RAND

Trends in Socioeconomic Inequalities in Under-Five Mortality: Evidence from Sao Paulo, Brazil, 1970-1991

Narayan Sastry

DRU-2934-NICHD

December 2002

RAND Labor and Population Program
Working Paper Series 02-15

**Trends in Socioeconomic Inequalities in Under-Five Mortality:
Evidence from São Paulo, Brazil, 1970-1991**

December 2002

Narayan Sastry

Social Scientist

RAND
1700 Main Street, P.O. Box 2138
Santa Monica, CA 90407-2138
sastry@rand.org

I gratefully acknowledge research assistance from Gabriela Lopez and Stephanie Williamson and financial support from the National Institutes of Health through grants HD36695 and HD38556.

Abstract. In this paper I examine the effects of social and economic development on inequalities in under-five mortality for the state of São Paulo, Brazil, over a twenty-one year period during which much of the infant and child mortality transition unfolded. I investigate whether the improvements in infant and child survival were accompanied by declining inequalities. I focus on inequality in under-five mortality by household wealth and by mother's education and use microdata from Brazilian censuses conducted in 1970, 1980, and 1991. I find that inequality according to household wealth underwent a clear decline over the study period. Inequality according to mother's education first declined and then increased, with a net rise over the study period. When I control for background demographic and socioeconomic characteristics, inequalities in under-five mortality according to household wealth remained roughly constant. On the other hand, inequality according to mother's education increased substantially.

1. Introduction

In the past few years, there has been growing policy and research interest in health inequalities and the health of the poor in less developed countries (Gwatkin, 2000). Reducing socioeconomic inequalities in health and improving the health of the poor have become central goals of the World Bank, the World Health Organization, other international organizations, and major donors of development assistance (Wagstaff, 2000). Yet progress towards these goals may have been stymied by an important research gap in documenting and understanding *trends* in socioeconomic differentials in infant and child mortality in less developed countries. There are few studies that have described trends in socioeconomic differentials in infant and child mortality in less developed countries and even fewer that have sought to explain them. Very little is known about how socioeconomic differentials have changed over time, as the development processes unfolded and levels of urbanization rose, women's educational attainment improved, infrastructure spread, and income and wealth increased.[1] Braveman and Tarimo (2002: 1622) noted that "relatively little information is routinely available on health

[1] Cleland, Bicego, and Fegan (1992) found that disparities in child survival by socioeconomic status and maternal education did not narrow between the 1970s and 1980s across a dozen developing countries. Wagstaff (2001) assembled and reanalyzed results from a number of studies to show that inequality in under-five mortality increased in Bolivia between 1994 and 1998, in Vietnam between 1993 and 1998 (Wagstaff and Nguyen, 2001), and in Uganda between 1988 and 1995 (Stecklov, Bommier, and Boerma, 1999). A study by Victora et al (2000), discussed below in more detail, found no changes in inequality in child health and infant mortality in two areas of Brazil between the late 1980s and early 1990s. A larger number of studies have shed some light on changes in differentials over time by examining differences in covariate effects over time. For example, DaVanzo and Habicht (1986) found that the effects of mother's education on child survival increased over time in Malaysia while Merrick (1985) found that in urban Brazil between 1970 and 1976 the effects on child survival of mother's education decreased but those of father's education increased.

status or health care disparities between better- and worse-off groups *within* most countries, and particularly on how within-country social disparities may change over time" (emphasis in original). In contrast, there has been a considerable amount of research that has documented trends in poverty and income inequality over time and has analyzed the factors underlying these trends—both in Brazil and in other parts of the developing world (e.g., Lam and Levinson, 1991; Psacharopoulos et al., 1995).

