Mortality, Income Distribution, and Rural–Urban Residence in Brazil

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Historically the transition from high to low mortality levels has been regarded as an integral part of broader transformations in economic and social organization. The specific factors associated with length of life are numerous and complex. They include such things as income, education, housing conditions, public health services, the control of communicable diseases, nutritional levels, medical facilities, and sanitation. Because mortality levels respond to the combined impact of all these factors, quantitative estimates of the influence of any one variable are difficult to obtain. Whether the long-run downward trend in mortality rates can be attributed primarily to improved living conditions, innovations in medical technology, or economic development is a long-standing controversy that is far from settled.[1] Notwithstanding the debate regarding the relative impact of these factors, mortality levels can serve as summary indicators of the general conditions of a population.[2]

In this study, estimates of life expectancy—the average number of years of life expected at birth—are used to reflect the mortality levels that characterize subgroups of the Brazilian population. Special tabulations of the 1970 census allow us to estimate life expectancy rates by region, rural or urban residence, and household income. The values provide quantitative indicators with which to determine the magnitude of the differences in quality of life that separate the rich from the poor in the cities and countryside for ten geographic subregions. These estimates are particu-

larly important in the case of Brazil, a nation characterized by extreme regional imbalances in socioeconomic development, an increasing concentration of income, and heavy rural-to-urban migration flows.

Method

The average number of years of life expected at birth (e^o) is one of the most frequently used measures of mortality. Because it is stated in years, it is an easily interpreted concept. It can also be used for comparative purposes since life expectancy rates are unaffected by the age composition of a population.

The life expectancy rates presented here are derived from the 1940, 1950, and 1970 censuses of Brazil. The techniques used to estimate values for the periods 1930–40 and 1940–50 have been described elsewhere.[3] The life expectancy rates for 1960–70, disaggregated by household income and place of residence, are derived from special tabulations of the 1970 census.[4] Using techniques developed by William Brass,[5] the proportion of children surviving among children ever born to women aged 20–24, 25–29, and 30–34, multiplied by the appropriate correction factor, yields estimates of the probability of dying by the exact ages of 2, 3, and 5. These values correspond to the ${}_xq_o$ life table function (in this case ${}_2q_o$, ${}_3q_o$, and ${}_5q_o$).[6] The Brass method is a simple transformation that allows estimates of the probability of death by age x from census data on the number of children ever born and the number of children surviving by age of mothers. To facilitate intergroup comparisons, the three survival probabilities can be converted into a summary measure of mortality. For this purpose the ${}_2q_o$, ${}_3q_o$, and ${}_5q_o$ life table values have been converted to life expectancy rates, using the 1960 life table for Mexico as a model.[7] The findings presented here, therefore, refer to the average number of years of life expected at birth (the e^o life table value).[8]

Regional Trends

Since the 1930s the average life expectancy in Brazil increased by nearly 30 percent. As shown in Table 1, however, the rate of improvement varied considerably by geographic region.[9] The highest percent increases were recorded in Sao Paulo, Amazonia, and Bahia, whereas those regions that already had high life expectancy rates in the 1930s (South and Central-West) experienced smaller increases over the last four decades.

These trends have influenced interregional differences in life expectancy rates over time. To provide a summary measure of regional diversity, we use a weighted index of dispersion.[10] The index values

Table 1
Life Expectancy at Birth, by Region, 1930–40 to 1960–70

Region[a]	1930–40[b]	1940–50[b]	1960–70[c]	Percent Increase
Amazonia	39.8	42.7	54.2	36.2
North	40.0	43.7	50.4	26.0
Northeast	34.7	34.0	44.2	27.4
Bahia	38.3	39.2	49.7	29.8
Minas	43.0	46.1	55.4	28.8
Rio	44.5	48.7	57.0	28.1
Sao Paulo	42.7	49.4	58.2	36.3
Parana	43.9	45.9	56.6	28.9
South	51.0	55.3	61.9	21.4
Central-West	46.9	49.8	57.5	22.6
Brazil	41.2	43.6	53.4	29.6
Range	16.3	21.3	17.7	
Index of dispersion	3.86	5.84	4.88	

NOTE: Estimates for the period 1950–60 are not available because the 1960 census was not published in its entirety.

