

MORTALITY AND FERTILITY IN INDIA, 1951-1961

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According to the Draft Outline of the Fourth Five Year Plan and the official posters displayed all over the country, the expectation of life at birth in India had reached 50 years in 1966.¹ If true, this estimate suggests a remarkable gain in real income, welfare, or at least in the effectiveness of health measures, because life expectancy was estimated at only 32 years during the period 1941-1950, or around the time of India's independence, and only 41.2 years during 1951-1960 or at the start of the Second Five Year Plan.² The basis for the estimate for 1966 is apparently the extrapolation over 1956-66 of the estimated average annual gain of 0.9 years in the life expectancy at birth from 1946 to 1956, because no new nationwide empirical observations are available. The validity of the estimated values of the expectation of life during 1951-1960 is, therefore, of crucial importance. It has implications also for the projections of India's population and the estimates of birth rates. The present study attempts an evaluation of the relevant evidence.

PROCEDURE UNDERLYING 1951-1960 ESTIMATES OF LIFE EXPECTANCY

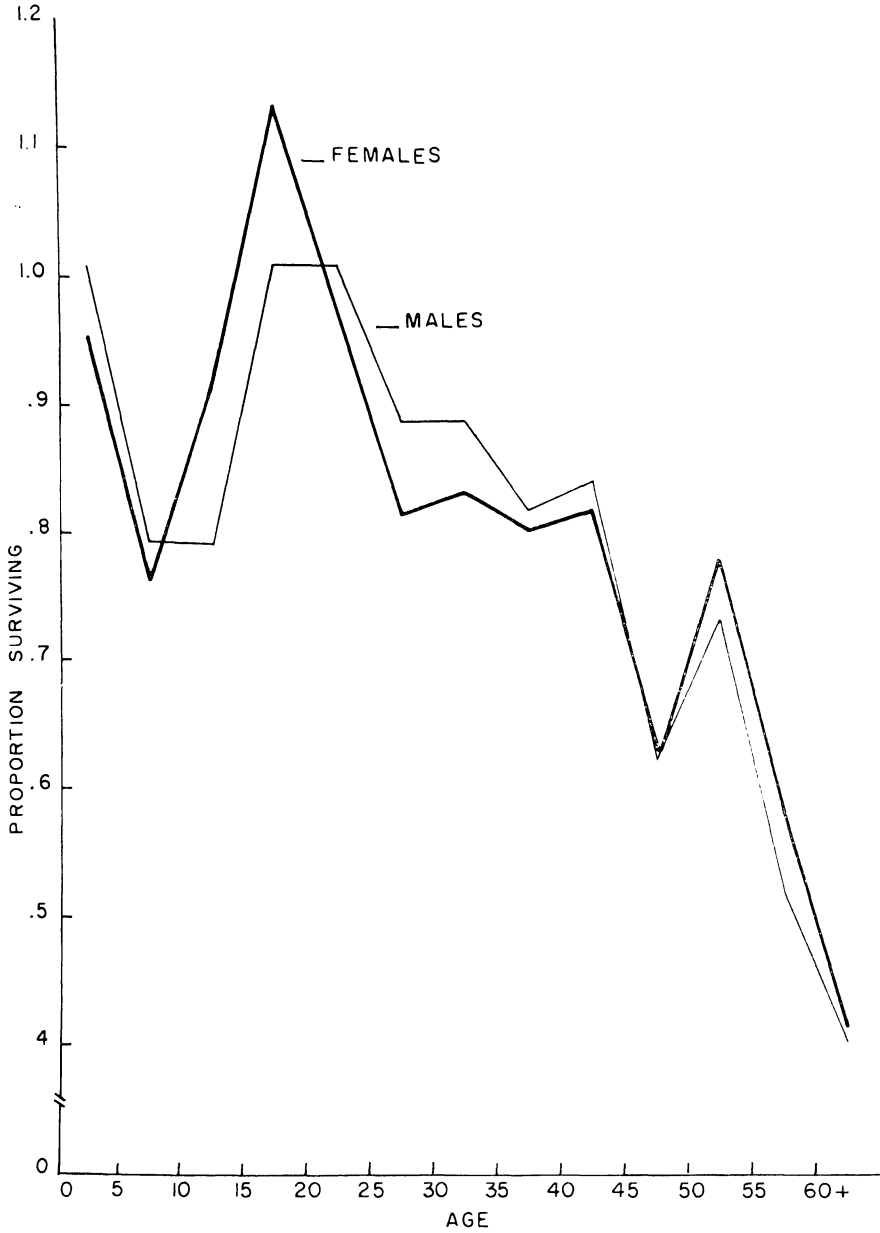
The procedures used to prepare the life tables for 1951-1960 have not been documented. However, they are presumably based on estimates of age-specific survivorship from the age distributions

for males and females reported by the 1951 and the 1961 censuses. A similar procedure was used to prepare the life tables for 1941–1950.³ The well-known errors of age reporting require a fairly drastic smoothing of the age distributions before decade-survivorship is calculated. The effect of errors of age reporting is evident in Figure 1, which shows the decade-survivorship ratios derived from unsmoothed data in successive five-year age groups from the Indian censuses of 1951 and 1961. For this purpose, the 1951 age data based on a sample of approximately ten per cent were inflated and the displaced persons were added to them.⁴ The usual exclusion of the displaced persons from the figures used for estimating the age distribution is inappropriate because the offspring of the displaced were in the sampled population. The 1961 figures were also adjusted to exclude the population of territories that were not censused in 1951⁵ as well as the estimated immigration from Pakistan during the period 1951–1960 and their surviving progeny.⁶ The flaws observable in Figure 1, such as survivorship ratios above unity and sharp fluctuations from one age group to another, are thus explained primarily by age misreporting.

The drastic smoothing of age data required to prepare the life tables from intercensal survivorship values tends to be “essentially arbitrary” and the estimated life table values contain “a strong component of the smoothing procedure used as well as the actual age schedule of mortality.”⁷ An even more important problem is the estimation of infant and child mortality—estimates that have an important influence on the derived values of the expectation of life at birth. The official Indian life tables for 1951–1960 have resolved the problem by accepting as the probability of death during the first year of life (or 10% of the life table) the values reported by the National Sample Survey from its fourteenth round in rural India during 1958–1959.⁸

As the analysis of these data at the Indian Statistical Institute has shown, the estimates of death rates based on survey responses tend to be subject to a high degree of “recall lapse,”⁹ greater than that in the reporting of births. Recently, the Registrar General’s Office in India has launched a sample registration scheme under

FIGURE I. CENSUS SURVIVORSHIP RATES OF MALES AND FEMALES FROM AGE X TO X + 5 IN 1951 TO AGE X + 10 TO X + 15 IN 1961



which the births and deaths recorded by local registrars are cross-checked with those reported during a six-monthly survey. The sample areas for the scheme are selected at random¹⁰ although that is not true of the pilot areas. In Table 1 the birth and death rates obtained under the sample registration scheme are compared with those estimated by the National Sample Survey from its fourteenth round in rural India during 1958–1959. Admittedly, the estimates from both sources are subject to sampling error. However, it is noteworthy that the Survey estimates for nine states were lower than, and for two states (Kerala and Madhya Pradesh) close to, those based on the sample registration scheme, despite an interval of about seven or eight years between their reference periods. Only in Uttar Pradesh and Maharashtra were the Survey estimates of death rates enough higher than the recent rates to suggest a clear-cut decline in mortality.