Research on health inequalities in less developed countries has, until recently, focused on categorical indicators of status, such as region, rural-urban place of residence, mother's education, sex, and race or ethnicity. In Brazil, attention has focused primarily on rural-urban and regional differentials in mortality, particularly between the poor and underdeveloped Northeast region and the rest of the country, and secondarily on differences by income and education.[2] The tremendous geographic diversity within Brazil in the level and pace of social and economic development has been the principal reason for this focus; differentials by socioeconomic status have tended to mirror the regional differentials and hence have received less attention. Another reason is that many past studies used basic indirect estimation techniques. Because stratification of the sample was necessary for estimating mortality differentials, these studies were restricted to examining the effects of one or two covariates at most. Less attention has been paid to examining the effects of broader social and economic

[2] See, for example, Barros and Sawyer (1991), Carvalho (1974), Carvalho and Wood (1978), Castilla (1996), Daly (1985), Monteiro (1996), Monteiro et al. (1992), Sawyer, Castilla, and Mor (1987), Schmertmann and Sawyer (1996), Simões and Monteiro (1995), Simões and Oliveira (1997), Szwarcwald and Castilho (1995), and Wood and Carvalho (1988).

trends on declines in infant and child mortality and on changes in mortality inequality.[3]

A growing number of studies have examined economic inequalities in health and survival in less developed countries. Virtually all of these have focused on infants and children, for whom the best data are available. These studies have drawn on data sets that have included measures of household economic status, such as the World Bank's Living Standards Measurement Study (Wagstaff, 2000; Wagstaff and Watanabe, 2000), or data sets that have measures of household asset ownership and housing characteristics, such as the Demographic and Health Surveys, together with techniques proposed by Filmer and Pritchett (1999 and 2001) for converting these measures into a wealth index (Bonilla-Chacin and Hammer, 1999; Gwatkin et al., 2000). These new studies of health inequalities have presented concentration curves and the concentration index—more sophisticated measures of inequality with some important advantages over the rate ratios across groups that are typically used—to characterize differences in inequality levels across countries. Few of these studies have examined trends in inequality. They have, however, uncovered substantial cross-country differences in inequality in child health and survival. Of considerable interest is that of the nine countries examined by Wagstaff (2000) and the 44 countries examined by Gwatkin et al. (2000), inequalities in under-five mortality were

[3] One exception is a recent study by Victora et al. (2000) that examined trends in child health inequality in Brazil. They found that in Ceará state in Northeast Brazil, inequalities between rich and poor for child health and infant mortality remained largely unchanged between 1987 and 1994. For the city of Pelotas, in southern Brazil, the situation over the period 1982-92 was largely the same. However, when the analysis of inequality in infant mortality for Pelotas was stratified by low birthweight status (there were no other controls), Victora et al. found that inequality declined among normal birthweight births but widened substantially among low birthweight births. (They argue that the narrowing of infant mortality inequality for normal birthweight births occurred because affluent families reached the minimum achievable level of infant mortality.)

highest for Brazil. Wagstaff (2000) found that the concentration curve for Brazil lay furthest from the 45-degree line and did not intersect with any other country's concentration curve, indicating that economic inequality for under-five mortality in Brazil was *unambiguously* the worst.

In this paper, I examine the effects of social and economic development on socioeconomic inequalities in under-five mortality for the state of São Paulo, Brazil, over a twenty-one year period during which much of the infant and child mortality transition unfolded. I investigate whether the improvements in infant and child survival were accompanied by declining inequalities. Instead, did the most advantaged segments of society benefit more from these improvements? I focus on inequality in under-five mortality by household wealth and by mother's education. I draw on microdata from Brazilian censuses conducted in 1970, 1980, and 1991. Major strengths of these data include the availability of detailed individual and household level covariates and extremely large sample sizes.

I begin, in the next section, by providing some background on trends and differentials in infant and child mortality in São Paulo, Brazil, over the past 30-40 years. In Sections 3, I describe the data and methods. The results are presented in Section 4 and I end the paper with some conclusions.

2. Background

São Paulo is Brazil's largest state, with one-fifth of the country's total population. The state, which is located in the southeast of Brazil, had a population of 31.5 million in 1991 (Fundação SEADE, 1993). The city of São Paulo and its surrounding metropolitan area is the most industrialized region in Latin America. This region, located in the southeast part of the state, forms Brazil's urban-industrial heartland and dominates the country economically. For instance, the greater São Paulo region generates one-third of the Brazil's income, although it contains only one-tenth of the country's population (Abranches, 1995). During the past 30 years, the city and state have led Brazil and Latin America in many important demographic and socioeconomic trends. For example, the state has the highest level of urbanization in the country, with 93 percent of the state's population living in urban areas in the mid-1990s.

