republic of Korea.

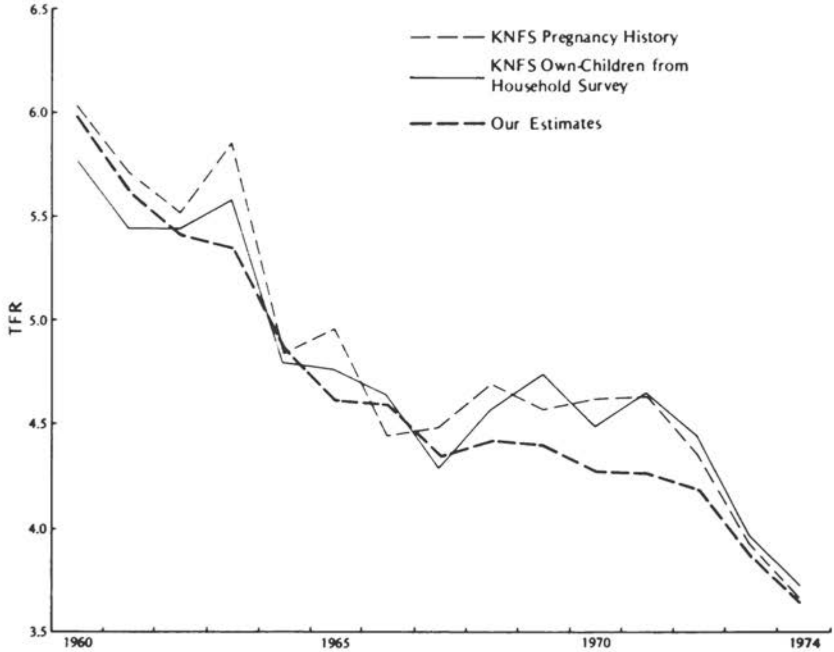


FIGURE 3 Estimated total fertility rates, 1960–1974: Republic of Korea.

NOTE: KNFS pregnancy history and own-children tabulation are based on unpublished tabulations in the Korean National Fertility Survey. Our estimates are adjusted census-based own-children estimates.

estimates obtained from the retrospective reports of previous births by individual women. The time patterns are similar, but differ in detail, especially from 1968 to 1972, when the survey-based estimates are higher. The source of this discrepancy is higher relative numbers of young children in the relevant birth cohorts recorded in the survey of 1974 than in the 1975 census (those aged 2–6 in 1974 and 3–7 in 1975). Because of problems associated with the limited size and possible bias in the sample employed in the survey, the census seems the more robust basis of estimates.

The weakest feature of the estimates in Table 1 is the sequence of rates by single years since 1970. The overall level appears correct because of the extraordinary agreement with corrected registered births. But in calculating fertility by single calendar years after 1970, the sole source of data was numbers of children under age 5 from the 1975 census—single-year cohorts enumerated but once; therefore, it was necessary to adjust the recorded numbers of children at each age under 5 by the average adjustment found for the two preceding censuses. For example, it is possible that the sharp drop in the total fertility rate from 1974 to 1975—from 3.62 to 3.14—is a slight exaggeration; this would be true if the undercount of children under age 1 in 1975 was more pronounced than the average undercount in 1966 and 1970.

The decline in aggregate fertility after 1960 shown in Table 1, and the especially large reductions in age-specific fertility at ages under 25 and over 30 shown in Table 2, can be explained by two patterns of changing behavior among Koreans. The first change is increasing age at marriage, which caused a large reduction in fertility at the younger childbearing ages. The mean age at first marriage, as calculated from the proportion of women single by age recorded in the censuses, was as follows (Coale et al. 1979):

Periods	Mean Age at First Marriage for Women
1950-1955	20.5
1955-1960	21.7
1960-1966	23.0
1966-1970	23.3
1970-1975	23.7

The second behavior change is a rapid increase in contraception and induced abortion, which caused a large reduction in fertility among older married women. According to surveys taken in 1965 and 1974, the proportion of married women currently practicing contraception increased from 16 percent to 37 percent; from 1968 to 1974 the proportion reporting having had at least one abortion rose from 16 percent to 30 percent (Bureau of Statistics and Korean Institute for Family Planning 1977).

In addition to estimates of fertility, a purpose of our research is to develop estimates of recent levels and trends in mortality in the Republic of Korea. Indeed, since our procedure involved reverse projection to calculate the annual number of births, estimates of mortality were an intrinsic part of our fertility estimates. Our estimates show a rapid decline in mortality from 1955 to 1975. The following table shows the average female infant mortality rate for each intercensal period since 1955 and the female expectation of life at birth and at age 5 for these same periods: (For reasons explained below, estimation of male mortality above age 5 was more difficult and was not attempted except for 1971–1975, since estimates of male mortality were not required for our estimates of fertility.

We noted, however, a peculiar property of male mortality in Korea—particularly high death rates among older males.)

Period	Infant Mortality Rate	Expectation of Life	
		At Birth	At Age 5
1955-1960	0.056	58.9	57.9
1960-1966	0.053	60.4	60.0
1966-1970	0.041	64.5	63.2
1970-1975	0.033	67.2	65.1

The estimates of infant mortality rates are not precise; the conventional procedure of estimation from the proportion dead among children ever born as recorded in censuses leads in Korea to an apparent underestimation, and we have accepted the infant mortality rates that were obtained in the 1971 Survey of Fertility and Abortion. This survey produces estimates of infant mortality rates that are uniformly above those from the more conventional estimation procedure, but they show a parallel downward trend. The estimation of mortality at ages above early childhood is derived from the recorded survival of the population from one census to the next and could be biased for particular periods by variation from one census to the next in the overall completeness of coverage. However, the decline in infant mortality and the rise in expectation of life at birth are undeniable and substantial.

The rapid decline in mortality would have caused an acceleration in the rate of increase in the population had it not been offset by the even more rapid decline in fertility. In fact, however, the rate of increase in the population declined sharply, as shown in the following table of the population of Korea by sex in the five censuses since 1955 and the average intercensal rates of increase:

Date	Population at Census Dates (in thousands)		Intercensal Period	Intercensal Rate of Growth	
	Male	Female		Male	Female
1955	10,753	10,749	1955-1960	0.031	0.029
1960	12,544	12,445	1960-1966	0.026	0.025
1966	14,684	14,475	1966-1970	0.018	0.020
1970	15,780	15,656	1970-1975	0.020	0.019
1975	17,445	17,234			

Estimation of Recent Trends in Fertility and Mortality in the Republic of Korea

ESTIMATION OF FERTILITY, 1955–1975, BY ADJUSTMENT OF OWN-CHILDREN CALCULATIONS

ESTIMATION OF FERTILITY BY REVERSE PROJECTION

Measures of fertility for the years preceding a census can be estimated by projecting in reverse the number of persons at different ages. Thus, the crude birth rate *t* years before the census may be estimated by reverse projection to birth of the number of persons aged *t* at the census, combined with reverse projection of the whole population to determine the appropriate denominator for the birth rate *t* years before the census. A more refined measure—the general fertility rate *t* years before the census—can be estimated by reverse projection to birth of the number of persons now aged *t*, combined with reverse projection of the women in the census aged $15 + t$ to $50 + t$ to estimate the appropriate denominator.

The accuracy of an estimate of fertility for a particular year derived by reverse projection depends on how well the projection allows for the actual change in the populations that form the numerator and denominator of the measure estimated and on how accurately the census records the subgroups projected to form the numerator and denominator of the fertility measure. Since the birth rate and the general fertility rate are ratios, however, equal proportionate errors in counting or projecting the two groups that form the numerator and denominator (for example, a 5-percent undercount of both populations or a 2-percent overstatement of the proportion surviving in each group) would still allow an accurate estimate of the birth rate or of the general fertility rate. But misstatement of age, transforming children from one age to another, or differences in omission rates by age would introduce spurious intertemporal variation in fertility estimates. For example, systematic overstatement of age such that the true number under 1 (or under 5) is understated produces the false appearance of declining birth rates and declining general fertility rates, as does differential omission of young children. In many populations, respondents do not know the age or date of birth of the children (or of the adults, for that matter) in the household. The age distribution recorded in the census of such a population is erratic and does not follow the true sequence of numbers of children by age; reverse projection consequently leads to an erratic sequence of estimated general fertility rates (or birth rates). Only when the age distribution is corrected, or can be closely approximated by adjustment of the reported numbers, does the estimated sequence of fertility rates resemble the true sequence. When an inaccurate age distribution is corrected, the time structure of estimated fertility is determined by the adjusted age distributions; if the corrections to the age distribution are imperfect, so is the validity of the estimated sequence.

Often there is no adequate basis for ascertaining the true age distribution, and reverse projection cannot then determine the true time variation in fertility before the census. If the adjustments are arbitrary, the estimated time structure is the artificial product of arbitrary procedures.

The own-children method is an elaborate form of reverse projection that yields much information in addition to the series of crude birth rates and general fertility rates that can be obtained from simple reverse projection. The additional information made possible by own-children procedures includes estimates of age-specific fertility rates. A particularly useful (age-distribution-free) aggregate measure of fertility—the total fertility rate or, alternatively, the gross reproduction rate—becomes calculable. Moreover, the fertility of subgroups of the population, defined, for example, by level of education, can be calculated by own-children techniques, but not by simple reverse projection. In short, own-children procedures, by identifying particular past births with particular women, introduce the opportunity for all kinds of microanalysis, whereas simple reverse projection is limited to the coarsest kind of macroanalysis.

The essence of the estimation by reverse projection of the general fertility rate x years before a census taken at time t is expressed in the equation:

$$\mathrm{GFR}\,(t-x) = \frac{C(x,t)\,(l_0/l_x)}{\int_{15+x}^{50+x} W(a,t)\,(l_{a-x}/l_a)\,da}\,. \qquad (1)$$

Children x years of age are projected in reverse to birth; women at ages from $15 + x$ to $50 + x$ are projected in reverse to determine the number aged 15 to 50 x years earlier.

OWN-CHILDREN ESTIMATES OF FERTILITY

The own-children technique requires a special tabulation that identifies individual children as the offspring of specified women on the basis of relationships within the household as recorded in the census. The essence of the own-children procedure is expressed in the equation[1]:

$$f(a-x, t-x) = \frac{C_a(x,t)\,(l_0/l_x)}{W(a,t)\,(l_{a-x}/l_a)}. \quad (2)$$

Those children x years of age whose mothers are a years old are projected in reverse to birth to estimate how many births occurred x years ago to women then $a - x$ years old (including children at age x without an own mother, who are allocated to women at age a); the denominator is an estimate, by reverse projection, of the number of women at age $a - x$, x years before the census.

The capacity of own-children analysis to yield age-specific rates and fertility measures for women of particular characteristics does not free it from the effects of misreported age distributions in the census to which it is applied. The point can be put very simply: own-children estimates add nothing to the precision of the estimated series of general fertility rates that can be calculated by simple reverse projection.[2] Own-children estimates of aggregate fertility are just as erratic, when derived from censuses in which the ages of children are misstated or in which children at different ages are differentially omitted, as are estimates of aggregate fertility derived by simple reverse projection.

In short, own-children estimates of fertility are useful when the distribution of the population by single years of age is highly accurate or can be made highly accurate by slight adjustment.

OWN-CHILDREN ESTIMATION OF FERTILITY IN KOREA

Because of the accurate reporting of the distribution of the population by age in the Republic of Korea, the own-children technique is particularly applicable to Korea. The special tabulations required by the method were made from the censuses of 1966, 1970, and 1975. The estimates presented

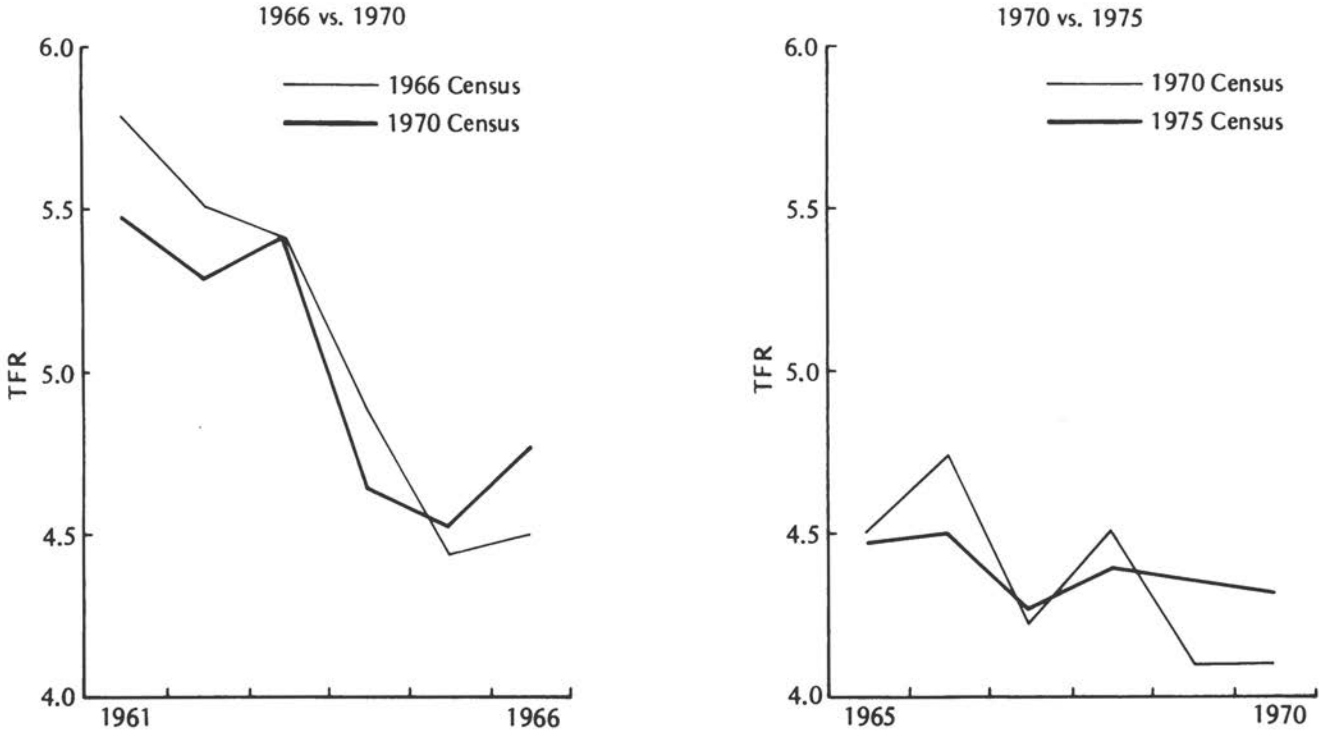


FIGURE 4 Total fertility rates based on uncorrected own-children estimates from consecutive censuses (1966 vs. 1970, 1970 vs. 1975): Republic of Korea.

SOURCES: TFRs based on 1966 census are taken from Cho (1971). TFRs based on 1970 census are taken from Cho (1974a) and unpublished data. TFRs based on 1975 census are taken from unpublished data.

here are based (after special corrections) on the own-children fertility schedules for 1957 to 1975 calculated by Lee-Jay Cho and his colleagues: fertility schedules based on the 1966 census (Cho 1971); revised estimates including those derived from the 1970 census (Cho 1974a); and calculations made at the East-West Population Institute of own-children estimates from the 1975 census (not yet published). The unusual accuracy of age reporting in Korean censuses is not sufficient to yield perfectly consistent own-children estimates when derived from data from different censuses. The age patterns of the fertility schedules are quite similar, but for particular years, estimated measures of aggregate fertility derived from different censuses are not in perfect agreement (Figure 4).

ADJUSTMENTS OF THE REPORTED AGE DISTRIBUTION AND OF OWN-CHILDREN FERTILITY ESTIMATES

We estimated more nearly correct age distributions of the female population by single years of age for 1966, 1970, and 1975 in three steps:

1. Special understatement and overstatement of numbers at different individual ages in 1970 were corrected. (The special defects in 1970 are associated with improper correction for the use of the lunar calendar in reporting age.)
2. The reported distributions by five-year age intervals of the female population in the three censuses were corrected by a technique of demographic analysis that predicates similar patterns of distorted age structure in consecutive censuses.
3. The proportion of each five-year cohort falling within single-year cohorts was calculated separately for males and females in the three censuses. An estimate of individual cohort size (within the five-year cohort) was derived from these six observations for each cohort.

By reverse projection of the corrected female age distributions, female births (and total births, on the assumption of a fixed sex ratio) were estimated for individual years from 1955 to 1970; corrected female populations at the childbearing ages were also calculated for the same years. The ratio of estimated births to estimated female population provided our estimates of annual general fertility rates. The age pattern of the fertility schedules previously constructed at the East-West Population Institute was accepted as correct; the entire schedule for each year was adjusted by scalar multiplication so that the age-specific rates when applied to the corrected female population yielded the estimated overall number of births. The age-specific schedules thus adjusted to the proper level were cumulated to provide our estimates of annual total fertility rates shown in Table 1. Fertility schedules for selected years appear in Table 2. A detailed description of the methods of estimation in this section is given in Appendix A.

ESTIMATION OF FERTILITY, 1971–1975, FROM REGISTERED BIRTHS ADJUSTED FOR UNDERREGISTRATION

Births in Korea are registered by year of birth and age of mother. The resulting data are little utilized and not widely publicized because of two deficiencies. First, there is often a substantial delay in registration: the births occurring in a given calendar year are registered during the next several years. Second, even after allowance for delayed registration, it is clear that the number of registered births falls short of the actual total.