SOURCES: [a] See note 9 for the states and territories included in each region.
[b] Carvalho (1973), cited in note 3.
[c] Estimates based on special tabulations of the 1970 census.

presented at the bottom of Table 1 indicate that regional differences in life expectancy rates followed a curvilinear pattern. From 1930–40 to 1940–50 the index increased from 3.9 to 5.8, then dropped to 4.9 in the 1960s. This reduction in the geographic differences in life expectancy rates in Brazil has accompanied a similar trend in other key socioeconomic variables. Between 1950 and 1970 there has been a decline in interregional differences in urbanization, adult literacy, income per capita, and the proportion of children in school.[11]

Despite the recent trend toward convergence, geographic disparities remain pronounced. During 1960–70 the average life expectancy in the South (61.9 years) exceeded that in the Northeast by nearly 18 years. The low life expectancy of 44.2 years in the Northeast is among the lowest in the world. It is only slightly higher than recent estimates for Africa[12] and represents a mortality level comparable to that in Europe in the 1870s.[13]

Household Income

Within each of the ten geographic areas, the chances of staying alive are strongly influenced by the level of household income. In an extensive

collection of international studies on the relationship between social class, life expectancy, and overall mortality, Antonovsky comes to the unsurprising conclusion that the poor have consistently higher probabilities of dying at an earlier age than the more privileged groups.[14] Despite the multiplicity of methods and indexes used in the many studies he cites, and despite the varied populations surveyed, this conclusion is supported almost without exception. Furthermore, the evidence suggests that as the overall death rate of a population is lowered, class differences may decline.[15]

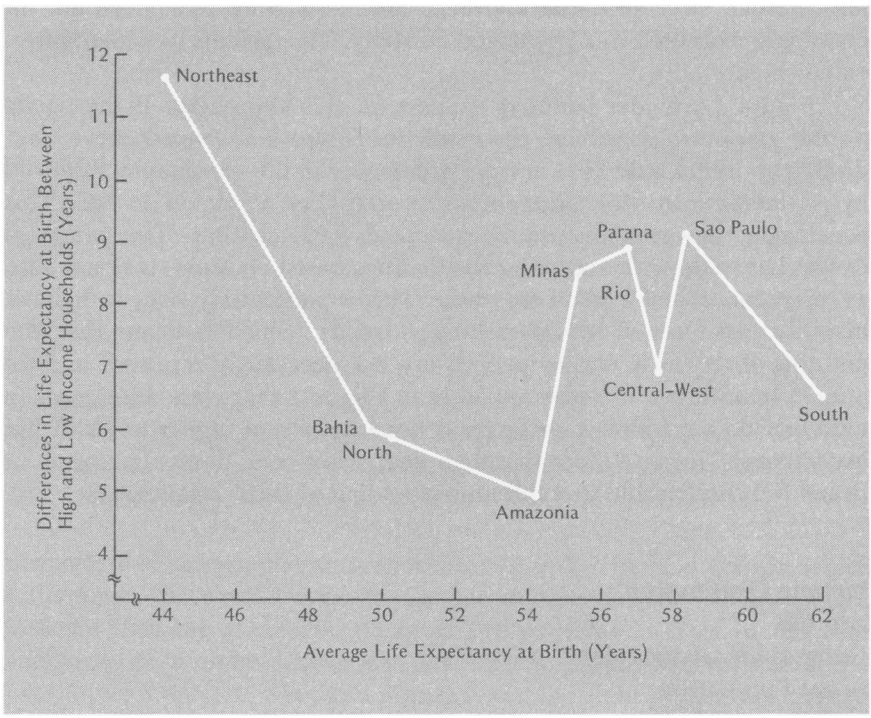
Estimates of life expectancy by four categories of monthly household income for each of the ten regions in Brazil are presented in Table 2. These findings indicate an increase in life expectancy with increases in income. For Brazil as a whole, families with the highest income enjoy a life expectancy of 62 years. This represents an average length of life that is more than 12 years longer than that in the lowest household income category.

These life expectancy differentials vary considerably by region. Comparing the lowest with the highest income groups within each region (Table 2, column 5), the gap is largest in the Northeast (11.6 years) and smallest in Amazonia (4.8 years). Between these two extremes the differences in the other eight regions average 7.4 years, and vary within a range of five to about nine years. This variation, moreover, is not linearly related to the level of life expectancy across regions. In other words, where life expectancy rates are on the order of 50 years (Bahia), there is a difference of six years between the lowest and highest income groups. This difference is approximately the same in some areas where life expectancy is much higher. In the South, for example, life expectancy is 61.9 years, but the difference between households in the lowest and highest income categories (6.4 years) is about the same as that found in Bahia.

The relationship between class differences in mortality and the level of life expectancy by region can be more clearly seen in Figure 1. According to Antonovsky's hypothesis, one would expect a downward-sloping curve: as life expectancy increases, class differences should diminish. This pattern is confirmed in the first four regions with the lowest levels of life expectancy. As the overall rate increases from 44.2 years in the Northeast to 54.2 years in Amazonia, the number of years separating low- and high-income families steadily declines. However, in the remaining six regions with higher levels of life expectancy, class differences become more erratic and show a tendency to increase.