There was a major decline in infant and child mortality in São Paulo state beginning in the early 1970s (see Figure 1). The infant mortality rate declined from 84 per 1,000 in 1970 to under 20 per 1,000 today. The decline in infant mortality rates that begin in the early 1970s followed a period during which rates actually increased substantially. Between 1964 and 1971 the infant mortality rate in São Paulo state rose by 26 percent, from 71 per 1,000 to 89 per 1,000.

A number of studies have investigated why infant mortality rates increased in São Paulo during this period. One set of studies (e.g., Sawyer, 1981; Wood, 1982; Yunes, 1981) has argued that the economic policies of the military government that took power in 1964 were the main cause of the upturn in infant mortality. Although there was rapid economic growth of over 10 percent per annum beginning in 1964, there was a sharp concurrent drop in real wages with the legal minimum wage falling by approximately 60 percent between 1964 and 1973. Other factors that were likely to have contributed to the rise in infant mortality rates included a lack of sufficient investment in water supply and sanitation (Monteiro and Benicio, 1989) and in health services (Leser, 1974) to keep pace with rapid rates of population growth.

Beginning in 1973, infant mortality rates began to decline in the state. Most researchers have attributed the fall to infrastructure improvements (Costa and Duarte, 1989). Brazil embarked in the 1970s on an intensive effort to improve water supply and sanitation (Merrick, 1985), which raised the proportion of households in São Paulo with running water from 71.3

percent in 1973 to 98.6 percent in 1984 (Sawyer, Castilla, and Mor, 1987). Other important changes that contributed to lower mortality rates were longer breastfeeding durations, increases in the use of oral rehydration therapy, higher immunization rates, and increases in the number of health centers (Monteiro et al., 1989; Victora et al., 1996; Zúñiga and Monteiro, 1995).

3. Data and methods

This study is based on data from the survey component of the Brazilian population censuses that were conducted in 1970, 1980, and 1991. One-quarter of households were selected for the survey component in 1970 and 1980, while in 1991 10 percent of households were selected in municipalities with a population of 15,000 or above and 20 percent were selected in the rest. Information was collected on housing conditions as well as demographic, social, and economic characteristics of each resident. Most of the core questionnaire had few, if any, changes between censuses, which allows identical measures to be created for each year. The high sampling fractions resulted in exceptionally large sample sizes. Although the analysis is based only on parous women aged 20-34 (for reasons discussed below), the sample sizes are 297,729 for 1970, 527,927 for 1980, and 406,976 for 1991—a total of 1,232,632 women.

The core questionnaire collected information from adult women on the number of children born and the number of these children alive at the time of the interview. I used this information to construct an index of under-five mortality for each mother based on the techniques proposed by Trussell and Preston (1982). The index was used to indirectly estimate of under-five mortality rates. Because the indirect estimates were based on individual-level index values, I was able to construct comparable indirect mortality estimates that controlled for individual- and household-level demographic and socioeconomic characteristics using linear regression analysis.

The index assumes that a child's risk of death is proportion to a standard mortality schedule and hence to the risk faced by other children (Trussell and Preston, 1982). A model life table is chosen as the standard mortality schedule. A proportionality factor is calculated for each mother based on her observed number of deaths divided by her expected number of deaths from the standard mortality schedule. A control for the duration of children's exposure to the risk of death (i.e., their age) is based on the mother's age.[4] I estimated the proportionality factor separately for subgroups of women based on five-year age categories and level of education.[5] The expected number of dead children for the *j*th woman in age group *d* and education group *i*, E_{ij}, was given by

$$E_{ij} = B_{ij} \times PD_i^s(d) ,$$

where B_{ij} is the number of children born to this woman and $PD_i^s(d)$ is the expected proportion of children who died among women in age group *d* and education group *i* under the standard mortality schedule. Note that the age groups $d = 1, 2, ..., 7$ correspond, respectively, to 15-19 years, 20-24 years, …, 45-49 years. Under the assumption of proportionality, the probability of a

[4] The duration since the mother's first marriage is a commonly used alternative to mother's age as a control for children's exposure. However, information on age at first marriage is not available from the Brazilian censuses.