If the crude death rates in the National Sample Survey were underestimates, the level of infant mortality was surely underestimated as well. Quite probably, therefore, the use of ${}_1q_0$ values based on the Survey in the official life tables for 1951–1960 has led to an overstatement of the expectation of life at birth.

The extent of overstatement can perhaps be gauged by reference to the available model life tables, if the e_5 values of official life tables are assumed as approximately correct and the age pattern of mortality in India is assumed to conform to international experience. The choice of model life tables poses some problem.

Applicability of Model Life Tables

The regional model life tables prepared by Coale and Demeny undoubtedly have a better empirical basis regarding the sex-age patterns of mortality than do the U.N. model life tables. However, in the 130 original life tables underlying the “West” model, recommended for general use, only one for females (Taiwan: 1921) and three for males (Taiwan: 1921, 1926–1930); (Netherlands: 1870–1879) had recorded expectations of life at birth below 40 years. The lowest e_0 values recorded were 34.5 years for males and 38.6 for females, both in Taiwan in 1921. The observations for model

TABLE I. ESTIMATED CRUDE BIRTH AND DEATH RATES FOR SPECIFIED STATES OF INDIA*

State	1961 Census (1951-1960)		National Sample Survey 1958-1959		Period (Month and Year)	Sample Registration Scheme		Death Rate
	Birth Rate	Death Rate	Birth Rate	Death Rate		Population Covered	Birth Rate	
Jammu and Kashmir			21.2	11.3	7/66-6/67	17,150	(41.5)	(18.7)
Punjab	44.7	18.9	41.3**	13.1				
Rajasthan	42.7	19.4	43.0	18.4	11/65-10/66	15,289	(41.0)	(23.8)
Uttar Pradesh	41.5	24.9	45.0	29.8	5/66-4/67	20,293	(45.3)	(23.1)
Madhya Pradesh	43.2	23.2	41.7	22.7	5/66-4/67	17,803	(45.6)	(21.6)
Assam	49.3	26.9	39.1	12.1†	5/66-4/67	17,670	(35.2)	(15.2)
Bihar	43.4	26.1	33.6	19.6	7/66-12/66	128,071	48.3	21.2
Orissa	40.4	22.9	36.3	18.4	8/66-1/67	17,755	(41.0)	(20.2)
West Bengal	42.9	20.5	30.8	10.3	7/66-12/66	25,821	(45.2)	(17.3)
Andhra Pradesh	39.7	25.2	31.8	14.2	8/66-1/67	29,167	(38.9)	(23.7)
Kerala	38.9	16.1	39.6	11.5	7/65-6/66	256,422	37.9	10.1
Madras	34.9	22.5	34.6	14.0				
Mysore	41.6	22.2	40.4	15.5	6/66-11/66	162,405	37.8	17.2
Gujarat	45.7	23.5	40.4	17.4	10/65-9/66	194,029	44.0	18.1
Maharashtra	41.2	19.8	37.3	19.1	7/65-6/66	168,989	36.0	16.0
India	41.7	22.8	38.3	19.0				

* According to the 1961 census, the National Sample Survey in Rural India and the Sample Registration Scheme of the Office of the Registrar General. † Including Manipur and Tripura.

Sources: Census of India, 1961 Census: *Life Tables, 1951-60* undated. The same figures appear in Jain, S. P., *State Growth Rates and Their Components*, in: Bose, A. (Editor), *PATTERNS OF POPULATION CHANGE IN INDIA, 1951-61*, Bombay, Allied Publishers, 1967, pp. 40-41; India, The National Sample Survey Report No. 48, *Preliminary Estimates of Birth and Death Rates and of the Rate of Growth of Population*, (fourteenth Round, July 1958-July, 1960), Delhi, 1961, pp. 40-45. The rates for Gujarat and Maharashtra are taken from: Bannerjee, Saibal and Das, Chandra N., *Natural Growth Rate in Rural India*, in: Bose, *op. cit.* Note that the death rates in these two sources differ slightly from those given in India, the National Sample Survey, Report No. 76, *FERTILITY AND MORTALITY RATES IN INDIA* (fourteenth Round: July, 1958-July, 1959), Delhi, 1963, pp. 138-140; India, Office of the Registrar General, *Bulletin: Sample Registration Scheme: Provisional Statistics*, Vol. 12, December, 1967.

Note: Figures based on the sample registration scheme are put in parentheses if they are obtained under the pilot program. All the figures from the scheme are based on data collected as part of continuous registration by enumerators and six-month cross-check surveys by supervisors.

life tables with expectations of life at birth lower than 40 years are thus derived essentially through extrapolation. The nonavailability of reasonably complete vital statistics for populations with high mortality explains the situation.

The U.N. model life tables, on the other hand, include as their basis 18 life tables with an expectation of life at birth of less than 40 years.¹¹ However, all these life tables were based on reputedly incomplete vital statistics or population data with serious age misreporting. When registration is incomplete the infant deaths (and corresponding births) seem to escape registration more frequently and the infant mortality rates (and therefore the ${}_1q_0$'s) tend to be underestimates. On the other hand, the life tables for countries such as India suffer from substantial age misreporting as well as the problem of making reasonable estimates of mortality under age five.

Thus, the applicability of the U.N. model life tables as well as those prepared by Coale and Demeny to countries with high mortality is subject to reservations. However, as Table 2 shows, the differences between the "West" model of Coale-Demeny and the U.N. model life tables are relatively minor. The latter have a lower ${}_4q_1$ than the "West" model for all life expectancies specified in the table, but their ${}_1q_0$ values are lower than the "West" model only at e_0 values of less than 37.3 for males and about 38.75 for females. The difference in e_5 values for the same e_0 is also small. The Coale-Demeny life tables are preferred because they take account of some of the limitations of the U.N. model life tables.

Model Life Tables Compared to Indian Life Tables

Table 3 shows the estimates of the expectation of life at birth for males and females in India during 1951-1960, obtained through interpolation from the "West," "North" and the U.N. Model life tables on the basis of e_5 values in the official life tables. The "North" model gives slightly higher estimates of the e_0 because, compared to the other models, it has lower infant mortality rates. The empirical basis of the "North" model is limited because the number of underlying life tables was only nine. (Like the "West" model, the "North" model life tables with e_0 values of less

than 40 years are obtained essentially through extrapolation.) However, the difference between the estimates based on the two models is small because the influence of lower infant mortality rate in the "North" model is offset by its higher mortality rate in the ages one to four compared with the "West" model. Both models give

TABLE 2. COMPARISON OF U.N. MODEL LIFE TABLES AND "WEST" MODEL OF COALE-DEMENY

<i>U.N. Model Life Tables</i>			<i>"West" Model Life Tables</i>			
e_0^*	$1q_0^{**}$	$4q_1^\dagger$	<i>Females</i>			
			$e_5^{\dagger\dagger}$	$1q_0$	$4q_1$	e_5
35.00	.206	.136	45.51	.214	.146	46.59
37.50	.193	.121	47.38	.195	.131	48.18
40.00	.180	.108	49.24	.178	.118	49.75
42.50	.167	.097	51.08	.161	.105	51.30
45.00	.154	.086	52.88	.146	.094	52.84
<i>Males</i>						
32.48	.237	.128	44.10	.248	.146	45.04
34.89	.222	.114	45.89	.227	.131	46.51
37.80	.207	.102	47.64	.207	.118	47.96
39.71	.193	.090	49.40	.189	.106	49.40
42.12	.179	.080	51.10	.172	.094	50.82

* Life expectancy at birth.