ESTIMATION OF COMPLETENESS OF REGISTRATION IN COMPARISON WITH DATA ON PARITY FROM CENSUSES

Births registered prior to December 31, 1976, for the calendar years 1971–1975 are shown in Table 3, by age of mother in single years. The accuracy of age reporting in Korea, and the tabulation of average number of children ever born (average parity) by single years of age in 1970 and 1975, makes it possible to estimate the fraction of the actual number of births that were registered in the years between the censuses. The principle is simple: the increase in average parity for women in a given cohort (for example those 15 in 1970 and 20 in 1975) is equal to the total number of births experienced by the cohort between the two censuses, divided by the mean size of the cohort. The registered number of births at the appropriate ages in the intercensal years divided by the mean size of the cohort is the *registered cohort intercensal birth rate*; the difference in average parity recorded in 1970 and 1975 can be called the *census cohort birth rate*. On the assumption that parity is correctly reported, the ratio of the registered rate to the census rate is a measure of the completeness of birth registration. In detail, the requisite calculations are rather complicated; they are described in Appendix C.

Table 4 and Figure 5 show the ratio of average registered births per cohort to the increase in average parity from 1970 to 1975. The sequence of ratios for individual cohorts fluctuates moderately around a constant value until it rises to more than one for the oldest cohort. The rising ratio for older cohorts is undoubtedly the result of understatement of parity at older ages in 1975; this understatement is discussed in detail below.

The median ratio of increase in parity estimated from registered births

TABLE 3 Births Occurring during 1971-1975 and Registered by the End of 1976, by Year of Birth and Age of Mother at Birth: Republic of Korea

	Year of Birth					
Age	1971	1972	1973	1974	1975	Total
14 (or less)	243	298	440	928	1,363	3,272
15	170	146	121	87	20	544
16	1,497	1,214	954	603	195	4,463
17	4,092	3,812	3,125	1,940	797	13,766
18	8,538	7,817	7,884	5,678	2,628	32,545
19	14,916	13,738	13,384	12,473	6,296	60,807
20	22,815	23,491	22,442	19,821	13,089	101,658
21	35,045	28,866	33,291	29,575	24,674	151,451
22	47,087	43,270	38,175	40,091	23,194	191,817
23	60,988	54,537	55,104	50,014	40,378	261,021
24	67,978	64,393	62,035	56,953	35,627	286,986
25	58,045	67,708	67,944	58,103	40,740	292,540
26	65,065	55,255	67,128	61,996	40,465	289,909
27	63,616	56,759	53,149	58,145	37,769	269,438
28	67,849	54,866	51,151	43,636	35,550	253,052
29	64,580	54,420	46,542	37,797	23,027	226,366
30	54,876	54,850	47,313	37,243	21,011	215,293
31	46,688	40,429	43,479	32,286	17,043	179,925
32	40,503	36,517	34,350	33,631	17,548	162,549
33	33,551	30,303	29,627	23,538	15,412	132,511
34	28,916	24,992	24,507	20,846	11,348	110,609
35	24,630	20,768	19,344	15,157	8,806	88,705
36	21,591	18,046	16,350	12,571	6,823	75,381
37	16,377	14,853	13,879	10,189	5,085	60,385
38	13,519	12,007	12,090	8,598	4,603	50,817
39	10,841	9,085	8,902	6,902	3,456	39,186
40	9,220	7,652	7,592	5,115	2,812	32,391
41	7,388	5,507	5,423	3,645	1,866	23,829
42	5,147	4,819	4,172	2,838	1,522	18,498
43	4,080	3,224	3,597	2,107	1,338	14,346
44	2,860	2,112	2,143	1,413	646	9,174
45	1,994	1,643	1,615	947	535	6,734
46	1,339	968	856	545	263	3,971
47	943	739	567	383	210	2,842
48	976	597	499	222	134	2,428
49	671	565	358	192	103	1,889
50 (and over)	1,074	842	484	476	166	3,042

SOURCE: Feeney (1977).

TABLE 4 Comparison of Average Number of Registered Births per Cohort (1971-1975) with Intercensal Cohort Birth Rate (1970 vs. 1975): Republic of Korea

Age in 1975	Registered[a] Cohort Birth Rate (1)	Intercensal[b] Cohort Birth Rate (2)	Ratio[c] (1) ÷ (2)
20	50	69	0.73
21	115	136	0.85
22	243	254	0.96
23	298	421	0.71
24	563	658	0.85
25	746	906	0.82
26	948	1,136	0.83
27	1,055	1,343	0.79
28	1,142	1,424	0.80
29	1,193	1,455	0.82
30	1,078	1,456	0.74
31	1,132	1,372	0.82
32	1,043	1,235	0.84
33	1,008	1,140	0.88
34	894	1,020	0.88
35	720	874	0.82
36	701	744	0.94
37	538	624	0.86
38	396	491	0.81
39	386	395	0.98
40	334	356	0.94
41	292	221	1.32

[a]1975 registered births increased by 39 percent for delayed registration.
[b]Intercensal birth rates corrected for one-half year of age.
[c]Median ratio equals 0.835.
SOURCES: Registered cohort birth rate calculated from Table 2 above, Economic Planning Board, Korea (1973: Vol. II, Table 1) and (1976: Table 1).
Intercensal cohort birth rate calculated from Economic Planning Board, Korea (1973: Vol. II, Table 1) and (1976: Table 3).

to the recorded increase in the censuses for cohorts no more than 35 years of age in 1975 may be taken as an estimate of the completeness of registration of births (after the births in 1975 have been given a preliminary correction of 1.39—see Appendix C). The median figure of 0.835 can then be used as a divisor of the number of registered births to provide estimates of the true number of births in the intercensal period (again after a special adjustment is made for the 1975 registered births). The adjusted aggregate number of births, 1971–1975, by single years of age have been divided by the estimated average number of person-years at each

FIGURE 5 Ratio of registered cohort birth rate (1971–1975) to intercensal cohort birth rate (1970–1975): Republic of Korea.

individual age (from the adjusted population) to construct the age-specific fertility schedule for the quinquennium between the two censuses. In Figure 1, this schedule of age-specific fertility rates derived from registered births is compared with a schedule of age-specific rates obtained by our corrections to own-children estimates calculated from the 1975 census. The two schedules in Figure 1, derived by wholly independent procedures, are in extraordinarily close agreement.

UNDERSTATEMENT OF PARITY IN 1975 AT AGES ABOVE 38

In Figure 5 the ratio of the registered birth rate to the census birth rate (for 1971–1975) is plotted by age of women in 1975. The ratio turns up sharply above age 38; it is not shown above age 41 because the reported increase in parity for older women becomes negative. The increase in parity implied by registered births adjusted for underregistration can be added to the parity reported by women in each cohort in 1970 to construct a figure for 1975, on the assumption that the 1970 reports were correct. This construction is compared with the parity reported in 1975 in Figure 6. Note that the two sets of numbers are virtually identical until just below age 40; the divergence then increases rapidly. At ages in the middle to late

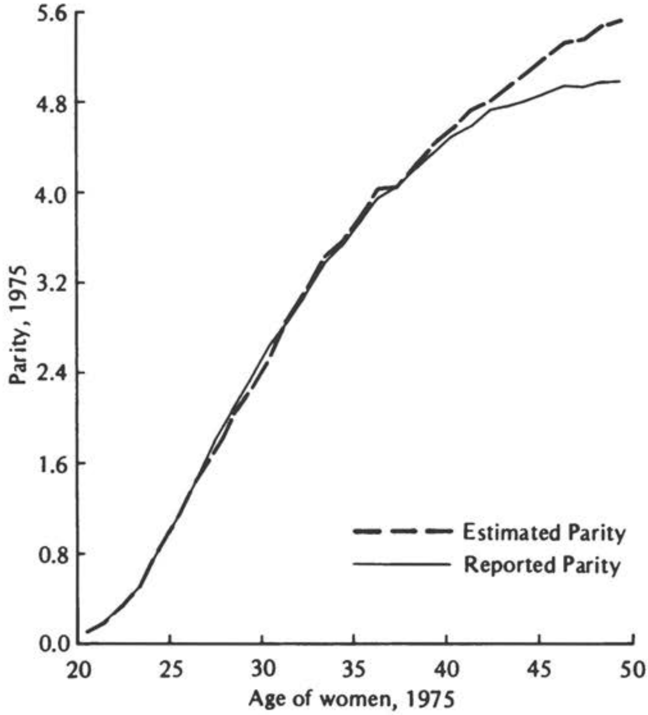


FIGURE 6 Reported parity in 1975 census vs. estimated parity (sum of parity in 1970 census and intercensal increase in parity from adjusted registered births 1971–1975): Republic of Korea.

forties even the constructed figure is too small, because parity was doubtlessly understated in 1970 by women then five years younger.

The initiation of a consequential understatement of parity only at ages older than 35 supports the hypothesis that the principal reason for increasing understatement of the number of children ever born with increasing age is the omission of children who have left the parental home, rather than forgetting. Respondents may misunderstand the intent of a question concerning the number of children they have ever borne and conclude that offspring who have matured and left home should be omitted. In Korea in 1975, the late thirties are ages at which women would be mothers of offspring old enough to be considered no longer children.

ESTIMATION OF FERTILITY FROM SPECIAL SURVEYS

Detailed fertility histories were obtained from large samples of ever-married women in the 1971 Fertility-Abortion Survey, conducted by the Korean Institute for Family Planning (Moon et al. 1973), and in the Korean National Fertility Survey (KNFS), conducted jointly in 1974 by the National Bureau of Statistics and the Korean Institute of Family Planning in cooperation with the World Fertility Survey. From these fertility histories, we have computed average age-specific fertility schedules for the five-year time intervals preceding each survey, in the belief that the effects of sampling variance, event misplacement, and omission would be minimized by aggregating the births that occurred during five years before the survey.

Detailed pregnancy records were obtained from approximately 6,300 and 5,400 ever-married women of reproductive age in the 1971 Fertility-Abortion Survey and the 1974 Korean National Fertility Survey, respectively. These women were identified from samples of approximately 6,800 and 21,000 households, respectively, in the two surveys. The calculation of age-specific fertility rates for periods preceding the survey dates was based on data from both the fertility histories and the household survey as follows:

1. Numerators consisted of births recorded in the pregnancy histories, classified by calendar year and by age of mother at the time of the birth.
2. Denominators consisted of person-years of exposure of women, classified by calendar year and by age of women. The age distribution of ever-married women at the time of the survey was inflated by the proportion of women in the household survey who were ever married at the corresponding age to obtain an age distribution for all women. By reverse counting, person-years were obtained for calendar years prior to the survey date.

For the KNFS, age-specific fertility rates for the year 1974 were increased by a factor of 1.23 to account for a full year's exposure because the survey was conducted between September and December. Also, since the individual survey in the KNFS restricted interviews to women under age 50, total fertility rates for years prior to 1974 were obtained from age-specific fertility rates derived partly from the detailed pregnancy history (at younger ages) and partly from the own-children tabulation of the household survey (for the latter portion of the reproductive age span).

The schedules derived from the surveys are compared with our adjusted own-children schedules in Figure 2. The total fertility rates for the time periods 1966–1970 and 1970–1974 are 4.57 and 4.22 as calculated from the surveys and 4.40 and 4.04 as calculated by adjustment of own-children estimates. Although our estimates are about 4 percent lower for both periods, the two sources show the same 8 percent proportionate decline and virtually the same age pattern at each date.

A more detailed comparison of the time pattern of fertility change was obtained by computing total fertility rates from 1960 to 1974 from data collected in the 1974 KNFS. Age-specific fertility schedules for each calendar year were derived from this survey in two essentially independent ways. A fertility schedule at each date was obtained by applying the own-children method to information about age distribution and household composition obtained in the Household Survey conducted as part of the KNFS. Another set of schedules (again, one for each year from 1960 to 1974) was derived from the detailed fertility history obtained from the sample of ever-married women interviewed in the survey.

The annual total fertility rates derived by these two procedures are compared in Figure 3 with our adjustment of own-children estimates based on the censuses. Although the estimates differ for some individual years (for example, 1963 and 1965), and our estimates are lower than the other two from 1968 to 1972, the time patterns are generally similar: a steep decline from 1960 to 1966 or 1967, little change from 1967 to 1972, and then a resumption of a decline. The difference in the estimates for 1968–1972 is caused by relatively larger numbers at ages 2–6 in the 1974 survey than at ages 3–7 in the 1975 census. Similarly, the difference in 1963 is the result of a large cohort reported at age 11 that is not matched by an equally large cohort at age 7 in 1970 or at age 12 in 1975. Evidently the distribution of children by age recorded in the Household Survey was consistent with the dates of birth reported in the fertility histories, as can be seen in the two curves in Figure 3 derived from the KNFS.

The household sample was large, but clustered: it included 103,000 persons in 316 enumeration districts, systematically sampled from the universe of some 76,000 districts. The age and sex distribution in the Household Survey is somewhat more erratic than in the censuses, as is evident, for example, in more erratic sex ratios by five-year age intervals (see Table 1 in Bureau of Statistics and Korea Institute for Family Planning 1977). The sex ratios at ages 30–60 in the Household Survey are unaccountably different from the ratios for the same ages, or for the same cohorts, in the censuses. Hence, much of the deviation at particular years shown in Figure 3 is the result of minor flaws in recording the population by age and births by year in the survey.

ESTIMATION OF MORTALITY

The life tables that are used in arriving at adjusted own-children fertility estimates are composites: a model life table is selected to match estimates of infant mortality derived from surveys, which provides mortality up to age 5, and another model life table is selected by forward projection to provide estimates of mortality above age five (see Appendix A).

INFANT MORTALITY ESTIMATED FROM RETROSPECTIVE DATA IN FERTILITY SURVEYS

The use of data on infant mortality from the 1971 Fertility-Abortion Survey and the Korean National Fertility Survey requires further comment. Since the Korean censuses of 1966, 1970, and 1975 incorporated questions about children ever born and children surviving, child mortality can be calculated by the Brass method or the Sullivan or Trussell modifications of the Brass procedures (Brass and Coale 1968; Sullivan 1972; Trussell 1975). These techniques have proved very useful; in only a few instances do they fail to provide robust indications of the recent levels of infant and child mortality. The estimates of infant and child mortality in Korea by these techniques, however, appear to be too low; that is, the implied infant mortality rate in the 1970s of less than 20 per thousand is too low to be readily accepted.

Employing an extension of child-survival techniques, Griffith Feeney has calculated a sequence of estimated infant mortality rates extending back to the 1950s using data on children ever born and children surviving from the censuses of 1966, 1970, and 1975. Infant mortality rates from the surveys of 1971 and 1974 (Kim 1976; Bureau of Statistics and Korean Institute for Family Planning 1977) are derived from annual births and annual deaths under age 1 as reported in the retrospective fertility histories. In Figure 7 the moving average (five-year average except for the last point, which is a three-year average) of the infant mortality rates based on the surveys is compared with estimates for selected points prior to each census calculated by Feeney from census data on child survival. The estimates based on child survival are almost always lower, although the bias usually found in survey reports is understatement of infant mortality. Moreover, the child-survival estimates are implausibly low (infant mortality rates at or below 20 per thousand in the 1970s); at the level of adult mortality estimated from forward projection, model life tables show infant mortality rates of over 50 per thousand. A response bias against reporting dead children or a minor processing error could be the source of

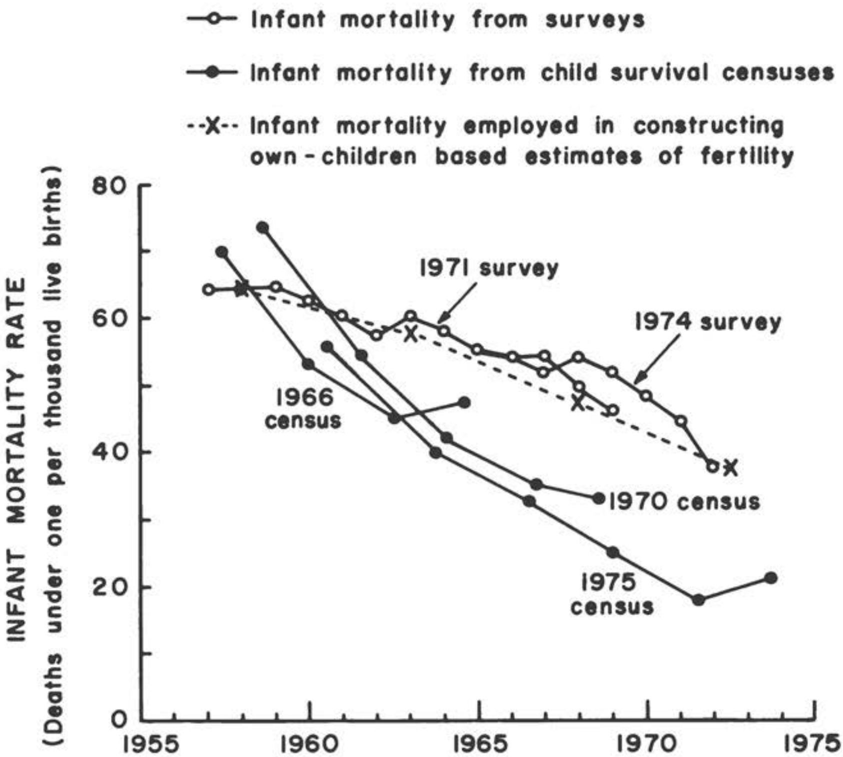


FIGURE 7 Infant mortality rates (deaths under 1 year of age per thousand live births) at various dates, 1957–1973, from surveys and censuses: Republic of Korea.

SOURCES: Survey data from Bureau of Statistics and Korean Institute for Family Planning (1977) and N. I. Kim (1976); child survival estimates from Cho and Feeney (1976).

NOTE: Survey rates (1971 and 1974) are five-year moving averages of annual infant mortality rates (except for the last data points for each survey, which are three-year moving averages).

understatement of the proportion dead among children ever born. Had lower infant mortality rates been accepted, the fertility estimates would have been lower by 2–4 percent.