[5] Women of higher socioeconomic status generally bear children at a later age. Hence, among mothers of the same age, those of higher socioeconomic status will have younger children. These children are less likely to have died both because they are younger and because of their higher socioeconomic status. If I ignore the fact that children of higher socioeconomic status are younger (holding mother's age constant), the estimated mortality rates for these children will be understated. Consequently, it is important that I control for fertility differences by mother's socioeconomic status when calculating the child mortality index. I did so by stratified mothers according to whether or not they completed elementary school, an outcome that was determined occurred well before the start of childbearing.

child dying by exact age a, $q_{ij}(a)$, is given by:

$$q_{ij}(a) = \beta_{ij} q^s(a),$$

where $q^s(a)$ is the standard mortality schedule. Since the observed number of dead children is $\beta_{ij} E_{ij}$, the ratio of observed to expected number of dead children—which, as explained below, is the index of child mortality—is simply β_{ij}, the proportionality factor. I estimated $PD_i^s(d)$ by inverting the conventional procedure for estimating childhood mortality from summary information from mothers on the number of children ever born and children dead.

I restricted my analysis to data on child mortality from women aged 20-34 years. I did so because mother's age was used to control for the duration of her children's exposure to the risk of death. As a result, deaths to children of older women correspond to births occurring in the more distant past. Since the covariates reflect conditions at the time of the interview, the inclusion of older women—and, hence, children born in the more distant past—may have led to misleading results given the rapid changes in living conditions over the study period. Also, underreporting of the number of children born is more likely among older women. I excluded women aged 15-19 years because children of teenage mothers face higher mortality due, in part, to their mother's age.[6] The most important assumptions underlying the indirect estimation of child mortality are that fertility and childhood mortality levels have been constant in the recent past. Restricting the analysis to women aged 20-34 minimizes the likelihood that these assumptions are violated.

This approach provided a value of the child mortality index (CMI) for each woman. For

[6] Although mother's age is measured and can be included in the analysis, it is confounded with children's exposure.

the *j*th woman in the *i*th education group this index is the ratio of observed child deaths (O_{ij}) to expected child deaths (E_{ij}):

$$CMI_{ij} = O_{ij} / E_{ij} .$$

I used this index to estimate the overall level of under-five mortality and inequality in under-five mortality.

I converted the index to an estimated under-five mortality probability, *q*(5), by multiplying the *q*(5) value for the chosen standard life table by the weighted average of the index—with the number of live births to each woman serving as the weight.[7] I chose Coale-Demeny West regional model life table level 18.5 as the mortality standard for this study based on a preliminary analysis (results not shown) that used indirect estimation techniques described in *Manual X* (United Nations, 1983). Preston and Haines (1991) recommended using the *q*(5) life table parameter because it is likely to be the least sensitive to time trends or an error in the choice of model life table. The weighting procedure provided a useful way to combine child mortality information across women of a wide age range (20-34 years) who had a corresponding large variation in the number of children born (and hence exposed to the risk of death). Values for the weighted average of *q*(5) are quite close to the corresponding unweighted estimates based only on the mortality of children to women aged 30-34, which represents the standard approach to estimating the *q*(5) parameter based on indirect estimation techniques (United Nations, 1983).

I used the index in a regression analysis that allowed me to estimate under-five mortality rates after controlling for demographic, social, and economic characteristics. The regressions were run using weighted ordinary least squares with the index as the dependent variable and the number of live births to the mother as the weight.

[7] Henceforth, I refer to *q*(5) × 1,000 as the under-five mortality rate or simply "under-five mortality".