** Probability of death at age zero.

† Probability of death at ages one to four.

†† Life expectancy at age five.

Sources: United Nations, *Manuals on Methods of Estimating Population, Manual III, METHODS FOR POPULATION PROJECTIONS BY SEX AND AGE*, New York, United Nations, 1956, pp. 70 ff.; Coale, A. J. and Demeny, P., *REGIONAL MODEL LIFE TABLES AND STABLE POPULATIONS*, Princeton, Princeton University Press, 1966.

TABLE 3. LIFE EXPECTANCY AT BIRTH AND AT AGE FIVE IN INDIA, 1951-1961

<i>Life Tables</i>	<i>Life Expectancy</i>		
	<i>at</i>	<i>Males</i>	<i>Females</i>
Indian Life Tables 1951-60	Birth	41.89	40.55
	Age five	48.72	47.01
"West" Model	Birth	38.58	35.66
"North" Model	Birth	39.26	36.27
U.N. Model	Birth	38.77	37.01

Sources: Census of India, *1961 Census: Life Tables, 1951-60*, undated; Coale, A. J. and Demeny, P., *REGIONAL MODEL LIFE TABLES AND STABLE POPULATIONS*, Princeton, Princeton University Press, 1966; United Nations, *Manuals on Methods of Estimating Population, Manual III, METHODS FOR POPULATION PROJECTIONS BY SEX AND AGE*, New York, United Nations, 1956, pp. 70 ff.

estimates of e_0 that are 2.6 to 3.3 years lower than the official values for males and 4.3 to 4.9 years lower for females. Even the U.N. model life tables show the official e_0 values to be overestimates. If these values of e_0 from model life tables are valid, the average annual gain in life expectancy during 1946–1956 was less than reckoned in official circles; even a linear extrapolation of that experience to 1966 would give an estimated e_0 of around 43.5 years.¹² Of course, in view of the apparent increase in the female disadvantage in e_0 during 1946–1956, a straight linear extrapolation separately by sex suggests an increasing and abnormal divergence in the life expectancy of the two sexes, contrary to the international experience that the female disadvantage shrinks over time.¹³ It is necessary, therefore, to seek alternative estimates of the life expectancy in India during 1951–1960 as well as 1941–1950.

METHOD OF FORWARD PROJECTION

In a recently published United Nations Manual on *Methods of Estimating Basic Demographic Measures from Incomplete Data*,¹⁴ Ansley Coale and Paul Demeny have proposed the estimation of life expectancy through a comparison of the observed census survivorship ratios of population aged x and over at time t to age $x + 10$ and over at time $t + 10$ with those indicated by projecting the initial population according to alternative model life tables.¹⁵ The use of survival ratios for the cumulated population mitigates the need to smooth the age data for errors as well as the effect of these errors on the estimated mortality level. From the alternative estimates, “the median level of mortality indicated by the proportion surviving among the first nine groups—i.e., all persons, persons five and over, ten and over, . . . forty and over” is recommended as a satisfactory selection.¹⁶

Application to India, 1951–1961

Figure 2 outlines the proportions surviving to 1961 from the 1951 population aged zero and over, five and over and so forth. The population data were adjusted as outlined earlier. Compared with

Figure 1, the proportions surviving in Figure 2 indicate a rather smooth change. However, the mortality levels implicit in these survival ratios, shown in Figure 3, fluctuate rather widely.¹⁷

Table 4 summarizes the various demographic measures estimated by selecting the median of the first nine mortality levels shown in Figure 3 for males and females. The crude death rate refers to the period 1951–1961 and is obtained by applying the age-specific death rates to the mean population of the period 1951–1961. The use of the unsmoothed age data probably understates the propor-

FIGURE 2. CENSUS SURVIVORSHIP RATES FOR MALES AND FEMALES FROM AGE X AND OVER IN 1951 TO AGE X + 10 AND OVER IN 1961 ACCORDING TO THE CENSUS OF INDIA

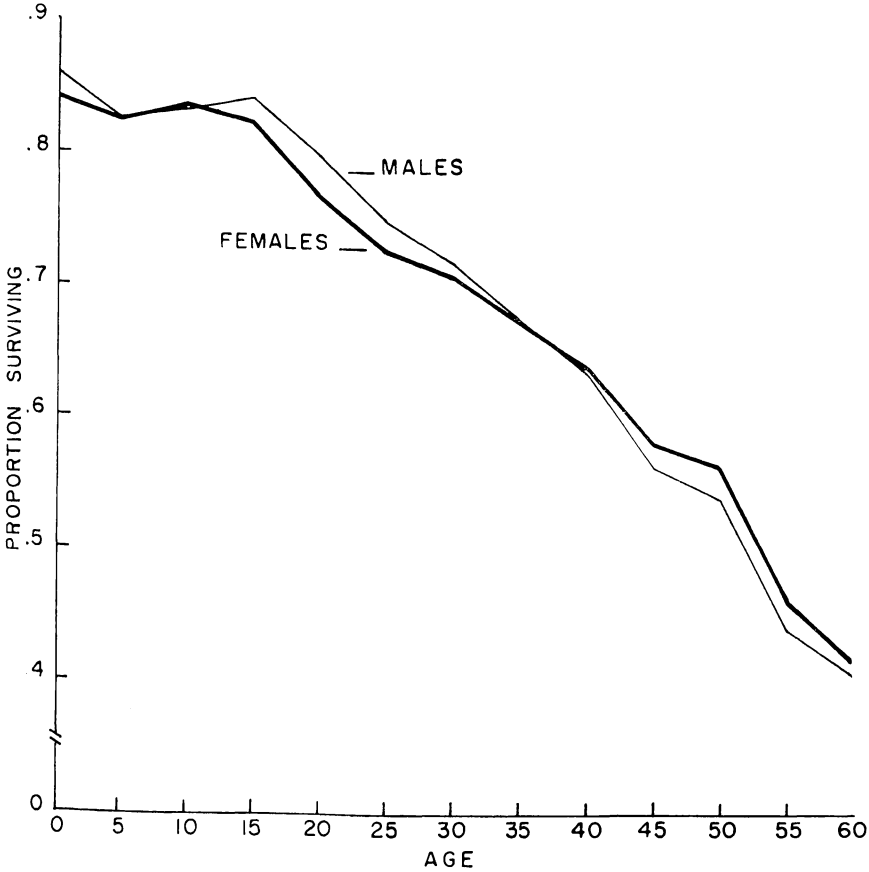


FIGURE 3. MORTALITY LEVELS IN "WEST" MODEL LIFE TABLES IMPLIED BY MALE AND FEMALE SURVIVAL RATES FROM AGE X AND OVER AT TIME t TO AGE X + 10 AND OVER AT TIME t + 10 ACCORDING TO THE INDIAN CENSUSES OF 1951 AND 1961

