Five Decades of Missing Females in China*

Ansley J. Coale

Senior Research Demographer,
  Office of Population Research
Princeton University
21 Prospect Avenue
Princeton, NJ 08540–2091
E-mail: coale@opr.Princeton.EDU

Judith Banister

Chief, Center for International Research
Bureau of the Census
Washington, DC 20233–3700

This paper seeks to explain the dearth of females in the population of China in cohorts born from the late 1930s to the present. We demonstrate that in virtually all cohorts, the shortage of females in comparison with males is revealed when the cohort is first enumerated in a census. Subsequently it barely changes, an indication that female losses occur very early in life. Using the high-quality data from the censuses and fertility surveys in China, we show that many of the births of the girls missing in the censuses were not reported in the surveys because they died very young. The incidence of excess early female mortality (probably infanticide) declined precipitously in the Communist period, but not to zero. The recent escalation in the proportion of young females missing in China has been caused largely by rapidly escalating sex-selective abortion.

INTRODUCTION

In the absence of special circumstances reducing the number of the male or the female members of a population, and in the absence of substantial gains or losses from migration, the numbers of males and females are approximately equal. These approximately equal numbers are the result of the usual slight majority of males at birth, and the usual somewhat higher mortality of males in the absence of differential treatment of the sexes or a large incidence of military mortality. In almost all well-recorded ratios of the number of male to the number of female births, the ratio falls between 1.05 and 1.07; the slightly higher male mortality gradually cancels the initial male majority as each cohort advances in age.

In some Asian and African countries, however, the ratio of males to females in the population is higher than would be expected from the typical sex ratio at birth and the typical differential mortality. The source of this high masculinity is female mortality that is

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* This article originated with a paper presented at the October 1993 conference on the 1990 Census of China, held in Beijing. Another, slightly different version was published as: *Five Decades of Missing Females in China* (Office of Population Research, Princeton University, Working Paper Series, 93–6; also available from the Center for International Research, U.S. Bureau of the Census).

higher, in relation to male mortality, than would prevail if both sexes had equal access to factors promoting good health. One of the populations with higher than expected masculinity is that of the People's Republic of China. In the 1990 census, the recorded ratio of males to females was 1.066; a normal sex ratio at birth and normal differences in survival would have yielded a ratio no higher than 1.02. Female mortality evidently has been abnormally high in relation to male mortality in China.

In this paper we analyze data from the four modern censuses of China, held from 1953 to 1990, and from two large-scale retrospective fertility surveys, held in 1982 and 1988, to trace the record of excess masculinity in successive Chinese birth cohorts from those born in the late 1930s to those born in the late 1980s. The extent and the high quality of the data permit several inferences, including the probable existence of high rates of female infanticide in the 1930s and early 1940s; a large reduction of this practice by the 1960s; the effect of the famine in 1959–1961 on the sex ratio in selected cohorts; evidence of the beginning, around 1970, of selective termination of childbearing following a male birth; and, in the 1980s, the emerging impact of sex-selective abortion on the sex ratio at birth.

We begin with a description of the relevant data in the Chinese censuses and in the large fertility surveys of the 1980s. Then we present an analysis of the data for cohorts born from 1936 to 1954, for cohorts whose childhood years occurred during the great famine of 1959–1961, for cohorts born before and during the national introduction of a family planning program, and for cohorts born in the 1980s.

RATIOS OF MALES TO FEMALES, BY BIRTH COHORT, IN THE CHINESE CENSUSES

The four modern censuses of China provide data of unusually high quality, which are especially suitable for examining the ratio of males to females at different ages. The absence of any consequential amount of international migration ensures that the relative number of males and females at each age is determined by the ratio of males to females at birth in each cohort, and by the relative survival (or, conversely, by the relative number of deaths) to which each cohort has been subject since birth.

A positive feature of the censuses is the unusual precision with which age is listed. Accurately listed ages are possible because of a characteristic of the dominant culture in China: every individual, even if illiterate, knows the exact date of his birth according to the Chinese calendar. Each year in this calendar has the name of an animal with a specified characteristic in a 60-year cycle of 12 animals and five characteristics for each animal. Within each year, "months" are lunar months; each individual knows the day of the lunar month in the animal year in which he was born. The accuracy of recall of this date is based on the astrological belief in the importance of date of birth in determining such decisions as marriage or change of residence. Each individual knows this fixed date and can supply it readily. For example, Chinese graduate students at Princeton report that parents or grandparents often have told them not only the date of their birth, but also the hour of the day. In conducting a census it is necessary to ask each individual the date of his or her birth, then to translate this date into the Western calendar and subtract it from the date of the census to obtain an exact age.[1]

As our unit of analysis we have chosen the ratio of males to females recorded for persons identified by the years in which they were born, rather than (for example) their age at the date of a census. This use of birth cohorts rather than age is illustrated by the ratios of males to females listed in Table 1. The cohorts have been combined into five-year groupings of birth years to smooth out any minor irregularities in the raw data. The earliest

Table 1. Sex Ratios in Censuses by 5-Year Birth Cohorts from Cohort Born 1936–1940

	Census			
Years of Birth	1953	1964	1982	1990
1936–1940	1.171	1.171	1.144	1.124
1937–1941	1.183	1.183	1.142	1.122
1938–1942	1.178	1.178	1.138	1.117
1939–1943	1.169	1.169	1.135	1.115
1940–1944	1.160	1.160	1.130	1.112
1941–1945	1.151	1.151	1.119	1.105
1942–1946	1.141	1.141	1.115	1.102
1943–1947	1.129	1.129	1.108	1.099
1944–1948	1.117	1.117	1.102	1.095
1945–1949	1.107	1.107	1.100	1.095
1946–1950	1.094	1.109	1.095	1.090
1947–1951	1.081	1.103	1.102	1.082
1948–1952	1.070	1.095	1.095	1.074
1949–1953		1.089	1.089	1.068
1950–1954		1.086	1.086	1.063
1951–1955		1.088	1.088	1.064
1952–1956		1.092	1.092	1.068
1953–1957		1.097	1.097	1.076
1954–1958		1.097	1.097	1.083
1955–1959		1.096	1.096	1.085
1956–1960		1.090	1.090	1.079
1957–1961		1.082	1.082	1.072
1958–1962		1.072	1.072	1.066
1959–1963		1.062	1.062	1.056
1960–1964			1.056	1.050
1961–1965			1.054	1.054
1962–1966			1.056	1.056
1963–1967			1.953	1.053
1964–1968			1.057	1.057
1965–1969			1.059	1.059
1966–1970			1.060	1.060
1967–1971			1.060	1.060
1968–1972			1.060	1.060
1969–1973			1.061	1.061
1970–1974			1.061	1.061
1971–1975			1.062	1.062
1972–1976			1.062	1.060
1973–1977			1.062	1.062
1974–1978			1.063	1.065
1975–1979			1.066	1.068
1976–1980			1.069	1.070
1977–1981			1.071	1.072
1978–1982				1.077
1979–1983				1.081
1980–1984				1.083
1981–1985				1.085
1982–1986				1.088
1983–1987				1.090
1984–1988				1.096
1985–1989				1.102

birth cohort listed, born in 1936–1940, was at ages 12–16 in 1953, 23–27 in 1964, 41–45 in 1982, and 49–53 in 1990.[2] The ratio of males to females for a given cohort tends to diminish at ages above the mid-thirties because male mortality becomes increasingly higher than female as age advances. A surprising feature of these cohort data is that of 79 instances in which ratios for the same cohort are listed in two consecutive censuses, masculinity is higher at the second date in only six.[3] Thus, in general, as these cohorts passed through life, the male attrition implied by the numbers recorded in the censuses was equal to or higher than female attrition over the ages reached by each cohort between two censuses. In spite of this normal trend in cohort sex ratios over time, the sex ratios at most ages are higher than would normally be the case.