MORTALITY ABOVE AGE 5 ESTIMATED BY FORWARD PROJECTION

Certain features of the selection of a model life table from age 5 to the end of life by forward projection also require comment. Forward projection provides a series of different estimates of the level of mortality. Specifically, a particular level of mortality is implied when the earlier population over age 10 is projected to match the later population over 15; quite a different level may be implied when the earlier population over 50 is projected to match the later population over 55. The levels of mortality will be about the same only if age misreporting is not extensive, if the censuses are of approximately equal completeness of coverage, and if the pattern of mortality in the model life tables is matched by the pattern of mortality in the population in question.

In Table A-1 (see Appendix A), the different levels of mortality (West model tables; Coale and Demeny 1966) determined by forward projection are shown for each intercensal period, for males and females. Mortality levels are specified in two ways: the level that yields the survival rate of each cohort from one census to the next, and the level that projects the entire population at ages x and over to match the later population at ages $x + n$ and over. In Korea, for each sex the individual cohort survival rates imply a very erratic sequence of mortality levels—at some ages even surpassing the highest, or falling below the lowest, survival rates in any model life table—because of different relative overstatement or understatement of cohort size in the two censuses. The levels determined by projection and cumulation are less variable, but are affected at the younger ages by special undercounts that occur at ages from about 15 to 30 in the different censuses. Above age 25 or 30, however, the forward projections are less affected by such census defects.

For females, the variation in mortality level in the West life tables selected by forward projection from age 25 to age 60 is confined to a narrow range for all intercensal periods, and to a very narrow range for the two most recent pairs of censuses. Apparently, recent Korean adult female mortality is quite consistent with the West family of model tables.

For males, no such consistency exists in the West levels of mortality estimated by forward projection. The fluctuations of estimated level for the childhood ages is even greater than for females, and above age 25 the sole consistency in pattern is a sort of systematic inconsistency, namely large declines in life table level (to schedules of higher mortality) as age increases. Apparently, recent Korean adult male mortality is not consistent with the West family of model life tables.

There are two possible interpretations of the declining levels shown in Table A-1: either the number of males is progressively more understated with increasing age in each of the Korean censuses, or male mortality at older ages has been persistently high in relation to expectations based on mortality among females (or among younger males) and the general relations expressed in the West model tables. To see whether the mortality rates themselves are unusually high for older males, we analyzed death rates derived from registered deaths.

MORTALITY ABOVE AGE 5, 1971–1975, ESTIMATED FROM REGISTERED DEATHS ADJUSTED FOR UNDERREGISTRATION

The registration of deaths in Korea is analogous to the registration of births. Records of registered deaths are maintained, classified by age and sex, but the number of events registered is known to be incomplete. A simple modification of the forward projection technique was applied to the deaths registered from 1971 to 1975 (Tables 5 and 6) to estimate the completeness of registration: the number of registered deaths in each age interval during the five years was divided by the estimated number of person-years lived in each interval—5 times the average of the number of persons at those ages in the censuses of 1970 and 1975. (The numbers at 15–30 were increased by 5 percent and the numbers at 30–35 by 2 percent as a rough allowance for the most conspicuous undercounts.) The result is a mortality schedule that would be correct if deaths were fully registered. Alternative schedules are fabricated by multiplying this schedule by constants greater than 1.0 (allowing, in effect, for an increasing underregistration of deaths); each mortality schedule is converted into a life table and employed for forward projection from 1970 to 1975.

The succession of multipliers required to produce a life table that provides the proper population in 1975 when applied to the population over age x in 1970 is shown in Table 7. For both males and females there is little variation in the sequence. The median value is 1.26 for males and 1.45 for females, implying that 79 percent of male deaths and 69 percent of female deaths are registered. When registered deaths are multiplied by these median adjustments, the cumulated projected population matches the recorded 1975 population with an error of less than one percent at all ages up to 60.

Life tables for which mortality above age 5 is taken from registered deaths adjusted for underregistration instead of West model tables are given in Table 8. The sequence of West levels of mortality corresponding to the corrected age-specific death rates are shown in Figure 8. The female death rates conform to essentially the same level of West mortality from age groups 5–9 to 60–64; male mortality is at about the same West level as

TABLE 5 Male Deaths Occurring during 1971-1975 and Registered by the End of 1976, by Year of Death and Age at Death: Republic of Korea

Age Group	Year of Death 1971	1972	1973	1974	1975	Total
Total	108,487	94,871	124,845	112,702	99,965	540,870
0–4	7,826	5,962	6,559	6,168	4,707	31,422
5–9	4,255	3,047	4,549	4,240	3,697	19,788
10–14	3,439	2,597	3,531	3,217	2,697	15,481
15–19	4,429	3,972	5,192	4,764	4,029	22,386
20–24	3,833	3,578	4,275	4,136	3,779	19,601
25–29	3,248	2,814	3,404	3,103	2,737	15,306
30–34	3,323	3,202	3,835	3,585	3,123	17,068
35–39	3,883	3,570	4,122	4,002	3,520	19,097
40–44	4,677	4,268	5,003	5,021	5,101	24,070
45–49	6,735	5,877	6,543	6,151	5,172	30,478
50–54	8,308	7,613	9,700	8,990	8,388	42,999
55–59	9,934	8,887	11,251	10,216	8,585	48,873
60–64	10,850	10,108	12,969	11,881	10,597	56,405
65–69	9,413	8,668	12,571	11,687	10,102	52,441
70–74	9,642	8,170	10,930	7,771	8,713	45,226
75–79	6,450	5,530	8,935	7,858	6,073	34,846
80–84	4,953	4,258	6,284	5,354	4,377	25,226
85+	3,289	2,750	5,192	4,558	4,368	20,157

SOURCE: Feeney (1977).

female mortality under age 40, but is at sharply decreasing levels (higher mortality) at higher ages.

The consistency of these life tables calculated from corrected registered deaths with survival from 1970 to 1975 shows that Korean male mortality does indeed deviate from West model tables; the death rates for older males are much higher (relative to female death rates and to male mortality at younger ages) than in the model tables. The non-conformity of male mortality to the West tables implies that forward projection does not select (for males) a life table that fits well at any age; we have therefore based all our fertility estimates on the adjusted female age distributions.

TABLE 6 Female Deaths Occurring during 1971-1975 and Registered by the End of 1976, by Year of Death and Age at Death: Republic of Korea

Age Group	Year of Death 1971	1972	1973	1974	1975	Total
Total	76,212	64,401	87,342	77,589	68,385	373,929
0-4	7,269	5,495	5,949	5,566	4,254	28,533
5-9	3,355	2,483	3,783	3,641	3,119	16,381
10-14	2,601	1,970	2,867	2,589	2,114	12,141
15-19	2,799	2,320	3,254	2,973	2,877	14,223
20-24	2,923	2,533	3,202	2,823	2,803	14,284
25-29	2,862	2,290	3,005	2,577	2,269	13,003
30-34	2,625	2,377	2,881	2,705	2,370	12,958
35-39	2,774	2,367	3,002	2,622	2,330	13,095
40-44	2,873	2,669	3,175	2,957	2,761	14,435
45-49	3,285	2,850	3,479	3,344	3,048	16,006
50-54	3,627	3,249	4,287	4,035	3,717	18,915
55-59	4,381	3,806	4,898	4,353	3,809	21,247
60-64	5,080	4,573	6,180	5,583	5,114	26,530
65-69	5,665	4,877	6,958	6,326	5,499	29,325
70-74	7,084	5,992	7,705	5,284	5,758	31,823
75-79	6,102	5,143	7,823	7,092	5,243	31,403
80-84	5,868	5,111	7,207	6,339	5,030	29,555
85+	5,039	4,296	7,687	6,780	6,270	30,072

SOURCE: Feeney (1977).

TABLE 7 Multiplying Factors for Registered Deaths (1971-1975) Derived from Forward Projection, Males and Females: Republic of Korea

Cumulated Ages in 1975	Male Factor	Female Factor
10+	1.25	1.51
15+	1.22	1.50
20+	1.13	1.45
25+	1.20	1.47
30+	1.18	1.57
35+	1.25	1.42
40+	1.28	1.45
45+	1.26	1.43
50+	1.25	1.48
55+	1.27	1.48
60+	1.26	1.44
65+	1.19	1.44
70+	1.15	1.44
Median Multiplying Factor	1.26	1.45
Completeness of Death Registration	79%	69%

TABLE 8 Life Tables (over Age 5) 1971-1975, Constructed from Corrected Death Registration Data, Males and Females: Republic of Korea

MALES e_5 = 57.2

Age	1,000 $q(x)$	$l(x)$	$L(x)$	West Level Implied by $q(x)$
5	10.60	100,000	497,080	17.6
10	8.43	98,940	492,700	17.3
15	14.55	98,106	487,100	16.6
20	16.30	96,678	479,610	18.2
25	15.43	95,102	471,990	18.9
30	18.68	93,635	463,980	18.5
35	23.35	91,885	454,280	18.4
40	37.69	89,740	440,580	17.0
45	58.25	86,358	419,720	15.4
50	94.93	81,328	388,110	12.9
55	134.94	73,608	344,200	11.8
60	202.63	63,675	287,410	10.3
65	277.35	50,772	220,070	9.9
70	380.86	36,690	149,920	9.6
75	503.08	22,717	85,013	10.3
80+	1,000.00	11,288	35,880	–

FEMALES e_5 = 63.9

Age	1,000 $q(x)$	$l(x)$	$L(x)$	West Level Implied by $q(x)$
5	10.85	100,000	497,020	17.1
10	8.17	98,915	492,630	17.2
15	11.20	98,107	487,900	17.6
20	14.44	97,008	481,680	17.7
25	15.36	95,607	474,510	18.2
30	17.03	94,138	466,840	18.4
35	18.55	92,535	458,550	18.7
40	24.45	90,818	448,760	18.5
45	32.42	88,598	436,100	18.4
50	46.81	85,726	419,000	18.2
55	63.34	81,713	396,150	18.7
60	96.63	76,538	364,940	18.7
65	137.79	69,142	322,840	19.9
70	207.56	59,615	268,380	21.0
75	303.37	47,241	200,380	22.2
80+	1,000.00	32,910	169,850	–

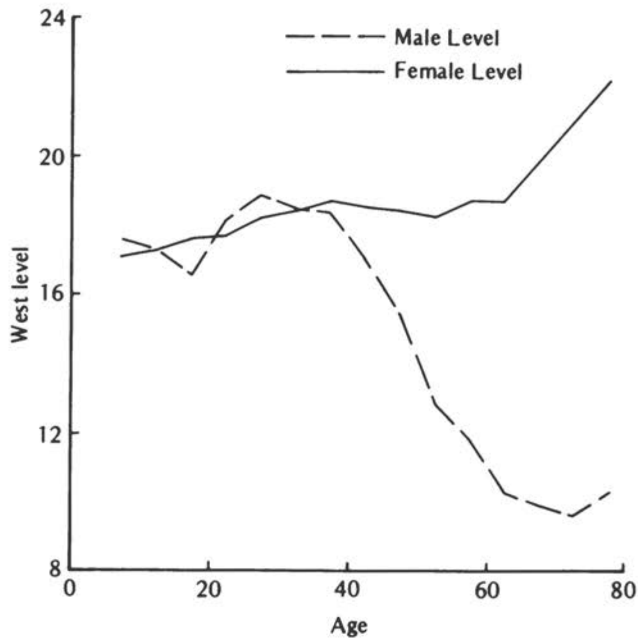


FIGURE 8 West levels of mortality calculated from age-specific death rates, for five-year age groups, based on corrected death registration data, males and females, 1971–1975: Republic of Korea.

Appendixes

A ADJUSTMENT OF OWN-CHILDREN FERTILITY ESTIMATES BY CORRECTION OF FEMALE AGE DISTRIBUTIONS IN KOREAN CENSUSES

ACCURATE AGE REPORTING

The own-children method by which our estimates were constructed is especially useful when ages are correctly reported. Censuses in Korea record the age distribution of the population with unusual accuracy because Koreans, even those without education, have very precise knowledge of the date of their birth. This knowledge derives from the importance in Korea of a belief in astrology that leads every individual to know the "animal year" of birth, and also, in most instances, the precise date of birth according to the Chinese lunar calendar. If the census in Korea includes a question on date of birth (rather than on age) and if age is then calculated by subtracting the date of birth from the date of the census, the determination of age is more accurate than in censuses taken in many highly educated Western populations. These aspects of Korean culture made it possible for the Japanese colonial government before World War II to record the age distribution of the population in a series of censuses from 1925 to 1944 with unusual accuracy. When the censuses were resumed in the Republic of Korea after World War II, the same precision in age determination could have been achieved; as explained below, however, that precision was not always attained. The first census with fully published tabulations after the war was in 1955, followed by censuses in 1960, 1966, 1970, and 1975.[3] In all but the 1960 census, age was ascertained by including a question on date of birth and calculating age by subtraction of this date from the date of the census. In 1960 there was an ill-advised change to a question about age at last birthday, a modification that appears to have led generally to reporting of age by the Chinese system of reckoning, according to which an infant is 1 year old at birth and becomes one year older on each New Year. This unfortunate change in procedure makes the age distribution of the population in 1960 imprecise and hard to relate to data in the other censuses.

CORRECTING THE REPORTED AGE DISTRIBUTION

Greater precision in estimating fertility—whether by simple reverse projection to estimate aggregate measures of fertility or by the own-children technique to estimate fertility schedules—can be obtained from the recorded age distribution of a closed population if errors in the distribution can be detected and corrected. The possibility of detecting errors in the Korean censuses is enhanced by the existence of five counts of the population (in 1955, 1960, 1966, 1970, and 1975) in 20 years. Experience with other populations has shown that basically unchanging procedures of enumeration create similar patterns of overstatement and understatement of numbers at different ages in consecutive censuses (Coale 1955; Coale and Zelnik 1963; Demeny and Shorter 1968; Coale and Rives 1973). The similarity of pattern is revealed, and the extent of overstatement and understatement estimated, by tracing the enumeration of the same cohorts in the different censuses. Changes in cohort size from one census to the next are approximated by survival rates in appropriately devised life tables.

Construction of Life Tables for Projecting the Population for Each Intercensal Period

The life tables used in the detection and correction of errors in the published age distribution are composite tables, one for each intercensal interval. Mortality up to age 5 was estimated from data on infant mortality obtained from the 1971 Korean Fertility-Abortion Survey, in which detailed fertility histories (including the date of death of each child who died) were recorded (Kim 1976). Values of $l_1, l_2, \ldots, l_5$, and of ${}_1L_0$, ${}_1L_1, \ldots, {}_1L_4$, were taken from West model life tables chosen to match the average infant mortality during each intercensal interval (Coale and Demeny 1966). Mortality above age 5 was determined by forward projection, a technique by which a model life table is chosen that provides that projection of the population recorded in the earlier census that best matches the population recorded in the later census. If the censuses are five years apart, a model life table can be found such that the total number in the projected population over age 5 matches the total recorded number aged 5 and over at the later date. Another model table can then be independently chosen so that it projects a population over age 10 to match the recorded population; similarly over age 15, etc. If the two age distributions are accurately recorded, if migration is negligible, and if the age pattern of mortality in the model life tables is mirrored in the mortality of the population, the sequence of model tables selected will scarcely differ in mortality level. (See United Nations 1967, and National Research Council 1980.)

For 1960–1966 and 1966–1970, forward projection was by six-year and four-year age intervals, respectively, utilizing West model life tables in single years of age constructed by Ruby Bussen at the East-West Population Institute. The final level of mortality selected was the median of the first 10 levels. For example, for 1955–1960, the median level was chosen from the life tables that produce the corrected total projection in 1960 at 5+, 10+, . . . , 50+ from the 1955 population.

Except for variation associated with apparent omission of young children and of young adult women, the sequence of mortality levels as calculated by forward projection is confined within rather narrow limits for females, but not for males (Table A-1). This approximate conformity of female but not male mortality to the West pattern is confirmed by the age-specific mortality schedule for 1971–1975 constructed from registered deaths adjusted for underregistration (see Table 8). The constructed intercensal life tables for females (a composite of forward projection with estimated infant mortality) are shown in Table A-2.

Because male survival was poorly matched by West model life tables, the calculation of adjusted populations by single years of age at the census dates was restricted to the female population. Since the principal purpose of the adjustments is to improve the estimation of fertility, corrected female age distributions are sufficient. When projected back to birth, the female cohorts provide estimates of annual female births; the number of male births is readily estimated on the assumption of a fixed sex ratio at birth.

