Regional Trends in Fertility and Mortality in Brazil*

J. A. M. CARVALHO

This article presents an analysis of the regional trends in fertility and mortality in Brazil since the 1930–40 decade. The aim is to show how the demographic variables have changed, rather than to provide explanations for the changes. A detailed discussion of the assumptions used to derive the estimates is not possible here, and those interested are referred to the author's thesis.[1]

REGIONAL DIVISION

The ten Brazilian regions, shown in the tabulations of the 1970 Brazilian Census (see map), will be used as the geographical units of analysis. The following labels will be adopted instead of the original reference numbers for the regions:

Region	State or Federal territory	Label
I	Acre, Amazonas, Pará, Rondônia, Roraima and Amapá	Amazônia
II	Maranhão and Piaui	North
III	Ceará, Rio Grande do Norte, Paraiba, Pernambuco, Alagoas and Fernando Noronha	Northeast
IV	Sergipe and Bahia	Bahia
V	Minas Gerais and Espirito Santo	Minas
VI	Rio de Janeiro and Guanabara	Rio
VII	São Paulo	S. Paulo
VIII	Paraná	Paraná
IX	Rio Grande do Sul and Santa Catarina	South
X	Goiás, Mato Grosso and Brasília (Federal District)	West

Brazil: the regions

AVAILABILITY OF DATA

The completeness of registration of vital events in Brazil varies widely between the regions. Since our aim is to study the regional trends in fertility and mortality, data from other sources have to be used.

Census Data

In the 1940 Census women were asked for the following information:

1. The number of live births to census date.
2. The number of stillbirths to census date.
3. The number of children alive at census date.

* This work is a summarized version of Chapters II, III and IV of my Ph.D. thesis written under the supervision of Professor D. V. Glass and Mr J. Hobcraft at the University of London. I am most grateful to my supervisors as well as to Professor W. Brass for valuable comments on several aspects of the thesis. While carrying out this study, the author was supported by grants from the Federal University of Minas Gerais, Brazil, and the Ford Foundation.

[1] J. A. M. Carvalho, Analysis of Regional Trends in Fertility, Mortality and Migration in Brazil, 1940–1970, Unpublished Ph.D. Thesis, University of London, October 1973.

No guidance was given to the enumerators on how to differentiate between stillbirths and miscarriages. When the results were analysed, it was concluded that the number of stillbirths had been overstated and that of live births understated. As a result, in the 1950 Census only the total number of births was asked for, without differentiating between live and stillbirths. In this connection, stillbirths should be considered as births 'occurring after seven months of pregnancy'. As in 1940, women were also asked to declare the number of children alive at census date. The 1950 census questions were repeated in 1960, but related only to a 25 per cent sample of the population.

I—Amazônia
II—North
III—Northeast
IV—Bahia
V—Minas
VI—Rio
VII—S. Paulo
VIII—Paraná
IX—South
X—West

In the 1970 Census the three questions originally asked in 1940 were repeated, and an additional question was introduced relating to the number of live births during the twelve months preceding the census date. These questions were asked of a 25 per cent sample of the population.

The 1940 and 1950 results were tabulated for each of the federal units of the country. Unfortunately, not all the 1960 results have yet been published; only data on the total number of births are available, and they refer only to four broad regions. These results are based on a sub-sample of 1·27 per cent of the population. The 1970 results were published for each of the ten regions, and are also based on a 1·27 per cent sub-sample of the population.

The 1970 census tabulations allow estimation techniques to be used to estimate fertility and child mortality.

Brass's technique for estimating fertility[2] makes use of the fact that the mean parity of a cohort of women is related to their fertility distribution during the childbearing period. The cumulated fertility distribution of a cohort of women should exactly match their mean parity.

[2] W. Brass *et al.*, *The Demography of Tropical Africa*, Princeton University Press, Princeton, 1968, Chapter III; United Nations, Manual IV, *Methods of Estimating Basic Demographic Measures from Incomplete Data*, ST/SOA/Series A/42, New York, 1967.

Assuming constant fertility, and working with theoretical fertility distributions, Brass developed sets of multiplying factors to convert cumulated current fertility into mean parity. In practice the two series of fertility data (current and retrospective) are not equal even after conversion; this is due mainly to two different kinds of errors, viz.: (1) current fertility data may be affected by 'reference period' errors, i.e. the respondents, when asked for the number of births during the previous twelve months, do not have an accurate perception of the length of the period; (2) the retrospective fertility data may be affected by 'recall' errors; however, it is likely that younger women will remember the number of births they have had more accurately than older women.

If the level of literacy and education in the population is relatively homogeneous, 'reference period' error will not vary significantly with age. In this case, current fertility rates will provide the pattern of the fertility distribution. If cumulated current fertility of younger women is compared with their mean parity, the ratio between the two will provide a factor which may be used to correct the level of fertility. Brass suggests using the mean parity of women aged 20–24 for the comparison.

If the population has experienced a rapid change in fertility this technique will not yield good results, since mean parity is a cohort variable while current fertility rates relate to different cohorts. However, provided the change has been small, the final estimates should be close to the true values, since the mean parity used for 'control' is taken from younger women.

There are two possible kinds of errors in the original data that may affect the results – understatement of live births, and age misstatement by women.

In countries where there are poor maternity services or few trained midwives, it is difficult to differentiate between stillbirths and live births if the child dies soon after birth. If data are available for 'stillbirths' and 'live births', a correction may be possible.

Age misstatement by women of childbearing age may distort the results more seriously. However, age misstatements will affect fertility indices obtained by any technique.

If the only errors in current fertility were age misstatements and an incorrect 'reference period', a 'corrected fertility distribution' would provide the true number of live births if an appropriate factor for adjusting the 'reference period' error was available. The best way to check for this possible source of error is to examine the series of ratios of mean parity to cumulative current fertility in different age groups. These ratios should be approximately equal for the age groups 20–24 and 25–29, and thereafter should decrease smoothly because of recall error among older women.

The 'corrected fertility distribution' would not necessarily be the true fertility distribution of the population, but should provide a better estimate of the total number of live births. Trends in estimates of total fertility rates would give correct results only if the pattern of age errors in childbearing ages had remained constant throughout the period analysed. It has been found that there is a common pattern of age misstatement among countries of the same region at different periods.[3] If the fertility levels between different regions in a country are to be compared, the total fertility rates estimated would provide a good indicator of the differentials.

Brass's estimation technique, using childhood mortality data, is based on the fact that the number of children surviving to a group of women depends on the previous fertility of that group of women and the mortality to which the children were subjected. Working with theoretical fertility and mortality functions, Brass developed sets of multiplying factors to convert proportions of children dead, for different age groups of mothers into probabilities of dying between birth and birthday x, i.e. life table ${}_xq_0$ values.[4]

In *The Demography of Tropical Africa* there is an extensive discussion of the degree of sensitivity of multiplying factors to different fertility and mortality patterns.[5] The main con-

[3] United Nations, *op. cit.*, in footnote 2, Chapter I.

[4] See references cited in footnote 2.

[5] W. Brass *et al.*, *ibid.*, pp. 109–114.

clusions are: (1) multiplying factors are not sensitive to different fertility patterns, except for the age group 15–19; (2) the multiplying factors will be approximately correct if the mortality pattern conforms to the West Regional Life Table pattern.[6] The estimates will also hold approximately true for other regional patterns with the exception of those for ${}_1q_0$, which are liable to serious distortion.

If mortality is declining, younger children of a group of women will have experienced lower mortality than the older children. The ${}_xq_0$ estimates would, therefore, represent neither current nor cohort mortality. The older the women, the greater the divergence between the ${}_xq_0$ values obtained and current mortality. Since women aged 20–24 and 25–29 years will have had the majority of their births in the decade preceding the census date, the ${}_xq_0$ estimates obtained should give a good indication of the average child mortality prevailing during the preceding decade, but an overestimation of that prevailing at the census date.