We can explain in part the six exceptions to the general pattern of declining masculinity of each cohort over time. As shown in Table 1, early cohort sex ratios rose between the 1953 and the 1964 census as the three youngest groups aged into the teen years. This finding suggests that a strong pattern of selective neglect of girls in childhood occurred between 1953 and 1964. As we will discuss, a severe famine intervened between these two censuses. Between the 1982 and the 1990 census, the recorded sex ratio of the three youngest groups rose very slightly; this suggests that selective neglect of young girls continued but was much reduced from earlier decades. The rise in these cohort sex ratios occurred at ages beyond which any female infanticide would have taken place; that tends to occur soon after birth.

To estimate the "excess" mortality to which females have been subject since birth in relation to males in the same cohort, we have made a rough estimate of the normal sex ratio that would be expected in each cohort at each census date. We calculated the normal ratio on the assumption that at birth the ratio of males to females was 1.06; relative survival rates for the two sexes were chosen to match the relative survival in a model life table at a level of mortality that we selected as about equal to the level we estimated as experienced by the given cohort. The normal sex ratio is what one would expect if the cohort began with the nearly universal sex ratio at birth and was subject to the relative survival rates in model life tables based on accurately recorded experience in populations at about the same level of mortality (see Table 2).[4]

When the ratio of males to females recorded in a census is compared with the estimated normal ratio, one sees the extent to which the ratio in the census has been increased as a result of female mortality higher than normal in relation to male mortality. Indeed, it can be shown that the proportion of females absent as the result of excess female mortality (in relation to male) is equal to the recorded ratio of males to females divided by the sex ratio in the model, minus 1.0. Figure 1 displays the proportion of absent females estimated in this way in each census in each cohort, identified by the years of its birth.

Very close agreement exists among the estimated proportions of absent females within each cohort in the different censuses, as illustrated by the closely clustered lines in Figure 1. This tight agreement shows that the excess female mortality which caused a high ratio of males to females in a cohort had taken its toll by the first time a cohort was enumerated; almost all of the excess deaths occurred very early in life.

Figure 1 illustrates the evolution of excess female mortality as the time period of the birth of successive cohorts advanced. The midpoint (median) of the estimates of missing females from the different censuses is above 15% for the four earliest cohorts (1936–1940 to 1939–1943) and above 10% for the next five cohorts (until 1944–1948). A sharp decline continues, interrupted by higher proportions of missing females in cohorts who spent early childhood years during the crisis period of 1959–1961, when early-age female mortality apparently rose more sharply than male. The resumed downtrend led to ratios below 3% in the 1960s, and then to a level not far above 2%. A gradual increase began in the mid-1970s (after the cohort born 1972–1976); this increase grew steeper after cohorts born in 1974–1978.

Table 2. Model Sex Ratios for Cohorts at Censuses, by Years of Birth

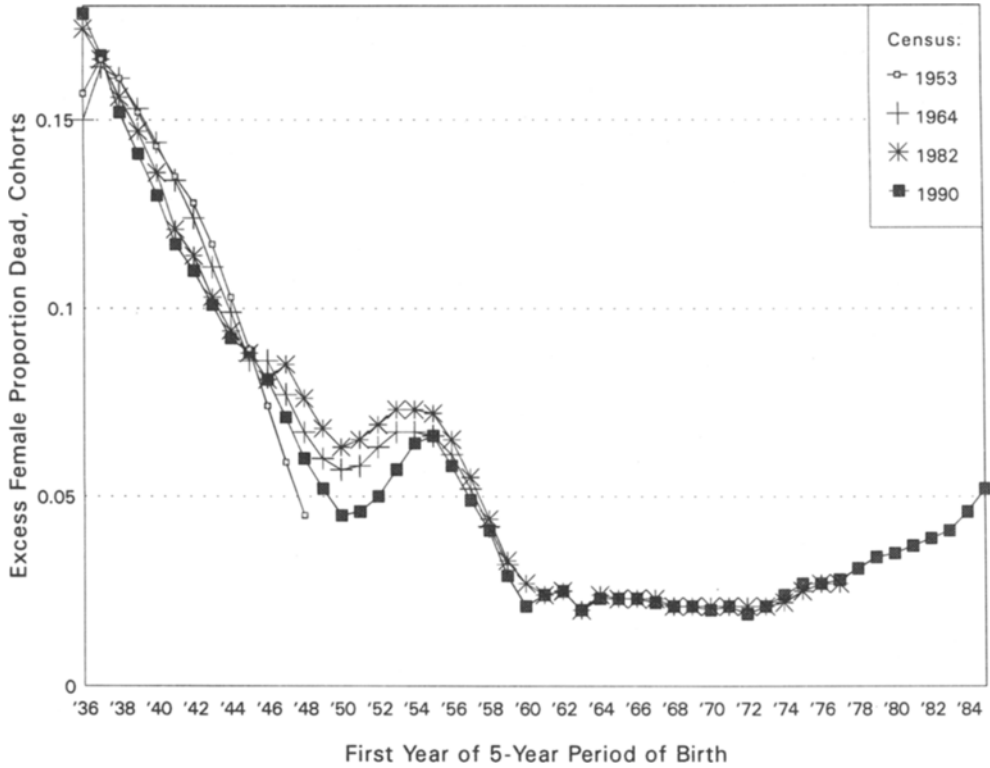| Years of Birth	Census			
	1953	1964	1982	1990
1936–1940	1.012	1.018	0.975	0.954
1937–1941	1.014	1.016	0.980	0.962
1938–1942	1.015	1.015	0.985	0.970
1939–1943	1.015	1.014	0.989	0.977
1940–1944	1.015	1.014	0.994	0.984
1941–1945	1.014	1.015	0.998	0.989
1942–1946	1.012	1.015	1.001	0.993
1943–1947	1.011	1.016	1.005	0.998
1944–1948	1.013	1.016	1.007	1.002
1945–1949	1.016	1.019	1.011	1.006
1946–1950	1.019	1.021	1.013	1.008
1947–1951	1.021	1.024	1.015	1.010
1948–1952	1.024	1.026	1.018	1.013
1949–1953		1.028	1.020	1.015
1950–1954		1.028	1.021	1.017
1951–1955		1.028	1.021	1.017
1952–1956		1.028	1.021	1.017
1953–1957		1.028	1.022	1.018
1954–1958		1.028	1.022	1.018
1955–1959		1.028	1.022	1.018
1956–1960		1.028	1.023	1.020
1957–1961		1.029	1.025	1.022
1958–1962		1.029	1.027	1.024
1959–1963		1.029	1.028	1.026
1960–1964			1.028	1.028
1961–1965			1.029	1.029
1962–1966			1.030	1.030
1963–1967			1.032	1.032
1964–1968			1.033	1.033
1965–1969			1.035	1.035
1966–1970			1.036	1.036
1967–1971			1.037	1.037
1968–1972			1.038	1.038
1969–1973			1.039	1.039
1970–1974			1.040	1.040
1971–1975			1.040	1.040
1972–1976			1.040	1.040
1973–1977			1.040	1.040
1974–1978			1.040	1.040
1975–1979			1.040	1.040
1976–1980			1.041	1.041
1977–1981			1.043	1.043
1978–1982				1.044
1979–1983				1.045
1980–1984				1.046
1981–1985				1.046
1982–1986				1.047
1983–1987				1.047
1984–1988				1.048
1985–1989				1.048