TABLE A-1 Expectation of Life at Birth (West Model Tables) in Intercensal Life Tables Calculated by Census Survival Rates and Forward Projection, Males and Females: Republic of Korea

Table A-1a: 1955-1960

	MALE e_o		FEMALE e_o	
Age at Earlier Census	Proportion of Cohort Surviving	Forward Projection	Proportion of Cohort Surviving	Forward Projection
5	63.9	44.6	48.7	49.8
10	18.0	43.2	20.0	49.9
15	18.0	52.1	28.9	57.6
20	73.9	64.2	77.5	62.5
25	73.9	56.3	62.1	58.9
30	73.9	46.6	77.5	58.5
35	67.4	42.0	53.7	54.6
40	55.7	38.6	59.0	54.8
45	26.3	35.5	38.8	54.0
50	45.4	39.1	77.5	57.8
55	37.7	37.3	65.2	52.7
60	34.1	37.0	48.8	48.7
65	35.5	39.2	44.8	48.6
70	45.7	44.0	57.3	53.0

Table A-1b: 1960-1966

	MALE e_o		FEMALE e_o	
Age at Earlier Census	Proportion of Cohort Surviving	Forward Projection	Proportion of Cohort Surviving	Forward Projection
6	31.1	49.2	52.9	59.1
12	42.1	51.7	38.1	59.8
18	39.8	53.0	77.5	63.0
24	73.9	55.5	60.6	57.5
30	73.9	46.9	71.9	56.9
36	49.3	42.2	47.1	54.1
42	48.7	40.5	59.4	55.8
48	42.5	38.2	66.5	55.0
54	37.1	36.2	53.7	51.6
60	34.5	35.8	49.3	50.7
66	37.7	37.0	51.2	52.0

Table A-1c: 1966-1970

	MALE e_o		FEMALE e_o	
Age at Earlier Census	Proportion of Cohort Surviving	Forward Projection	Proportion of Cohort Surviving	Forward Projection
4	53.4	39.2	51.0	54.1
8	30.7	37.9	52.3	54.4
12	18.0	38.5	20.0	54.6
16	27.9	45.6	33.2	61.5
20	18.0	47.6	77.5	64.7
24	73.9	57.5	55.7	63.9
28	73.9	54.0	77.5	64.9
32	67.4	50.5	63.8	63.4
36	59.3	48.3	61.3	63.3
40	55.4	46.8	61.2	63.6
44	54.4	45.4	71.5	63.9
48	46.9	43.8	55.4	62.9
52	50.3	43.1	68.9	64.0
56	37.0	41.4	50.3	63.2
60	44.3	43.1	67.1	66.3
64	36.0	42.6	51.8	66.1
68	44.2	47.5	67.7	71.3
72	38.9	50.7	59.4	72.9

Table A-1d: 1970-1975[a]

	MALE e_o		FEMALE e_o	
Age at Earlier Census	Proportion of Cohort Surviving	Forward Projection	Proportion of Cohort Surviving	Forward Projection
5	67.7	50.7	77.4	60.8
10	18.0	49.3	20.0	59.7
15	73.7	57.4	59.1	67.3
20	54.1	56.0	77.5	68.2
25	73.9	56.3	60.0	66.2
30	73.9	51.3	76.9	67.0
35	60.6	46.9	68.0	65.7
40	52.0	44.3	69.7	65.4
45	51.4	42.9	61.9	64.7
50	44.0	40.8	70.5	65.2
55	37.1	39.7	51.8	64.1
60	39.0	41.0	65.5	67.9
65	40.2	42.4	65.0	68.9
70	40.5	44.4	66.0	70.7

[a]1975 age distributions are based on the 5-percent sample.

TABLE A-2 Intercensal Female Life Tables, Constructed by Splicing Mortality above Age 5 from Forward Projection with Mortality up to Age 5 from Reported Infant Mortality: Republic of Korea

Table A-2a: FEMALES 1955-1960, e_0 = 58.9

Age	1,000 $q(x)$	$l(x)$	$L(x)$
0	56.40	100,000	95,599
1	23.35	94,360	371,817
5	15.43	92,158	457,234
10	11.95	90,735	450,968
15	17.09	89,651	444,426
20	22.31	88,119	435,680
25	25.48	86,153	425,276
30	28.95	83,958	413,711
35	32.89	81,527	400,929
40	37.72	78,845	386,791
45	45.29	75,872	370,764
50	61.34	72,435	351,066
55	83.31	67,991	325,797
60	123.72	62,328	292,358
65	179.82	54,616	248,527
70	270.42	44,795	193,690
75	393.57	32,682	131,251
80	1,000.00	19,819	96,828

Table A-2b: FEMALES 1960-1966, e_0 = 60.4

Age	1,000 $q(x)$	$l(x)$	$L(x)$
0	52.57	100,000	95,838
1	20.77	94,743	373,963
5	13.55	92,777	460,744
10	10.52	91,520	455,194
15	15.15	90,558	449,356
20	19.87	89,185	441,493
25	22.80	87,412	432,080
30	26.02	85,419	421,541
35	29.83	83,196	409,780
40	34.66	80,716	396,584
45	42.28	77,918	381,353
50	57.71	74,623	362,351
55	79.04	70,317	337,691
60	117.94	64,759	304,704
65	173.23	57,122	260,872
70	262.61	47,227	205,129
75	385.35	34,825	140,575
80	1,000.00	21,405	106,836

Table A-2c: FEMALES 1966-1970, $e_O = 64.5$

Age	1,000 $q(x)$	$l(x)$	$L(x)$
0	41.40	100,000	96,583
1	13.38	95,860	380,195
5	8.91	94,578	470,784
10	6.95	93,736	467,051
15	10.33	93,085	463,018
20	13.79	92,123	457,439
25	16.04	90,853	450,619
30	18.56	89,396	442,828
35	21.90	87,736	433,878
40	26.55	85,815	423,379
45	34.17	83,536	410,546
50	47.77	80,682	393,776
55	67.26	76,828	371,222
60	101.88	71,661	340,050
65	154.72	64,360	296,904
70	240.50	54,402	239,302
75	361.83	41,319	169,218
80	1,000.00	26,368	140,272

Table A-2d: FEMALES 1970-1975,[a] $e_O = 67.2$

Age	1,000 $q(x)$	$l(x)$	$L(x)$
0	32.91	100,000	97,194
1	8.75	96,709	384,775
5	6.35	95,863	477,796
10	4.96	95,255	475,092
15	7.67	94,782	472,094
20	10.43	94,055	467,826
25	12.28	93,075	462,518
30	14.35	91,933	456,363
35	17.35	90,613	449,135
40	21.80	89,041	440,350
45	29.30	87,100	429,117
50	41.74	84,548	413,914
55	60.04	81,018	392,932
60	91.96	76,155	363,264
65	143.13	69,151	321,012
70	226.50	59,254	262,715
75	346.79	45,832	189,426
80	1,000.00	29,938	166,228

[a]Female 1975 age distribution is based on the 5-percent sample.

The Search for a Uniform Pattern of Understatement and Overstatement of Numbers by Age

If successive censuses were affected by similar patterns of exaggeration or understatement of numbers, the patterns should be visible in a comparison of what may be called survival ratios—the ratio of a census survival rate (the number of persons in a cohort recorded in a later census divided by the number recorded in an earlier census) to a life table survival rate (the corresponding fraction in the stationary population). This survival ratio can be expressed as

$$\frac{{}_nP_{a+n}(t+n)/{}_nP_a(t)}{{}_nL_{a+n}/{}_nL_a}\,. \qquad \text{(A-1)}$$

If a series of censuses with a constant intercensal interval were subject to similar errors, a plot of the survival ratios for each pair of censuses would exhibit more or less congruent fluctuations around 1.0.

There are two complications that impede the simple detection of the pattern of age misstatement in the Korean censuses. The more serious complication is the use in 1960 of a question on current age rather than date of birth; the less serious is the irregularity in intercensal intervals caused by the scheduling of a census in 1966 instead of 1965, which would have maintained five-year spacing. An attempt has been made to convert the ages reported in 1960 to Western ages by the following rule: the number at age x (last birthday) equals 11/12 the number listed at age $x + 1$ plus 1/12 the number listed at $x + 2$. This expedient for converting ages reported by the Chinese method of reckoning is an improvement on the ages as listed, but it is clearly not successful in reconstructing the age distribution into what would have been obtained by asking date of birth. The single-year survival ratios for 1955–1960 and 1960–1966 are erratic in ways that clearly show the different (and much larger) misreporting in 1960. The large and idiosyncratic undercounts and overcounts in 1960 are confirmed in our final estimates (see Figure A-12).

Because of the different basis for the determination of age in 1960, the search for a recurrent pattern of misstatement was confined to the censuses of 1966, 1970, and 1975 (the last available in the form of a 5-percent sample tabulation). The survival ratios for 1966–1970 and 1970–1975 are surprisingly variable and have a puzzling lack of similarity from one pair of censuses to the next (Figure A-1). Recall that if every cohort had been enumerated each time with the same completeness, all of the ratios would be very close to 1.0. The ratios oscillate irregularly around 1.0 above age

25, but are more than 1.0 at the two youngest ages, less than 1.0 in the early teens, and more than 1.0 around age 20. The most puzzling feature is the large amplitude and irregular ups and downs over the full span of ages, often quite different in detail for 1966–1970 and 1970–1975. The failure of the bumps and hollows to coincide was at first thought to be the result of the different duration of the intercensal intervals: for example, the cohort aged 15 in 1966 would be 19 in 1970, but a cohort aged 15 in 1970 would be 20 in 1975. Even after allowance for this difference, however, no simple hypothesis of heaping or avoidance at particular ages explains the differences in the two sets of ratios.

The Effect of the Chinese Calendar on Age Misreporting

In puzzling over this irregular pattern, Lee-Jay Cho speculated that some of the respondents had reported the Chinese year of birth rather than the Western year. According to the prescribed procedures, the date of birth was to be converted to the Western calendar before age was calculated. This conversion was necessary to prevent the recording of artificially large cohorts in some years and artificially small cohorts in others. The normal Chinese year consists of 12 lunar months, containing some 354 days. The calendar is kept in phase with the evolution of solar years by the insertion at irregular intervals of a Chinese leap year containing 13 lunar months. If seasonality of births is not quantitatively important, Chinese leap years contain 13/12 as many births as non-leap years, or 8.33 percent more. The prescribed conversion to a Western calendar avoids the creation of cohorts artificially enlarged or diminished (except for the trivial effect of one extra day in Western leap years). Retention of the Chinese calendar instead of conversion to the Western calendar would not explain the peculiarities in the sequence of survival ratios, however, since a cohort born in a leap year would be too large each time it was counted.

The hypothesis that the irregular survival ratios were somehow the result of imperfect conversion from the Chinese calendar was too tantalizing to abandon. It was recalled that there was hearsay evidence that the 1970 census had been less meticulously conducted in some respects than the censuses of 1966 and 1975. It was assumed, as a working hypothesis, that conversion of date of birth to the Western calendar had been neglected, or incompletely applied, in 1970, but not in 1966 or 1975. According to this hypothesis, leap-year cohorts would be inflated, and non-leap-year cohorts diminished, in 1970, but not in the other two years. The result would be high survival ratios for leap-year cohorts in 1966–1970 and low survival ratios for such cohorts in 1970–1975.

In Figure A-1, triangles appear above the survival ratios of leap-year

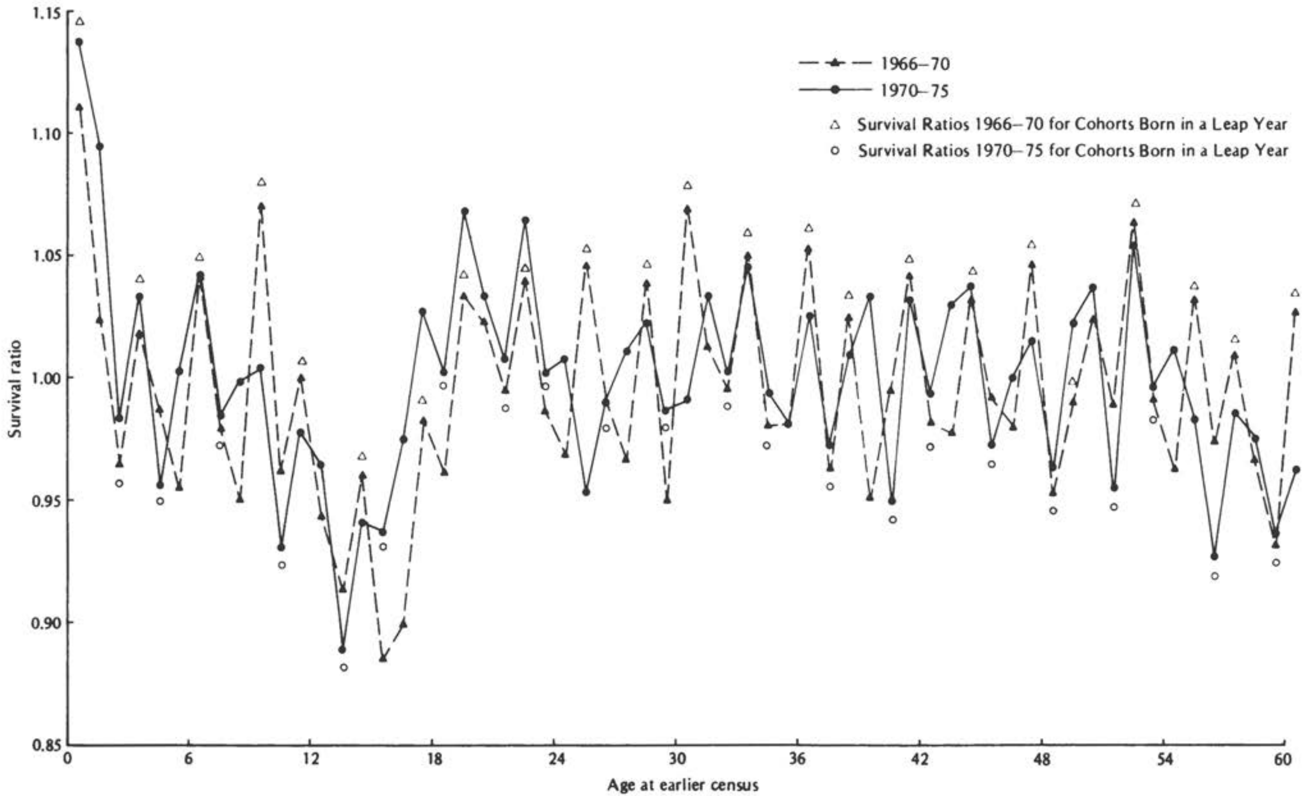


FIGURE A-1 Survival ratios (ratio of census survival rates to life table survival rates), females, 1966–1970 and 1970–1975: Republic of Korea.

cohorts in 1966–1970, and circles appear below the survival ratios of leap-year cohorts in 1970–1975. With one exception (age 49), triangles correspond to high points in the survival ratios for 1966–1970, and with only two exceptions, the circles correspond to dips in the survival ratios for 1970–1975. The missing dips (at ages 26 and 34) are concealed by still greater dips at ages 25 and 35. As will be shown below, there was a tendency in 1975 (and in 1966) to understate numbers of persons at ages above 20 divisible by 5, and a slight opposite tendency in 1970. The resultant dips in survival ratios have nothing to do with leap years. (See Appendix B for a comparison of the 5-percent sample with the complete enumeration of the 1975 female age distribution with respect to the survival ratios.)

The coincidence of peaks and troughs in Figure A-1 with the predicted locus of high and low ratios leaves no room for doubting that conversion to the Western calendar was less complete in 1970 than in the other censuses. Adjustment factors to normalize the number of persons in 1970 were calculated as follows: the survival ratio from 1966 to 1970 of each leap-year cohort was divided by the mean value of the survival ratios for the two adjacent cohorts to form an estimate of the excess size of leap-year cohorts. (Since leap years never occur consecutively, the adjacent cohorts are always non-leap-year cohorts.) The excess size of female leap-year cohorts so calculated is shown in Figure A-2.

The median value of excess size for female cohorts was 1.062; the corresponding median for males was 1.058. Since leap-year cohorts exceed non-leap-year cohorts by 8.33 percent, the excess numbers just calculated would have averaged 1.0833 had all dates of birth in 1970, and none in 1966, been given on the Chinese calendar. If the 1970 census is accepted as the culprit, the median of 1.06 implies that 6.0/8.33 or 72 percent of dates of birth were reported in this way in 1970. A Chinese leap year is 5.1 percent longer than a Western year; other Chinese years, consisting of 12 lunar months, are 97.0 percent as long as a Western year. Thus, the number of persons at any age corresponding to a Chinese leap year in 1970 was divided by $1 + (.72)(.051)$ and the number born in intervening years divided by $1 - (.72)(.03)$. The 1970 age distribution adjusted for the effect of the Chinese calendar is presumably subject to defects one might expect to be shared by the adjacent censuses. In Figure A-3 survival ratios for 1966–1970 and 1970–1975 are shown after the 1970 female age distribution has been adjusted for the effects of years of nonconstant length in the Chinese calendar. The two sequences are much less irregular than in Figure A-1 (before such adjustment); the low points for 1970–1975 at 20, 25, 30, 35, and 40 are now clearly visible. Further search for overstatement

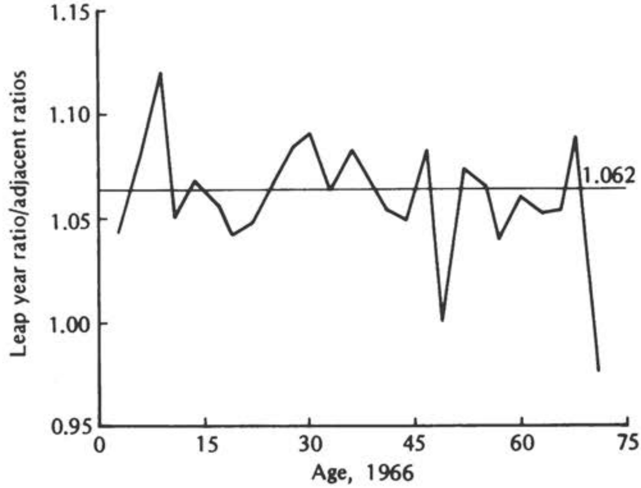


FIGURE A-2 Survival ratios, 1966–1970, of female leap-year cohorts divided by the mean survival ratio of adjacent cohorts: Republic of Korea.

and understatement of numbers uses the 1970 data adjusted in this manner.[4]

These adjustments may not have removed completely the effect of the Chinese calendar on the reported size of cohorts. The corrections applied to data from the 1970 census ensure allowance only for the conspicuous excess resulting from the use of the Chinese calendar in that census; there is no correction for whatever slight tendency there may have been for reporting year of birth by that calendar in 1966 and 1975. However, we have examined the median size of leap-year cohorts relative to the median size of their neighbors (see Table A-3) and find no systematic remaining excess.