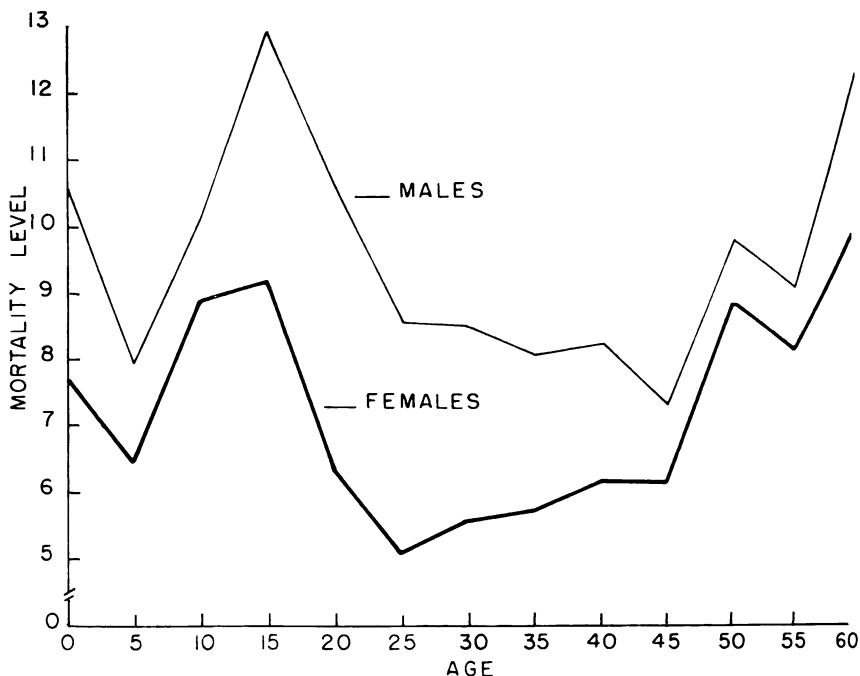


TABLE 4. DEMOGRAPHIC MEASURES DERIVED FROM "WEST" MODEL LIFE TABLES CORRESPONDING TO THE CENSUS SURVIVAL RATES FOR INDIA (1951-1961) FROM AGE X AND OVER TO AGE X + 10 AND OVER

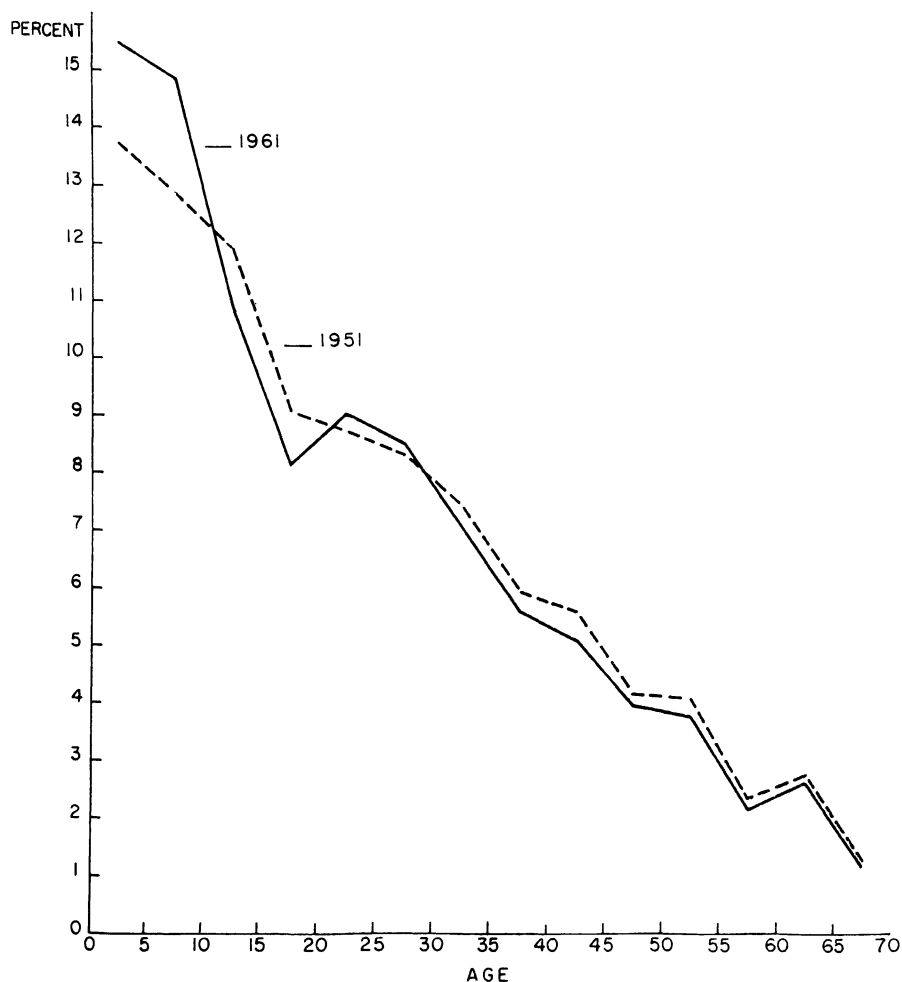
	<i>Males</i>	<i>Females</i>
Mortality level	8.56	6.31
Life expectancy at birth	36.25	33.27
Crude death rate	25.93	29.51
Observed intercensal growth rate	19.53	18.94
Crude birth rate	45.46	48.45
Consistent birth rate* for		
the other sex	46.01	47.88
both sexes	45.73	48.15

* These estimates assume a sex ratio at birth of 1.05 and take account of the observed masculinity of the population in 1961—1.0626.

tion of population under five years of age and therefore the crude death rate; but this tendency is partly offset by an overstatement of the proportion of population at older ages. The addition of the observed intercensal average growth rate¹⁸ to the death rate yields an estimate of the birth rate.

The estimate of female life expectancy in Table 3 appears very low and suggests that the selection of the median mortality level as