Figure 1. Estimated Excess Proportion Dead Females Relative to Males, Cohorts

DATA ON SEX RATIOS FROM THE FERTILITY SURVEYS

Two large-scale fertility surveys have been conducted in China, one in 1982 (the so-called one-per-thousand survey) and another in 1988 (the two-per-thousand survey). Both surveys asked a large sample of married women (311,000 age 15–67 in 1982, and 459,000 age 15–57 in 1988) for a lifetime history including each respondent's date of birth, her date of marriage, and the birth date of each child that she had borne. The respondents also were asked, with respect to each birth reported, whether the child had survived to the date of the survey.

The 1982 survey has provided invaluable information about the course of marriage and fertility in China, and has proved to be very consistent with relevant data taken from the 1982 census. For example, the age-specific fertility rates that have been tabulated for individual years after 1950 from the ratio of the reported number of births at each age to the number of women in that age in each year can be cumulated to determine the average number of children ever born to women at different ages in 1982. The 1982 census included a question about the number of children ever born. The average number by single years of age from 20 to 50 from the two sources agrees within 1%, a remarkable degree of consistency from two independent sources of information (Coale 1984).

Consistency is not certain proof of accuracy, however. It is surprising that the ratio of reported male to reported female births for individual past years was not virtually constant at about 1.06 male births for each female birth, as was surely true of the actual, rather than the reported, births.[5] The sex ratio at birth in populations with accurate registration falls

between about 1.05 and 1.07; notably it is usually within this range in data from China's neighbor Japan (Japan 1991).

Table 3 shows the recorded sex ratio at birth from the two surveys by five-year birth cohorts, with births through 1981 from the one-per-thousand survey, for 1982–1987 from the two-per-thousand survey, and for 1989 from the sample tabulation of the 1990 census (the ratio for 1988 was taken as the average of 1987 and 1989). The ratio falls within the usual bounds for only three of 50 cohorts; the average is 1.091, about 3% above the expected norm.

We see a striking congruence between the reported sex ratio by period of birth and the sex ratio reported for the same cohort in the 1990 census (Figure 2). Where masculinity is reported as especially high in 1990, the masculinity of the births reported in the retrospective fertility surveys for the same cohort is also generally high. As stated above in the discussion of the excess masculinity in the four modern censuses of China, the sex ratio of each excessively masculine cohort is too high in the first census in which it is enumerated; this finding indicates that the excess masculinity in the census is the result of excess female mortality and that the excess mortality occurs in infancy and childhood.

As shown by the similarity of time pattern between the sex ratio of the cohorts enumerated in the 1990 census and the reported sex ratio for the births in the years when these cohorts were born, the births of some of the females who were omitted in the censuses (evidently because an unusual proportion of the females were dead) were simply not reported in the fertility surveys. Thus, where the high masculinity in the census indicates

Table 3. Sex Ratios of Births Reported in Fertility Surveys, 1936–1940 to 1985–1989

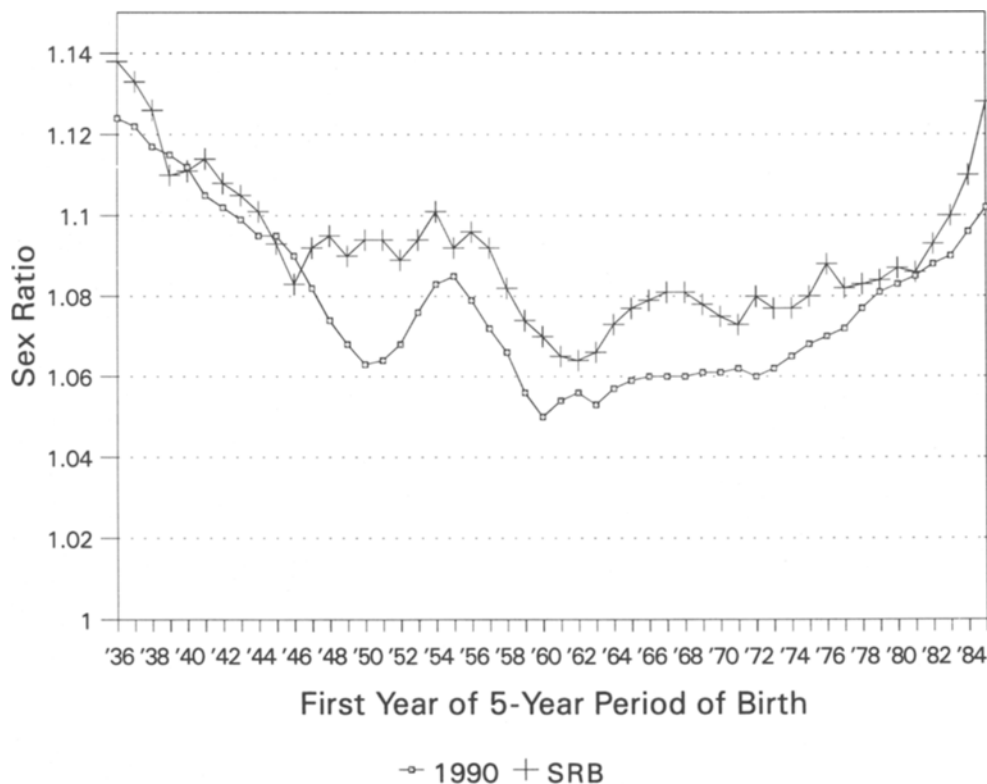| Years of Birth	Sex Ratio	Years of Birth	Sex Ratio
1936–1940	1.138	1961–1965	1.065
1937–1941	1.133	1962–1966	1.064
1938–1942	1.126	1963–1967	1.066
1939–1943	1.110	1964–1968	1.073
1940–1944	1.111	1965–1969	1.077
1941–1945	1.114	1966–1970	1.079
1942–1946	1.108	1967–1971	1.081
1943–1947	1.105	1968–1972	1.081
1944–1948	1.101	1969–1973	1.078
1945–1949	1.093	1970–1974	1.075
1946–1950	1.083	1971–1975	1.073
1947–1951	1.092	1972–1976	1.080
1948–1952	1.095	1973–1977	1.077
1949–1953	1.090	1974–1978	1.077
1950–1954	1.094	1975–1979	1.080
1951–1955	1.094	1976–1980	1.088
1952–1956	1.089	1977–1981	1.082
1953–1957	1.094	1978–1982	1.083
1954–1958	1.101	1979–1983	1.084
1955–1959	1.092	1980–1984	1.087
1956–1960	1.096	1981–1985	1.086
1957–1961	1.092	1982–1986	1.093
1958–1962	1.082	1983–1987	1.100
1959–1963	1.074	1984–1988	1.110
1960–1964	1.070	1985–1989	1.128

Figure 2. Sex Ratio at Birth and in 1990 Census, Same Cohort

excess female mortality, some of the females subject to excess mortality were omitted from the births reported in the fertility survey. The true sex ratio at birth was approximately constant until the mid 1980s when sex-selective abortion began to raise the true ratio. The true correlation between the sex ratio at birth of each cohort and the sex ratio in the 1990 census is about zero; the calculated correlation between these two sets of numbers is 0.91.