If we interpret these cross-sectional findings from a longitudinal perspective, the pattern suggests that class differences in life expectancy may diminish as mortality is reduced from very high to moderately high levels, but that this trend may be reversed as mortality continues to fall. A plausible explanation is related to changes in the factors associated with

Figure 1
Differences in Life Expectancy at Birth Between High and Low Income Households by Level of Regional Life Expectancy



mortality reduction. According to Bourgeois-Pichat's graphic analogy, mortality is composed of causes of death that differ in their resistance to control as strata of a rock formation differ in their resistance to erosion.[16] The strata of "soft" causes due to infectious and parasitic diseases are eliminated first. But as mortality continues to decline, its structure "hardens" as less tractable causes of death assume proportionately greater importance.

It is generally believed that the initial decline in the mortality levels of developing countries that took place primarily after World War II was achieved by the importation of relatively inexpensive, community-oriented public health measures.[17] These factors, which sharply lowered overall mortality levels, may have disproportionately favored low-income groups, thus tending to reduce class differentials. Once the impact of these "exogenous" factors has run its course, however, additional gains in life expectancy become increasingly associated with individual purchasing power. As infectious and parasitic diseases are controlled at the community level, further reductions in mortality depend on access to specialized, hospital-

based medicine, the limitation of delay in seeking treatment, and access to individual-oriented curative medicine. In the absence of an effective and equitable state-supported health service system, this type of medical care is restricted to those who can afford to pay for such services. This implies that, after an initial mortality decline, further reductions are increasingly restricted to a privileged minority. The effect is to widen differentials in mortality.

Figure 1 provides tentative support for this hypothesis. If the points on the graph are smoothed, the result resembles a U-shaped curve, suggesting an initial reduction in class differences in life expectancy followed by an increase in such differentials as mortality continues to fall. This conclusion, however, should be accepted with caution. The principal caveat has to do with accepting the findings based on cross-sectional data as representative of a trend over time. This is particularly risky in light of historical analyses of world mortality trends, which indicate that the patterns observed in earlier periods are not necessarily repeated in later ones.[18] In addition, it is also apparent in Figure 1 that class differences in mortality do not follow a perfectly defined pattern at higher levels of life expectancy. Clearly a more thorough analysis of each particular region in Brazil is indispensable to a full understanding of these relationships.

Income Distribution and the Geographic Distribution of the Population

The mortality rate of a population as a whole is a weighted average of the mortality rates of the subgroups within it, the weights being the relative size of each subgroup. Therefore, the overall mortality rate is sensitive to a skewed distribution of income to the extent that the high mortality rates of the poor receive a greater weight because of the large population concentrated in low-income categories. The mortality rate for the population as a whole is also sensitive to the geographic distribution of the population to the extent that a large proportion of people are concentrated in high mortality areas.

These effects can be demonstrated by a few simple calculations. To illustrate the impact of income distribution, take the Northeast as an example. If the population in this region were equally distributed among the four categories of family income presented in Table 2, the life expectancy rate for the Northeast would be the arithmetic mean of the four subgroups—or 48.4 years—since each family income group would receive an equal weight. Actual life expectancy, however, is 44.2 years, considerably below the arithmetic mean. It is lower because a larger

Table 2
Regional Life Expectancy at Birth, by Monthly Household Income, 1970

Region	Overall Average	Household Income (in Cr$) 1–150 (1)	151–300 (2)	301–500 (3)	501+ (4)	Difference between Highest and Lowest Income (5)
Amazonia	54.2	53.4	53.9	54.8	58.2	4.8
North	50.4	50.0	50.8	52.7	55.7	5.7
Northeast	44.2	42.8	46.1	50.3	54.4	11.6
Bahia	49.7	48.9	50.3	51.9	54.9	6.0
Minas	55.4	53.8	55.4	55.6	62.3	8.5
Rio	57.0	54.1	54.8	57.6	62.1	8.0
Sao Paulo	58.2	54.7	56.1	58.7	63.9	9.2
Parana	56.6	54.8	56.5	59.3	63.7	8.9
South	61.9	60.5	61.2	63.4	66.9	6.4
Central-West	57.5	56.5	57.1	58.2	63.3	6.8
Brazil	53.4	49.9	54.5	57.6	62.0	12.1

proportion of the population is concentrated in low-income groups, which pulls down the overall average. Similar calculations for all ten regions indicate that the arithmetic mean of life expectancy rates in the four categories of household income is consistently higher than the actual life expectancy rate (the weighted average) for the total population in each region.

The same principle applies to the spatial distribution of the population. In this case, we turn our attention from the rows to the columns in Table 2. For example, the arithmetic mean of life expectancy rates for families with monthly incomes between Cr$1 and Cr$150 (column 1) is 53.0 years, higher than the actual weighted mean of 49.9 years for the total population in that income bracket. In other words, among low-income families the aggregate life expectancy rate for the country is reduced because more families are concentrated in high mortality areas.