FERTILITY ESTIMATES FOR BRAZIL AND REGIONS

Estimates from the 1970 Census Results

Data collected in the 1970 Census allow the application of Brass's fertility estimation technique. There is a formal problem, however. The data were tabulated by quinquennial age groups up to age 30, and by decennial age groups thereafter, whereas the multiplying factors are intended for five-year age groups or ten-year age groups exclusively. If the assumptions underlying this technique apply, this is not important since the correction factor for the 'reference period' error is

TABLE 1. *Ratios of live births as declared in the 1940 and 1970 Brazilian censuses*

Age of women	1940	1970	1940	1970	1940	1970	1940	1970	1940	1970	1940	1970
	Amazônia		North		Northeast		Bahia		Minas		Rio	
15–19	93·2	94·2	94·4	91·9	94·4	92·3	93·7	93·8	95·3	93·9	93·9	93·7
20–29	91·7	94·1	91·6	91·7	93·3	91·8	91·9	92·5	93·5	93·0	92·8	93·0
30–39	91·3	93·5	90·9	90·9	93·7	91·5	91·5	92·0	92·8	91·9	91·8	91·9
40–49	90·7	92·7	90·7	90·4	92·5	90·5	91·2	90·9	92·1	90·9	91·0	90·6
	S. Paulo		Paraná		South		West				Brazil	
15–19	95·0	92·4	95·7	92·4	95·9	92·1	94·0	92·4			94·6	92·8
20–29	93·7	93·9	93·6	92·5	95·1	95·1	92·0	91·5			93·2	92·9
30–39	93·1	92·9	93·1	91·5	95·0	94·6	91·4	90·9			92·7	92·2
40–49	92·5	91·7	92·7	90·0	94·5	93·7	90·6	89·3			92·2	91·1

usually taken from the 20–24 year age group of women. However, one of the most powerful checks on the validity of the assumptions is provided by the series of ratios of mean parity to cumulated fertility. Fortunately, Brass has computed a special multiplying factor table that could be used in the Brazilian case.

Table 1 gives the ratio between live births and total births obtained from the 1940 and 1970 Brazilian censuses. With the exception of the values for the first age group (which are not very reliable in 1970 since they are subject to large sampling errors), the remaining ones do not show any clear change between the two censuses. Mortara, in his analysis of the 1940 Census, concluded that the reported proportion of live births was understated, and used a ratio of 0·95 of total births as being closer to reality.[7] There are several good estimates of expectation of life at birth for

[6] A. J. Coale and P. Demeny, *Regional Model Life Tables and Stable Populations*, Princeton, 1966.

[7] G. Mortara, 'A Fecundidade da Mulher e a Sobrevivência dos Filhos no Brasil, Segundo o Censo de 1950', in *Contribuições para o Estudo de Demografia do Brasil*, FIBGE, Rio de Janeiro, 1970.

Brazil in 1940–50 and applying Brass's childhood mortality estimation technique, Merrick thought that the ${}_xq_0$ estimates obtained would be more compatible with those estimates of e_0^o if all the births enumerated in the 1950 Census had actually been live births.[8] Of course, compatibility between a given value of e_0^o and ${}_xq_0$ values for young ages depends on the mortality pattern of the population. It will be seen later that the ratio suggested by Mortara, i.e. 0·95, is not incompatible with those e_0^o estimates, provided the Brazilian mortality pattern during 1940–50 was similar to the 1940 Mexican pattern.

If the proportions of live births in the 1940 Census are too low, so are those in the 1970 Census. Data on foetal deaths published in the *UN Demographic Yearbook*[9] based on civil registers, show that in Ecuador, Venezuela, Trinidad and Tobago, and Mauritius, proportions of live births during 1966–68 exceeded 0·95, and were usually greater than 0·97 of total births. Consequently, it was decided to take 0·95 as the proportion of live births for all periods and regions, instead of accepting the proportions provided by the 1940 and 1970 censuses.

Table 2 shows the P/F (mean parity/cumulative fertility) ratios for each region and for the country as a whole. The P/F ratio for the first age group is not very reliable, for the reason mentioned earlier. The ratios for the 20–24 and 25–29 year age groups are approximately the same in each region, with the exception of Amazônia. In Amazônia the ratio of 1·53 for the 20–24 age group appears to be too high relatively to that for the 25–29 age group in the same region and the 20–24 ratios for the other regions and the country as a whole. Therefore, it was decided to use the P/F ratio in the broader age group 20–29 as a factor for correcting the fertility level in each region and in the country as a whole. Since the women aged 20–29 years will have had the majority of their children during the preceding ten years, the results will correspond approximately to the average of the 1960–70 period.

There is no clear decline by age in the P/F ratios for Minas, Rio, S. Paulo, Paraná and the South. These regions are the most developed in Brazil and perhaps recall error is not so significant here. Moreover, as we shall see later, all these regions with the exception of Paraná experienced a decline in fertility between 1940–50 and 1960–70. Declining fertility would raise the P/F ratios for older women, and so would offset the recall error effect. The P/F ratios in Amazônia, North, Northeast, Bahia and West show a clearly declining trend. Apart from the recall problem, it is plausible that increasing fertility during previous decades intensified this trend. In general, the P/F ratios for the regions and the country do not suggest the existence of any 'extreme age misreporting' that would invalidate the results.

Table 3 shows the 1960–70 fertility distributions, the total fertility rates (TFRs) and the mean age of the fertility distribution ($\bar{m}$) for the regions and the country. In all cases, with the exception of Paraná, the peak of the distribution occurs in the 25–29 year age group. It may be that the exception is due to sampling error, but in the absence of other indications it is not advisable to make any further adjustment.

The variation in $\bar{m}$ is quite small, from 29 to 31 years. The most striking point is the wide variation in the fertility level. On average, a woman in Amazônia would have more than twice as many live births as in Rio. The Rio region is, of course, very urbanized, with 48 per cent of its population living in the city of Rio de Janeiro. If we use a concept of 'modernity' based on a combination of indices relating to urbanization, literacy, the proportion of people working in the modern sectors of the economy, and the level of productivity in agriculture, the regions may be divided into two broad groups: (1) developed regions: Minas, Rio, S. Paulo, Paraná and South; and (2) underdeveloped regions: Amazônia, North, Northeast, Bahia and West. It is clear that the underdeveloped regions exhibit high fertility and the better-off regions lower fertility.

Given the large differences in regional fertility levels, we might also expect regional variations

[8] T. Merrick, *Trends and Interregional Differences in the Birth Rates in Brazil, 1930 to 1970*, Cedeplar, Belo Horizonte, 1972.

[9] United Nations, *Demographic Yearbook 1970*, New York, 1971, pp. 641–642.