Omission of females who died early in life from a fertility history is consistent with a tendency found in the registration of births and early deaths in some of China's neighbors. In registration systems in these countries, which are generally precise, the deaths that occur very early in life are underregistered. Even in Japan, which has unusually complete and accurate registration of births and deaths, the number of very early deaths is underrecorded. The proportion of deaths in the first year of life that occur on the first day is more than 30% in almost all of the countries with low infant mortality. The proportion registered is only 23% and 24% in two different years in Japan, and is less than 8% in Hong Kong. A revealing sign of bias is the ratio of registered stillbirths to registered deaths in the first day of life. In Hong Kong this ratio is over 6; in Japan, over 4; in most European and North American countries, about 2 to 2.5. In Japan and Hong Kong, the person registering births and deaths evidently does not follow the international recommendation of the World Health Organization to count as a live birth an issue from the womb that shows any signs of life after delivery-either respiration or pulse, for example. A stillbirth is to be registered only for a fetus that shows no such signs. From the much higher ratio of reported stillbirths to reported deaths in the first day of life in these populations, it is clear that the registering

person sometimes counts as a stillbirth an event that would be counted in Europe as an early infant death.

In China the birth of a child traditionally is not celebrated until the child has reached an age of one month or more, and the child is not given a name until the passage of some such period of time. The basis for this custom apparently is a belief that celebrating a birth and giving a name soon after the birth tempts the fates to cancel the early celebration by the death of the child. Because this custom apparently causes a bias in otherwise accurate official registration of vital events, it is certainly likely that respondents who share this culture omit from a history of their births those which are followed shortly by the child's death.

Reported Sex Ratios at Birth, by Birth Order

One peculiar feature of the data from the fertility surveys has caused comment: the sex ratio at birth reported for higher-order births is higher than for the first or for the first and second. This feature indicates a higher rate of omission of higher-order female births because careful studies of the true relation between birth order and the sex ratio at birth in several reliable data bases indicate a very slight tendency toward *lower* masculinity at higher orders (Teitelbaum, Mantel & Stark 1971). China's one-per-thousand fertility survey called attention to the increase in sex ratio at birth with birth order reported for 1981, from a ratio of 1.05 for first births to respective ratios of 1.07, 1.13, and 1.16 at orders 2, 3, and 4; the Chinese report on the survey says that the reason for this trend remains to be found.

Through the generous cooperation of the East-West Population Institute in Honolulu, we were able to obtain data (from the full tape of the one-per-thousand fertility survey) bearing on the number of births by birth order and sex, in order to trace by birth cohort the relative reported sex ratios at birth of higher-order and lower-order births. Masculinity of reported births increased with birth order in the reports for earlier cohorts, as well as for those born just before the survey. The relevant information is contained in Table 4, which lists the ratio of male-to-female births in five-year periods from 1936–1940 to 1985–1989 for birth orders 1 and 2 and birth orders 3 and 4.[6] In all but a few cohorts, the sex ratio reported at birth for orders 3 and 4 is higher than for orders 1 and 2; the mean difference is 2%. Among first and second births, 12 of 50 cohorts have sex ratios within the expected limits of 1.05–1.07; for third and fourth births, only four cohorts fall within these limits.

As indicated by the congruence between the reported sex ratio at birth in the fertility surveys and for the same cohorts in the 1990 census, a high reported sex ratio at birth is evidence of excess female mortality in an early period after birth. The higher reported sex ratio at birth for third and fourth births in most cohorts implies a greater degree of excess early female mortality among higher order births.

Sex Ratios by Birth Order within Each Sex

Table 5 lists the reported ratio of first-male births in China to first-female births, second-male births to second-female births, and higher-than-second-order male births to higher-than-second-order female births. Note that the birth order discussed here is the order within the sex. It is not male births among first births and female births among first births, but births of first sons (whatever the absolute order of the birth) relative to births of first

Table 4. Sex Ratio of Births Reported in Fertility Surveys, Birth Orders 1 and 2 and
Birth Orders 3 and 4, 1936–1940 to 1985–1989

Period	Birth Orders 1–2	Birth Orders 3–4
1936–1940	1.129	1.167
1937–1941	1.126	1.151
1938–1942	1.125	1.125
1939–1943	1.123	1.095
1940–1944	1.119	1.119
1941–1945	1.114	1.141
1942–1946	1.105	1.134
1943–1947	1.106	1.120
1944–1948	1.086	1.129
1945–1949	1.086	1.119
1946–1950	1.081	1.105
1947–1951	1.092	1.118
1948–1952	1.088	1.116
1949–1953	1.092	1.101
1950–1954	1.088	1.109
1951–1955	1.090	1.100
1952–1956	1.085	1.097
1953–1957	1.087	1.099
1954–1958	1.091	1.099
1955–1959	1.083	1.093
1956–1960	1.088	1.102
1957–1961	1.088	1.098
1958–1962	1.080	1.098
1959–1963	1.065	1.094
1960–1964	1.067	1.081
1961–1965	1.065	1.073
1962–1966	1.063	1.064
1963–1967	1.064	1.058
1964–1968	1.069	1.066
1965–1969	1.074	1.073
1966–1970	1.079	1.068
1967–1971	1.079	1.076
1968–1972	1.075	1.084
1969–1973	1.071	1.084
1970–1974	1.065	1.081
1971–1975	1.056	1.085
1972–1976	1.062	1.092
1973–1977	1.060	1.088
1974–1978	1.064	1.085
1975–1979	1.065	1.086
1976–1980	1.080	1.088
1977–1981	1.074	1.084
1978–1982	1.077	1.090
1979–1983	1.077	1.088
1980–1984	1.081	1.113
1981–1985	1.078	1.113
1982–1986	1.086	1.155
1983–1987	1.094	1.171
1984–1988	1.103	1.200
1985–1989	1.113	1.228

Table 5. Sex Ratio of Births Reported in 1/1000 Fertility Survey, Birth Order within
         Each Sex, 1936–1940 to 1977–1981