The impact of the regional distribution of the population can also work in the opposite direction. For example, within the highest class of household income, a greater proportion of families is concentrated in the more developed areas of the country characterized by higher life expectancy rates. Thus, the actual weighted mean of 62.0 years is higher than the arithmetic mean of 60.5 years.

The overall level of life expectancy in Brazil is thus influenced by both the distribution of household income (row effects) and the spatial distribution of the population (column effects). It is the combined effect

of these two factors that explains an otherwise puzzling feature of Table 2: the difference of 12.1 years in life expectancy at birth between the lowest and the highest category of household income for Brazil as a whole is greater than a comparable difference found in any of the ten geographic regions (column 5).

Place of Residence

Observing the congested and unsanitary conditions characteristic of the cities of his day, Max Weber held that death rates varied directly with the degree of agglomeration of population.[19] Historical analyses of mortality rates prior to the twentieth century support the conclusion that death rates were generally higher in urban than in rural areas. In the United States in 1830, conditions were far worse in the large cities than in smaller ones or in rural areas. Similarly, the average life expectancy for England and Wales in 1841 is estimated to have been about 40 years, but the corresponding figures for the industrial cities of Manchester and Liverpool were about 24–25 years.[20]

The decline in mortality rates in developed countries, however, led to a progressive narrowing of the rural–urban differential. Recent estimates show less than a half-year's difference in life expectancy at birth between urban and rural residents in the United States and in a number of European countries.[21]

In contrast to the industrialized nations, the limited information available for developing countries indicates that cities may have an advantage over the rural hinterland. The dangers of urban life are apparently offset by the importation of new methods of reducing mortality and by the concentration in cities of medical facilities and public health services. According to Kingsley Davis, "cities in developing countries have been outposts of the advanced nations."[22] Since they were the first to benefit from technological and medical advances accomplished abroad, their mortality rates dropped below those of rural areas.[23]

Estimates of life expectancy by place of residence in Brazil are given in Table 3. To facilitate comparison, the ratio of urban to rural rates is presented in the right-hand column. In six regions rural life expectancy slightly exceeds urban rates (ratio less than 1), but the reverse is true (ratio greater than 1) in the four remaining geographic areas. Whether the ratio is greater or less than unity is also unrelated to the level of life expectancy. That the mortality differentials between rural and urban areas are minimal and follow no apparent pattern may be due to problems related to the categories used by the census bureau. The official definition of urban areas is seriously flawed because it defines as urban all political-administrative centers of *municipios* (roughly equivalent to counties in the

Table 3
Regional Life Expectancy at Birth, by Rural–Urban Residence, 1970

Region	Overall Average	Rural	Urban	Urban–Rural Ratio
Amazonia	54.2	53.7	54.9	1.02
North	50.4	50.8	49.2	0.97
Northeast	44.2	44.6	43.8	0.98
Bahia	49.7	50.7	48.2	0.95
Minas	55.4	55.9	54.7	0.98
Rio	57.0	56.6	57.1	1.01
Sao Paulo	58.2	57.1	58.5	1.02
Parana	56.6	56.4	57.0	1.01
South	61.9	63.0	60.9	0.97
Central-West	57.5	57.7	57.2	0.99
Brazil	53.4	52.9	53.9	1.02

United States) and *distritos* (subdivisions of *municipios*). Many of these localities contain fewer than 1,000 people and are hardly characterized by those features conventionally defined as urban.

Nevertheless, systematic differences between rural and urban areas do emerge when the aggregate mortality rates for each region are disaggregated by four categories of household income, as shown in Table 4. The ratio of urban to rural rates in the last column of Table 4 indicates a clear pattern. Urban life expectancy is below that of rural areas for low-income households, but the reverse is true for families in the highest income class. Thus, city dwellers have a higher probability of a longer life provided they have greater economic resources. This pattern holds true in all ten geographic areas, although there is variation in the "threshold point," or the income category in which urban rates first exceed rural ones.[24]

Despite the remarkable consistency of these findings, several factors should be kept in mind. It is important to note that the census only includes data on monetary income. As a result, the income categories used in this analysis may not permit accurate urban–rural comparisons. Households in the countryside undoubtedly have higher levels of real income compared to those in cities because they are more likely to produce goods for their own consumption. Similarly, city dwellers may have lower real incomes because they face higher prices in urban areas and because they are more likely to need a broader range of services. Because they live in areas of high population density, urban residents may require water and sewage facilities and have a greater demand for medical services. They also face higher costs to the extent that they must pay for rent, transportation, and other necessities associated with city life. The higher levels of

Table 4
Regional Life Expectancy at Birth, by Household Income and Place of Residence, 1970