Estimation of Relative Overstatement or Understatement of Numbers in Five-Year Age Intervals in 1966, 1970, and 1975

We now return to a search for similarities in the pattern of errors in the reporting of the female age distribution in consecutive censuses. It is evident in Figure A-3 that there must have been differences in patterns of overstated or understated numbers at individual ages among the three censuses since 1966. It was therefore decided to break up the estimation of the correct age distributions into two steps: first, to estimate relative

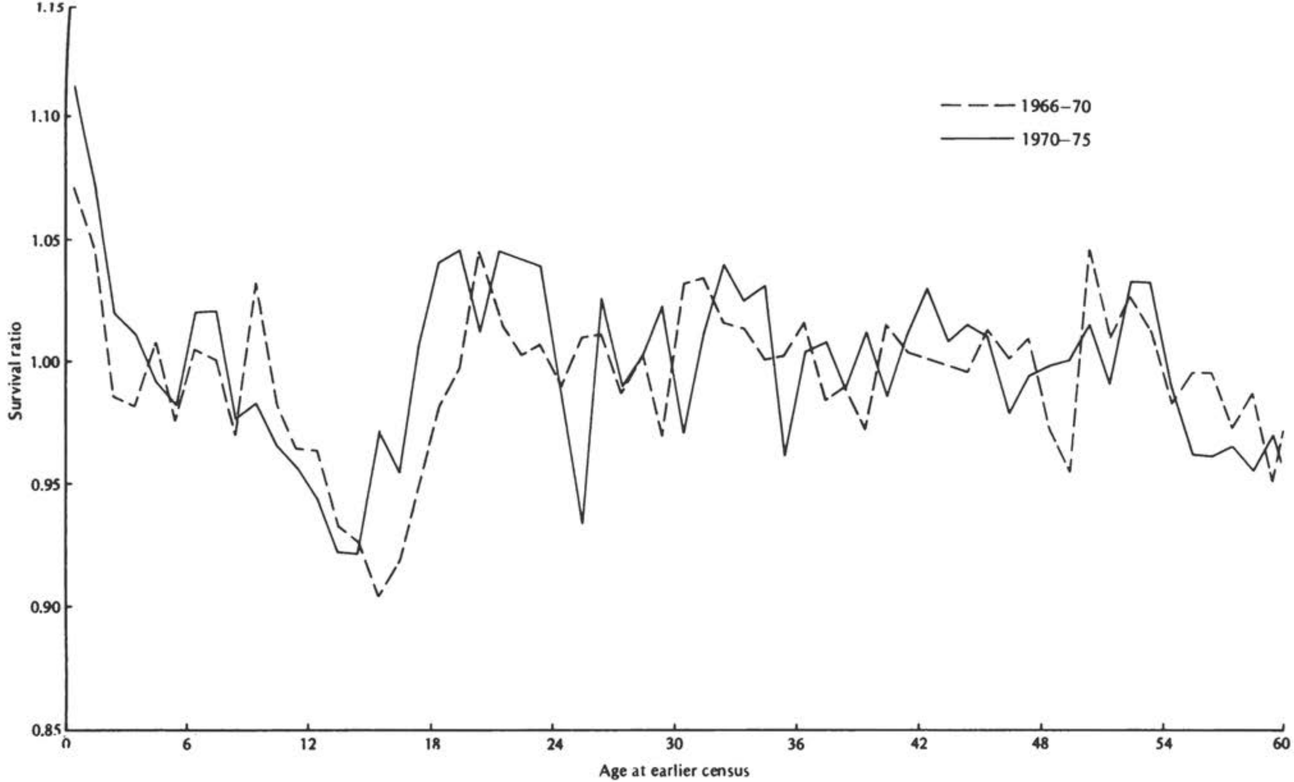


FIGURE A-3 Survival ratios, females, 1966–1970 and 1970–1975, with numbers in 1970 adjusted for leap years: Republic of Korea.

TABLE A-3 Single-Year Age Distribution within Five-Year Age Groups, by Cohort, 1966, 1970, and 1975: Republic of Korea

	1966			1970			1975[a]				
	Percent of Five-Year Age Groups			Percent of Five-Year Age Groups			Percent of Five-Year Age Groups		Age in	Median Percent	
Age	Male	Female	Age	Male	Female	Age	Male	Female	1970[b]	Male	Female[c]
1	18.4	18.4	5	19.1	19.2	10	18.9	18.9	5	18.9	
2	19.3	19.4	6	19.1	19.2	11	19.4	19.6	6	19.4	
3	20.9	20.7	7	20.5	20.4	12	21.0	20.9	7	20.8	
4	20.4	20.4	8	20.7	20.6	13	20.4	20.2	8	20.4	
5	21.0	21.1	9	20.6	20.6	14	20.3	20.4	9	20.6	
6	21.8	21.9	10	22.1	22.1	15	22.6	22.6	10	22.1	
7	21.2	21.2	11	21.4	21.2	16	21.6	21.6	11	21.3	
8	21.0	21.0	12	20.4	20.4	17	20.9	20.4	12	20.7	
9	18.2	18.1	13	18.7	18.7	18	18.3	18.3	13	18.3	
10	17.8	17.8	14	17.4	17.6	19	16.5	17.1	14	17.5	
11	24.9	24.8	15	25.7	25.5	20	24.0	24.8	15	24.8	
12	20.9	20.9	16	21.7	21.4	21	21.7	20.4	16	21.2	
13	18.5	18.5	17	18.5	18.3	22	18.7	18.4	17	18.5	
14	19.8	19.7	18	19.2	19.4	23	20.6	20.1	18	19.7	
15	16.0	16.2	19	15.0	15.5	24	15.0	16.2	19	15.8	
16	21.3	21.4	20	19.6	20.2	25	19.9	19.9	20	20.1	
17	20.7	20.6	21	20.0	20.0	26	20.1	20.4	21	20.2	
18	20.9	20.5	22	21.8	20.7	27	20.4	21.0	22	20.8	
19	20.2	20.3	23	21.0	20.8	28	21.5	21.0	23	20.9	
20	17.0	17.1	24	17.7	18.3	29	18.0	17.6	24	17.7	
21	20.0	18.7	25	18.7	18.9	30	18.2	17.7	25	18.7	
22	20.6	18.9	26	18.2	18.9	31	19.7	19.4	26	19.2	
23	20.8	19.3	27	19.5	19.4	32	19.1	19.3	27	19.3	
24	19.9	22.0	28	22.3	21.6	33	21.8	21.8	28	21.8	
25	18.7	21.1	29	21.3	21.2	34	21.2	21.8	29	21.2	
26	20.2	20.4	30	20.6	20.6	35	19.6	19.8	30	20,3	
27	20.5	20.9	31	20.5	20.7	36	20.5	20.6	31	20.5	
28	20.0	19.7	32	20.1	19.7	37	20.9	20.2	32	20.1	
29	20.3	20.3	33	19.5	19.7	38	19.6	19.8	33	19.7	
30	19.0	18.7	34	19.2	19.3	39	19.5	19.6	34	19.3	
31	22.7	21.8	35	23.1	22.3	40	22.7	21.6	35	22.7	21.8
32	21.7	20.9	36	21.7	20.9	41	22.0	21.2	36	21.7	20.9
33	19.2	18.9	37	19.3	18.9	42	19.2	19.2	37	19.2	18.9
34	19.6	20.3	38	19.3	20.0	43	19.3	19.9	38	19.3	20.0
35	16.8	18.2	39	16.6	18.0	44	16.8	18.2	39	16.8	18.2

Table A-3 (Continued)

	1966			1970			1975[a]				
	Percent of Five-Year Age Groups			Percent of Five-Year Age Groups			Percent of Five-Year Age Groups		Age in 1970[b]	Median Percent	
Age	Male	Female	Age	Male	Female	Age	Male	Female		Male	Female[c]
36	21.2	21.1	40	21.5	21.6	45	21.0	21.1	40	21.1	
37	21.6	21.6	41	21.6	21.4	46	21.0	21.5	41	21.6	
38	19.8	19.8	42	19.5	19.7	47	20.5	20.1	42	19.8	
39	19.2	19.4	43	18.8	18.9	48	18.8	18.9	43	18.9	
40	18.2	18.1	44	18.5	18.4	49	18.8	18.5	44	18.5	
41	19.6	20.7	45	19.8	20.8	50	19.8	21.2	45	19.8	20.8
42	19.9	20.3	46	20.2	20.3	51	20.3	20.0	46	20.2	20.3
43	21.1	20.8	47	21.2	20.7	52	21.6	20.6	47	21.2	20.7
44	20.3	19.6	48	20.0	19.5	53	19.7	19.5	48	20.0	19.5
45	19.0	18.6	49	18.9	18.7	54	18.6	18.7	49	18.9	18.7
46	22.6	22.2	50	22.9	22.4	55	23.3	22.6	50	22.9	22.4
47	19.3	18.5	51	19.4	18.8	56	19.6	18.4	51	19.4	18.5
48	19.3	19.4	52	19.0	19.0	57	18.9	19.3	52	19.0	19.3
49	19.6	20.4	53	19.0	19.5	58	19.5	19.8	53	19.5	19.8
50	19.2	19.5	54	19.6	20.4	59	18.7	19.8	54	19.2	19.8
51	21.5	21.1	55	21.8	21.4	60	22.6	21.7	55	21.6	
52	20.0	19.4	56	20.3	19.9	61	20.3	20.0	56	20.0	
53	19.8	20.2	57	20.2	20.3	62	20.4	20.3	57	20.2	
54	19.8	20.1	58	19.2	19.6	63	19.0	19.3	58	19.4	
55	19.0	19.1	59	18.4	18.8	64	17.6	18.7	59	18.8	
56	23.1	22.1	60	23.8	22.7	65	23.6	21.8	60	23.6	22.1
57	22.0	21.4	61	22.0	21.4	66	23.8	21.6	61	22.0	21.4
58	19.7	19.7	62	19.9	19.8	67	19.3	20.0	62	19.7	19.8
59	17.1	18.1	63	16.6	17.4	68	15.9	17.6	63	16.6	17.6
60	18.0	18.7	64	17.7	18.7	69	17.4	19.0	64	17.7	18.7

[a]1975 age distributions are based on the 5-percent sample.

[b]For ages 0-4 in 1970 the median percent is based solely on ages 5-9 in 1975 as follows:

Age in 1970	*Median Percent*
0	20.5
1	20.5
2	20.2
3	19.2
4	19.7

[c]Equal to male values except where indicated.

undercounts by five-year age groups, thereby smoothing out many of the differences from census to census at individual ages; and second, to utilize the repeated enumeration of each cohort in the three censuses to estimate the size of each single-year cohort relative to the larger cohort spanning several ages of which it is a member. (These steps are described in more detail below.)

If one abstracts from the individual peaks and hollows in the series of points in Figure A-3, one can see a pattern of census survival ratios: well above 1.0 at ages 0 and 1, varying around 1.0 from about age 3 to 10 or 11, falling below 1.0 through the mid-teens, climbing above 1.0 again in the late teens or early twenties, and finally returning to variations around 1.0 from the late twenties on, at least into the fifties. The ratios for the two intercensal periods have a similar general structure, although the ratios are higher for 1970–1975 at the first two ages, somewhat lower in the early teens, and generally higher from the mid-teens until the mid-twenties. The general similarity of pattern suggests that indeed there may have been similar rates of relative omission in the three censuses by broad age groups. In Figure A-4 the ratios of census survival rates to life table survival rates are shown by age intervals of a length that corresponds to the duration of the intercensal interval, namely four-year age intervals from 1966 to 1970 and five-year age intervals from 1970 to 1975.

In Figure A-4 the irregularities caused by particular features of single-year enumeration are to a large extent canceled out. The higher ratio of census to life table survival rates in early childhood for the second intercensal period is evident, as are the other differences noted from Figure A-3. The sawtooth pattern of alternate ups and downs after age 20 for the second intercensal period reflects an apparent tendency for slightly more complete enumeration in the latter half of each age decade: the fraction apparently surviving from ages ending in numerals 0–4 to ages ending in numerals 5–9 is always higher than in a life table, whereas apparent survival from ages ending in 5–9 to those ending in 0–4 is always somewhat lower than in a life table. This tendency could be the result of a reluctance to report a year of birth that puts the individual into the next age decade. This tendency shows up less clearly in survival rates from 1966 to 1970 because the four-year time interval requires the use of four-year age intervals that do not mesh with age decades, as do quinquennial age intervals.

To estimate relative completeness of enumeration by grouped ages in the three censuses, we used an adaptation of a method first employed by Demeny and Shorter (1968) in estimating the true age distributions in a series of censuses in Turkey. The procedure generates estimates of the completeness of enumeration by age intervals of the same length as the

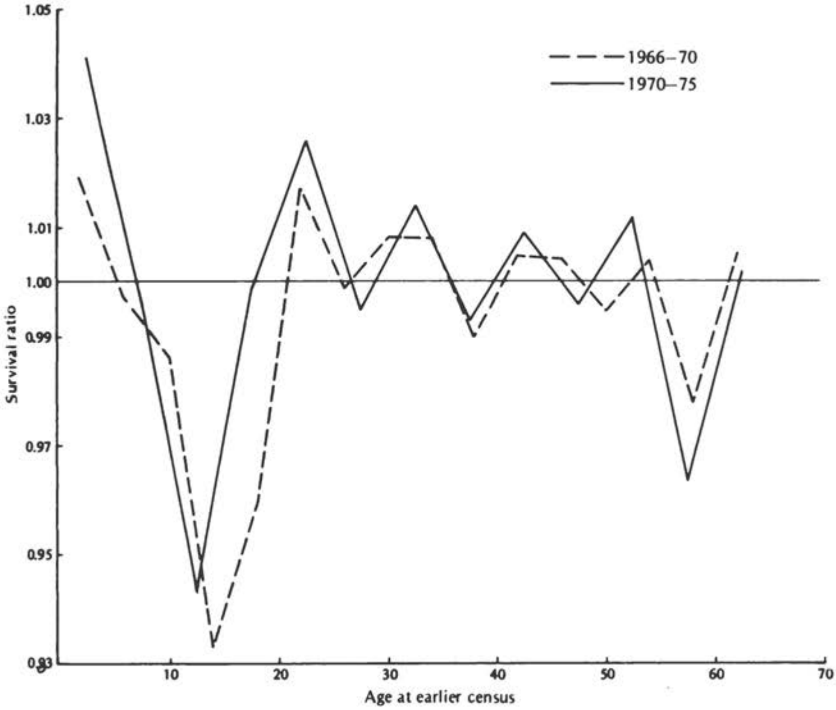


FIGURE A-4 Survival ratios, females, 1966–1970 and 1970–1975, by four-year and five-year age intervals, respectively: Republic of Korea.

interval between two consecutive censuses, on the basis of estimated survival rates for the intercensal period and an assumption that the completeness of enumeration of each age group is the same in each of the two censuses.

Details of the Demeny-Shorter Method of Adjusting Age Distributions

Suppose that the numbers of persons enumerated in the first of two censuses in age intervals 1, 2, 3, 4, . . . are designated as A_1, A_2, A_3, A_4, . . . , and in the second of two censuses as B_1, B_2, B_3, B_4, ... The width of the age intervals is equal to the time difference between the dates of the two censuses. This choice of intervals implies that persons in the second age interval in the second census (B_2) are the survivors of the group A_1 in the first census. Suppose that the survival factors p_1, p_2, p_3, . . . , which denote the proportions surviving from the first age interval to the second, and so on, are known. Now make the provisional assumption (subject to later change) that the number of persons in the first census and the earliest age interval (A_1) is correctly recorded; then designate the correct number of persons by an asterisk: we thus assume provisionally that $A_1^* = A_1$. Then $B_2^* = p_1 A_1^*$, and the adjustment factor needed to correct any error in B_2 is $R_2 = B_2^*/B_2$.

The adjustment factor R_2 can then be used to multiply A_2 to generate an estimate of A_2^*. Repeated application of this procedure creates an adjusted population at all ages, based on the stated assumptions of knowledge of the correct survival rates, the existence of the same degree of completeness of enumeration at each age interval in the two censuses, and the provisional assumption that A_1^* equals A_1. We may now form the sum of all of the values of A_i^* to get a provisional estimate of the total population. To obtain estimates of *relative* undercount (which is all that this system can yield unless there is independent evidence of the completeness of coverage of some segment of the population), the values of A_i^* can be normalized by multiplying each A_i^* by a scalar so chosen that the sum is the same as the recorded total population. This normalization will rectify whatever error is introduced by the original provisional assumption that A_1^* equals A_1. For example, if A_1 were really undercounted by 10 percent, the provisional estimate of B_2^* would be 10 percent too small. This shortfall would lead in turn to a reduction by 10 percent of all of the subsequent values of A_i^*, and the sum of the set of A_i^*'s would also be 10 percent too small. Normalization would increase A_1^*, (and all A_i^*'s) by 10 percent. In other words, the provisional assumption makes no difference to the final set of estimated adjustment factors.