Finally, I used the index to calculate mortality concentration curves and concentration indices that describe and summarize inequalities in under-five mortality according to household economic status or mother's years of education. The concentration curve plots the cumulative proportion of mothers ranked in ascending order by household economic status or years of education (on the *x*-axis) against the cumulative proportion of mothers ranked by their value of the child mortality index (on the *y*-axis). If there were perfect equality in child deaths according to household economic status and mother's years of education, then the concentration curve would lie along the diagonal. The further the concentration curve lies above the diagonal, the more that inequalities in child mortality favor mothers from household of higher economic status or with more education.[8]

The concentration index can be used to compare concentration curves. It is especially useful in situations where two curves cross and hence unambiguous comparative assessments of inequality in mortality cannot be made. The concentration index is defined as twice the area between the concentration curve and the diagonal and is negative when the concentration curve lies above the diagonal. The index is calculated as follows (see Kakwani, Wagstaff, and van Doorslaer, 1997):

$$C = \frac{2}{n\bar{x}} \sum_{i=1}^{n} x_i R_i - 1,$$

where x_i is the child mortality index for the *i*th mother, $R_i = (2i-1)/2n$ is the relative rank for the *i*th mother, and $\bar{x}$ is the mean of the child mortality index. The variance for the concentration index (which takes into account serial correlation in the data) is calculated as

[8] Note that the concentration curves and indexes did *not* weight each mother's child mortality index value by her number of children ever born. This was because these measures should not reflect differential fertility, which would have been the case if I used weighted values.

$$\hat{Var}(C) = \frac{1}{n}\left[\frac{1}{n}\sum_{t=1}^{n} a_t^2 - (1+C)^2\right],$$

where

$$a_t = \frac{x_t}{\bar{x}}\left(2R_t - 1 - C\right) + 2 - q_t - q_{t-1}$$

and

$$q_t = \sum_{j=1}^{t} x_j \bigg/ \sum_{j=1}^{n} x_j \ .$$

I used an index of household wealth based on a principal components analysis of housing characteristics and ownership of consumer durables (see Filmer and Pritchett, 2001) to capture the family's economic status. I also calculated the concentration index based on mothers' years of education that reflected her highest level of educational attainment (rather than her number of years of schooling, which is affected by grade repetition).

4. Results

I present my results in two subsections. I begin by describing trends in levels of under-five mortality and trends in inequality in under-five mortality according to household wealth and mother's education. Next, I present adjusted inequality measures that control for the effects of a variety of demographic, social, and economic characteristics.

Levels and Inequality in Under-Five Mortality

Under-five mortality rates for São Paulo state were 117.0 for 1970, 96.0 for 1980, and 45.7 for 1991 (see Table 1). Under-five mortality dropped by 61 percent over the entire 21-year period. It fell by18 percent between 1970 and 1980 and by 52 percent between 1980 and 1991.

The estimated levels of under-five mortality are consistent with infant mortality rates based on vital statistics that were calculated by Fundação SEADE, the São Paulo state statistical agency. The under-five mortality estimates based on data for women aged 20-34 refer, on average, to a period approximately four years before the date of each census.[9] The infant mortality rates for 1966 (75.9 per 1,000), 1976 (77.2 per 1,000), and 1987 (33.9 per 1,000) were all between 76 and 80 percent of the corresponding under-five mortality rate. My estimates and those based on vital statistics (see Figure 1) both suggest that it was not until the mid-1970s that sharp and sustained declines in infant and child occurred in São Paulo.

Inequality in under-five mortality by household economic status declined over the study period (see Table 1). The drop occurred between 1970 and 1980, when the concentration index rose from -0.216 to -0.163. There was a small but statistically significant decrease in the concentration index (indicating higher levels of inequality) between 1980 and 1991, when the concentration index reached -0.175. Figure 2 shows concentration curve deviations (from the diagonal, which implies perfect equality) for 1970, 1980, and 1991. The deviations plot is useful for examining inequality over the entire range of the economic status measure. I highlight two important findings. First, the 1980 curve dominates the curve for 1970—i.e., the 1980 curve is below the 1970 curve throughout the entire wealth distribution. This indicates that there was unambiguously less inequality in under-five mortality in 1980 than in 1970.[10] Second, the 1991 curve is most clearly above the 1980 curve in the bottom one-third of the household wealth distribution. This indicates that there was a relative increase in under-five mortality for women in the least wealthy one-third of households between 1980 and 1991. In fact, for the bottom one-fifth there was a relative increase in under-five mortality compared to 1970. In contrast, there

[9] See United Nations (1983) for details on calculating the reference period for indirect estimates of child mortality.