TABLE 2. *P/F ratios for Brazil and regions – 1970 Census*

Age of women	Amazônia	North	Northeast	Bahia	Minas	Rio	S. Paulo	Paraná	South	West	Brazil
15–19	1·87	1·59	1·62	1·80	1·54	1·46	1·54	1·22	1·46	1·55	1·56
20–24	1·53	1·39	1·38	1·47	1·37	1·29	1·28	1·24	1·28	1·35	1·34
25–29	1·28	1·35	1·39	1·42	1·40	1·34	1·31	1·28	1·39	1·26	1·34
30–39	1·25	1·23	1·31	1·27	1·38	1·41	1·31	1·27	1·39	1·19	1·30
40–49	1·13	1·14	1·29	1·15	1·37	1·38	1·32	1·25	1·42	1·16	1·27
20–29	1·37	1·36	1·39	1·44	1·39	1·32	1·30	1·26	1·35	1·29	1·34

TABLE 3. *Brazil and regions – fertility distributions (per woman), 1960–70*

Age of women	Amazônia	North	Northeast	Bahia	Minas	Rio	S. Paulo	Paraná	South	West	Brazil
15–19	0·0869	0·0896	0·0684	0·0696	0·0496	0·0469	0·0490	0·0969	0·0559	0·0848	0·0635
20–24	0·3011	0·2846	0·2861	0·2843	0·2527	0·1917	0·2110	0·2981	0·2203	0·3213	0·2522
25–29	0·3789	0·3223	0·3763	0·3776	0·3140	0·2079	0·2311	0·2833	0·2471	0·3349	0·2936
30–39	0·3181	0·2920	0·3239	0·3332	0·2478	0·1286	0·1399	0·2127	0·1823	0·2452	0·2224
40–49	0·1197	0·0940	0·1031	0·0933	0·0796	0·0333	0·0325	0·0776	0·0595	0·0791	0·0671
TFR	8·2	7·3	7·9	7·9	6·4	3·9	4·2	6·3	5·0	6·9	3·9
$\bar{m}$	31·01	30·64	31·00	30·88	30·73	29·16	29·02	29·74	30·14	29·87	30·19

TABLE 4. *Brazil and regions – proportional distribution of the 1960–70 total fertility rates*

Age of women	Amazônia	North	Northeast	Bahia	Minas	Rio	S. Paulo	Paraná	South	West	Brazil
15–19	0·05	0·06	0·04	0·04	0·04	0·06	0·06	0·08	0·06	0·06	0·06
20–24	0·19 }0·42	0·19 }0·41	0·18 }0·42	0·18 }0·42	0·20 }0·45	0·25 }0·52	0·25 }0·47	0·24 }0·52	0·22 }0·46	0·23 }0·47	0·21 }0·46
25–29	0·23	0·22	0·24	0·24	0·25	0·27	0·27	0·23	0·24	0·24	0·25
30–39	0·39	0·40	0·40	0·42	0·39	0·34	0·34	0·33	0·36	0·36	0·37
40–49	0·14	0·12	0·14	0·12	0·12	0·08	0·08	0·12	0·12	0·11	0·11

in fertility patterns. Table 4 shows the proportional distribution of the TFRs by age of women. From Table 3 we can distinguish three broad levels of fertility: (1) high in Amazônia, North, Northeast and Bahia; (2) medium in West, Minas, Paraná and South; and (3) low in Rio and S. Paulo. In Table 4 we can see that these levels correspond roughly to three different patterns: in regions with high fertility about 42 per cent of total fertility is concentrated in the 20–29 age group, in regions with medium fertility about 46 per cent, and in those with low fertility about 52 per cent. These are no significant differences in the 15–19 age group.

Estimation of Fertility Distributions for 1930–40, 1940–50, and 1950–60

As mentioned above, no questions relative to the number of births during the twelve months preceding the census date were asked in the 1940 and 1950 censuses. The absence of data on current fertility creates a serious problem relating to the fertility pattern. If Table 4 had shown a uniform regional fertility pattern during 1960–70, we would have assumed that the pattern had not changed between 1930 and 1970, since cross-sectional analysis would reveal that the fertility level was independent of the pattern. However, we have already demonstrated the existence of three patterns relating to the three levels of fertility.

TABLE 5. *Brazil and regions – ratios between mean parities*

Regions	$\frac{P_{20-29}\ (1970)}{P_{20-29}\ (1940)}$	$\frac{P_{20-29}}{P_{30-39}}$ 1940	1950	1970
Amazônia	1·19	0·42	0·43	0·40
North	1·05	0·42	0·42	0·40
Northeast	1·01	0·37	0·36	0·35
Bahia	1·15	0·38	0·39	0·38
Minas	0·89	0·37	0·37	0·35
Rio	0·92	0·42	0·42	0·39
S. Paulo	0·86	0·38	0·39	0·40
Paraná	1·07	0·39	0·41	0·42
South	0·92	0·37	0·38	0·36
West	1·13	0·41	0·43	0·43
Brazil	0·98	0·40	0·39	0·39

The first column in Table 5 shows the ratios between the mean parities in the 20–29 age group for women in 1970 and 1940. These ratios do not necessarily indicate the exact change in the fertility level between 1930–40 and 1960–70, since the age pattern of fertility might have changed; but they give a rough idea of the possible direction and significance of the changes. During the 30 years, mean parity increased most in Amazônia (19 per cent) and fell most in S. Paulo (14 per cent). Regional fertility levels, as represented by the mean parity of the 20–29 age group, did not change greatly during the period. The age pattern of mean parities might provide some clues to possible changes in the fertility pattern. It is true that it is not directly related to the current fertility distribution, since it depends on the experience of different cohorts of women at different periods of time. Nevertheless, a significant change in fertility patterns should affect the age patterns of mean parity. We showed that the main difference between the three fertility patterns was the degree of concentration of fertility in the 20–29 age group. The ratios between the parities of the age group 20–29 and 30–39 are presented in Table 5. The maximum change in the ratios between 1940 and 1970 is three percentage points. The results do not show significant changes in regional fertility patterns during the period covered by this analysis.

TABLE 6. *Brazil and regions – total fertility rates (per woman) and crude birth rates (per thousand) – 1930–40 to 1960–70*

Region	Total fertility rates 1930–40	1940–50	1950–60	1960–70	1960–70 / 1940–50	1960–70 / 1950–60	Crude birth rates 1930–40	1940–50	1950–60	1960–70	1960–70 / 1940–50	1960–70 / 1950–60
Amazônia	6·9	7·3	n.a.	8·2	1·12	—	50·2	50·6	n.a.	52·0	1·03	—
North	7·0	7·0	n.a.	7·3	1·04	—	51·1	49·4	n.a.	49·3	1·00	—
Northeast	7·9	7·7	n.a.	7·9	1·03	—	55·5	55·1	n.a.	52·9	0·96	—
Bahia	6·9	7·3	n.a.	7·9	1·08	—	50·3	52·9	n.a.	52·7	1·00	—
Minas	7·2	6·8	n.a.	6·4	0·94	—	50·4	48·6	n.a.	42·6	0·88	—
Rio	4·2	4·0	n.a.	3·9	0·98	—	33·7	33·0	n.a.	30·0	0·91	—
S. Paulo	5·6	5·1	n.a.	4·2	0·82	—	41·8	39·3	n.a.	32·5	0·83	—
Paraná	5·9	5·9	n.a.	6·3	1·07	—	42·1	42·9	n.a.	43·0	1·00	—
South	6·2	6·2	n.a.	5·0	0·81	—	43·0	43·6	n.a.	35·5	0·81	—
West	6·2	6·4	n.a.	6·9	1·08	—	44·3	45·8	n.a.	47·3	1·03	—
Brazil	6·5	6·3	6·1	6·0	0·95	0·98	47·2	46·5	43·7	42·3	0·91	0·97

To derive estimates of fertility for 1930–40 and 1940–50, two steps were taken:

1. It was assumed that the fertility pattern in each region was the same as that observed in 1960–70. Fertility levels were obtained by adjusting the 1960–70 level by means of an adjustment factor computed by dividing the mean parity of the 20–29 age group in 1940 and 1950 by the mean parity of the group in 1970. Crude birth rates based on the estimated fertility distributions were computed and compared with those estimated by Merrick[10] using the reverse survival method. If the two sets of estimates agreed for 1960–70 and diverged for the two earlier periods, this could suggest that the assumptions used to obtain the estimates for 1930–40 and 1940–50 were not realistic. In fact, the pattern of differences between the two sets of estimates for each region for the three periods is approximately the same, with two exceptions: S. Paulo and South. The estimates for 1960–70 produced here should be better than those derived by the reverse survival method, since they were obtained on the basis of data relating directly to fertility.