Application of Demeny-Shorter Procedure to the Korean Censuses of 1966, 1970, and 1975

Because of the noncomparability of the determination of age in the 1960 census with other censuses, the use of the Demeny-Shorter procedure was limited to the intercensal periods 1966–1970 and 1970–1975. Survival rates were taken from the life tables previously described. Adjustment factors (R_i) were generated for four-year age intervals for 1966–1970, and for five-year intervals for 1970–1975. The R_i's for 1966–1970 have been rather crudely converted to five-year intervals by linear interpolation. The calculated R_i's by five-year intervals for 1966–1970 and 1970–1975 are shown in Table A-4 along with the ratios of the R_i's in the two intercensal intervals. Since 1970 belongs to both intercensal intervals, the assumption of similar patterns of completeness of enumeration by age in each pair of censuses implies that the two sets of R_i's should be essentially the same. As

TABLE A-4 Calculated Preliminary Adjustment Factors (R_i), Females 1966-1970 and 1970-1975,[a] before and after Special Corrections: Republic of Korea

Table A-4a: R_i Adjustments before Special Corrections

Age Group	1966-1970	1970-1975	Ratio
	(1)	(2)	(1) ÷ (2)
0-4	0.9559	1.0088	0.948
5-9	0.9428	0.9694	0.973
10-14	0.9527	0.9732	0.979
15-19	1.0128	1.0320	0.981
20-24	1.0650	1.0334	1.031
25-29	1.0510	1.0077	1.043
30-34	1.0466	1.0127	1.033
35-39	1.0363	0.9982	1.038
40-44	1.0438	1.0050	1.039
45-49	1.0381	0.9959	1.042
50-54	1.0384	0.9999	1.039
55-59	1.0373	0.9883	1.050
60-64	1.0594	1.0268	1.032

Table A-4b: R_i Adjustments after Special Corrections

Age Group	1966-1970	1970-1975	Ratio
	(1)	(2)	(1) ÷ (2)
0-4	0.9975	0.9984	0.999
5-9	0.9798	0.9786	1.001
10-14	0.9901	0.9825	1.008
15-19	1.0419	1.0418	1.000
20-24	1.0399	1.0432	0.997
25-29	1.0236	1.0173	1.006
30-34	0.9956	0.9971	0.998
35-39	0.9788	0.9829	0.996
40-44	0.9859	0.9895	0.996
45-49	0.9805	0.9806	1.000
50-54	0.9808	0.9845	0.996
55-59	0.9798	0.9731	1.007
60-64	1.0006	1.0110	0.990

Special corrections:
1966, 15-19: 0.950
25-29: 0.965
1970, 0-4: 1.020
25-29: 0.990
1975, 30-34: 1.015

[a]Female 1975 age distribution is based on the 5-percent sample.

the ratio column in Table A-4a makes clear, however, the R_i's for the first intercensal period are a few percent lower than in the second intercensal period for ages up to the mid-teens and then rise to a set of values that are more or less uniformly higher at ages above 30. The almost uniform ratios for the early part of the age span and for the later part of the age span suggest that there are only a few ages (from about 15 to 30) in which there is an important deviation from the assumption of a similar pattern of errors in the three censuses. In other words, there must have been a difference in completeness of reporting at early adult ages among the three censuses. This difference is also evident from Figure A-4, in which it can be seen that the undercount of those aged 0–4 in 1970 relative to those aged 5–9 in 1975 was greater than the undercount of very young children in 1966 compared to their later enumeration in 1970. Similarly, the enumeration of women in their early twenties in 1970 was more deficient relative to enumeration of women in their late teens in 1966 than the approximately corresponding age groups in the censuses in 1970 and 1975.

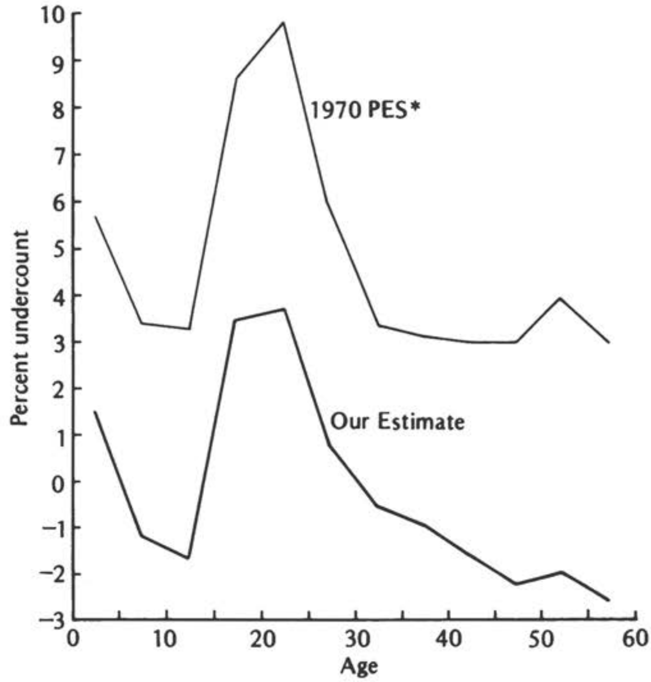
The Demeny-Shorter procedure is predicated on proportionate understatements and overstatements that are the same in consecutive censuses; the method creates the adjustment factors implied by this assumption. The two sets of R_i's for 1966–1970 and 1970–1975 should both be applicable to 1970 and thus should be equal. The discrepancies between the R_i's in Table A-4a are the result of particular differences in understatement or overstatement at certain ages among the three censuses. After experimentation with various possible choices, special individual adjustments were made to particular age groups in the three censuses so as to make the two sets of R_i's nearly equal. The aim was to introduce a minimum of special adjustments and yet to assure essential uniformity in the two sets of R_i's. The special adjustments listed at the bottom of Table A-4 were constructed by eliminating the major inconsistencies between the 1966–1970 and the 1970–1975 survival ratios shown in Figure A-4. They include the assumptions that in 1966 the age intervals 15–19 and 25–29 were undercounted less than in the other censuses (5 percent for the former group and 3.5 percent for the latter); that in 1970 the age group 0–4 was undercounted by an extra 2 percent and the age group 25–29 was undercounted by 1 percent less; and that in 1975 the age group 30–34 was subject to an extra 1.5 percent undercount. These special adjustments led to sets of R_i's for the two intercensal levels that differed by less than 1 percent (Table A-4b).

The special adjustments and the resulting R_i's were then applied to the reported five-year age distributions in the three censuses to yield provisional estimates of the female age distribution by five-year intervals. For 1966 the R_i's of 1966–1970 were applied; for 1975 the 1970–1975 R_i's were applied; and for 1970 the average of the two. The nature of the adjustments guarantees that, within the limits of interpolation and averaging, the adjusted size of every cohort was necessarily consistent across the three censuses.

As was noted earlier, the adjustments just described provide indications only of *relative* undercounts and overcounts. If the censuses in addition are subject to an overall omission rate of several percent, the calculated R_i's would be unaffected. In Figure A-5, the estimated undercounts in 1970 have been arbitrarily adjusted (by multiplication of the adjusted populations by an appropriate constant) to yield complete coverage, on the average, of ages 5–14 in 1975. The set of estimated undercounts by age was compared with estimates derived from the Post-Enumeration Survey (PES) of the 1970 census (Cho 1974b). The PES consisted of an intensive recanvass of a representative sample of districts to produce in these areas an independent list of persons classified by age and sex; this list was checked against the census list of the same persons on a name-by-name basis. Despite the wholly different basis of the figures, our estimated pattern of undercounts by age agrees closely with the PES results: both sets of estimates show the particularly high undercounts in the age groups 0–4, 15–19, 20–24, and 25–29, as well as the less marked peak in the age group 50–54.

Estimates of Single-Year Female Age Distribution in 1966, 1970, and 1975

To achieve the goal of estimating fertility from the age distribution for 1955–1975, the most important need is an accurate determination of the number of persons at individual ages for those under 20 in 1975 and under 15 in 1970. It would be advantageous as a contribution to more accurate knowledge of the Korean population to have estimates of the number of persons at other individual ages as well. Therefore, single-year estimates were constructed. The size of each single-year cohort relative to the size of the five-year cohort of which it is a member was determined in each census (1966, 1970, and 1975) for each sex. At any given census, a single-year cohort might be counted as unusually large or unusually small either because of genuine differences in cohort size or because of peculiarities in the count for that particular age and sex in that year. However, with three census age distributions for each sex, there are six records of the relative size of the cohort over a five-year time interval. Except for the ages of high mortality, in infancy and at the end of the span of life, the relative sizes of a single-year cohort and the five-year cohort to which it belongs would not change very much between 1966 and 1975. In effect, then, the six figures



*Based on Cho (1974b: Table 1-4b).

FIGURE A-5 Estimated female undercounts (percent) by five-year age group in the 1970 census: comparison with Post-Enumeration Survey: Republic of Korea.

for relative size (three censuses and two sexes) are six values of a number that in each instance would be approximately the same if all the data were accurate. The median of the six values was selected as the final estimate of the relative size of each cohort.[5] The median ratio of the size of each single-year cohort to the size of the five-year cohort was applied to the appropriate corrected five-year age group to estimate the number at each individual age.

The relative sizes of the single-year cohorts and the five-year age groups in the three censuses are shown for the population that was aged 1–60 in 1966 in Table A-3. Note that for most cohorts the ratio varies only slightly from census to census. Note in particular that certain cohorts (for example, those that were aged 5, 13, 14, 17, and 19 in 1970) are seen as consistently small and that others (e.g., those that were 10 and 15 in 1970) are consistently large.

After corrected single-year distributions of the female population had been constructed, it was a matter of simple reverse projection (utilizing life tables already constructed) to calculate single-year age distributions at the dates of the censuses of 1955 and 1960. Because of the awkwardness arising from the four-year interval between the 1966 and 1970 censuses, the single-year estimates for 1966 were rederived by reverse projection from 1970. Figures A-6 through A-10 show the recorded and adjusted age distributions at all five censuses, and Figures A-11 through A-15 show the estimated undercounts by age. In Figures A-11 and A-12, cohorts born in leap years are indicated by a dot below the estimated undercount. Note that leap-year cohorts were usually overcounted (or undercounted less than neighboring cohorts) in 1955 and also in 1960, despite the different basis for age determination in the latter census. Percent undercounts by single years of age for females in all five censuses are also given in Table A-5. (The overall level of undercounts is set by an arbitrary assumption of complete coverage, on the average, at ages 5–14 in 1975.)

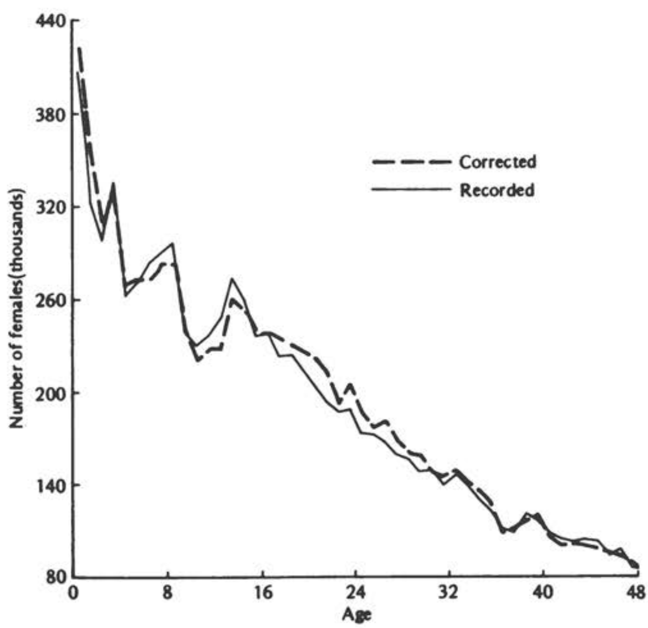


FIGURE A-6 Recorded and corrected female age distribution, 1955 census: Republic of Korea.

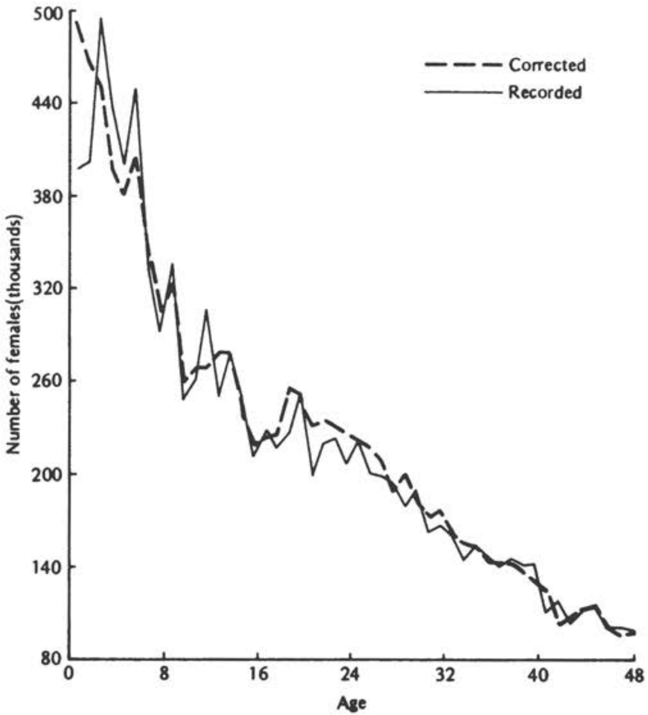


FIGURE A-7 Recorded and corrected female age distribution, 1960 census: Republic of Korea.

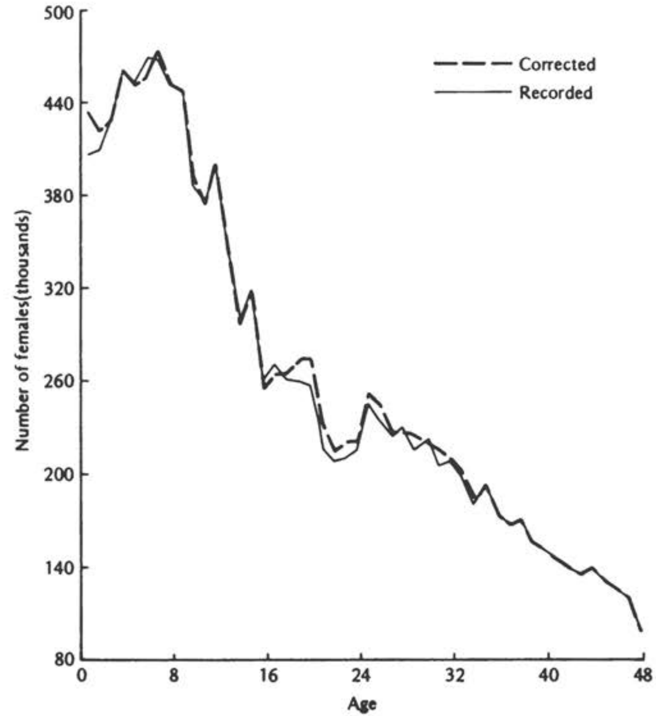


FIGURE A-8 Recorded and corrected female age distribution, 1966 census: Republic of Korea.

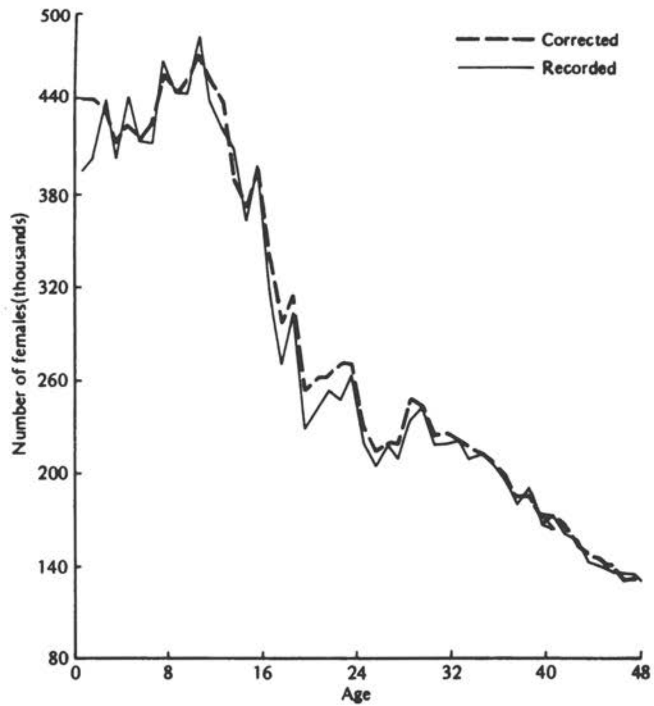


FIGURE A-9 Recorded and corrected female age distribution, 1970 census: Republic of Korea.

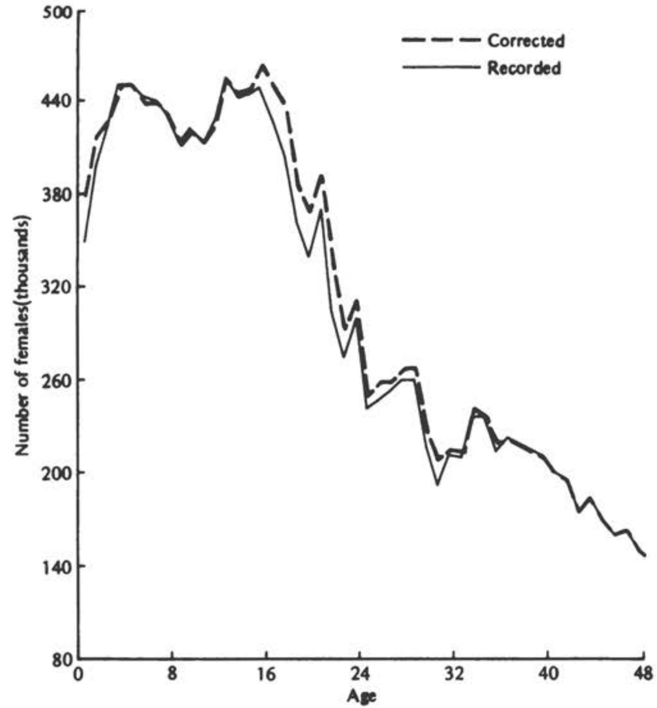


FIGURE A-10 Recorded and corrected female age distribution, 1975 census: Republic of Korea.

NOTE: Recorded data are as recorded in the 5-percent sample age distribution.