FIGURE 4. PROPORTIONATE AGE DISTRIBUTION OF FEMALES REPORTED BY THE INDIAN CENSUSES OF 1951 AND 1961



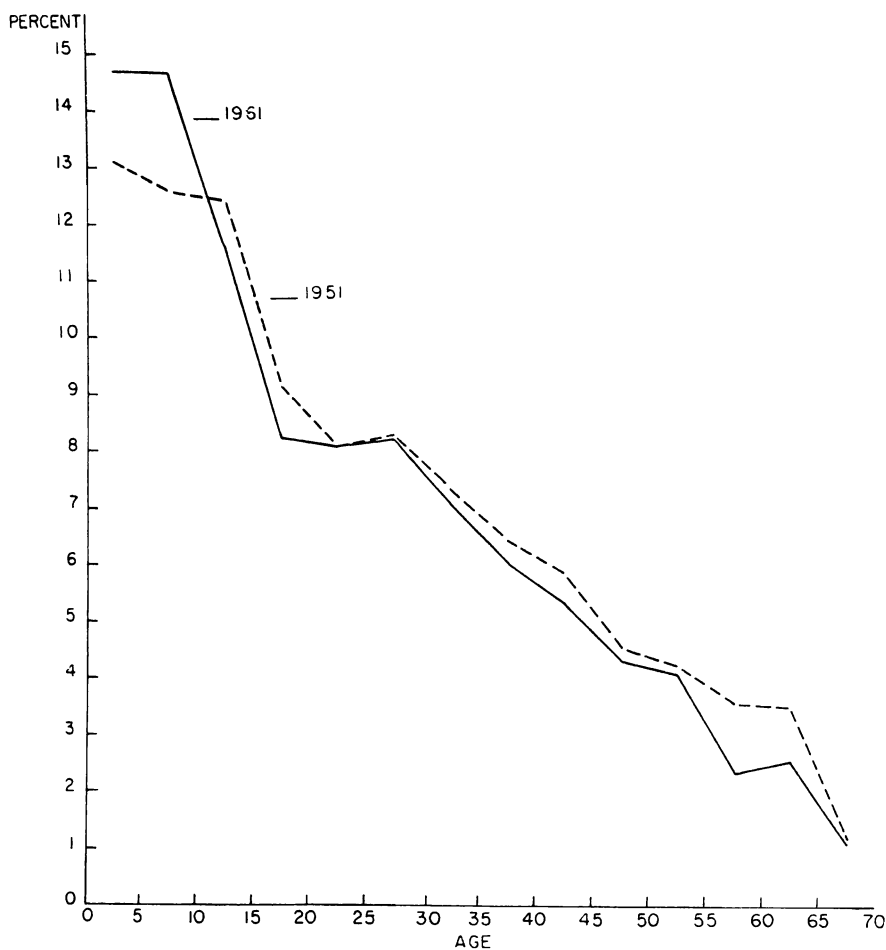
a “rule of thumb” may not always give satisfactory results. The proportionate age distributions of Indian females for 1951 and 1961, shown in Figure 4, indicate some difference in the pattern of age misreporting in the two censuses according to which the usual hollow in ages 15 to 19 reappears in 1961, with a somewhat bigger hump in ages 20 to 29 and a relatively smoother slope after age 30 (both compared to the 1951 age distribution).¹⁹ Partly as a result of this shift in the age misreporting, the mortality levels estimated by projecting the 1951 females aged 20 and over, 25 and over . . . 45 and over, are probably all too low. Obviously, a rule of thumb necessarily requires an exercise of supplementary judgment.

The male age distributions of 1951 and 1961 are shown in Figure 5. After a reappearance of the hollow at ages 15 to 19 in 1961, the shape of the 1961 age distribution at ages above 20 is broadly the same as in 1951. However, the absolute difference between the male e_0 estimate in Table 3 and that based on “West” model in Table 2 (with the same e_s^0 as the official life table) is about the same (2.23 years) as for the females (2.41 years). Therefore, one more attempt will be made to estimate the life expectancy and the vital rates.

THE QUASI-STABLE POPULATION MODEL

The quasi-stable population model, applicable when the fertility level has remained essentially unchanged but mortality declines gradually, provides an alternative procedure for estimating the various demographic measures. In the United Nations Manual,¹⁴ an illustrative example provides the estimates of vital rates in India during 1951–1961 on the basis of the quasi-stable model applied to females.²⁰ The essence of the procedure consists of obtaining alternative estimates of the birth rates by comparing the recorded age distribution cumulated to various ages up to 40 or 45 with that in the stable populations having the observed intercensal rate of natural increase (r) and then adjusting them for the effect of declining mortality on reported age distribution. The alternative estimates of gross reproduction rates are obtained simultaneously on the basis of

FIGURE 5. PROPORTIONATE AGE DISTRIBUTION OF MALES REPORTED BY THE INDIAN CENSUSES OF 1951 AND 1961



an appropriate mean age of the fertility schedule. The death rate is estimated by subtracting the observed r from the birth rate, and the mortality level or the e_0 of the population is taken as that for the stable population with the estimated vital rates.

Coale and Demeny recommend the use of the female age distributions for countries with what is called the “African-South Asian” pattern of age misreporting and the male age distributions for populations with the “Latin American” pattern of age report-

ing. The criterion for the selection is the relative range of the stable population estimates of the male and female birth rates in countries with the two patterns of age reporting. Among the estimates based on the female age distribution the one corresponding to C(35) or the proportion of population under age 35 is expected to be at "about the right level;" among the estimates from the male age distribution, the median value of the birth rate among those agreeing with C(5), C(10) . . . C(45) is the one recommended for selection.

Stable and Quasi-Stable Estimates for India, 1951-61

In view of the difference in the above estimates obtained through the forward projection of males and females, an attempt has been made to estimate the stable and quasi-stable birth rates from both male and female age distributions. Tables 5 and 6 present the estimates of birth rate and the gross reproduction rate corresponding to the cumulated proportion of population to successive ages and the specified intercensal rate of natural increase of the relevant sex.²¹ For the gross reproduction rate, which depends on the mean age of the fertility schedule (\bar{m}), two sets of estimates are presented, one corresponding to the \bar{m} suggested by the fertility schedule reported by the Indian National Sample Survey on the basis of the first and the second sub-rounds of its fourteenth round in rural India,²² and the other corresponding to the \bar{m} estimated by Coale and Demeny on the basis of a "standard" marital fertility schedule and the proportions of married females at relevant ages reported by the 1961 census.

It is interesting that the stable population estimates of birth rates based on the male age distribution show a slightly smaller range (8.15) than those from the female age distribution (8.70). In fact, this appears plausible because of higher literacy among Indian males than among females although, admittedly, a person's knowledge of his age is probably contingent more on the literacy of his parents than on his own.

However, the median value of the stable population birth rate based on the male age distribution is about 4.5 points lower than

TABLE 5. STABLE POPULATION ESTIMATES OF THE BIRTH RATE AND GROSS REPRODUCTION RATE*

Age x (1)	$C(x)$ (Proportion up to age x) (2)	Stable Estimates from $C(x)$ and ' r ' (1951-1961)**		Adjustment Factors for $t = 15$ and $k = .01116$		Adjusted Estimates	
		Birth Rate (3)	Gross Reproduction Rate ($\bar{m} = 28.8$) ($\bar{m} = 28.04$) (4)	Birth Rate (5)	Gross Reproduction Rate (6)	Birth Rate (7)	Gross Reproduction Rate ($\bar{m} = 28.8$) ($\bar{m} = 28.04$) (8a)
5	.1548	40.55	2.70	2.64	.9699	39.33	2.59
10	.3034	47.79	3.19	3.12	.9788	46.78	3.09
15	.4117	44.56	2.97	2.90	1.0123	45.11	3.01
20	.4928	39.09	2.60	2.55	1.0480	40.97	2.73
25	.5827	39.52	2.63	2.58	1.0714	42.34	2.82
30	.6675	41.34	2.75	2.69	1.0815	44.71	2.98
35	.7373	42.17	2.81	2.75	1.0848	45.75	3.05
40	.7930	41.87	2.79	2.73	1.0848	45.42	3.03

* Based on age distribution of females reported in the 1961 census and on their annual rate of natural increase during the intercensal period 1951-1961 (0.01894), and estimates adjusted for the effects of declining mortality.