2. The two sets of estimates for S. Paulo and South suggest that these regions experienced a change in fertility patterns, and that in 1930–40 and 1940–50 their fertility was less concentrated in the 20–29 age group. It was decided to accept the assumption of constant fertility patterns for all regions, except S. Paulo and South. For S. Paulo, 1930–40 and 1940–50, we applied the 1960–70 fertility pattern of the South, and for the South the 1960–70 fertility pattern of Minas. The new sets of estimated fertility distributions produced CBRs more compatible with Merrick's estimates.

For the country as a whole, the fertility estimates were obtained by aggregating the regional estimates.

The 1960 census data on fertility were tabulated only for four broad regions, so that estimates could not be obtained for the ten regions individually. The national fertility estimate was derived by aggregating the four regional fertility distributions, assuming that the fertility pattern in each region was the same as in 1960–70.

1930–1970 Fertility Estimates

Table 6 shows the estimates of TFRs and CBRs for 1930–40, 1940–50, 1950–60 and 1960–70. In all the regions considered as underdeveloped (Amazônia, North, Northeast, Bahia and West), fertility levels (TFRs) either increased or remained constant between 1940–50 and 1960–70. Fertility in the developed group (Minas, Rio, S. Paulo, Paraná and South) showed a decline, with the exception of Paraná. For most of the regions, the declining or rising trend in fertility began in 1930–40.

For the country as a whole, the estimates indicate only a slight decline in the total fertility rate. The divergent trends among the regions cancelled out any major effect at the national level. It seems that the opinion widely expressed in Brazil after the 1970 census results were published, that fertility had declined considerably, has little basis in fact. The crude birth rate declined more markedly than the total fertility rate because of changes in the age distribution.

Comparison with other Estimates for Brazil

Table 7 shows the fertility distributions estimated by Mortara for 1930–40 and 1940–50, and those obtained here. Mortara applied his own technique to estimate the fertility distribution underlying the retrospective fertility reported in the census.[11] For the first period, the two sets of estimates show roughly the same pattern, with the largest proportional differences in the youngest and oldest age groups. The two estimates of total fertility rate are the same. Mortara's estimates for the second period show a change in the pattern of fertility, with a significant decline in the fertility rates of the 25–29 and 30–39 age groups.

[10] T. Merrick, *op. cit.*, in footnote 8.
[11] G. Mortara, *op. cit.*, in footnote 7.

Table 8 gives estimates of crude birth rates for Brazil from different sources. Mortara's results are based on his estimates presented in Table 7. Merrick's estimates[12] were obtained by the reverse survival technique, using the 0–9 age group and assuming an underenumeration of 2·5 per cent in the 0–4 age group. His survivorship estimates are based on $_xq_0$ values obtained by Brass's childhood mortality technique. There is little difference between Mortara's estimates and those derived from this analysis. Our estimates for all periods are seven per cent higher than Merrick's. This difference might be due to the typically large underenumeration of the 0–9 age group.

TABLE 7. *Brazil – estimated fertility distributions (per woman)*

Age of women	1930–40 Mortara	1930–40 Carvalho*	1940–50 Mortara	1940–50 Carvalho*
15–19	0·081	0·062	0·080	0·061
20–24	0·256	0·261	0·258	0·254
25–29	0·308	0·317	0·284	0·306
30–39	0·242	0·252	0·209	0·245
40–49	0·088	0·080	0·089	0·077
Total Fertility Rate	6·5	6·5	6·0	6·3

Source: Mortara's estimates: 1930–1940 in G. Mortara, 'The Development of Brazil's Population', *Population Studies*, **8,** November 1954, p. 130; 1940–1950 in G. Mortara, 'A Fecundidade da Mulher e a Sobrevivència dos Filhos no Brasil, Segundo o Censo de 1950', in *Contribuições para o Estudo de Demografia do Brasil*, FIBGE, Rio de Janeiro, 1970, p. 72.

* From the fertility distribution of the ten regions.

TABLE 8. *Different sets of estimates of crude birth rates for Brazil*

	1930–40	1940–50	1960–70
Mortara	47·4	45·1	—
Merrick	44·0	43·6	39·5
Carvalho*	47·2	46·5	42·3

Source: Mortara's estimates are based on the fertility distributions presented in Table 7.
Merrick's estimates: in T. Merrick, *Trends and Interregional Differences in Birth Rates in Brazil 1930 to 1970*, Cedeplar, Belo Horizonte, 1972, p. 13.

* From the fertility distributions of the ten regions.

MORTALITY ESTIMATES FOR BRAZIL AND REGIONS

In applying Brass's childhood mortality technique, we faced the same technical problem as with the fertility technique, because of the age intervals adopted in the tabulations of the 1970 Census. However, Brass provided a special table of factors that could be applied to such age groups, converting the proportion of children who had died to women aged 30–39 and 40–49 years into $_5q_0$ and $_{15}q_0$ values respectively.

Table 9 shows the series of $_xq_0$ estimates for each region and the country as a whole obtained from the 1970 census data. Again, as in the fertility analysis it is assumed that live births

[12] T. Merrick, *op. cit.*, in footnote 8.

TABLE 9. *Brazil and regions – $_xq_0$ estimates from the 1970 Census*

x	$_xq_0$	e_0^o BMLT	e_0^o WMLT	$_xq_0$	e_0^o BMLT	e_0^o WMLT	$_xq_0$	e_0^o BMLT	e_0^o WMLT	$_xq_0$	e_0^o BMLT	e_0^o WMLT
		Amazônia			North			Northeast			Bahia	
1	0·0746	50·0–52·5	58·2–60·6	0·1235	42·5–45·0	48·5–51·0	0·1880	32·5–35·0	38·6–41·1	0·1095	45·0–47·5	51·0–53·4
2	0·1227	47·5–50·0	53·4–55·8	0·1326	47·5–50·0	51·0–53·4	0·2078	37·5–40·0	41·1–43·5	0·1417	45·0–47·5	51·0–53·4
3	0·1179	52·5–55·0	53·4–55·8	0·1474	47·5–50·0	51·0–53·4	0·2351	37·5–40·0	41·1–43·5	0·1587	45·0–47·5	48·5–51·0
5	0·1341	52·5–55·0	53·4–55·8	0·1623	47·5–50·0	51·0–53·4	0·2755	37·5–40·0	38·6–41·1	0·1938	45·0–47·5	46·0–48·5
15	0·1870	50·0–52·5	51·0–53·4	0·2121	47·5–50·0	48·5–51·0	0·3136	37·5–40·0	38·6–41·1	0·2321	45·0–47·5	46·0–48·5
		Minas			Rio			S. Paulo			Paraná	
1	0·0914	47·5–50·0	53·4–55·8	0·0830	50·0–52·5	55·8–58·2	0·1042	45·0–47·5	51·0–53·4	0·0848	50·0	55·8–58·2
2	0·9320	52·5–55·0	58·2–60·6	0·0806	55·0–57·6	58·2–60·6	0·0776	55·0–57·6	60·6–63·1	0·7810	55·0–57·6	60·6–63·1
3	0·1081	52·5–55·0	55·8–58·2	0·0861	57·6–60·4	58·2–60·6	0·0842	57·6–60·4	60·6–63·1	0·0941	55·0–57·6	58·2–60·6
5	0·1279	52·5–55·0	55·8–58·2	0·1172	55·0	55·8–58·2	0·0999	57·6	58·2–60·6	0·1140	55·0–57·6	55·8–58·2
15	0·1698	52·5–55·0	53·4–55·8	0·1603	52·5–55·0	53·4–55·8	0·1476	55·0–57·6	55·8–58·2	0·1523	52·5–55·0	53·4–55·8
		South			West			Brazil				
1	0·1024	45·0–47·5	53·4	0·0934	47·5–50·0	53·4–55·8	0·1130	42·5–45·0	51·0			
2	0·0546	60·4–63·2	63·1–65·5	0·1247	47·5–50·0	53·4–55·8	0·1172	50·0–52·5	53·4–55·8			
3	0·0574	63·2	63·1–65·5	0·1412	47·5–50·0	51·0–53·4	0·1302	50·0–52·5	53·4–55·8			
5	0·0733	60·4–63·2	63·1	0·1315	52·5–55·0	53·4–55·8	0·1526	50·0–52·5	51·0–53·4			
15	0·0955	60·4–63·2	60·6–63·1	0·1695	52·5–55·0	53·4–55·8	0·1939	50·0–52·5	51·0–53·4			

are 95 per cent of total births. This assumption also applies to the mortality analysis for the other periods.