Region	Household Income[a]	Overall Average	Rural	Urban	Urban–Rural Ratio
Amazonia	1	53.4	53.8	52.6	0.98
	2	53.9	53.6	54.3	1.01
	3	54.8	53.2	55.8	1.05
	4	58.2	54.5	59.3	1.09
North	1	50.0	50.7	47.0	0.93
	2	50.8	51.2	50.2	0.98
	3	52.7	51.9	53.3	1.03
	4	55.7	49.8	57.7	1.16
Northeast	1	43.8	44.3	40.0	0.90
	2	46.1	46.6	45.9	0.98
	3	50.3	48.2	50.8	1.05
	4	54.4	53.4	54.4	1.02
Bahia	1	48.9	50.4	45.1	0.89
	2	50.3	52.4	48.8	0.93
	3	51.9	52.3	51.8	0.99
	4	54.9	52.6	55.3	1.05
Minas	1	53.8	55.3	49.6	0.90
	2	55.4	57.2	54.5	0.95
	3	58.6	59.2	58.4	0.99
	4	62.3	61.9	62.4	1.01
Rio	1	54.1	56.8	51.2	0.90
	2	54.8	55.9	54.6	0.98
	3	57.6	56.9	57.6	1.01
	4	62.1	61.1	62.1	1.02
Sao Paulo	1	54.7	56.4	51.9	0.92
	2	56.1	57.5	55.7	0.97
	3	58.7	58.3	58.8	1.08
	4	63.9	61.4	64.0	1.04
Parana	1	54.8	55.3	51.2	0.93
	2	56.5	57.1	55.5	0.97
	3	59.3	60.0	59.0	0.98
	4	63.7	62.3	64.1	1.03
South	1	60.5	62.0	54.6	0.88
	2	61.2	63.4	59.3	0.94
	3	63.4	65.2	62.6	0.96
	4	66.9	66.2	67.1	1.01
Central-West	1	56.5	57.1	54.8	0.96
	2	57.1	58.7	55.6	0.95
	3	58.2	57.6	58.5	1.02
	4	63.3	62.5	63.4	1.01
Brazil	1	49.9	51.4	46.0	0.89
	2	54.5	55.9	53.7	0.96
	3	57.6	57.6	57.6	1.00
	4	62.0	60.0	62.2	1.04

[a] Categories of household income conform to those used in cols. 1–4, Table 2.

life expectancy among the poorest rural households may therefore be due to higher levels of real income compared with urban families in the same category of monetary income.

However, focusing on the highest income group (where the contribution to real income from home production is proportionately less), one cannot reject the hypothesis that urban areas may have an advantage over rural ones because of the greater concentration of medical facilities and better living conditions. The critical question is whether one can afford access to these benefits. The fact that life expectancy rates for upper-income families are higher in urban areas suggests that cities may indeed be a better place to live, but only for those who can pay for adequate protection against the hardships that otherwise beset those with fewer financial resources. From this standpoint, it is not surprising that the lowest and the highest life expectancy rates are found in urban settings. The poorest urban families in the Northeast have a life expectancy of 40.0 years, which is over 25 years lower than that found for the highest income group in the South (67.1).

Conclusion

Current trends in Brazilian socioeconomic development have a bearing on the mortality differentials presented in this study. Of particular importance are changes in the size distribution of household income during the recent period of economic growth. While a skewed income profile is hardly a new feature of the Brazilian economy,[25] analyses of 1960 and 1970 census data reveal a significant increase in the concentration of income during the decade. Comparing the preliminary tabulations of the 1970 census with the more or less comparable data for 1960, Duarte found that the share of total income in the richest 5 percent of the population increased from 27.3 to 36.2 percent, while the participation of the poorest 40 percent fell from 11.2 to 9.1 percent.[26] A more detailed analysis using individual records of the 1970 census concluded that the increase in inequality was due to small gains in real income made by those close to the minimum wage while the real income of the top 10 percent of the population increased by 66.9 percent.[27] Although estimates of the degree of change vary according to method and data, a number of studies conclude that the Gini coefficient for Brazil, already among the highest in Latin America in 1960, rose substantially in the following decade.[28]

The increase in the concentration of income, concomitant with high annual growth rates in the GNP, reflects the unequal impact of recent Brazilian development. The mortality rate for Brazil and the mortality differentials within the country are influenced by this trend in several ways. The level of life expectancy for the country as a whole will be

depressed to the extent that a large proportion of the population remains in low-income, high-risk circumstances. Moreover, there is likely to be a further widening in class differences in mortality should the benefits of economic growth continue to accrue disproportionately to a small elite.