[10] In contrast, if two concentration curves cross, then weights assigned to different parts of the wealth distribution will determine which of the two groups is said to have greater inequality.

was little relative change between 1980 and 1991 in under-five mortality for women in other parts of the household wealth distribution. The results presented in Table 1 suggest that the rise in inequality between 1980 and 1991 for the state was due to a sharp increase in rural inequality in under-five mortality (since there were declines in inequality for urban areas). Between 1980 and 1991, rural inequality increased dramatically, to levels well above those found in 1970. Because of these diverging trends in inequality for rural and urban areas, the subsequent analysis focuses exclusively on social and economic inequalities for urban areas.

I present information on differentials and inequality in under-five mortality by household wealth in urban areas of São Paulo state in Table 2. Three different measures of inequality are shown: the ratio of under-five mortality in the first wealth quintile to that in the fifth quintile, the difference in under-five mortality between the top and bottom wealth quintiles, and the concentration index. All three measures reveal a consistent decrease in levels of inequality in under-five mortality according to household wealth between 1970 and 1991. The ratio of under-five mortality for the first to fifth quintile of household wealth fell from 3.08 in 1970, to 2.72 in 1980, to 2.22 in 1991. Over this period, the difference in under-five mortality between the first and fifth wealth quintiles shrank relative to the overall level of mortality. In 1970, the difference between the top and bottom wealth quintiles was 116.4 while the overall under-five mortality rate for urban areas was 114.4—indicating that the difference was slightly greater than the overall mortality rate. By 1980 the difference of 91.4 was lower than the overall under-five mortality rate of 95.8, while by 1991 the difference of 36.5 was only 80 percent of the overall mortality rate of 45.2. Finally, the concentration index dropped from –0.208 in 1970, to –0.176 in 1980, to –0.163 in 1991.

An examination of under-five mortality rates by wealth quintile reveals that the decline in wealth inequality in under-five mortality was the result of a much larger relative drop in under-five mortality for lower quintiles than for higher quintiles. Specifically, there was a 61 percent decline in under-five mortality for the first quintile between 1970 and 1991, which is one-third larger than the 46 percent decline for the fifth quintile over this period. Overall, and for each group, the magnitude of the mortality declines was much smaller for 1970-80 than for 1980-91. For the first wealth quintile, under-five mortality rates fell by 16 percent between 1970 and 1980 but by 54 percent between 1980 and 1991. For the fifth quintile, under-five mortality fell by only 5 percent during the earlier period but by 44 percent during the later period.

I present information on levels and inequality of under-five mortality by mother's level of education in Table 3. I examined three measures of inequality of under-five mortality: the ratio of under-five mortality in the bottom group (mother with elementary or less education and illiterate) compared to the top group (mother with higher education); the difference in under-five mortality between the bottom and top education groups; and the concentration index (based on the mother's years of education). Although parallel to the measures used for examining inequality by household wealth, they are different in one important aspect, which is that the rate ratios and absolute differences are based on fixed—rather than relative—categories.

All three measures indicate that inequality in under-five mortality according to mother's education fell between 1970 and 1980, but then increased in 1991 to a level above that in 1970. For example, the ratio of under-five mortality for illiterate mothers compared to mothers with higher education was 5.95 in 1970, 4.22 in 1980, and 6.60 in 1991. There was a large improvement in average education levels over this period, as reflected in the distribution of mothers across education categories. In 1970, for instance, 15.3 percent of mothers were illiterate while only 0.8 percent had a higher education; by 1991, fewer than 5 percent of mothers were illiterate while 7.6 percent had a higher education. This absolute improvement in education could potentially affect the assessment of changes in inequality in under-five mortality, especially when comparing these results to those based on wealth inequality. In particular, rises in the ratio of mortality among the least educated group to the most educated group may be less important because the number of women in the former group declined while the numbers in the latter group increased. However, the results for the concentration index, which is based on mothers' single years of education, suggests that this is not the case because exactly the same findings emerge when examining this measure.