** r + annual rate of natural increase.

TABLE 6. STABLE POPULATION ESTIMATES OF THE MALE BIRTH RATE*

Age x (1)	$C(x)$ (Proportion up to age x) (2)	Stable Estimates from $C(x)$ and 'r' (1951-1961)** Birth Rate (3)	Adjustment Factors for $t = 15$ and $k = .01241$ Birth Rate (4)	Adjusted Estimates Birth Rate (5)
5	.1468	36.41	.9655	35.15
10	.2933	43.76	.9764	42.73
15	.4096	44.11	1.0136	44.71
20	.4918	37.92	1.0534	39.94
25	.5722	35.96	1.0794	38.82
30	.6542	36.90	1.0906	40.24
35	.7249	37.45	1.0943	40.98
40	.7850	37.71	1.0943	41.27
45	.8385	38.50	(1.0943)	(42.13)

Note: The adjustment factors and the adjusted values for $C(45)$, i.e., the proportion of males under age 45, are put in parentheses because Table III.1 of the Manual (*op. cit.*, pp. 119-120) provides factors only up to $C(40)$. However, the factors for $t = 15$ tend to stabilize after age 35, and they are assumed to be the same for $C(40)$ and $C(45)$.

* Based on the age distribution of males reported in the 1961 census and their annual rate of natural increase during the intercensal period 1951-1961 (0.01953), and estimates adjusted for the effects of declining mortality.

** r = annual rate of natural increase.

the value corresponding to $C(35)$ among females. The adjustment for declining mortality does affect the estimates, as will be shown.

Of the various procedures suggested for such adjustment, only that based on the change in the intercensal growth rate (r) can be applied in the Indian case because no other reliable index of the decline in mortality is known. In their illustration in the Manual, Coale and Demeny have used the change in r during 1951–1961 from the value recorded during 1881–1921 as the indicator of the pace of decline in mortality. The r during 1881–1921 was very low (.0043);²³ and therefore, the r of .0189 during 1951–1961 is almost entirely the result of the decline in mortality during 1921–1961.

It can be reasonably argued also that in view of the virtual constancy of the intercensal rate of increase during 1921–1951, the decline in mortality occurred essentially during the period 1951–1960 or since 1946, the midpoint of the decade 1941–1950 to which the r based on the 1941 and the 1951 censuses refers. It is known that at each moment of time during a period of declining mortality, the age distribution resembles more closely the stable age composition implied by the current mortality and fertility rather than that of the past high mortality period; in other words, the age composition continually adjusts to the declining mortality. Therefore, such decline in mortality as occurred in India during 1921–1931, for example, is unlikely to have much effect on the age composition in 1961. (The 1951 age distribution was broadly comparable to that reported by the 1921 census.) The adjustment for the decline in mortality based on the increase in r during 1946–1956 is, therefore, deemed adequate. Table 7 summarizes the calculations indicating the rate of mortality change.

Tables 5 and 6 also show the adjustment factors for stable birth rates and gross reproduction rates, appropriate for the estimated rate and duration of mortality decline (15 years since 1946), as well as the adjusted estimates. The median birth rate based on the male age distribution corresponds to $C(35)$ or the proportion under age 35, and is about 41 per 1,000 population; but the adjusted birth rate corresponding to $C(35)$ of the female age distribution is about 45.8. Given the close intercensal rates of increase for the two sexes,

TABLE 7. INTERCENSAL RATE OF INCREASE AMONG MALES AND FEMALES, 1941-1951

	<i>Males</i>	<i>Females</i>
r 1941-1951	.01255	.01268
r 1951-1961	.01953	.01894
Δr (1946-1956)	.00697*	.00627*
$\Delta r/\Delta t$ ($\Delta t = 10$ years)	.000697	.000627
$k^{**} = 17.8 (\Delta r/\Delta t)$.01241	.01116

* These figures are based on values of 'r' before rounding.

** k = factor for adjusting the stable population estimates for declining mortality.

TABLE 8. QUASI-STABLE ESTIMATES OF VITAL RATES IN INDIA, 1951-1961

	<i>Males</i>	<i>Females</i>
Birth rate	40.98	45.75
Death rate	21.45	26.81
Mortality level	10.89	7.58
Life expectancy (years)		
at birth	41.86	36.44
at age 5	50.67	47.51
Gross reproduction rate ($\bar{m} = 28.04$)		2.99
Consistent estimates for the other sex**		
Birth rate	41.22	45.20
Death rate	22.53	23.14
Mortality level	9.38	8.97
Life expectancy (years)		
at birth	40.96	37.23
at age 5	50.34	47.92

* From male and female age distributions reported by the 1961 census according to the recommended procedures in the U.N. Manual and "consistent" estimates for the other sex.

** The consistent estimates for the other sex assume a sex ratio at birth of 1.05 and take account of the observed masculinity of the population in 1961—1.0626.

this difference in estimated birth rates implies a difference also in the death rate and the life expectancy, shown in Table 8.²⁴ The same table also shows alternative estimates for the other sex that would be consistent with values based on male and female age distribution if the sex ratio at birth is assumed to be 105 males per 100 females and the observed masculinity of the population is taken into consideration.

It is interesting that the estimates based on the male age distribution imply a female life expectancy during 1951-1961 higher

than that shown by official life tables. The female age distribution, on the other hand, leads to an estimate of e_0 significantly lower than the official figures but noticeably higher than that obtained through the forward projection (see Table 4). However, the life expectancy at age five for each sex, estimated from the male age distribution, is noticeably above that suggested by the official life tables and does not seem to be plausible.

The Consistency of Estimates: A Supplementary Criterion

If one adopts the consistency of estimates based on the male and female age distributions as a criterion, the estimates of birth rates corresponding to $C(15)$ or the proportion under 15 appear to be closest to each other, and seem to merit due attention. As can be seen in Table 5, the stable estimate of birth rate corresponding to $C(15)$ is slightly higher than that for $C(35)$ of females. Also, the adjustment factor for quasi-stability or the effects of decline in mortality is the least important in its case, a fact that holds for all time durations of mortality decline when the stable birth rates have been estimated from $C(x)$ and from a ten-year intercensal growth rate or "from average mortality during ten years preceding the census."²⁵ If, therefore, the stable estimates of birth rates based on the proportion of population under age 15 seem acceptable, as is true for India during 1951–1961, the suggested adjustments for declining mortality become unimportant. In this respect, it is noteworthy that in estimating vital indices for several African populations, Coale and Etienne van de Walle preferred to use the proportion of total population (both sexes together) under age 15 as the basis for estimation.²⁶ Although further experimentation with the techniques suggested in the U.N. Manual is obviously necessary to confirm the validity of stable birth rate estimates corresponding to $C(15)$ under conditions of quasi-stability, an examination of the consistency of estimates from male and female age distributions appears a worthwhile supplement.

Table 9 shows the various estimates for India based on the proportion of males and females under age 15 and "consistent" indices for the other sex. The range of estimates for each sex derived from

TABLE 9. THE QUASI-STABLE ESTIMATES OF VITAL RATES IN INDIA, 1951-1961, MALES AND FEMALES UNDER AGE 15*

	<i>Males</i>	<i>Females</i>
Birth rate	44.71	45.11
Death rate	25.18	26.17
Mortality level	9.18	7.82
Life expectancy (years)		
at birth	37.73	37.04
at age 5	48.22	47.89
Gross reproduction rate ($\bar{m} = 28.04$)		3.01
Consistent estimates for the other sex**		
Birth rate	45.25	44.57
Death rate	26.31	25.04
Mortality level	7.76	9.24
Life expectancy (years)		
at birth	36.91	37.88
at age 5	47.80	48.30
Gross reproduction rate ($\bar{m} = 28.04$)	2.93	

* From the proportions of males and females under age 15 reported by the 1961 census, selected on the criterion of mutual closeness, and "consistent" estimates for the other sex.