As mortality rates are lowered by the application of indirect technologies for reducing mortality, additional declines are more difficult to achieve. As discussed earlier, once the "soft" strata of causes of death have been reduced, further gains increasingly depend on individual purchasing power, for income is a major determinant of life chances through a complex set of interrelationships. Low income tends to exclude the poor from access to medical facilities, reduce investments in sanitary modifications of the environment, deplete reserves or surpluses that could serve as a buffer in times of epidemics or emergencies, relegate families to substandard housing in high-risk areas, and reduce diet quality and quantity.[29]

Infant mortality rates are particularly sensitive to changes in real income. Although vital statistics and cost of living indexes over time are lacking for most Brazilian cities, the data for Sao Paulo indicate a 48 percent rise in infant mortality rates during 1960–70, and a 68 percent increase in Belo Horizonte during the period 1966–74. In both cases the upsurge in deaths of children under age one is highly correlated with declines in the real minimum wage.[30]

The reduction in the purchasing power of the official minimum salary was the result of government policies designed to control inflation and stimulate economic growth. Among the measures adopted by the post-1964 regime was the deliberate strategy of allowing pay increases to lag behind rises in the cost of living, which resulted in a substantial decline in the real minimum wage during the period.[31] Since nearly a quarter of the labor force in Sao Paulo and almost a third in Belo Horizonte earned the minimum salary or less in 1969, the proportion of people affected is large.[32] Since infant mortality rates reflect deficiencies in basic requirements, the increase in infant deaths indicates a deterioration in the absolute standard of living for low-income groups in these two cities.

This discussion has emphasized the relationship between mortality, development policies, and patterns of economic growth. The estimates of life expectancy at birth presented in this study serve as quantitative indicators of socioeconomic differences by region, social class, and urban or rural residence in Brazil. The wide differentials among the ten geographic areas and the gap that separates rich and poor households pose a major challenge to the future of Brazilian development. If we accept Berg's assumption that "the quality of human existence is the ultimate measure of development,"[33] then the possibility that these differentials may increase should current trends continue calls for a fundamental change in policy priorities.

Notes

This study is part of a larger project entitled "Análise econômico e social das tendências de mortalidade no Brasil," being carried out by CEDEPLAR in Belo Horizonte, Brazil. The research is supported by the II Plano Nacional de Pesquisas Econômicas (II PNPE), coordinated by INPES/IPEA. An earlier draft of this paper entitled "Renda e a concentração da mortalidade no Brasil" was published in *Estudos Econômicos* 7, no. 1 (1977): 107–130. The revised and considerably expanded version presented here benefited from helpful comments by Manoel Costa, Juan Carlos Lerda, Diana Sawyer, Morvan de Mello Moreira, Donald Sawyer, and Pamela Richards.

1. See S. H. Preston, "The changing relation between mortality and level of economic development," *Population Studies* 29 (July 1975): 231–248; T. McKeown, *Medicine in Modern Society* (London: Allen and Unwin, 1965); McKeown, *The Modern Rise of Population* (London: Edward Arnold, 1976); H. Frederiksen, "Malaria control and population pressure in Ceylon," *Public Health Reports* 75 (October 1960): 865–868; Frederiksen, "Determinants and consequences of mortality trends in Ceylon," *Public Health Reports* 76 (August 1961): 659–663; and United Nations, *The Determinants and Consequences of Population Trends* (New York: United Nations, Department of Economic and Social Affairs, 1973).

2. It is widely held that mortality rates have become increasingly dissociated from economic levels. This is attributed to the diffusion of medical and health technologies that has lowered death rates independently of significant economic progress. See K. Davis, "The amazing decline of mortality in underdeveloped areas," *The American Economic Review* 46 (1956): 305–318; and G. Stolnitz, "Recent mortality trends in Latin America, Asia and Africa: Review and re-interpretation," *Population Studies* 19 (1965): 117–138. The impact of these "exogenous" factors has been estimated to account for approximately 84 percent of the growth in life expectancy for the world as a whole between the 1930s and the 1960s (see Preston, cited in note 1). But as Preston (p. 240) argues, despite the fact that the relationship between mortality and national income has shifted upward, at a certain point in time mortality may have become more responsive to income in low-income countries. In any event, the preceding considerations focus on the relationship between income per capita and aggregate mortality rates and seek to explain patterns of association across countries. In this study we use life expectancy rates to reflect overall living conditions of the population of Brazil. As social indicators they are sensitive to differential access of subgroups of the population to income (as it influences mortality "endogenously" through such factors as housing, nutrition, etc.) and to the benefits of technological transfers.

3. See José Alberto Magno de Carvalho, "Analysis of regional trends in fertility, mortality, and migration in Brazil, 1940–1970" (unpublished dissertation, London School of Economics, 1973); and "Regional trends in fertility and mortality in Brazil," *Population Studies* 28, no. 3 (1974): 401–421.