Since the Brazilian mortality pattern is not known, intervals of e_0^o corresponding to the ${}_xq_0$ estimates are taken from two different groups of Model Life Tables: the first from the Brass One-Parameter Model Life Tables (BMLT)[13] and the second from the West Family of the Regional Model Life Tables (WMLT).[13]

In several regions the e_0^o intervals corresponding to the estimates of ${}_1q_0$ do not seem to be consistent with those corresponding to ${}_2q_0$ and ${}_3q_0$. Estimates of ${}_1q_0$ are not very reliable, because of sampling errors and the sensitivity of the multiplying factor for the 15–19 age group of mothers to discrepancies between actual fertility and mortality patterns and the standard patterns used to derive the multiplying factors. Therefore, it is advisable to obtain estimates of infant mortality from other sources.

The ${}_2q_0$ and ${}_3q_0$ values in each region usually correspond to the same interval of e_0^o in the given Model Life Table System. The ${}_5q_0$ and ${}_{15}q_0$ values usually correspond to a lower e_0^o interval than ${}_2q_0$ and ${}_3q_0$, especially in the WMLT. The series of ${}_xq_0$ estimates, with the exception of ${}_1q_0$, generally show internal consistency inasmuch as the values increase with x; the two exceptions are: ${}_2q_0 > {}_3q_0$ in Amazônia and ${}_3q_0 > {}_5q_0$ in the West.

Computation of ${}_xq_0$ Estimates from the 1940 and 1950 Censuses

To select the multiplying factors it is necessary to have estimates of P_1/P_2 and $\bar{m}$, i.e. the ratio between the mean parities of women aged 15–19 and 20–24 and the mean age of the fertility distribution. There are no estimates of $\bar{m}$ for 1930–40 and 1940–50. The 1970 Census did not show large regional variations in $\bar{m}$, which suggests that it probably has not varied substantially in the past. The ratios of the mean parities between the first two quinquennial age groups of mothers from the 1940, 1950 and 1970 censuses show little variation and absence of a clear trend. If the 1970 multiplying factors are applied to the proportion of children dead in the 1940 and 1950 censuses, the maximum 'error' will be less than two per cent for the estimates of ${}_2q_0$ and less than one per cent for the estimates of ${}_3q_0$. Thus, we shall assume a constant fertility location in the computation of the ${}_xq_0$ estimates from the 1940 and 1950 census data.

${}_xq_0$ *Estimates from the 1940 and 1950 Censuses*

Table 10 shows the estimates from the 1940 census data. These estimates, and those from the 1950 Census, are not subject to sampling errors, since sampling was used neither at the questionnaire stage nor in the preparation of the tables.

The ${}_1q_0$ estimates seem closer to the true values than those from the 1970 Census. Discrepancies between the e_0^o intervals corresponding to ${}_1q_0$ and those corresponding to ${}_2q_0$ and ${}_3q_0$ are less frequent. This improvement is possibly due to the absence of sampling errors. The ${}_xq_0$ estimates increase smoothly within each region, with the exception of ${}_3q_0$ in the North. The ${}_2q_0$ and ${}_3q_0$ estimates correspond to the same interval of e_0^o within a given Model Life Table System, with a few exceptions. The ${}_5q_0$ and ${}_{15}q_0$ estimates do not show a decline in childhood mortality during the three decades prior to the census. Any decline in childhood mortality appears to have been very small and was compensated for by the 'recall' errors in the mean parity of women aged 30–39 and 40–49.

Table 11 shows the ${}_xq_0$ estimates from the 1950 census data. In this census, women were asked only for the total number of births and not the total number of live births experienced by them.

[13] N. Carrier and J. Hobcraft, *Demographic Estimation for Developing Countries*, Population Investigation Committee, London, 1971.

[14] A. J. Coale and P. Demeny, *op. cit.*, in footnote 6.

TABLE 10. *Brazil and regions* – $_xq_0$ *estimates from the 1940 Census*

x	$_xq_0$	e_0^o BMLT	e_0^o WMLT	$_xq_0$	e^o BMLT	e^o WMLT	$_xq_0$	e_0 BMLT	e_0 WMLT	$_xq_0$	e_0^o BMLT	e_0^o WMLT
		Amazônia			North			Northeast			Bahia	
1	0·1710	35·0–37·5	41·1–43·5	0·1411	40·0–42·5	46·0–48·5	0·2242	30·0–32·5	33·7–36·2	0·1865	35·0	38·6–41·1
2	0·2087	37·5–40·0	41·1–43·5	0·2176	37·5–40·0	41·1–43·5	0·2651	32·5–35·0	36·2	0·2208	37·5–40·0	41·1
3	0·2275	37·5–40·0	41·1–43·5	0·2141	40·0–42·5	43·5–46·0	0·2818	32·5–35·0	36·2–38·6	0·2458	37·5–40·0	38·6–41·1
5	0·2653	37·5–40·0	38·6–41·1	0·2460	40·0–42·5	41·1–43·5	0·3086	35·0–37·5	36·2–38·6	0·2706	37·6–40·0	38·6–41·1
15	0·2781	40·0–42·5	41·1–43·5	0·2929	40·0–42·5	41·1–43·5	0·3427	35·0–37·5	36·2–38·6	0·3082	37·5–40·0	38·6–41·1
		Minas			Rio			S. Paulo			Paraná	
1	0·1499	37·5–40·0	43·5–46·0	0·1491	37·5–40·0	43·5–46·0	0·1606	37·5–40·0	41·1–43·5	0·1361	40·0–42·5	46·0–48·5
2	0·1808	40·0–42·5	46·0	0·1651	42·5–45·0	46·0–48·5	0·1849	40·0–42·5	43·5–46·0	0·1786	40·0–42·5	46·0–48·5
3	0·1939	42·5–45·0	46·0–48·5	0·1850	42·5–45·0	46·0–48·5	0·1953	42·5–45·0	46·0–48·5	0·1815	42·5–45·0	46·0–48·5
5	0·2178	42·5–45·0	43·5–46·0	0·2115	42·5–45·0	46·0–48·5	0·2177	42·5–45·0	43·5–46·0	0·2017	42·5–45·0	46·0–48·5
15	0·2587	42·5–45·0	43·5–46·0	0·2587	42·5–45·0	43·5–46·0	0·2556	42·5–45·0	43·5–46·0	0·2305	45·0–47·5	46·0–48·5
		South			West			Brazil				
1	0·1128	42·5–45·0	51·0–53·4	0·1154	42·5–45·0	51·0	0·1635	37·5	41·1–43·5			
2	0·1213	47·5–50·0	53·4–55·8	0·1501	45·0–47·5	48·5–51·0	0·1954	40·0–42·5	43·5–46·0			
3	0·1284	50·0–52·5	53·4–55·8	0·1593	45·0–47·5	48·5–51·0	0·2125	40·0–42·5	43·5–46·0			
5	0·1398	50·0–52·5	53·4–55·8	0·1840	45·0–47·5	48·5–51·0	0·2356	40·0–42·5	43·5–46·0			
15	0·1737	50·0–52·5	51·0–53·4	0·2139	47·5–50·0	48·5–51·0	0·2751	42·5–45·0	43·5			