Period	Ratio (Male Births/Female Births)		
	Order 1	Order 2	Order 3
1936–1940	1.093	1.231	1.391
1937–1941	1.075	1.230	1.370
1938–1942	1.069	1.190	1.334
1939–1943	1.062	1.169	1.247
1940–1944	1.055	1.173	1.270
1941–1945	1.063	1.162	1.257
1942–1946	1.055	1.139	1.251
1943–1947	1.049	1.133	1.223
1944–1948	1.035	1.127	1.233
1945–1949	1.033	1.108	1.219
1946–1950	1.028	1.085	1.212
1947–1951	1.041	1.084	1.218
1948–1952	1.044	1.074	1.223
1949–1953	1.042	1.061	1.207
1950–1954	1.046	1.063	1.206
1951–1955	1.043	1.070	1.192
1952–1956	1.034	1.075	1.182
1953–1957	1.038	1.071	1.193
1954–1958	1.040	1.081	1.192
1955–1959	1.028	1.078	1.181
1956–1960	1.033	1.078	1.178
1957–1961	1.039	1.072	1.166
1958–1962	1.025	1.079	1.137
1959–1963	1.020	1.061	1.127
1960–1964	1.021	1.057	1.117
1961–1965	1.017	1.062	1.114
1962–1966	1.012	1.069	1.114
1963–1967	1.015	1.075	1.110
1964–1968	1.026	1.091	1.108
1965–1969	1.028	1.108	1.103
1966–1970	1.040	1.100	1.103
1967–1971	1.048	1.091	1.106
1968–1972	1.051	1.091	1.106
1969–1973	1.051	1.098	1.093
1970–1974	1.063	1.085	1.082
1971–1975	1.066	1.092	1.067
1972–1976	1.083	1.117	1.039
1973–1977	1.091	1.129	1.005
1974–1978	1.102	1.140	0.969
1975–1979	1.104	1.164	0.939
1976–1980	1.128	1.168	0.896
1977–1981	1.133	1.139	0.856

daughters, again without regard to overall order. A first son can be of any birth order (1, 2, 3, . . . , *n*), depending on the presence of female births in the mother's sequence.

Until the mid-1960s, the ratio of reported male-to-female births by order within each sex rises as order increases. Among births reported in the 1940s and 1950s, the reported ratio of third-male to third-female births is 15 to 20% higher than the ratio of first males compared to first females.

The difference remains large until the 1970s and 1980s, when the sex ratio of first males to first females rises, and the ratio of third males to third females falls to substantially below 1. The anomalous "crossover" of these sex ratios at birth is discussed later.

Survival Rates to Date of Survey by Sex

The material presented above shows that the omission of females from censuses in China is evidence of early excess female mortality. The positive association between the sex ratio of cohorts in the 1990 census and the reported sex ratio at birth of these cohorts in the fertility surveys indicates that early female mortality led to the omission from the survey of more female births in cohorts that register high male-to-female ratios in the censuses.

The surveys contain direct information on the relative mortality of males and females whose births are reported. The reported survival of each birth to the date of the survey is recorded; Table 6 shows the proportion dead of males and females born in each cohort from 1936–1940 to 1977–1981. These are the proportions dead of births that the respondents recalled as births; it appears that a child who died very early may have been omitted in the report of births. Therefore these proportions dead are net of early deaths that led to the omission of a birth in the survey. The reported proportion dead is higher for males than for females in all but nine of 42 cohorts. One of these nine is the cohort born in the war years 1938–1942; the other cohorts were children during the great famine of 1959–1961, which we discuss later. Thus the survey suggests that excess female mortality occurred predominantly before the dead infant survived long enough to be recalled as having been born (as indicated by the excess sex ratio at birth); once a child survived long enough to be reported as a birth, female survival rates generally were a little higher than male-although not as much higher as they should be under nondiscriminatory conditions.

Proportion Dead by Birth Order within Each Sex

When the proportion dead from the reported birth to the survey is calculated for male and for female births by birth order within each sex, the sex difference for each order is modest: the proportion dead among first males is higher than for first females except for five cohorts subject to excess child mortality during 1959–1961. The median ratio of male-to-female proportion dead is 1.04 for first boys and first girls, 1.015 for second boys and second girls, and .976 for third. The most conspicuous feature of the proportions dead by order within each sex is that the proportion grows higher as the order increases. Within each sex in every cohort, the proportion dead is higher for second girls and second boys than for first, and higher for third than for second. The average difference between proportion dead for first and second births within the sex is 2.7% for females and 2.3% for males; between first and third births within each sex, the average differences respectively are 7.1% and 5.7% for females and for males. Differences by birth order within each sex in the reported proportion dead are generally larger than sex differences for a given birth order.

Table 6. Proportion Dead, from Reported Birth to Survey Males and Females,
          1936–1940 to 1977–1981

Period	Males	Females	Males/Females
1936–1940	0.4562	0.4545	1.0039
1937–1941	0.4489	0.4418	1.0162
1938–1942	0.4398	0.4416	0.9961
1939–1943	0.4359	0.4339	1.0045
1940–1944	0.4250	0.4195	1.0132
1941–1945	0.4095	0.4063	1.0080
1942–1946	0.3999	0.3940	1.0148
1943–1947	0.3840	0.3759	1.0215
1944–1948	0.3655	0.3583	1.0201
1945–1949	0.3482	0.3409	1.0213
1946–1950	0.3307	0.3247	1.0184
1947–1951	0.3118	0.3080	1.0124
1948–1952	0.2920	0.2883	1.0128
1949–1953	0.2710	0.2683	1.0102
1950–1954	0.2548	0.2528	1.0079
1951–1955	0.2380	0.2379	1.0002
1952–1956	0.2280	0.2287	0.9970
1953–1957	0.2225	0.2249	0.9894
1954–1958	0.2236	0.2289	0.9770
1955–1959	0.2238	0.2290	0.9773
1956–1960	0.2184	0.2254	0.9692
1957–1961	0.2103	0.2178	0.9656
1958–1962	0.1962	0.2011	0.9759
1959–1963	0.1732	0.1742	0.9944
1960–1964	0.1557	0.1517	1.0259
1961–1965	0.1406	0.1364	1.0309
1962–1966	0.1273	0.1215	1.0477
1963–1967	0.1210	0.1155	1.0479
1964–1968	0.1156	0.1117	1.0348
1965–1969	0.1087	0.1056	1.0291
1966–1970	0.1046	0.0988	1.0591
1967–1971	0.0984	0.0931	1.0578
1968–1972	0.0938	0.0881	1.0647
1969–1973	0.0910	0.0839	1.0838
1970–1974	0.0868	0.0804	1.0795
1971–1975	0.0819	0.0778	1.0532
1972–1976	0.0791	0.0754	1.0495
1973–1977	0.0738	0.0707	1.0440
1974–1978	0.0696	0.0657	1.0586
1975–1979	0.0660	0.0622	1.0603
1976–1980	0.0629	0.0597	1.0541
1977–1981	0.0587	0.0560	1.0476

EXCESS FEMALE MORTALITY IN BIRTH COHORTS IN FOUR PERIODS OF BIRTH

The sex ratios recorded in the four modern censuses make possible four estimates of the proportion missing caused by excess female mortality for the first 13 five-year cohorts born beginning in 1936, three estimates for the next 11 cohorts, two for the next 18, and one for the remainder. As Figure 1 makes clear, the estimates from the different censuses agree closely. To simplify the exposition, we use a single number for each cohort, namely the median of the separate estimates that are available.

The consistency of the estimates derived from as many as four censuses at ages separated by as much as 37 years (1953 to 1990), and the congruence (by cohort) of census sex ratios with the reported sex ratio at birth in retrospective surveys, show that much of the excess female mortality occurred soon after birth, and that many of the children who died early were not included among the births reported in the fertility surveys.