4. Because the special tabulations of the 1970 census data are disaggregated by household income, individuals who reported no monetary income or who did not declare themselves members of a household were excluded. As a result, the estimates of life expectancy for the period 1960–70 presented here differ somewhat from other findings based on published census data (e.g., Carvalho, "Regional trends," cited in note 3).

5. William Brass et al., *The Demography of Tropical Africa* (Princeton, N.J.: Princeton University Press, 1968).

6. Under ideal conditions seven x^qo values can be estimated using the Brass method. Of these only three (2^qo, 3^qo and

$5q_0$) are used in this analysis. The probability of dying by age one ($1q_0$) is excluded since it is especially sensitive to peculiarities or defects in the data. See United Nations, *Manual IV: Methods of Estimating Basic Demographic Measures from Incomplete Data.* ST/SOA/Series A/42 (New York: United Nations, 1967), pp. 35–36. Estimates of survivorship beyond the fifth birthday (above $5q_0$) are also unreliable. They are based on the memory of remote events by older women (aged 35–49), and the values are not representative of current mortality levels under conditions of falling death rates. On the other hand, the probability of survival to ages two, three, and five can be accepted as minimum indicators of the levels of recent child mortality. They are more accurate and more closely reflect the mortality levels during the 1960–70 period since they are based on information about children born largely during the decade prior to the census.

7. The process of converting xq_0 values into estimates of life expectancy at birth (e^0) is hampered by the lack of reliable vital registration statistics. If such data were available, and if the mortality patterns prevailing in Brazil and its ten subregions were known, it would be possible to generate life tables compatible with the level of mortality indicated by the xq_0 estimates. In the absence of this information, the 1960 life table for Mexico is used (E. E. Arriaga, *New Life Tables for Latin American Populations in the Nineteenth and Twentieth Centuries* [Berkeley, Calif.: University of California Press, 1968], pp. 206–207) since other analyses indicate that the mortality pattern of Mexico is similar to that of Brazil (Carvalho, "Analysis of regional trends," cited in note 3). Having selected this pattern, we estimate the level of mortality by converting the xq_0 values to life expectancy rates by logit transformation using the Mexican life table as a model (Brass et al., cited in note 5, pp. 127–135; and Carvalho, "Analysis of regional trends," cited in note 3, pp. 92–93).

While the assumptions and the limitations of the Brass method are discussed elsewhere (Brass et al., cited in note 5; Carvalho, "Analysis of regional trends," cited in note 3; and H. S. Shryock and J. S. Siegal and Associates, *The Methods and Materials of Demography* [Washington, D.C.: US Government Printing Office, 1971]), several additional comments are in order here. By using the 1960 Mexican life table to estimate life expectancy rates, it is assumed that the Mexican pattern of mortality approximates that of the total Brazilian population (as demonstrated by Carvalho, "Analysis of regional trends," cited in note 3) and that of its various subgroups. The latter assumption is warranted in light of the remarkable stability of mortality patterns found among groups of geographically linked populations (A. J. Coale and P. Demeny, *Regional Model Life Tables and Stable Populations* [Princeton, N.J.: Princeton University Press, 1967]). But even if the Mexican pattern departs from the Brazilian one, this would not totally invalidate our findings since the primary focus is upon relative differences between groups rather than on absolute levels of mortality.

8. When mortality estimates are disaggregated by income groups, a few caveats are necessary. Consider, for example, estimates of the probability of death before age two ($2q_0$) for children in households of income i. This refers to the mortality of children born to women 20–24 years of age who in 1970 were recorded to be in families with i income, although, because of the nature of the method (Brass et al., cited in note 5, p. 119), the $2q_0$ value represents the mortality experience over a retrospective period of five to six years prior to the census enumeration. Since survival rates are correlated with income, these estimates will be distorted to the extent that mobility occurs. To minimize this bias and to provide sufficient cases to generate stable estimates, only four broad categories of family income are used. The life expectancy rates by family income presented

here should be interpreted with the following in mind: the estimates represent the average life expectancy at birth for the period 1960–70 that corresponds to the mortality experience of children born to women who were 20–34 years of age in 1970 and who were found within households of a given monetary income in that year.

9. The ten geographic units of analysis are those used by the 1970 Brazilian census. The states and federal territories included in each region are given in parentheses following the labels used in this study: Amazonia (Acre, Amazonas, Para, Roraima, Rondonia Amapa); North (Maranhao, Piaui); Northeast (Ceara, Rio Grande do Norte, Paraiba, Pernambuco, Alagoas, Fernando Noronha); Bahia (Sergipe, Bahia); Minas (Minas Cerais, Espirito Santo); Rio (Rio de Janeiro, Cuanabara); Sao Paulo (Sao Paulo); Parana (Parana); South (Rio Grande do Sul, Santa Catarina); and Central-West (Goias, Mato Grosso, Brasilia).