TABLE 11. *Brazil and regions – ${}_xq_0$ estimates from the 1950 Census*

x	${}_xq_0$	e_0^o BMLT	e_0^o WMLT	${}_xq_0$	e_0^o BMLT	e_0^o WMLT	${}_xq_0$	e_0^o BMLT	e_0^o WMLT	${}_xq_0$	e_0^o BMLT	e_0^o WMLT
		Amazônia			North			Northeast			Bahia	
1	0·2309	30·0–32·5	33·7	0·1446	40·0	43·5–46·0	0·2573	27·5–30·0	28·8–31·2	0·2043	32·5–35·0	36·2–48·6
2	0·1861	40·0–42·5	43·5–46·0	0·1745	42·5–45·0	46·0–48·5	0·2762	32·5–35·0	33·7–36·2	0·2792	37·5–40·0	41·1–43·5
3	0·1951	42·5–45·0	46·0–48·5	0·1876	42·5–45·0	46·0–48·5	0·2843	32·5–35·0	36·2–38·6	0·2294	37·5–40·0	41·1–43·5
5	0·2285	40·0–42·5	43·5–46·0	0·2162	42·5–45·0	43·5–46·0	0·3080	35·0–37·5	36·2–38·6	0·2541	37·5–40·0	41·1–43·5
15	0·2870	40·0–42·5	41·1–43·5	0·2554	42·5–45·0	43·5–46·0	0·3369	35·0–37·5	36·2–38·6	0·2883	40·0–42·5	41·1–43·5
		Minas			Rio			S. Paulo			Paraná	
1	0·1393	40·0–42·5	46·0–48·5	0·1105	45·0–47·5	51·0–53·4	0·1170	42·5–45·0	48·5–51·0	0·1205	42·5–45·0	48·5–51·0
2	0·1552	45·0	48·5–51·0	0·1316	47·5–50·0	51·0–53·4	0·1279	47·5–50·0	51·0–53·4	0·1552	45·0	48·5–51·0
3	0·1657	45·0–47·5	48·5–51·0	0·1517	47·5–50·0	51·0–53·4	0·1440	47·5–50·0	51·0–53·4	0·1699	45·0–47·5	48·5–51·0
5	0·1896	45·0–47·5	48·5–51·0	0·1835	45·0–47·5	48·5–51·0	0·1774	47·5	48·5–51·0	0·1918	45·0–47·5	48·5
15	0·2262	45·0–47·5	46·0–48·5	0·2328	45·0–47·5	46·0–48·5	0·2189	47·5–50·0	48·5–51·0	0·2184	47·5–50·0	48·5–51·0
		South			West			Brazil				
1	0·0861	47·5–50·0	55·8–58·2	0·1097	45·0–47·5	51·0–53·4	0·1617	37·5–40·0	41·1–43·5			
2	0·0941	52·5–55·0	58·2	0·1265	47·5–50·0	53·4	0·1762	40·0–42·5	46·0–48·5			
3	0·1013	55·0–57·6	58·2	0·1403	47·5–50·0	51·0–53·4	0·1892	42·5–45·0	46·0–48·5			
5	0·1164	55·0–57·6	55·8–58·2	0·1649	47·5–50·0	51·0–53·4	0·2152	42·5–45·0	46·0			
15	0·1437	55·0–57·6	55·8–58·2	0·2035	47·5–50·0	48·5–51·0	0·2493	42·5–45·0	46·0			

Again, live births were assumed to be 95 per cent of total births.

The features of the ${}_xq_0$ series are similar to those obtained from the 1940 Census.

Uses of the ${}_xq_0$ Estimates

If data on adult mortality were available, it would be possible to obtain direct estimates of general mortality in the country and regions and the corresponding e_0^os. Until now, estimates of e_0^o in Brazil were obtained by stable population techniques or inter-censal survival ratios. For the ten regions, these techniques could only be applied for the 1940–50 period, because only the 1940 and 1950 censuses permit tabulations of the people *born* in each region classified by age.

The use of inter-censal survival ratios to obtain estimates of e_0^o depends fundamentally on the assumption of constant coverage in two successive censuses. The application of stable population techniques to a region is advisable only when the assumptions of constant fertility and mortality are met, and also if inter-regional migration is not significant. When migration is substantial and has occurred for some time, the 'native regional population' will have too many people in the younger ages in in-migrant regions and too few in the out-migrant regions since some of the children of migrants are born in their region of residence.

Since ${}_xq_0$ estimates are available for 1930–40, 1940–50 and 1960–70, and seem to be quite accurate for ages two and three, they can be used to derive estimates of e_0^o for each region and the whole country.

The ${}_xq_0$ estimates derived by use of the Brass childhood mortality technique are not very sensitive to underenumeration or changes in coverage between censuses, unless the children of women not enumerated in the census differ in mortality from the average, and this difference and the number of women not enumerated are large enough to distort the census proportions. Another advantage is that the ${}_xq_0$ estimates relate to the proportion of children of women living in the region at the census date who have already died. Of course, the proportion of children who have died to women recently arrived in the region relates more to the mortality of the region of origin than to that of the region where they are living at census date. This could introduce some distortion into the estimates of regional mortality. However, the in-migrating adults, too, will have experienced the mortality of their region of origin, and therefore the effect of migration on the mortality of the in-migrant region will be in the same direction at both young and adult ages. The impact of migration on mortality estimates for a region will not, however, be equal for all groups, since migration rates are usually a function of age.

If accurate estimates of e_0^o corresponding to the ${}_2q_0$ and ${}_3q_0$ estimates could be obtained, they would represent the mortality level in the region more closely than estimates obtained from inter-censal survival ratios of the population born in the region.

Mortality Pattern of Brazil

The fundamental problem that arises in estimating e_0^o, or generating life tables for an area with no reliable vital statistics is that of deciding the mortality *pattern* for the population. In the present study good estimates of ${}_2q_0$ and ${}_3q_0$ are available, and if the mortality patterns prevailing in 1930–40, 1940–50 and 1960–70 were known, it would be possible to generate life tables compatible with the known mortality patterns and the level of childhood mortality.

There are robust estimates of e_0^o for Brazil as a whole for 1940–50. Several analyses using different techniques arrived at very similar estimates for both sexes combined, and these estimates are presented in Table 12.

Arriaga[15] applied a stable population technique developed by himself, using the age distribution of the population aged 10 to 59 from the 1950 Census and the growth rate between 1940 and 1950. These life tables are based on the mortality pattern underlying the United Nations Model Life Tables (UNMLT).

Mortara[16] used the UNMLT to find out which life tables had ${}_{10}p_x$ values that would yield the best results, when projecting the 1940 population to 1950 and comparing the results with the 1950 Census. For males he selected life table Level 45 and for females Level 50.

The first estimates from *UN Manual IV*[17] were obtained for males by taking the median of the series of e_0^o estimates underlying the proportions of the male population under ages 5, 10, 15, . . . 40 and 45 in 1950, the inter-censal growth rate and assuming it to be a stable population with WMLT pattern. The e_0^o estimate for females is taken from the stable population table matching the Brazilian growth and death rates for females. The female death rate was obtained from the male death rate, the sex ratio at birth of 1·05, and the overall sex ratio of the population.