Females Missing and Related Information for Cohorts Born from the Late 1930s to the Early 1950s

The estimated proportion of females missing because of excess mortality in these 15 early five-year birth cohorts declined steadily from over 16% in the two earliest cohorts to below 6% in the cohort born in 1950–1954 (Figure 1). The decline in the proportion of females missing was interrupted in the next eight or nine cohorts, which experienced excess child mortality during the Great Leap Forward (see next section).

The principal source of excess female mortality in the 15 early cohorts was very likely sex-selective infanticide, a traditional practice in China. A missionary (and naturalist) observer in the late nineteenth century interviewed 40 women over age 50 who reported having borne 183 sons and 175 daughters, of whom 126 sons but only 53 daughters survived to age 10; by their account, the women had destroyed 78 of their daughters (Wolf and Huang 1980:230). The continuation of this practice as late as the 1930s and 1940s may have been stimulated in part by troubled times, including civil war and the Japanese invasion. The decline of excess female mortality after the establishment of the People's Republic was assisted by the action of a strong government, which tried to modify this custom as well as other traditional practices that it viewed as harmful.

The especially high reported sex ratios among higher-order births (particularly when birth order is measured separately within each sex), as shown in Tables 4 and 5, are a natural result of sex-selective infanticide. The preference for a male child apparently had little effect on the survival of the first female born. The first female presumably was useful in helping to care for younger siblings and for performing tasks associated with the female role in the household. A female child with one or more older sisters, however, seems to have been especially unwelcome in comparison with a second or third male birth.[7] The sex ratio reported for third births within each sex exceeds the ratio reported for first births by about 20 to 30% in the cohorts born around 1940 and by about 15% for cohorts born in the early 1950s. The ratio of reported first male to first female births, with the exception of births before 1942, falls within or even below the normal range of 1.05–1.07.

By the date of the one-per-thousand fertility survey, the proportion dead among the births in each of these early cohorts is higher for males than for females (Table 6), with one exception (1938–1942). This mortality pertains to deaths that occurred between the remembered birth and the survey; a remembered birth is a birth that survived the very early

days of life. On average, a female child who survived long enough to be reported as a birth had slightly lower reported mortality between the reported birth and the survey than a male child in the same cohort.

Females Missing and Related Information for Cohorts Born 1951–1955 to 1960–1964

The estimated proportion of females missing in the censuses declines monotonically from the cohort born in 1937–1941 to that of 1950–1954. Then the estimated proportion missing rises to a local peak in the six five-year cohorts from 1952–1956 to 1957–1961 (Figure 1). This hump probably does not reflect a temporary increase in sex-selective infanticide. Certainly it is connected with the excess mortality in the famine that occurred in the crisis years of 1959–1961 during the "Great Leap Forward." For the whole population, the excess deaths in these years (above those which would have occurred with a linear change in death rates from 1957 to 1964) have been estimated at nearly 30 million.

The hump in the estimated proportion of females missing in cohorts born in the 1950s is not at all closely matched in the sequence of sex ratios at birth derived from the fertility survey for these cohorts. The reported sex ratio at birth follows a fairly level course from 1945–1949 to 1957–1961. For males the proportion dead from reported birth to the survey declined in relation to the proportion dead for females, from the cohort born in 1950–1954 to the 1957–1961 cohort; then it rose until the years of cohorts born after 1962 (Table 6). These facts show that the hump in the estimated excess female mortality among cohorts born in the 1950s was not primarily an increase in the very early female mortality that is revealed as an increase in the reported sex ratio at birth. Rather, it was an increase in childhood mortality beyond early infancy, revealed by a rise in the ratio of male survival to female survival from reported birth to the survey.

Females Missing and Related Information for Cohorts Born in the 1960s and 1970s

After the hump in the estimated excess female proportion dead for cohorts born in the 1950s and subject to excess childhood mortality during the crisis years, the estimated proportion of missing females in the cohorts born after 1960 settled at around 2%. This figure remained almost level until the later 1970s, when a gradual increase began. An extraordinary feature of this period is the evolution of the ratio of male-to-female births classified by birth order within each sex. Note again that the ratio of third-male to third-female births does not relate to the normally defined ratio of males to females among third order-births; instead it relates to the ratio of the number of males born after two preceding male births to the number of females born after two preceding females. The ratio declines from over 1.25 among the first seven cohorts, beginning with 1936–1940, to about 1.11 for cohorts born in the 1960s. Beginning with a ratio of 1.106 for the cohort born in 1968–1972, the sex ratio at birth of third males to third females descends monotonically to .856 in 1977–1981.

This decline is accompanied by a rise in the reported ratio of first-male to first-female births, from 1.052 to 1.133. First we suspected that the quality of the data had failed for these cohorts. Later, however, we realized that the decline in masculinity of third births (within each sex) and the increase in first births could be the result of a new "stopping rule," whereby couples prevent further childbearing when they have had the number of boys

they want. A sex-guided rule for initiating effective birth control does not affect the sex ratio of birth by order of birth, as ordinarily defined, but it does affect the ratio by order within sex.

Imagine that all couples cease reproduction as soon as a male is born, and that the sex ratio at birth always averages one male for every female. Half of the first births would be male. Only those women with a female first birth would have a second birth; half of the second births would be male; half would be male at all higher orders. All of these higher-order male births, however, would be first *male* births; the higher-order (conventional) female births would be second-female, third-female, and so on. The sex ratio of births by the usual definition of birth order would be 1.0 at each order; but the ratio of first-male to first-female births would be 2.0. At all higher orders (within each sex) the ratio would be zero because no males would be born beyond the first-male birth. Thus the rather steep decline in the ratio of third-male to third-female births (to well below 1.0), which begins around 1970, is not evidence of faulty data, but the result of the initiation of selective birth prevention according to the sex of the preceding births. After 1969–1973, as seen in Table 5, the ratio of first-male to first-female births increased steadily because of an increasing tendency to terminate childbearing after the birth of a male child. The timing supports the idea that these trends are due to a newly initiated stopping rule: the government introduced a strong birth control program in 1970, which provided family planning services and incentives to reduce fertility. The total fertility rate fell from 5.8 in 1970 to 2.7 in 1979.

Before 1970 there is little indication of widespread, deliberate limitation of births (except in the cities). William Lavely (1986) has calculated the measure m of the degree of voluntary control of marital fertility for urban and rural China from 1950 to 1981. Until 1970 the value of m in rural China is close to horizontal at values indicating the virtual absence of deliberate control of fertility. In that year the index begins a steep rise; by 1980 it reaches a value approximating that found in industrialized countries with fertility near the replacement level. We have combined Lavely's values of m into five-year groups to match the birth cohorts from 1950–1954 to 1977–1981. The correlation between the ratio of third-male to third-female births and the index of the intensity of fertility control is $-.97$.

The changes in the ratio of male-to-female births by birth order within each sex were caused by the emergence of a stopping rule, whereby couples tend to stop after satisfying a preference for at least one male (or perhaps, in some instances, at least two males). The stopping rule began to be employed when the government family planning program was implemented and when deliberate control of childbearing first became common.