** The consistent estimates for the other sex assume a sex ratio at birth of 1.05 and take account of the observed masculinity of the population in 1961—1.0626.

the two age distributions is very small. The expectation of life at birth appears to be 37.73 to 37.88 years for males and 36.91 to 37.04 years for females. The corresponding life expectancy at age five appears to be very close to the official estimates (see Table 3) although it is slightly lower than the latter for males and higher than the latter for females. An acceptable final set of various vital indices obtained by averaging the two alternative estimates in Table 9 is shown in Table 10. The expectation of life at ages zero and five is close to the official estimates if the latter were adjusted for the underestimation of infant and child mortality.

Estimates for 1941-1951 and the Pace of Decline in Mortality

To evaluate the pace of decline in mortality suggested by the estimates in Table 10, for example, it is necessary to calculate comparable vital rates for the previous decade, 1941-1951. The available unsmoothed age distributions for 1941 are based on a two per cent sample of slips for nine provinces, which included about 76.2 per cent of the total population residing in the territories of post-

TABLE 10. FINAL QUASI-STABLE ESTIMATES OF VITAL RATES IN INDIA, 1951-1961*

	<i>Males</i>	<i>Females</i>	<i>Both Sexes**</i>
Birth rate	44.64	45.18	44.90
Death rate	25.11	26.24	25.66
Life expectancy			
at birth	37.80	36.98	37.40
at age 5	48.26	47.84	48.06
Gross reproduction rate ($\bar{m} = 28.04$)		2.97	
General fertility rate		.212	

* Obtained by averaging the two estimates for each sex in Table 9.

** The estimates for the population as a whole are weighted averages of the estimates for each sex.

TABLE 11. DEMOGRAPHIC MEASURES FOR INDIA DURING 1941-1951

	<i>Males</i>	<i>Females</i>
Forward Projection Method*		
Mortality level	6.94	5.19
Life expectancy at birth	32.34	30.48
Crude death rate	29.61	32.16
Observed intercensal growth rate	12.49	12.60
Crude birth rate	42.10	44.76
Consistent birth rate† for		
other sex	42.36	44.49
both sexes	42.23	44.62
Stable Estimates Corresponding to C(15)**		
Mortality level	7.35	6.13
Life expectancy (years)		
at birth	33.33	32.83
at age 5	45.55	45.20
Crude birth rate	42.11	42.99
Crude death rate	29.62	30.39
Gross reproduction rate ($\bar{m} = 27.9$)		2.75
Consistent estimates for the other sex†		
Birth rate	42.37	42.73
Death rate	29.77	30.24
Mortality level	6.35	7.12
Life expectancy (years)		
at birth	33.38	32.77
at age 5	45.54	45.21
Gross reproduction rate ($\bar{m} = 27.9$)	2.71	

* Derived from "West" Model Life Tables corresponding to the census survival rates from age x and over in 1941 to age x + 10 and over in 1951.

** Stable population estimates based on the proportion under age 15 (C(15)) among males and females reported by the 1951 census and their annual rate of natural increase during the intercensal period 1941-1951.

† The consistent estimates for the other sex assume a sex ratio at birth of 1.05 and take account of the observed masculinity of the population in 1951—1.0576.

partition India at the time of the 1941 Census.²⁷ Table 11 summarizes the vital rates estimated through the forward projection of the 1941 population and those based on the stable model obtained from the age distribution reported by the 1951 census and the intercensal growth rate.²⁸ Once again, stable birth rates corresponding to the proportion of males and females under age 15 are selected on the ground that they are very close.²⁹ The estimated birth rate for the population as a whole (the average of figures based on the age distributions of males and females) is 43.4 according to the forward projection method and 42.6 according to the stable model.³⁰ A comparison of these figures with the quasi-stable estimates for 1951–1961 (Table 10) indicates a slight rise in the level of birth rate, and about eight to nine per cent increase in the gross reproduction rate. It is difficult to speculate on the reasons for this apparent rise except that the change in the age composition between 1951 and 1961, observable in Figures 4 and 5, may be partly due to reasons other than the decline in mortality.

The estimates of life expectancy during 1941–1951, obtained through the forward projection method, are close to the official estimates, especially for males. (The same is true for 1951–1961 when the official estimates of e_0 are adjusted for the apparent underestimation of infant and child mortality). This is reassuring although not surprising because the essential basis for both estimates is the intercensal survivorship ratios for each sex calculated from the census age distributions. The stable estimates of life expectancy are higher than the official estimates for the 1940's and suggest a value of 33 years for the population as a whole. The quasi-stable estimates for 1951–1961 corresponding to the proportion of population under age 15 (Tables 9 and 10) show a gain of about 4.4 years in the life expectancy over the preceding decade although, quite probably, most of the mortality decline occurred during the 1950's because the conditions in India were far from settled throughout the 1940's.³¹ The gains in mortality might have accelerated during the late 1950's or early 1960's when the antimalaria and other public health campaigns had been completed over the entire country. However, in the absence of any conclusive evidence, such as

might emerge from the sample registration scheme of the Registrar General, a linear extrapolation of the gains in life expectancy over the early 1950's suggests an expectation of life at birth of about 46.2 years in 1966.³²

To conclude, evidence indicates that the official life tables for 1951-1960 overstate the expectation of life at birth in the country; and, therefore, the official estimates of mortality decline by 1966 seem to exaggerate the gains. As a result, the population projections currently in use need to be modified; however, the effect of any such modification will be relatively small because the overstatement of life expectancy is offset by an underestimation of the birth rate or fertility level.

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¹ India, Planning Commission, *FOURTH FIVE-YEAR PLAN: A Draft Outline*, Delhi, 1966, p. 346.

² The values of life expectancy are arithmetic averages of the estimates for males and females, which were as follows:

1941-1950: males, 32.45 years; females, 31.66 years
1951-1960: males, 41.89 years; females, 40.55 years

³ Census of India, Paper No. 2 of 1954, *Life Tables, 1951 Census*.

⁴ The ages of displaced persons were tabulated in ten-year groups in many states. These data were split into five-year groups by assuming that their proportion in relevant ages was the same as for the total nondisplaced population; i.e., the pattern of age misreporting among the displaced was the same as of the latter. For the age distribution of displaced persons, see: Census of India, Paper No. 4 of 1954, *Displaced Persons, 1951 Census*, Table IV. It covers 7.18 of a total of 7.30 million displaced persons.

⁵ The territories were: Jammu and Kashmir; Pondicherry; Dadra and Nagar Haveli; Goa, Daman and Diu; and the North East Frontier Agency. Their total population was 4.65 million. In excluding them from the 1961 population for comparison with the 1951 census, the net migration between these territories and the rest of India is implicitly assumed to be zero.