TABLE 12. *Estimates of* e_0^o *for Brazil, 1940–50*

	Males	Females	Both sexes*
Arriaga	42·05	43·87	42·94
Mortara	41·65	46·06	43·80
UN Manual IV (1)	42·9	47·5	45·1
UN Manual IV (2)	41·2	44·9	43·0
BMLT ${}_2q_0$			42·5
BMLT ${}_3q_0$			43·7
WMLT ${}_2q_0$			46·5
WMLT ${}_3q_0$			46·8

* For comparison purposes a sex ratio at birth of 1·05 was assumed.

Sources: E. E. Arriaga, *New Life Tables for Latin American Populations in the Nineteenth and Twentieth Centuries*, IIS, University of California, Berkeley, 1968, pp. 38–39.
UN Manual IV, *Methods of Estimating Basic Demographic Measures from Incomplete Data*, ST/SOA/Series A/42, New York, 1963, pp. 67 and 77.
G. Mortara, 'Novas Contribuições para a Determinação do Nível da Mortalidade no Brasil', in *Contribuições para o Estudo da Demografia do Brasil*, FIBGE, Rio de Janeiro, 1970.

The second set of estimates from the *UN Manual*[18] was based on a slightly modified technique. The levels of mortality from age five upwards from the first set of estimates were accepted. Since divergences between actual and Model Life Table mortality patterns are greatest in the 0–5 age group, ${}_2q_0$ estimates from the proportion of children dead in the 20–24 age group of women in the 1950 Brazilian Census were used to obtain estimates of ${}_5L_0$ for males and females.

The four different e_0^o estimates for both sexes combined show a surprisingly narrow range of variation, and 43–45 years may be accepted as the probable range of e_0^o for Brazil as a whole during 1940–50.

Table 12 also shows the exact e_0^o in the BMLT and WMLT corresponding to our ${}_2q_0$ and ${}_3q_0$ estimates. The Brazilian mortality pattern in the 1940s seems to be closer to the 'African

[15] E. E. Arriaga, *New Life Tables for Latin American Populations in the Nineteenth and Twentieth Centuries*, I.I.S., University of California, Berkeley, 1968.

[16] G. Mortara, 'Novas Contribuições para a Determinação do Nível de Mortalidade no Brasil', in *Contribuições para a Estudo da Brasil*, FIBGE, Rio de Janeiro, 1970.

[17] United Nations, *op. cit.*, in footnote 2, pp. 67–88.

[18] *Ibid.*, pp. 76–78.

mortality pattern' underlying the BMLT than to the pattern underlying the WMLT, if the $_xq_0$ estimates are taken to represent the mortality of the very young during the decade.

Table 13 shows the e_0^o estimates for 1960–70 obtained by Cassinelli.[19] Using the 1960 and 1970 population classified by sex and five-year age groups, he computed the proportion of each sex aged x and over surviving ten years. He then compared these survivorship ratios with those in the WMLT to obtain the corresponding e_0^o, and took the median of the first nine estimates to represent the Brazilian e_0^o for the intercensal period. Table 13 also shows the exact e_0^o in the BMLT and WMLT corresponding to the $_2q_0$ and $_3q_0$ estimates for 1960–70. If the $_xq_0$ estimates are accepted, the comparison suggests that Cassinelli's estimate for the combined sexes is overestimated by 4·5 years, since he accepts the WMLT pattern of mortality. If the BMLT mortality pattern is used, it should provide an e_0^o of about 50·5 years. Between 1940–50 and 1960–70 the country would have experienced an increase in e_0^o of about eight years; this is low in comparison with other estimates for Latin American countries, all of which show a rapid increase in e_0^o during this period. It is likely that during 1960–70 the Brazilian mortality pattern was closer to the WMLT than to the BMLT pattern. This would mean that mortality declined faster for adults than for children.

TABLE 13. *Estimates of* e_0^o *for Brazil, 1960–70*

	Males	Females	Both sexes*
Cassinelli	57·0	61·1	59·0
BMLT $_2q_0$			50·3
BMLT $_3q_0$			50·9
WMLT $_2q_0$			54·7
WMLT $_3q_0$			54·2

* For comparison purposes a sex ratio at birth of 1·05 was assumed.

Source: R. R. Cassinelli, *Estimativas para o Brasil da Vida Média ao Nascer Durante o Período 1960/1970 a Partir de Razões de Sobrevivência Inter-Censitárias*, FIBGE, Rio de Janeiro, 1971, p. 18.

Is there any indication of such a change in other Latin American countries? Unfortunately, very few Latin American countries have complete death registration. Arriaga[20] computed life tables for 17 Latin American countries, and only for four was it possible to use vital registration data: Chile (1930), Venezuela (1961), Costa Rica (1963) and Mexico (1921, 1930, 1940, 1950 and 1960). For the other countries he used stable population techniques, and the results do not provide any information about possible changes in mortality patterns. In fact, only the Mexican tables give us a clue to the changes in mortality pattern, since there is only one life table based on vital statistics in Chile, Venezuela and Costa Rica.

As there has been a lag between the mortality levels of Mexico and Brazil since 1940, and the Mexican tables refer to exact years while our $_xq_0$ estimates refer roughly to the average for the decade preceding the census, we used the 1940 and 1960 Mexican life tables to obtain e_0^o estimates for Brazil for 1940–50 and 1960–70 respectively. The $_2q_0$ and $_3q_0$ estimates indicated the Brazilian level of mortality, and a logit transformation was applied to the Mexican l_x/l_0 values to obtain the corresponding values for Brazil. Our computations yielded an e_0^o for both sexes of 43·6 years for 1940–50 and of 55·7 years for 1960–70. If these results are compared with the e_0^os corresponding to the $_2q_0$ and $_3q_0$ estimates in Tables 12 and 13, we may conclude that the mortality pattern underlying the 1940 Mexican life tables is very similar to the BMLT pattern, while that underlying the 1960 Mexican life tables is close to the WMLT.

[19] R. R. Cassinelli, *Estimativas para o Brasil, da Vida Média ao Nascer Durante o Período 1960/1970 a Partir de Razões de Sobrevivência Inter-Censitárias*, FIBGE, Rio de Janeiro, 1971.

[20] E. E. Arriaga, *op. cit.*, in footnote 15.

Earlier it was shown that the $_2q_0$ and $_3q_0$ values and the e_0^o estimates for 1940–50 suggested a mortality pattern similar to the 'African standard'; it was also shown that for 1960–70 the 'African pattern' would provide estimates of e_0^o that were too low, and that, in this instance, the WMLT seemed more appropriate. The Mexican life tables indicate a similar change in mortality pattern between 1940 and 1960. Hence, the decision to use the 1940 and 1960 Mexican life tables as standards for the generation of life tables for Brazil for 1940–50 and 1960–70 respectively. The $_2q_0$ and $_3q_0$ estimates for 1930–40 and 1940–50 suggest an increase in e_0^o in Brazil between those two periods of only about two years, using either of the two Model Life Table Systems. Since the Mexican tables showed an increase of five years between 1930 and 1940, the 1940 Mexican tables were used as the standard for the 1930–40 Brazilian life tables.

National Pattern versus Regional Pattern

Although we have some indirect evidence of the mortality patterns prevailing in Brazil as a whole during the period analysed, there is no information on regional variations. The national mortality pattern is a combination of the regional patterns, and the latter are not necessarily uniform. Coale and Demeny[21] in their analysis of life tables based on accurate data found that 'groups of geographically linked populations' exhibited similar mortality patterns. They also found that mortality patterns in a given population were often similar at different points in time. In this analysis it was shown that the Brazilian population probably experienced a change in the pattern of mortality during the quite short period of 20 years.

It is reasonable to suppose that the regional mortality patterns changed in the same direction, though at different rates, given the large regional inequalities. However, in the absence of relevant data, we used the national mortality pattern for the computation of the regional life tables.