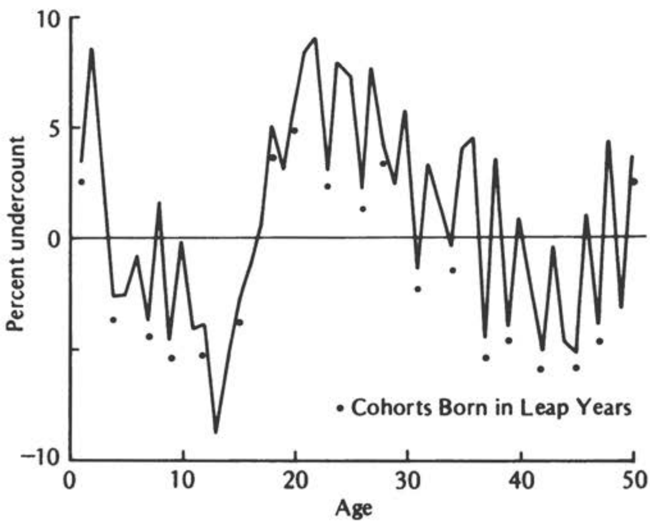


FIGURE A-11 Percent undercount by single years of age, females, 1955 census: Republic of Korea.

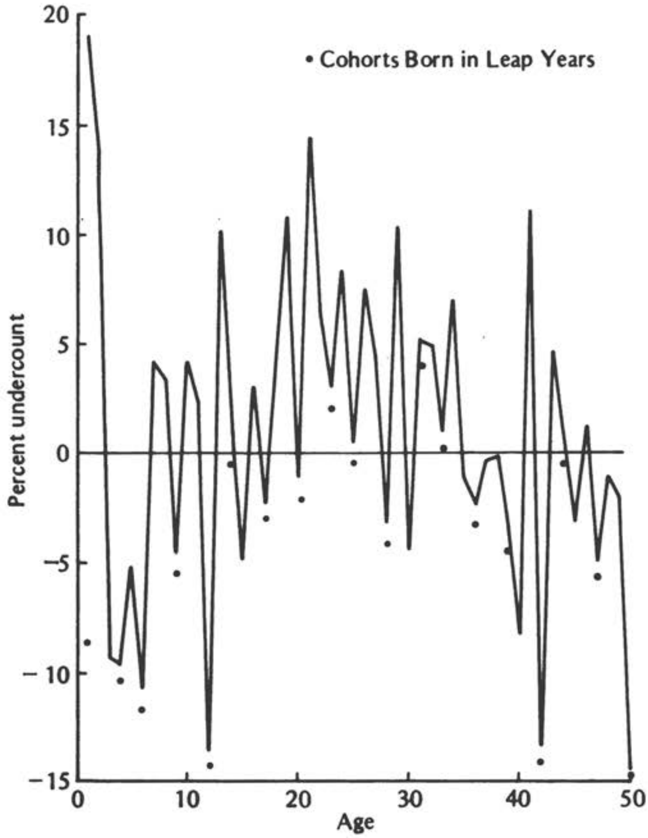


FIGURE A-12 Percent undercount by single years of age, females, 1960 census: Republic of Korea.

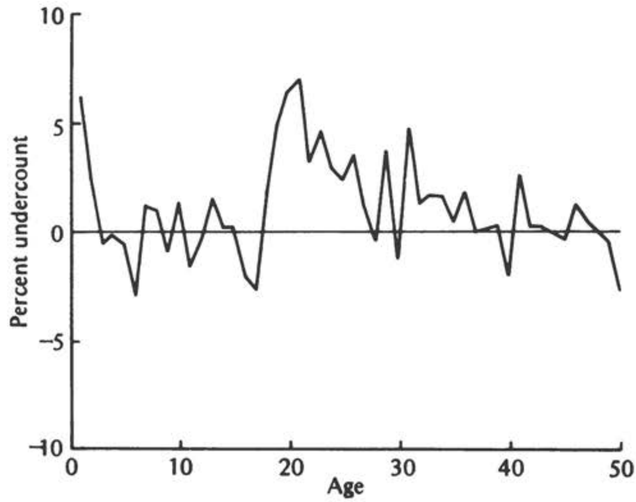


FIGURE A-13 Percent undercount by single years of age, females, 1966 census: Republic of Korea.

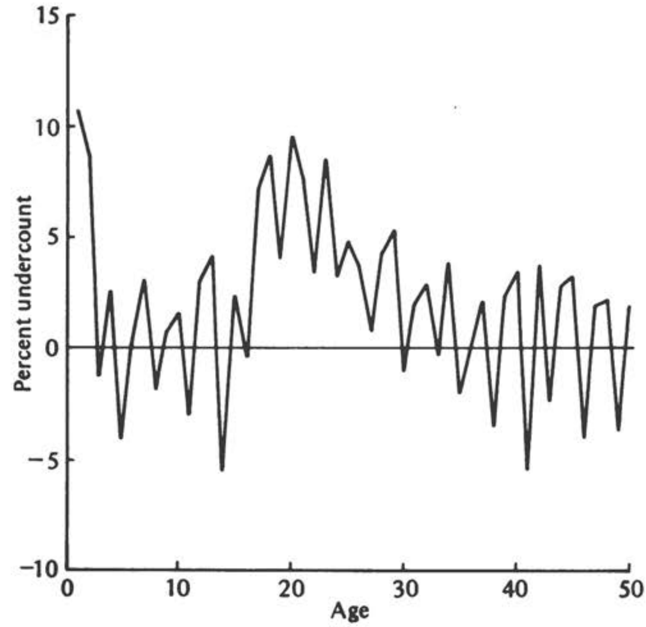


FIGURE A-14a Percent undercount by single years of age, females, 1970 census: Republic of Korea.

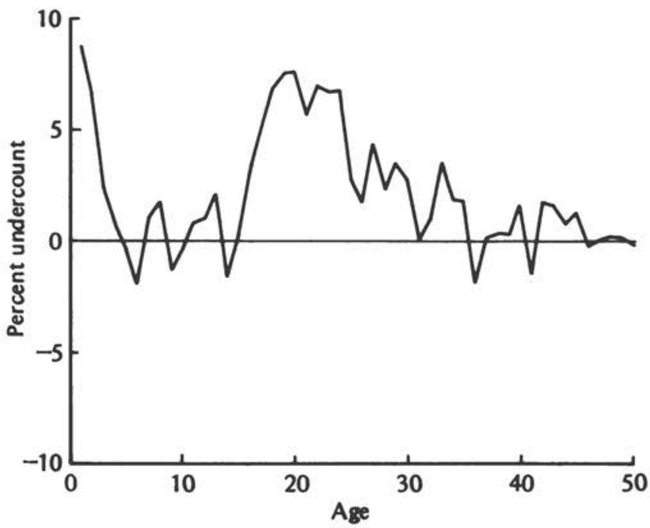


FIGURE A-14b Percent undercount by single years of age after correcting for leap years, females, 1970 census: Republic of Korea.

TABLE A-5 Percent Undercounts[a] by Single Years of Age for Females, 1955, 1960, 1966, 1970, and 1975 Censuses: Republic of Korea

Age at Census	1955	1960	1966	1970	1975[b] 5-Percent Sample	1975[b] Complete Count
0	3.6	19.1	6.3	10.7	–	–
1	8.6	13.8	2.5	8.5	–	–
2	3.2	-9.3	-0.4	-1.2	–	–
3	-2.6	-9.6	-0.0	2.6	–	–
4	-2.5	-5.2	-0.5	-4.1	–	–
5	-0.7	-10.7	-3.0	0.2	-0.9	-0.6
6	-3.6	4.3	1.2	3.1	-0.1	-1.2
7	1.6	3.4	1.0	-1.9	0.4	0.1
8	-4.4	-4.5	-0.9	0.8	-0.7	-0.8
9	-0.0	4.2	1.5	1.7	0.3	0.8
10	-4.1	2.4	-1.5	-2.9	-0.1	-0.5
11	-3.9	-13.6	-0.3	3.0	-0.9	0.8
12	-8.6	10.3	1.5	4.2	-0.3	0.4
13	-5.2	0.9	0.2	-5.4	0.9	1.8
14	-2.7	-4.7	0.1	2.4	1.3	-0.8
15	-1.2	3.1	-2.2	-0.3	3.8	2.6
16	0.6	-2.3	-2.7	7.1	4.8	3.7
17	5.1	4.2	1.8	8.8	7.3	4.7
18	3.1	10.8	4.9	4.1	6.0	3.9
19	5.8	-1.1	6.4	9.6	8.0	4.7
20	8.4	14.4	6.9	7.6	6.0	4.4
21	9.1	6.3	3.2	3.5	9.4	7.9
22	3.2	3.1	4.6	8.6	6.4	4.7
23	7.9	8.5	2.9	3.3	3.9	3.2
24	7.4	0.6	2.4	4.8	3.6	3.2
25	2.3	7.5	3.5	3.8	4.7	3.8
26	7.6	4.6	1.1	0.9	2.9	2.4
27	4.2	-3.2	-0.4	4.3	2.9	4.9
28	2.3	10.4	3.6	5.5	3.4	3.9
29	5.7	-4.4	-1.2	-0.9	4.3	3.9
30	-1.3	5.3	4.7	2.1	7.9	4.8
31	3.3	5.0	1.4	3.0	1.7	2.8
32	1.4	1.1	1.7	-0.2	3.0	1.2
33	-0.4	7.0	1.6	3.9	3.1	2.8
34	4.0	-0.9	0.4	-1.9	0.3	0.6
35	4.6	-2.4	1.9	0.2	3.0	2.1
36	-4.4	-0.2	0.0	2.2	-0.2	-0.9
37	3.5	-0.0	0.1	-3.3	-0.2	0.9
38	-3.9	-3.3	0.3	2.4	-0.4	0.6
39	0.8	-8.1	-2.1	3.6	-1.0	-0.1
40	-2.0	11.2	2.7	-5.3	2.1	1.5
41	-5.0	-13.3	0.2	3.8	-0.1	1.1
42	-0.4	4.7	0.2	-2.2	-0.2	1.1
43	-4.6	1.1	-0.0	2.9	1.8	2.7

TABLE A-5 (continued)

Age at Census	1955	1960	1966	1970	1975[b] 5-Percent Sample	1975[b] Complete Count
44	-5.0	-3.0	-0.4	3.3	0.8	3.0
45	1.0	1.3	1.2	-3.9	-0.1	0.2
46	-3.9	-4.8	0.5	2.1	0.8	1.9
47	4.4	-0.9	-0.0	2.2	-1.3	-0.3
48	-3.1	-1.9	-0.5	-3.6	0.3	1.2
49	3.6	-14.3	-2.6	2.0	0.3	1.6

[a]The level of undercounts has been arbitrarily adjusted to yield a 0-percent undercount, on the average, for ages 5-14 in 1975 (5-percent sample).
[b]In the last two columns, undercounts are of the 5-percent sample and of the 100-percent tabulation respectively, relative to our corrected 1975 female population (Table A-6).

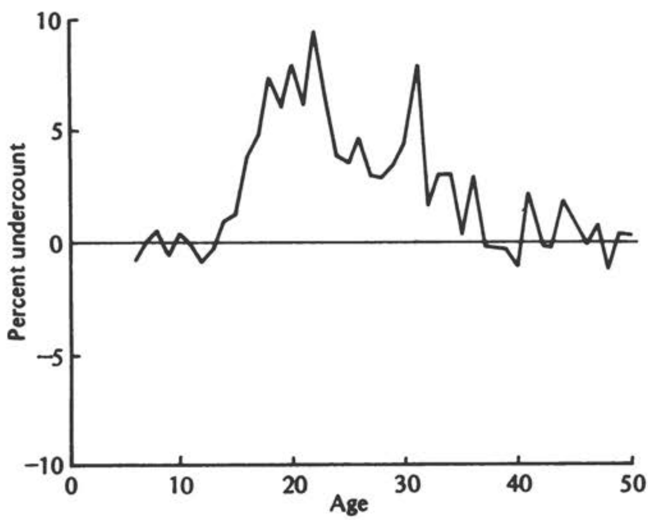


FIGURE A-15 Percent undercount by single years of age, females, 1975 census: Republic of Korea.

NOTE: Undercounts are of the 5-percent sample age distribution.

Estimates of Births and Fertility from 1955 to 1975

The rather complicated calculations just described have yielded corrected estimates of the female age distribution, by single years of age, from 1955 to 1975 for all cohorts up to age 69 in 1975 (Table A-6). The life tables employed in these calculations can also be used to project corrected single-

TABLE A-6 Corrected[a] Female Single-Year Age Distributions (in thousands), Censuses 1955-1975: Republic of Korea

Age	1955	1960	1966	1970	1975
0	421	491	434	442	378[b]
1	355	467	420	442	417[b]
2	308	451	430	436	429[b]
3	328	398	460	414	450[b]
4	263	380	451	425	449[b]
5	272	406	456	415	439
6	274	347	473	426	439
7	282	303	456	457	433
8	284	322	443	448	411
9	241	259	392	453	422
10	221	268	374	470	413
11	228	270	399	453	424
12	229	278	342	440	454
13	260	280	298	389	445
14	254	238	318	372	450
15	236	218	255	397	465
16	239	225	264	339	449
17	235	226	265	296	436
18	231	256	273	315	385
19	227	249	275	253	369
20	222	232	233	261	394
21	213	235	215	263	336
22	193	231	221	271	294
23	205	226	222	272	313
24	187	222	251	230	251
25	176	217	244	212	259
26	181	208	226	218	260
27	167	189	229	219	268
28	160	200	224	248	269
29	157	182	220	241	228
30	148	172	216	224	209
31	145	176	210	226	215

TABLE A-6 (continued)

Age	1955	1960	1966	1970	1975
32	149	162	202	221	216
33	141	155	183	217	244
34	136	153	193	212	237
35	129	144	176	207	220
36	107	141	166	199	222
37	113	144	171	180	218
38	117	137	157	190	214
39	118	132	150	173	209
40	106	125	146	163	204
41	100	104	139	167	195
42	102	109	136	153	177
43	100	113	139	146	187
44	98	114	131	143	170
45	96	102	126	136	160
46	95	96	120	133	163
47	90	98	99	135	150
48	82	96	104	128	143
49	90	94	107	122	140
50		91	107	116	131
51		90	100	96	128
52		85	93	100	131
53		78	94	103	123
54		85	91	103	118
55			88	96	111
56			87	89	91
57			85	90	95
58			79	86	98
59			71	84	98
60				82	88
61				80	82
62				74	83
63				66	79
64				70	77
65					73
66					71
67					66
68					58
69					62

[a]Age distributions are arbitrarily adjusted to yield a 0-percent undercount in ages 5-14 in 1975.

[b]Corrected 1975 population aged 0-4 is based on average of 1966 and 1970 correction factors for corresponding ages.

year cohorts back to birth, to provide consistent estimates of the number of female births for each year from 1955 to 1975.[6] The number of male births for each year can be estimated in turn as 1.075 times the number of female births.[7] The intercensal life tables previously constructed (Table A-2) incorporate mortality up to age 5 that is consistent with the average infant mortality rates for the time period in question, as reported in the 1971 Korean Fertility-Abortion Survey. To make rough allowance for the time trend of infant mortality, a value of ${}_1q_0$ for each year was estimated by linear interpolation between values for the surveyed years. A ${}_1L_0$ consistent with each individually estimated ${}_1q_0$ was used in projecting the cohort from under age 1 back to birth.

The number of female births, the crude birth rate, the general fertility rate, and the total fertility rate for each year from 1955 to 1975 are shown in Table 1.[8] The denominator of the general fertility rate (women aged 15–49) is obtained by reverse projection of the female population by single years to each date from 1955 to 1975.

The total fertility rate was calculated by incorporating the structure by age of fertility each year estimated by the own-children method (Cho 1971, 1974a; and unpublished preliminary calculations from the 1975 census). The age-specific fertility rates by five-year age intervals in the estimated own-children schedules were applied to the adjusted female age distributions to determine the number of births implied by these schedules and the corrected age distributions. The final estimate of age-specific fertility rates (from which total fertility was calculated) was a simple scaling up or down of the own-children schedule to yield the corrected number of births estimated for the appropriate year. Since own-children estimates of fertility began in 1957, total fertility rates for 1955 and 1956 were estimated from the trend in general fertility rates between 1955 and 1957. The birth cohort of 1955 was unusually large (probably because of the effect of demobilization after the Korean War); thus, the total fertility rate shown for 1955 is derived from the average number of births in 1954–1956.

In Figure A-16, the resultant total fertility rates are compared with the rates estimated by the own-children method. The new estimates are much less erratic in the late 1960s because of the adjustment of the 1970 age distribution for the leap-year effect.[9] The 20-year sequence of total fertility rates has two remarkable features—increases in the late 1950s before the decline began, and a decline, once begun, that reached nearly 50 percent in only 15 years.

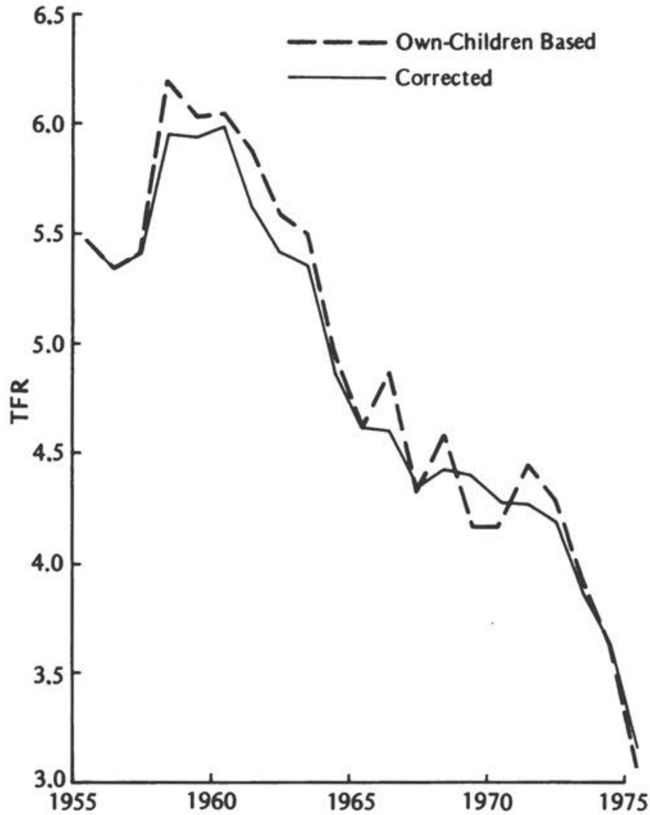


FIGURE A-16 Corrected total fertility rates (15–49 year olds) and rates estimated by own-children method, 1955–1975: Republic of Korea.

