Chapter VIII

EXAMPLES OF ESTIMATION BASED ON CHILD SURVIVAL AND AGE DISTRIBUTIONS

A. Estimation of fertility and mortality from data in a single census that records the age composition of the population, the number of children ever born and the number surviving

The estimation of child mortality from the reported survival of children ever born to women in various age intervals in the census of Brazil, 1950, (see chapter VII, section B) is combined with the age distribution in the example given in this section, to provide estimates of fertility and over-all mortality by methods described in chapter III, section B. The example begins with the estimates of ${}_2q_0$ in table 34., i.e., ${}_2q_0$ for both sexes equal to 0.219. The method of estimation (employing the age distribution of the *male* population in 1950 and the family of model stable populations) requires determination of the level of male mortality. The first step is to ascertain whether the relations between male and female mortality in the "West" model life tables can plausibly be assumed to characterize mortality in Brazil. Life tables based on registered deaths in the Federal District have mortality differences as large as in the "West" tables; sex differences in mortality in Latin America are almost without exception unfavourable to males up to age two; and the sex ratio of the Brazilian population supports the inference that sex differences in mortality of about the magnitude found in the "West" tables have prevailed in Brazil. The level of mortality identified by a ${}_2q_0$ of 0.219 is 10.1 (both sexes). The question is whether the sex ratio of the Brazilian population (males/females = .993 for the whole population, and .988 for the native population in 1950) is consistent with the sex differences found at level 10.1 in the "West" model life tables. The last entries in each model stable population make it possible to calculate the sex ratio on the assumption of any stipulated sex ratio at birth (of, say, 1.05 males/females) and the "West" differences in mortality at the same level. We shall assume growth rates of .015 and .025, almost certainly bracketing the Brazilian rate of increase, here provisionally assumed unknown. The sex ratio in a tabulated stable population is calculated as follows: (*a*) assume the sex ratio at birth to be 1.000. Note the figure "Pop. size, B(0) = 1" at, for example, mortality level 9, growth rate .015. The figure is 26.095 for females and 24.701 for males, and the sex ratio of the stable population under these circumstances is 24.701/26.095 or .9466. If the sex ratio at birth is 1.04 or 1.05, the sex ratio of the stable population becomes $1.04 \times .9466 = .984$, or $1.05 \times .9466 = .994$. Futher calculations of this nature provide the figures in table 35.

The sex ratio among more than 200,000 births registered in the Federal District in 1949-1952 was 1.058, so that a sex difference of mortality at least as large as in the "West" model tables is needed to account for the masculinity of the Brazilian population, and more especially the native population in 1950. Thus it will be assumed that ${}_2q_0$ for the male population of Brazil just prior to 1950 was 0.232, and that the appropriate life table is level 10.1. Table 36 shows (columns 4.*a*, 4.*b* and 4.*c*) birth rates, death rates and rates of increase associated with this mortality level and recorded values of C(5), C(10), ..., C(45) for Brazilian males, 1950.

Female and total population parameters are estimated as in chapter VI, section C. The resultant values are shown in table 37.

Note that these estimates indicate slightly higher fertility and mortality than were obtained from the same age distribution and the intercensal rate of increase. The fertility estimates presented here are based on evidence

Table 35. Sex ratio in stable populations with the "West" sex differences in mortality, various mortality levels, rates of increase and sex ratio at birth

Rate of increase	*Sex ratio at birth 1.04*			*Sex ratio at birth 1.05*		
	Level 7	*Level 9*	*Level 11*	*Level 7*	*Level 9*	*Level 11*
.015	.979	.984	.988	.989	.994	.998
.025	.986	.991	.995	.995	1.001	1.005

TABLE 36. CALCULATION OF STABLE POPULATION ESTIMATES OF BIRTH AND DEATH RATES BASED ON A REPORTED AGE DISTRIBUTION AND ON A LEVEL OF MORTALITY DERIVED FROM REPORTED CHILD SURVIVAL RATES, BRAZIL, 1950, MALES.