Estimates of $_2q_0$ and $_3q_0$ for Males and Females

The $_xq_0$ estimates for Brazil and the regions refer to both sexes, since the sex of children ever born or surviving was not obtained in the censuses. To derive $_xq_0$ values for each sex separately from the combined values, two items of information are necessary: the sex ratio at birth and sex differences in mortality. The analysis of Brazilian mortality in the *UN Manual*, using the 1950 Brazilian Census, the sex ratio derived from 200,000 births registered in 1949–52 in the city of Rio de Janeiro (1·058), and the overall sex ratio of the Brazilian population (0·993), concluded that 'a sex difference in mortality at least as large as in the "West" model tables is needed to account for the masculinity of the Brazilian population'.[22]

To obtain estimates of $_2q_0$ and $_3q_0$ for separate sexes for Brazil and the regions, we assumed a sex ratio at birth of 1·05 and a sex difference in mortality as indicated by the WMLT.

Generation of Life Tables using Logit Transformation

The BMLT use logit transformations to generate individual life tables from a standard life table.[23] The basic equation is:

$$Y_{(x)} = \alpha + \beta Y_{s(x)}$$

where:

$Y_{(x)} = \text{logit } l_x/l_0$

[21] A. J. Coale and P. Demeny, *op. cit.*, in footnote 6, p. 12.
[22] United Nations, *op. cit.*, in footnote 2, p. 76.
[23] W. Brass *et al.*, *op. cit.*, in footnote 2, pp. 127–128; W. Brass, 'On the Scale of Mortality', in W. Brass (ed.), *Biological Aspects of Demography*, Taylor & Francis Ltd, London, 1971; N. Carrier and J. Hobcraft, *op. cit.*, in footnote 13.

TABLE 14. *Brazil and regions – estimates of expectation of life at birth*

Period	Amazônia	North	Northeast	Bahia	Minas	Rio	S. Paulo	Paraná	South	West	Brazil
1930–40	39·78	40·01	34·69	38·31	42·98	44·46	42·73	43·85	50·99	46·92	41·24
1940–50	42·67	43·73	34·03	39·16	46·05	48·65	49·42	45·94	55·31	49·78	43·56
1960–70	54·81	53·41	43·83	51·99	59·36	62·40	62·87	61·93	68·09	54·40	55·70

$Y_{s(x)}$ = logit l_x/l_0 in the standard life table
α and β are parameters. β determines the mortality pattern, and α the level of mortality. When β is kept constant and α varies, a family of one-parameter life tables is generated, all of them with the same mortality pattern.

In our study, we used as $Y_{s(x)}$ the logits of $l_x l_0$ from the Mexican life tables and as α the mean of the differences between the logits of our estimates of $(1-{}_2q_0)$ and $(1-{}_3q_0)$ and the logits of l_2/l_0 and l_3/l_0 from the Mexican life tables. We also assumed $\beta = 1{\cdot}0$ in each period.

Estimates of Expectation of Life at Birth

The life table estimates of l_x and ${}_nL_x$ by sex for Brazil and the ten regions for 1930–40, 1940–50 and 1960–70 are provided elsewhere.[24] As a summary of the results obtained, the e_0^o estimates for both sexes are presented in Table 14.

The e_0^o estimates for Brazil as a whole indicate an average increase of only 0·2 years per annum between 1930–40 and 1940–50. The estimates show a faster decline in mortality between 1940–50 and 1960–70, with an average increase in e_0^o of about 0·6 years per annum.

Regional Inequalities in Mortality

The most striking features of Table 14 are the wide regional differences in e_0^o. For 1960–70, there is a difference of 24·3 years between the estimates for the Northeast and the South. In the South the value of e_0^o is similar to that prevailing in Western European countries to-day, while in the Northeast it is close to the average for Brazil in 1940–50. It should be emphasized that the estimate for Brazil for this period is considerably influenced by the high mortality in the Northeast, the population of which constituted 19 per cent of the total population of the country at the 1950 Census.

TABLE 15. *Brazil – differences and ratios between regional and national estimates of* e_0^o

Region	Differences 1930–40	Differences 1940–50	Differences 1960–70	Ratios 1930–40	Ratios 1940–50	Ratios 1960–70
Amazônia	−1·46	−0·89	−0·89	0·96	0·98	0·98
North	−1·23	0·17	−2·29	0·97	1·00	0·96
Northeast	−6·55	−9·53	−11·87	0·84	0·78	0·79
Bahia	−2·93	−4·40	−3·71	0·93	0·90	0·93
Minas	1·74	2·49	3·66	1·04	1·06	1·07
Rio	3·22	5·09	6·70	1·08	1·12	1·12
S. Paulo	1·49	5·86	7·17	1·04	1·13	1·13
Paraná	2·61	2·83	6·23	1·06	1·05	1·15
South	9·75	11·75	12·39	1·24	1·27	1·22
West	5·68	6·22	−1·30	1·14	1·14	0·98

To show the trends in regional mortality in relation to national mortality, two measures are presented in Table 15: (1) the differences between the regional and the national e_0^o, and (2) the ratios between the two estimates. Among the poor regions (Amazônia, North, Northeast, Bahia and West), none improved its relative position between 1930–40 and 1960–70. In the Northeast the difference (negative) increased by 80 per cent and its relative position deteriorated by six per cent. The West had a surprisingly good position in 1930–40 and 1940–50, and fell below the national average in the last decade.

To provide an index of the convergence or divergence in regional mortality levels, a simple

[24] J. A. M. Carvalho, *op. cit.*, in footnote 1, pp. 176–187 and 194–199.

measure of dispersion is adopted. Weighted averages of the differences presented in Table 15 were taken, using as weights the regional populations in 1940, 1950 and 1970. The results are provided in Table 16. The increase in the index shows that the differences between the regional and national e_0^os increased over the decades.

These trends in regional mortality levels combined with those in regional fertility presented earlier, could provide one possible explanation for the change in mortality patterns assumed in this work. The five regions (Amazônia, North, Northeast, Bahia and West) with e_0^o lower than the national average in the last decade are also those with the highest fertility in the country, and we saw that between 1940–50 and 1960–70 all of them experienced constant or increasing fertility. The five regions with e_0^o above the national average experienced a decline in fertility, with the exception of Paraná. Childhood mortality in a country is an average of regional childhood mortality levels weighted by the number of births in the regions. Even if the mortality *pattern* remained constant in each region throughout the period, the combination of the different trends in mortality and fertility *levels* in the developed and underdeveloped regions is likely to have caused a change in the national mortality pattern, resulting in relatively high childhood mortality.

TABLE 16. *Brazil – weighted averages of the absolute values of the differences between regional and national estimates of expectation of life at birth*

1930–40	1940–50	1960–70
3·86	5·84	6·68

It is probable that such divergences also occurred between the socio-economic groups within each region. Analysing income distribution (from the 1960 Census) in three broad regions, Fishlow[25] says 'what does seem clear, . . . is the limited contribution of income variations among regions to the observed total inequality'. This means, that in spite of the considerable differences between regional incomes per head, the income distribution within each broad region was very similar to the income distributions in the other regions. Analysing the 1970 census results, but at the national level, he concluded that in spite of the rapid growth of the Brazilian economy since 1967, the income distribution had deteriorated between 1960 and 1970, with the result that the 'upper 3·2 per cent of the labour force commands 33·1 per cent of the income in 1970, compared to about 27 per cent in 1960'. It is very possible that within each of the ten regions a concentration of income occurred since the beginning of the industrialization process in the 1940s, causing the same divergent trends in fertility and mortality between the various socio-economic groups.

[25] A. Fishlow, 'On the Emerging Problems of Development Policy—Brazilian Size Distribution of Income', *American Economic Review*, **62,** May 1972.