We have also tabulated the ratio of male-to-female births by birth order within each sex from the city sample that was included in the 1982 survey. In this sample, a monotonic decline in the sex ratio for third-order births within each sex began in the early 1960s, as did the effective birth control program in urban China.

We found a puzzling feature of the reported ratio of first-male to first-female births: until about 1970, when the increase began, the ratio was chronically below the normal level of about 1.06. If the incidence of infanticide is negligible for first-female births, and if very early mortality (other than infanticide) leads to omission of a birth from the fertility history, higher male than female mortality in the first day, the first week, and the first month of life (as in almost all high-quality systems of registration) might lead to the omission of slightly more (early-dying) males than females.

Females Missing and Related Information for Cohorts Born after 1980

The estimated proportion of females missing because of excess female mortality began to increase in the mid-1970s; the increase grew steeper for birth cohorts extending into the

1980s (Figure 1). The reported sex ratio at birth from the fertility surveys also rose markedly, from 1.082 for the births in 1977–1981 to 1.128 for births in 1985–1989. The most conspicuous increase occurred in the sex ratio at higher-order births: for third and fourth orders combined, the ratio rose from 1.084 in the cohort born in 1977–1981 to 1.228 for the 1985–1989 cohort, higher than for any cohort since the early 1940s.

Couples had an increased incentive to avoid a higher-order female birth after 1980 because of the one-child policy introduced in 1979; this policy was administered at the local level to induce couples to avoid having a second (and especially a third or higher-order) birth. Apparently the tradition of infanticide was restored somewhat; the Chinese press carried many stories and editorials reporting (and condemning) this practice. On April 9, 1983, for example, the *China Daily* published an article titled "Female Infanticide Evokes Danger of Sexes Imbalance."

Another source of high reported sex ratios at birth, particularly at higher orders, is the Chinese custom of adopting out a child, particularly a child found to be especially burdensome. This long-standing custom continues to be practiced; the two-per-thousand survey of 1988 includes information (provided by the adopting parent) of recent adoptions. Female adoptions outnumber male by 3 to 1. Women, in supplying a history of their births, might well omit some or all of the children adopted out, and the adopting mother quite properly would not list an adopted child in her own birth history (Johanssen and Nygren 1991). Thus adopting out might contribute to the omission of female births from fertility histories, especially at higher orders. Adopted children do not appear to be omitted differentially from censuses, however; they are members of the adopting household and presumably would be listed in the household to qualify for benefits. Therefore adopting out cannot explain the especially high estimated excess female proportion dead in the 1990 census among cohorts born in the late 1980s. In view of the similar increases in the cohort sex ratios at birth in the birth histories and in the census, the rising sex ratio at birth in the late 1980s, especially at higher orders, cannot be explained by adoption.

Foreign demographers had not widely accepted conjectures that the sex ratio at birth increased in the 1980s because of increased recourse to sex-selective abortion. It was believed that the technical means for identifying the sex of the fetus were not available, except perhaps in major cities. In 1992, however, the Chinese government and Chinese scholars revealed previously unreported evidence that adequate technology may be widely available, and that the sex ratio at birth has risen.

At the International Seminar on China's 1990 Population Census, held in Beijing, several of the Chinese participants discussed the existence, in China, of a large number of "ultrasound B" machines, capable of ascertaining an embryo's sex. "China manufactured its first ultrasound B machine in 1979. . . . Records of the Customs administration show that 2,175 high quality color ultrasound B machines were imported in 1989, with the peak years of importation falling between 1985 and 1989. It is estimated that China now has the capacity to produce over 10,000 such devices per year. . . . According to the Ministry of Health . . . every county is equipped with machines of high quality, operated by skilled technicians." (Yi et al. 1993: 291). The machines are intended for diagnosis (including fetal defects), for locating previously inserted IUDs, and for various health purposes. Identification of an embryo's sex is strictly forbidden by the government authorities, but when the technician (typically a local resident) observes the sex on his machine, he can let the parents (usually his friends) know by a simple, quiet gesture (Yi et al. 1993).

Chinese scholars at the Beijing conference also revealed previously unpublished data that confirm a rise in China's sex ratio at birth, when biased reporting of number of births by sex is hardly possible. They reported figures from birth records in hospitals on the numbers of male and female births; these figures were unaffected by female infanticide or by selective neglect of girls. Based on 1.2 million births a year in what was thought to be a
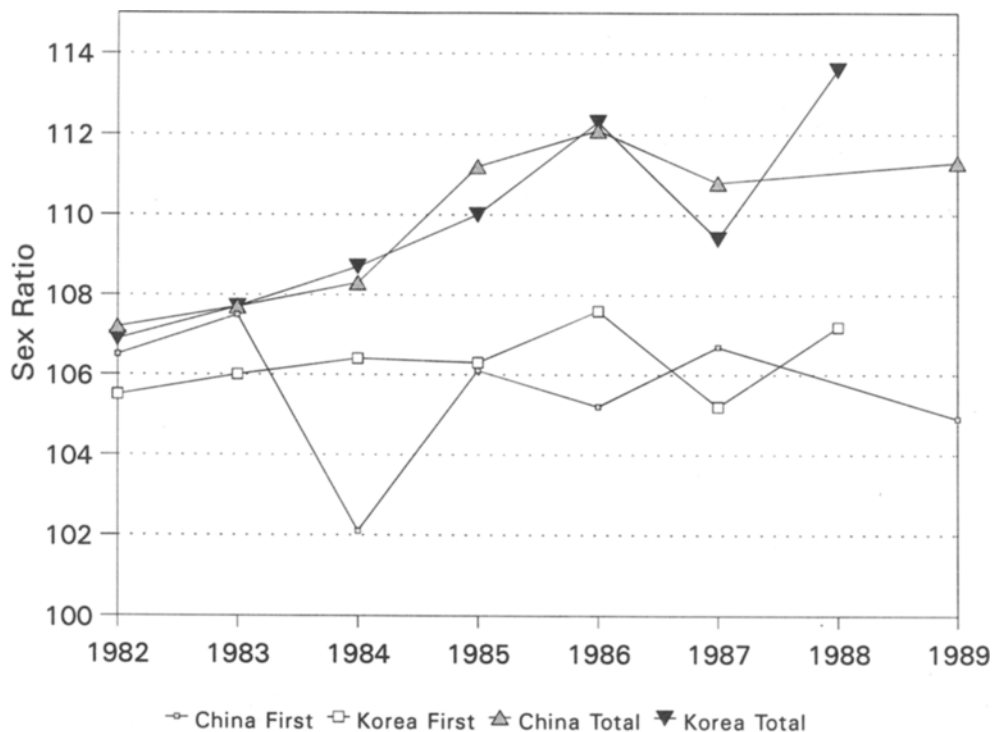
representative sample of hospitals, the number of male births per 100 female births had risen to 108.0 in late 1986 and 1987, to 108.3 in 1989, to 109.1 in 1990, and to 109.7 in 1991. Possibly these figures are a biased sample (on the high or the low side) for the nation's 20 million annual births. For example, these hospitals may represent urban births more heavily than rural; even within a community, the masculinity ratio of births outside hospitals may be different from that in hospitals. Births outside hospitals, or rural births, may have a higher sex ratio than births in hospitals, or urban births, if rural parents have a stronger preference for males and if they have as much access to the technology as do city dwellers. But if people in remote or rural areas do not have as much access to functioning ultrasound B machines as people in urban or advanced rural areas-a likely situation-then the underrepresented births may have lower masculinity than those recorded in the hospitals. In view of the uncertainty even in the direction of bias, the hospital data strongly confirm an above-normal sex ratio at birth in China during each year from 1987 to 1991.