10. The index of dispersion $= \Sigma \mid x_i - x_B \mid \cdot P_i / \Sigma P_i$ where x_i is the average life expectancy at birth for region i; x_B is the average life expectancy for Brazil, and P_i is the population in region i.

11. Thomas Merrick, "Interregional differences in fertility in Brazil, 1950–1970," *Demography* 11 (August 1974): Table 4.

12. United Nations, cited in note 1, p. 110.

13. United Nations, cited in note 1, p. 111.

14. A. Antonovsky, "Social class, life expectancy and overall mortality," *The Milbank Memorial Fund Quarterly* 45 (April 1967): 66.

15. Antonovsky, cited in note 14, p. 68.

16. United Nations, cited in note 1, pp. 26–27.

17. Davis, cited in note 2.

18. Preston, cited in note 1; Stolnitz, cited in note 2; Stolnitz, "International mortality trends: Some main facts and implications," *The Population Debate: Dimension and Perspectives*, Vol. 1 (New York: United Nations, Department of Economic and Social Affairs, 1975), pp. 220–236; and Davis, cited in note 2.

19. United Nations, cited in note 1.

20. United Nations, cited in note 1.

21. United Nations, cited in note 1.

22. K. Davis, "Cities and mortality," in *International Population Conference*, Vol. 3 (Liege, Belgium: International Union for the Scientific Study of Population, 1973), p. 276.

23. Davis, cited in note 22, pp. 276–277.

24. That life expectancy rates in the highest income bracket are higher in urban than in rural areas could be attributed to the distribution of income in the open-ended category. Since wealthier families are likely to be concentrated in cities, the effect would be to increase life expectancy rates in urban areas for reasons unrelated to place of residence. However, estimates of life expectancy for more detailed categories of household income (Cr$501–Cr$1,000; Cr$1,001–Cr$1,500; Cr$1,501–Cr$2,000; and Cr$2,000+) indicate that the pattern of higher urban rates persists. These findings are not presented because many of the estimates are unstable due to the small number of cases in some regions.

25. W. R. Cline, *Potential Effects of Income Distribution on Economic Growth: Latin American Cases* (New York: Praeger, 1972).

26. J. C. Duarte, *Aspectos da Distribuição da Renda no Brasil em 1970* (Piracicaba, Sao Paulo: Universidade de Sao Paulo, 1971), p. 42.

27. Carlos G. Langoni, *Distribuição da Renda e Desenvolvimento Econômico no Brasil* (Rio de Janeiro: Editora Expressão e Cultura, 1973), p. 64.

28. A. Fishlow, "Some reflections on post-1964 Brazilian economic policy," in *Authoritarian Brazil*, ed. A. Stepan (New Haven: Yale University Press, 1973), pp. 69–118; Langoni, cited in note 27; Duarte, cited in note 26; and R. Hoffman and J. C. Duarte, "A distribuição da renda no Brasil," *Revista de Administração de Empresas* 14 (1972): 46–66.

29. J. Craviotto and E. R. De Licardie, "The effect of malnutrition on the individual," in *Nutrition, National Development and Planning*, ed. Alan Berg, N. S. Scrimshaw, and D. Call (Cambridge, Mass.: MIT Press, 1971); and Alan Berg, *The Nutrition Factor: Its Role in National Development* (Washington, D.C.: The Brookings Institution, 1973).

30. E. L. Bacha, "Issues and evidence on recent Brazilian economic growth," Discussion Paper No. 12 (Cambridge, Mass.: Harvard Institute for International Development, 1976; W. Leser, "Crescimento da população e nivel de saúde no cidade de São Paulo," *Problemas Brasileiros* 16 (October 1974): 17–36; E. M. Suplicy, "Alguns aspectos da política salarial,"*Revista de Administração de Empresas* 14 (September/October 1974): 32–45; and Charles H. Wood, "Infant mortality trends and capitalist development in Brazil: The case of Sao Paulo and Belo Horizonte," *Latin American Perspectives* 15 (Fall 1977): 56–65.

31. Departamento Intersindical de Estatística e Estudos Sócio-Econômicos (DIESSE), *Família Assalariada: Padrão e Custo de Vida* (Sao Paulo: DIESSE, 1974); and *10 Anos de Política Salarial* (Sao Paulo: DIESSE, 1975).

32. George Martine and J. C. P. Peliano, *Os Migrantes nos Mercados de Trabalho Metropolitanos*. Brasília: Projecto de Planejamento de Recursos Humanos, Relatorio Técnico Numero 32.

33. Berg, *The Nutrition Factor*, cited in note 29, p. 5.