Age x	*C(x) (proportion up to age x) Brazil, 1950, males*	*Values of C(x) and various parameters in male stable populations with a level of mortality of 10.1*		*Values of various parameters in male stable populations with C(x) as shown in col. 2 and with mortality level of 10.1*		
		r = .020	r = .025	*Birth rate*	*Death rate*	*Growth rate*
(1)	(2)	(3.a)	(3.b)	(4.a)	(4.b)	(4.c)
5	.164	.160	.177	.0444	.0232	.0212
10	.302	.293	.321	.0449	.0233	.0216
15	.424	.410	.444	.0453	.0233	.0222
20	.527	.514	.550	.0451	.0233	.0218
25	.619	.604	.641	.0453	.0233	.0220
30	.698	.682	.717	.0456	.0233	.0223
35	.760	.750	.781	.0449	.0233	.0216
40	.819	.807	.834	.0455	.0233	.0222
45	.867	.855	.878	.0459	.0233	.0226
	Birth rate	.0432	.0484			
	Death rate	.0232	.0234			

TABLE 37. STABLE POPULATION PARAMETERS FOR BRAZIL, 1950, DERIVED FROM THE MALE AGE DISTRIBUTION, LEVEL OF MORTALITY FROM ESTIMATES $_2q_0$ FOR BOTH SEXES, THE SEX RATIO OF THE POPULATION AS REPORTED, AND ASSUMED SEX RATIO AT BIRTH OF 1.05

	Males	*Females*	*Total population*
Birth rate	.0453	.0428	.0441
Death rate	.0233	.0210	.0222
Level of mortality	10.1	10.1	—
$^0e_0$	40.0	42.8	—
GRR ($\bar{m}$ = 29.1)	—	2.91	—
Total fertility	—	5.97	—

that is in principle preferable, because fertility estimates derived from l_2 are less affected by variations in the age pattern of mortality. Moreover, the fertility estimates obtained in this way are closer to the average parity reported by women 45-49 years of age; which in the Brazilian census of 1950 appears a remarkably valid report. On the other hand, estimates of the death rate and and of the expectation of life at birth are strongly dependent on how closely the age pattern of mortality in Brazil conforms to the "West" model tables.

B. ESTIMATION OF FERTILITY AND MORTALITY FROM DATA ON AGE DISTRIBUTION, THE INTERCENSAL RATE OF INCREASE, AND SURVIVAL RATES OF CHILDREN EVER BORN

If an approximately stable population has been enumerated twice in about a decade, and if the second census contains information making it possible to calculate childhood mortality, the birth rate can be estimated (as in the preceding section) in a way that has relatively little sensitivity to age–mis-statement and unusual age patterns of mortality, and the death rate estimated in turn by subtracting the intercensal rate of natural increase from this estimated birth rate. The resulting death rate figures are little affected by an age pattern of mortality that does not in fact conform to the model life tables (table 38).

TABLE 38. BIRTH RATES CALCULATED FROM C(x) AND l_2 (MALES), AND DEATH RATES FROM $b-r$, BRAZIL, 1950

	Males	*Females*	*Total population*
Birth rate	.0453	.0428	.0441
Intercensal rate of natural increase	.0232	.0238	.0235
Death rate	.0221	.0190	.0206

It is not difficult to construct a life table approximately consistent with these rates, embodying mortality above age five derived from C(x) and r, and mortality under age five from the estimated value of l_2. The procedure is as follows: (*a*) find the value of $_5L_0$ and l_5 consistent with the estimated l_2 (*i.e.*, at mortality level 10.1 for each sex); (*b*) find the value of $^0e_5$ in the stable population selected from C(x) and r for males, and estimated for females from the male C(x) and r plus the recorded sex ratio of the population, the estimated sex ratio at birth, and the female intercensal rate of natural increase (*i.e.*, at mortality level 11.3 for males and 12.0 for females); (*c*) calculate $^0e_0$ as $(l/l_0)\ (_5L_0 + l_5 \times {^0e_5})$.

The results are as follows:

	Males	*Females*
$^0e_5$	51.3	54.4
l_5	72700	75200
$_5L_0/l_0$	3.898	4.023
$^0e_0$	41.2	44.9

Comments. The analysis of the male age distributions in Brazil in 1950, combined with the estimated intercensal rate of natural increase, the recorded sex ratio, and data on child survival leads to estimates of the birth rate of about 44 per thousand, a death rate of about 21 per thousand, an expectation of life at birth of about forty-three years, and a total fertility of about six children per woman passing through the child-bearing years. The only independent information available—the average parity reported by women 45-49—indicates a slightly higher total fertility of 6.2. It is slightly surprising (and not at all typical of results found from other censuses) to find reported parity by older women *exceeding* the estimate derived from the age distribution. Moreover, the average parity reported by women 45-49 exceeds $(P_3)^2/P_2$, which equals 5.76 in this case. But there is enough consistency—in the level of mortality indicated by the succession of $_xq_0$ estimates (see chapter VII, section B), in the not very wide divergence between estimates based on $C(x)$ and r, and on $C(x)$ and l_2, and in the total fertility as estimated and reported—to lend substantial authority to the approximate values of these parameters.