Earlier in the decade-as of the 1982 census, for example-evidently there were not enough ultrasound B machines or other fetal sex detection devices in China to affect the nation's sex ratio at birth. Even so, girls were missing from the youngest age groups in the census. Eight years later, the 1990 census count of children age 8 and older showed that young children had been an undercounted in the 1982 census, but the undercount was the same for each sex. The slight increase in the estimated proportion of females missing from the birth cohorts of the mid-1970s to the early 1980s must be explained by an increase in relative female mortality at very young ages.

Can we assume that only special factors such as communism, compulsory family planning, or the one-child policy can cause a sharp rise in the masculinity of young cohorts, of the type that occurred in China in the 1980s and early 1990s? The answer appears to be "no" because a very similar increasing dearth of young girls is observed in data from the Republic of Korea from 1983 to 1988. In both populations, the total fertility rate fell from about 6.0 in the late 1950s to about 2.6 around 1980, and marital fertility changed from an age pattern indicating little voluntary control to a pattern implying widespread practice of birth limitation. Figure 3 shows the sequence of reported sex ratios at birth for first births and for all births in the two populations during the 1980s. In both countries, the ratio for first births, although erratic, shows no upward trend, while the overall sex ratio at birth increases to values at least 6% higher than the first-birth ratio. The sex ratio of third-order births rises from 1.09 in both populations in 1982 to 1.70 in Korea in 1988 and to 1.25 in China in 1989. Sex-selective abortion also has emerged in Korea (Shim et al. 1991), which enjoys many forms of advanced technology and where the demand for sex identification is very high because the preference for males is much like that in China. No coercive one-child policy exists in Korea, but through voluntary use of contraception and abortion, the total fertility rate in Korea has fallen to about 1.5 births per woman. In both the People's Republic of China and South Korea, couples strongly desire more sons than daughters, on average. As prenatal sex determination has become available, parents in both countries evidently have used it.

DISCUSSION AND CONCLUSIONS

In each of the periods we have considered, we see evidence of a strong preference for males in China, as shown by various features of the evolution of cohorts born in the period. A persistent feature is the indication of a smaller number of females in each cohort, relative to the number of males, than would be yielded by a normal sex ratio at birth, and normal differential mortality. Available evidence suggests that the large excess female mortality for the cohorts born in the 1930s and 1940s resulted from the persistence of the traditional

Figure 3. Comparison of Sex Ratio at Birth Order, between China and Republic of Korea

practice of female infanticide. As this practice became less prevalent, the fraction of females missing in successive cohorts declined steadily. This decline was interrupted for cohorts born in the 1950s because female children (beyond the neonatal period) suffered more than male children from the increased mortality in the years of the great famine.

The degree of effective voluntary control of fertility was negligible until the early 1960s in the cities, and until 1970 in the numerically predominant rural population. The initiation of effective control coincided with a strong government program designed to reduce the level of childbearing. An effect of this introduction of contraception was the beginning of a rise in the ratio of first-male births (within the male sex) to first-female births, and a decline in the ratio among third births (within each sex). The beginning of birth control around 1970 was not marked by a large change in the sex ratio at birth at the third and fourth orders or at the first and second (as ordinarily defined), because the cessation of childbearing (even selective cessation by the sex of the previous births) has no effect on the sex ratio at birth at each order. When ratios of male-to-female births are calculated by order of birth within each sex, however, the sex ratio at birth is affected strongly by a "stopping rule." In short, the spread of birth control in the 1970s had only a minor effect on the reported sex ratio at birth, but the new birth control led to cessation of fertility after the birth of a wanted male.

During the 1960s and 1970s, the proportion of missing girls in each five-year grouped cohort reached a low point at about 2% of the girls born, indicating a reduction but not a disappearance of female infanticide and neglect of girls past early infancy. In the late 1970s

and early 1980s, before ultrasound B machines became widely available in China, the proportion of girls missing rose to 3%. Those detected as missing in the 1982 census count had been lost at a young age before the census.

In the 1980s the sex ratio at birth as reported from fertility surveys rose sharply, especially at higher birth orders. An increase in the adopting out of girls, more than of boys, contributed to this trend, but this component probably is counteracted in the census data from 1982 and 1990, which show a sharp increase in missing girls during the decade. Data from 1.2 million hospital births a year presumably are free of sex-selective underregistration, yet may be affected by a difference in the masculinity of the births that take place in hospitals. These data show that these births are affected by sex-selective abortion of female fetuses but not by sex-selective postnatal mortality, and thus are excessively masculine in the late 1980s.

NOTES

[1] The high quality of age reporting in the Chinese censuses, derived as it is from date of birth reported according to the lunar calendar, is evident in the near absence of "age heaping" on the usual preferred numbers, such as those divisible by 10. Such heaping is prominent in the many less developed countries in which knowledge of age is inexact. As proof of the tendency to report the correct date in the lunar calendar, proportions are slightly elevated at ages at which the lunar date of birth falls in a year containing 13 lunar months instead of the more usual 12. Also, the survival rates calculated by single years of age from one census to the next are consistent with survival rates from model life tables at the appropriate level of mortality (Coale 1984, 1993; Coale and Li 1991).

[2] Ages of military personnel, the great majority of whom are men, have not been reported from the censuses of 1953 and 1964. The 1982 census listed the military population in five-year age-sex groups, and the 1990 census did so by single years of age. Even in these censuses, however, the military population is not reported accurately, apparently because the figures come from imprecise administrative records. The civilian data by age and sex understate the proportion masculine at late teen and young adult years. To adjust for this understatement, we reassigned the masculinity ratios at ages 14–18 to 30–34 as the highest ratio for the cohort recorded in any census.

[3] This observation is affected by the necessity of adjusting for the missing or misreported military population. The adjusted sex ratios in fact did not contribute many instances of a rise in cohort masculinity.

[4] The model life tables employed in calculating the expected sex ratios were the "West" tables from Coale and Demeny (1983). The mortality levels were set at a female life expectation of 25 years before 1940, and of 32.5, 45.0, 52.5, 62.5, and 70 years in the 1940s, 1950s, 1960s, 1970s, and 1980s. We assumed that the change in sex ratio from birth to ages 0–4 was determined by the model table at the level of mortality when the cohort was born. From age 0–4 to the age at the date of the relevant census, we assumed the proportionate change in the sex ratio to be equal to the change over this age span at a mortality level intermediate between the level when the cohort was born and the level at the date of the census.

[5] In the 1980s the real sex ratio at birth rose because of the effect of sex-selective abortion, but constancy (except for slight random fluctuation) prevailed until about 1983.

[6] In the 1980s the sex ratio at birth order 2 (and therefore the average at the first two orders) rose because of the combined effect of the one-child policy and sex-selective abortion.

[7] See Muhuri and Preston (1991) for a similar and well-documented phenomenon in Bangladesh.

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