⁶ The volume of net migration from Pakistan has been estimated at 1.32 million and the survivors of their progeny born in India have been estimated at 0.36 million. See: Visaria, P. M., *Population Mobility between India and Pakistan, 1951-61*, (mimeographed), pp. 13, 18-20. Note that the volume of net immigration has been estimated in an official census publication at 3.14 million, but the statement therein that "net migration during 1951-60 shown by the birthplace data, is negligible" overlooks the impact of mortality on Pakistan-born persons enumerated in India in 1951. See: Census of India, Paper No. 2 of 1963, *1961 Census: Age Tables*, p. 55, para 3.30.

⁷ United Nations, *Manuals on Methods of Estimating Population*, Manual IV, *Methods of Estimating Basic Demographic Measures from Incomplete Data*, New York, United Nations, 1967, p. 7.

⁸ India, The National Sample Survey, Report No. 76, FERTILITY AND MORTALITY RATES IN INDIA (Fourteenth Round: July 1958–July 1959), Delhi, 1963, p. 142. The iq_0 values are .15322 for males and .13826 for females.

⁹ Som, R. K., On Recall Lapse in Demographic Studies, in: *International Population Conference, Vienna, 1959*, London, International Union for the Scientific Study of Population, 1959, pp. 50–57; Indian Statistical Institute, The Use of the National Sample Survey in the Estimation of Current Birth and Death Rates in India, in: *International Population Conference, New York, 1961*, Tome II, London, International Union for the Scientific Study of Population, 1963, pp. 395–402.

¹⁰ Wells, H. B. and Agrawal, B. L., Sample Registration in India, *Demography*, 4, 374–387, 1967.

¹¹ The countries whose life tables with e_0 of less than 40 years and that were used in the calculation of the U.N. model life tables were: Egypt (1936–1938); Mauritius (1942–1946); Guatemala (Department of Guatemala only, 1939–1941); Mexico (1930 and 1940); Jamaica (1920–1922); Brazil (1920); Chile (1930 and 1940); British Guiana (1910–1912 and 1920–1922); Ceylon (1920–1922); India (1891–1901; 1901–1911; 1921–1931; 1941–1950); Spain (1900); USSR (1896–1897); see: United Nations, *Age and Sex Patterns of Mortality: Model Life-tables for Under-Developed Countries*, New York, 1955, Appendix. Some of these life tables were used to estimate the infant and early childhood mortality in the Indian life tables for 1941–1950.

¹² For this estimate, the e_0^o values in official life tables for 1941–50 are taken as valid. Some alternative estimates, discussed above, are very close to the official values.

¹³ The international experience referred to pertains essentially to the Indian populations in Malaya, South Africa and Fiji Islands. See Visaria, P. M., The Sex Ratio of the Population of India and Pakistan and Regional Variations during 1901–61, in: Bose, A. (Editor), PATTERNS OF POPULATION CHANGE IN INDIA, 1951–61, Bombay, Allied Publishers, 1967, p. 359. However, in Ceylon, females seem to have had an e_0 about two years lower than males for a very long time despite a substantial decline in mortality.

¹⁴ United Nations, *op. cit.*

¹⁵ The major advantage of the procedure is its applicability even in situations where fertility cannot be assumed to be constant and the population is not stable.

¹⁶ United Nations, *op. cit.*, pp. 11–12.

¹⁷ The charts for females in Figures 1, 2 and 3 in this paper differ from those for India in Figures I, II and III in. United Nations, *op. cit.*, pp. 9–11. The difference stems from an unintended use of a smoothed age distribution for calculating the values charted in the Manual.

¹⁸ The growth rates are exponential rates of natural increase, estimated after excluding the population of territories not censused in 1951 and the estimated immigrants from Pakistan as well as their surviving progeny. They are slightly different from the estimated r of .01918 for males and .01860 for

females given by S. P. Jain in: *Census of India*, Paper No. 2 of 1963, *op. cit.*, p. 55 (para 3.30).

¹⁹ The hollows and humps have been a regular feature of the age distributions reported by successive censuses of the Indian subcontinent during 1881–1921. They disappear in 1931 only because the age data were smoothed before publication.

²⁰ United Nations, *op. cit.*, pp. 68–70.

²¹ All the estimates based on the stable or quasi-stable population model are obtained by the “West” model life tables and the corresponding stable populations worked out by Coale and Demeny.

²² India, the National Sample Survey, Report No. 76, *op. cit.*, p. 129.

²³ This estimate is based on the population figures for undivided India (excluding Burma) as adjusted by Davis. See Davis, K., *THE POPULATION OF INDIA AND PAKISTAN*, Princeton, Princeton University Press, 1951, pp. 235–236. An alternative estimate for territories censused in both 1881 and 1921 and excluding territories now in Western Pakistan is .0042 for males and .0040 for females.

²⁴ G. B. Saxena used the “South” model life tables and stable populations, which have a relatively high mortality under age five, for his estimates of e_0 on the basis of quasi-stability. According to his calculations, the proportion of males and females under age 35 in 1961 suggested an e_0 of 40.74 and 35.26 years, respectively. See Saxena, G. B., *Estimates of Birth Rate and Expectation of Life in India on the Basis of Quasi-Stability*, in: *Papers Contributed by Indian Authors to the World Population Conference, Belgrade, Yugoslavia, August 30–September 10, 1965*, New Delhi, Office of the Registrar General, 1965, pp. 61–68.

²⁵ Reference is to Parts (a) and (c) of Table III. 1 in Annex III of: United Nations, *op. cit.*, pp. 119–120.

²⁶ Brass, W., *et al.*, *THE DEMOGRAPHY OF TROPICAL AFRICA*, Princeton, Princeton University Press, 1968, pp. 168–182.

²⁷ The execution of sampling procedures was far from optimal. See: Census of India, Paper No. 1 of 1948, *Age Tables—West Bengal, 1941, on Y—Sample*, pp. 1–2.

²⁸ The postpartition population transfers between India and Pakistan caused a net gain of only about 70,000 persons by the former according to the 1951 census data for the two countries. Most of the movement was of entire families and the age composition of movers in either direction was probably similar. The population figures were adjusted to exclude Jammu and Kashmir, which was not censused in 1951.

²⁹ Unlike in Tables 5 and 6, the range of stable birth rates based on the 1951 female age distribution was smaller than that of rates from male age distribution.

³⁰ Both figures are close to the estimate of 43.1 suggested by S. P. Jain, the former census actuary, in his *State Growth Rates and Their Components*, in: Bose, *op. cit.*, pp. 30–31. Jain’s estimates for 1951–1961 are, however, lower than those presented in Table 10.

³¹ The earlier calculations (in Tables 5 and 6) of factors to adjust the stable birth rates from the 1961 age distributions for declines in mortality assumed the intercensal rate of increase during 1941–1951 to refer to 1946, the midpoint of the decade. If the growth rate of the decade 1941–1951 is assumed to hold for 1950–1951, a higher rate of increase in r is offset by a shorter duration of decline in mortality. The adjusted quasi-stable estimates of birth rates are not notably different.

³² The life expectancy at birth is assumed to have remained unchanged until about 1950. If the estimates for 1941–1951 are taken to apply to the midpoint of decade, a linear extrapolation would suggest a lower value of about 41.8 years for 1966.

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