SOURCES: Uncorrected own-children TFRS: 1957–1958 (Cho 1971); 1959–1970 (Cho 1974a); 1971–1975 (unpublished data from the 1975 census).

B THE FEMALE AGE DISTRIBUTION OF KOREA IN 1975 AS RECORDED IN THE COMPLETE COUNT AND IN THE 5-PERCENT SAMPLE

When the undercounts in the 1966, 1970, and 1975 censuses were estimated as the basis for our adjustments of own-children fertility schedules, the only available tabulations for 1975 were from a 5-percent sample. All references to the 1975 enumeration in the text of the report and in Appendix A are references to this sample. After our analysis was completed, the age distribution of the complete count was published. The distributions are not identical, and they differ at certain points by more than would be expected from random variation. Percent differences between the two distributions of the female population, by single years and five-year intervals, are shown in Table B-1.

The complete count is affected to a lesser extent by a characteristic of the 5-percent sample distribution, noted previously: an undercount at some ages divisible by five, especially age 30. The large dip at age 25 in the census survival rates from 1970 to 1975 (Figure A-1) would be less with the complete count distributions than with the sample. In other respects, the 1975 complete count distribution was less consistent with the 1970 census than was the 5-percent distribution (for example, in having smaller numbers at higher ages). The estimated relative size of single-year cohorts within five-year cohorts (Table A-3) would barely be changed by basing the estimates on the full count: for only one single-year cohort would the estimate be altered by as much as 1.5 percent. Thus, we concluded that estimates of the correct distribution from the complete count would be only slightly different from and not an improvement over the estimates presented.

TABLE B-1 Comparison of 1975 Female Age Distributions, by Single Years and Five-Year Age Groups, 5-Percent Sample vs. Complete Enumeration: Republic of Korea

Age	Percent Difference[a]	Age	Percent Difference	Age	Percent Difference
0-4	1.7	25-29	0.2	50-54	1.2
0	4.1	25	-0.8	50	3.7
1	1.0	26	-0.5	51	-0.5
2	1.5	27	2.1	52	0.1
3	2.9	28	0.6	53	1.1
4	-0.6	29	-0.5	54	1.7
5-9	-0.2	30-34	-0.7	55-59	1.4
5	0.3	30	-3.3	55	4.0
6	-1.1	31	1.2	56	-0.5
7	-0.3	32	-1.9	57	1.2
8	-0.0	33	-0.3	58	1.0
9	0.5	34	0.3	59	1.0
10-14	0.1	35-39	0.3	60-64	-1.4
10	-0.4	35	-0.9	60	-1.0
11	1.7	36	-0.7	61	-1.1
12	0.7	37	1.2	62	-0.3
13	0.9	38	1.0	63	-3.0
14	-2.1	39	0.9	64	-2.0
15-19	-2.1	40-44	1.0	65-69	2.4
15	-1.3	40	-0.6	65	-0.6
16	-1.2	41	1.2	66	-1.3
17	-2.7	42	1.3	67	4.8
18	-2.2	43	1.0	68	5.3
19	-3.4	44	2.2	69	5.0
20-24	-1.3	45-49	0.9	70-74	2.3
20	-1.7	45	0.3	70	-1.4
21	-1.7	46	1.2	71	4.4
22	-1.7	47	1.0	72	3.1
23	-0.8	48	0.9	73	3.3
24	-0.4	49	1.3	74	2.6

[a]Percent difference = (5-percent sample – complete count) ÷ complete count.

SOURCES: Economic Planning Board, Korea (1976: 24-26) and (1977: 22-33).

C COMPARISON OF AVERAGE INCREASES IN PARITY FROM 1970 TO 1975 (CENSUS COHORT BIRTH RATE) WITH NUMBER OF REGISTERED BIRTHS PER WOMAN (REGISTERED COHORT INTERCENSAL BIRTH RATE)

The comparison of census cohort birth rates and registered cohort intercensal birth rates requires precise synchronization of fertility data recorded in different ways. Registered births are recorded for cohorts that are at exact age x to $x + 1$ at the midpoint of 1971, $x + 1$ to $x + 2$ at the midpoint of 1972, and $x + 4$ to $x + 5$ at the midpoint of 1975. The relevant data from the censuses on cohort size are numbers of persons at exact ages y to $y + 1$ on October 1, 1970, and $y + 5$ to $y + 6$ on October 1, 1975. The average size of the cohort that was x to $x + 1$ in mid-1971 was estimated as

$$\frac{3}{4}\left(\frac{P_{x-1}^{70} + P_{x+4}^{75}}{2}\right) + \frac{1}{4}\left(\frac{P_{x}^{70} + P_{x+5}^{75}}{2}\right). \qquad \text{(C-1)}$$

The numbers in parentheses are the estimated sizes of two consecutive cohorts enumerated in the censuses, with the weights of 3/4 and 1/4 allowing for the 3/4 year displacement between October 1 and the midpoint of the following year. Dividing the sum of the registered births at x to $x + 1$ in 1971, $x + 1$ to $x + 2$ in 1972, . . . , and $x + 4$ to $x + 5$ in 1975 by the average size of cohort gives the five-year increase in cumulated fertility (i.e., the intercensal cohort birth rate) for women who were at exact age x on January 1, 1970. The increase in parity between the two censuses is the average number of births to women who were y to $y + 1$ or, on the average, $y + 0.5$ years of age on October 1, 1970, and became $y +$ 5.5 years of age on October 1, 1975. The possible difference in average number of births per woman in a five-year period beginning on October 1 and in one beginning on December 31 was taken as negligible; but the difference in age of 1/2 year between the cohorts experiencing registered births and the cohorts enumerated in the censuses could not be ignored. To determine the census cohort birth rate comparable to the registered cohort birth rate, cohort birth rates of persons x to $x + 1$ were calculated from rates for persons $x + 0.5$ to $x + 1.5$ by quadratic interpolation.

Before the registered cohort birth rates were computed, a preliminary adjustment was applied to the numbers of registered births listed for 1975. The unadjusted birth rates for individual years are[10]:

Year	Crude Birth Rate
1971	28.3
1972	25.0
1973	23.9
1974	20.4
1975	12.8

The sharp decline from 1974 to 1975 is not credible—the birth rate fell more or less smoothly in the other years before this precipitous drop. The source of this discontinuity is a combination of delayed registration and the cutoff date of December 31, 1976. Therefore an assumption was introduced that the average decline during 1971–1974 persisted through 1975, and a special adjustment in the form of a 39-percent increase in the number of registered births was made in 1975, to raise the registered figures for that year to approximately the level of underregistration prevailing in the earlier years.

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Notes

1. Practical estimation by the own-children method must utilize tabulations of women and children in finite age intervals, rather than as numbers that are continuous functions of age, as implied in equation (2). This equation is intended to illustrate the logical basis, not the computational steps, of own-children estimation. It therefore avoids complicated problems of the relations between cohort and period experience in a given age interval, problems involving the use of Lexis diagrams that often are encountered in demographic calculations. There is an additional practical problem of allocating to women at different ages the small fraction of children who are not identified as any woman's own children. These questions are rigorously analyzed in Cho and Feeney (1978).

2. What the own-children technique adds to the general fertility rate as an aggregate measure of fertility is evidence of the age pattern of fertility, so that the total fertility rate, an age-distribution-free measure of fertility, can be estimated. The general fertility rate is age distribution free in that it is independent of variations in how large a fraction of the population is constituted of women of childbearing age. It is not independent of different concentrations of women within the childbearing span at the most prolific ages, as is the total fertility rate.

3. The first census for the Republic of Korea was conducted in 1948, but most of the data were destroyed during the Korean War.

4. The effect of the use of both lunar and solar calendars on age misreporting in the Korean censuses is analyzed for censuses prior to 1970 by Kwon (1977).

5. For certain five-year cohorts in which relative numbers of males had been strongly affected by participation in World War II or the Korean War, the estimate of cohort size for females is based on the three enumerations of the female cohort alone. These were ages 35–39, 45–54, and 60–64 in 1970.

6. To construct estimates for 1970–1975, it is necessary to adjust the single-year distribution under age 5 in the 1975 census for misreporting. No empirical basis for such adjustment exists; we have assumed corrections equal to the average of those calculated for 1966 and 1970.

7. A ratio of males to females at birth as high as 1.075 is required to be consistent with the uniformly high proportions of males in the child populations. This sex ratio is at the high end of reliably reported ratios based on large numbers of births. The sex ratio is 1.07 or above in Poland, Yugoslavia, and Hungary. Assigning a lower number of male births would have lowered our estimates by less than 1 percent.

8. Since the most recent censuses were conducted on October 1 and own-children estimates are based on reported ages at the time of the census, these annual fertility measures refer to a year ending on October 1 rather than to an actual calendar year.

9. Because no two leap years occur consecutively and because the excess births in leap years are borrowed from neighboring non-leap years, the corrections for the lunar calendar would have been closely approximated by a two-year moving average of the total fertility rates.

10. Registered births for 1971–1975 are taken from Feeney (1977).

Glossary

AGE HEAPING A tendency for enumerators or respondents to report certain ages instead of others; also called age preference or digit preference. Preference for ages ending in 0 or 5 is widespread.

AGE PATTERN OF FERTILITY The relative distribution of a set of *age-specific fertility rates*. It expresses the relative contribution of each age group to *total fertility*.

AGE-SPECIFIC FERTILITY RATE The number of births occurring during a specified period to women of a specified age or age group, divided by the number of person-years-lived during that period by women of that age or age group. When an age-specific fertility rate is calculated for a calendar year, the number of births to women of the specified age is usually divided by the midyear population of women of that age.

AGE STANDARDIZATION A procedure of adjustment of crude rates (birth, death, or other rates) designed to reduce the effect of differences in age structure when comparing rates for different populations.

BIRTH HISTORY A record of the number and dates of all live births experienced by a particular woman; see also *pregnancy history*. Survival of each child to the date of the interview and, where pertinent, the date of death are also generally recorded.

BIRTH ORDER The ordinal number of a given live birth in relation to all previous live births of the same woman (e.g., 5 is the birth order of the fifth live birth occurring to the same woman).

BIRTH RATE See *crude birth rate*.

CHILDBEARING AGES The span within which women are capable of bearing children, generally taken to be from age 15 to age 49 or, sometimes, to age 44.

CHILDREN EVER BORN(E) The number of children ever borne alive by a particular woman; synonymous with *parity*. In demographic usage, stillbirths are specifically excluded.

COHORT A group of individuals who experienced the same event in the same period. Thus an age cohort is a group of people born during a particular period, and a marriage cohort is a group of people who married during a particular period. The effects of a given set of mortality or fertility rates are often illustrated by applying them to hypothetical cohorts.

COHORT FERTILITY The fertility experienced over time by a group of women or men who form a birth or a marriage cohort. The analysis of cohort fertility is contrasted with that of *period fertility*.

CRUDE BIRTH RATE The number of births in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as births per thousand population. The crude birth rate for a single year is usually calculated as the number of births during the year divided by the midyear population.

CRUDE DEATH RATE The number of deaths in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as deaths per thousand population. The crude death rate for a single year is usually calculated as the number of deaths during the year divided by the midyear population.

CUMULATED FERTILITY An estimate of the average number of children ever borne by women of some age x, obtained by cumulating *age-specific fertility rates* up to age x; also often calculated for age groups.

DEATH RATE See *crude death rate*.

EXPECTATION OF LIFE AT BIRTH The average number of years that a member of a *cohort* of births would be expected to live if the cohort were subject to the mortality conditions expressed by a particular set of age-specific mortality rates.

FERTILITY HISTORY Either a *birth history* or a *pregnancy history*.

FORWARD SURVIVAL A procedure for estimating the age distribution at some later date by projecting forward an observed age distribution. The procedure uses *survival ratios*, often obtained from model *life tables*. The procedure is basically a form of population projection without the introduction of new entrants (births) to the population.

GENERAL FERTILITY RATE The ratio of the number of live births in a period to the number of person-years-lived by women of *childbearing ages* during the period. The general fertility rate for a year is usually calculated as the number of births divided by the number of women of childbearing ages at midyear.

GROSS REPRODUCTION RATE The average number of female children a woman would have if she survived to the end of her childbearing years and if, throughout, she were subject to a given set of *age-specific fertility rates* and a given *sex ratio at birth*. This number provides a measure of replacement fertility in the absence of mortality.

GROWTH RATE The increase or decrease of a population in a period divided by the number of person-years-lived by the population during the same period. The increase in a population is the result of a surplus (or deficit) of births over deaths and a surplus (or deficit) of immigrants over emigrants. (The annual increase is often expressed as a fraction of the total population at the beginning of the year, but this convention has the inconvenient characteristic of not being readily defined for a five-year interval and of being unequal to the difference between the birth rate and the death rate even in the absence of migration.) See also *rate of natural increase*.

INFANT MORTALITY RATE The number of deaths of children under 1 year of age occurring in a year per 1,000 live births occurring in the same year; also used in a more rigorous sense to mean the number of deaths that would occur under 1 year of age in a *life table* with a *radix* of 1,000.

LIFE TABLE A listing of the number of survivors at different ages (up to the highest age attained) in a hypothetical cohort subject from birth to a particular set of age-specific mortality rates. The rates are usually those observed in a given population during a particular period of time. The tabulations accompanying a life table include other features of the cohort's experience: its expectation of life at different ages, the probability of surviving from the beginning of each age interval to the end of that interval, etc.

MARITAL FERTILITY Any measure of fertility in which the births (in the numerator) are births to married women and in which the number of person-years-lived (in the denominator) also pertains to married women. In some instances, the designation "married" includes persons in consensual unions.

MEDIAN The central value of a set that is ordered by size or some other characteristic expressed in numbers.

MEAN AGE OF CHILDBEARING The average age at which a mortality-free *cohort* of women bear their children according to a set of *age-specific fertility rates*.

MEAN AGE OF CHILDBEARING IN THE POPULATION The average age of the mothers of the children born in a population during a year. This measure incorporates the effects of both mortality and the age distribution.

MODEL LIFE TABLE An expression of typical mortality experience derived from a group of observed *life tables*.

MOVING AVERAGES The successive averaging of two or more adjacent values of a series in order to remove sharp fluctuations.

NATURAL FERTILITY The age pattern of *marital fertility* observed in non-contraceptive populations where reproductive behavior is not affected by the number of children already born.

NET MIGRATION The difference between gross immigration and gross emigration.

NET REPRODUCTION RATE The average number of female children born per woman in a *cohort* subject to a given set of *age-specific fertility rates*, a given set of age-specific mortality rates, and a given *sex ratio at birth*. This rate measures replacement fertility under given conditions of fertility and mortality: it is the ratio of daughters to mothers assuming continuation of the specified conditions of fertility and mortality.

OWN-CHILDREN METHOD A refinement of the *reverse survival* procedure for fertility estimation, whereby estimates of *age-specific fertility rates* for the recent past are obtained by relating mothers to their own children, using information on relationship and other characteristics available from a census or survey.

PARITY See *children ever born*.

PERIOD FERTILITY The fertility experienced during a particular period of time by women from all relevant birth or marriage *cohorts*; see also *cohort fertility*.

PREGNANCY HISTORY A record of the number and the dates of occurrence of all the pregnancies experienced by a particular woman. The outcome of the pregnancy—live birth, stillbirth, fetal death—is also recorded.

$_xq_0$ The probability of dying between birth and some exact age x, sometimes also written $q(x)$: q is the probability of dying, 0 is birth, and x is the exact age up to which the probability of dying refers.

RADIX The hypothetical birth cohort of a *life table*. Common values are 1, 1,000, and 100,000.

RATE OF NATURAL INCREASE The difference between the births and deaths occurring during a given period divided by the number of person-years-lived by the population during the same period. This rate, which specifically excludes changes resulting from migration, is the difference between the *crude birth rate* and the *crude death rate*.

RETROSPECTIVE SURVEY A survey that obtains information about demographic events that occurred up to some specific time, generally the time of the survey.

REVERSE SURVIVAL A technique to estimate an earlier population from an observed population, allowing for those members of the population who would have died according to observed or assumed mortality conditions. It is used as a method of estimating fertility by calculating from the observed number of survivors of a given age a the expected number of births that occurred a years earlier. (In situations for which mortality is known or can be reliably estimated, reverse survival can be used to estimate migration.)

ROBUSTNESS A characteristic of estimates that are not greatly affected by deviations from the assumption on which the estimation procedure is based.

SEX RATIO AT BIRTH The number of male births for each female birth, or male births per 100 female births.

SINGULATE MEAN AGE AT MARRIAGE (SMAM) A measure of the mean age at first marriage, derived from a set of proportions of people single at different ages or in different age groups, usually calculated separately for males and females.

SURVIVAL RATIO The probability of dying between one age and another; often computed for age groups, in which case the ratios correspond to those of the person-years-lived function, $_nL_x$, of a *life table*.

SYNTHETIC PARITY The average parity calculated for a hypothetical cohort exposed indefinitely to a set of period *age-specific fertility rates*.

TOTAL FERTILITY RATE (TFR) The average number of children that would be born per woman if all women lived to the end of their childbearing years and bore children according to a given set of *age-specific fertility rates*; also referred to as total fertility. It is frequently used to compute the consequence of childbearing at the rates currently observed.

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