One interesting result that emerges when examining under-five mortality levels by mother's level of education is that the mortality levels *increased* between 1970 and 1980 for women with middle, secondary, or higher education. Only for women with elementary or less education was there a decrease in under-five mortality over this period. It is unclear what accounts for this result, although it may be caused in part by the large increases in educational attainment between 1970 and 1980 that shifted women from disadvantaged backgrounds up the education distribution. Between 1980 and 1991, however, all groups experienced substantial declines in under-five mortality. For the bottom group (illiterate women), there was a 37 percent decline in under-five mortality; for the top group (women with higher education), there was a 60 percent decline.

Adjusted Levels of Inequality in Under-Five Mortality

The results presented so far have been of raw differentials and inequalities in under-five mortality rates. Of considerable interest is the extent to which underlying differences in demographic, social, and economic characteristics shape these results. For instance, low levels of under-five mortality among the most educated women may reflect, in part, the survival advantages conferred by higher household wealth. By controlling for other variables, I examined the effects of mother's level of education alone, net of other factors. The covariates that were included in the analysis are the household possessions-based wealth index, household water supply, household sanitation, woman's education, woman's current age, and woman's inter-state migration status.

I begin by examining adjusted wealth inequalities in under-five mortality across all urban areas (see Table 4), using the same three measures of inequality as before. The results suggest that there was little change in wealth inequality in under-five mortality during the study period once I controlled for demographic and socioeconomic factors. There is a slight discrepancy in the trend based on the rate ratio or the absolute difference between top and bottom wealth quintiles and that based on the concentration index. In particular, the results based on the wealth quintiles suggest there was a modest decline in wealth inequality in under-five mortality. The ratio of under-five mortality for the first quintile to the fifth decreased from 1.87 in 1970, to 1.54 in 1980, to 1.46 in 1991. The absolute difference between the first and fifth quintiles narrowed over this period, from 66.1 in 1970 (58 percent of overall level), to 40.1 in 1980 (42 percent of the overall level), and to 16.9 in 1991 (37 percent of overall level). On the other hand, the results based on the concentration index suggest that there was no significant change over this period. However the concentration index did fall, from -0.068 in 1970, to –0.070 in 1980, to –0.078 in 1991, indicating a minor, statistically insignificant increase in wealth inequality over this period.

Based on all three inequality indicators, for each year there was substantially less wealth inequality in adjusted under-five mortality than in unadjusted mortality. This suggests that the specific covariates included in the models explained a considerable proportion of the observed differences in under-five mortality by household wealth. In addition, the fact that the decline in mortality inequality over time was reduced after adjusting for covariates indicates that these factors helped explain the downward trend in inequality in under-five mortality. These results suggest that inequality in wealth is positively correlated with inequalities in education and living conditions. From a policy perspective this suggests that there are multiple pathways through which to reduce economic inequalities in health beyond simply reducing household wealth disparities.

By adjusting for covariates, a clearer picture emerged of trends in under-five mortality differentials by mother's level of education. The results, presented in Table 5, showed that adjusted inequality in under-five mortality according to mother's level of education increased consistently over the entire study period. The ratio of mortality among the least educated group to the most educated group rose from 1.73 in 1970, to 1.93 in 1980, to 4.07 in 1991. The absolute gap in under-five mortality between the least educated and most educated groups increased slightly (by 7 percent) even though the overall level of under-five mortality declined substantially (by 60 percent). Lastly, the concentration index, which was based on mother's years of education, declined steadily over time, from –0.068 in 1970, to –0.086 in 1980, to –0.194 in 1991, indicating an increase in inequality in under-five mortality. An interesting finding is that the concentration index indicated a larger relative increase in inequality over the study period compared to the ratio of the lowest to highest level of mother's education.

The covariates in the models accounted for a substantial proportion of inequality in under-five mortality according to mother's education in 1970. However, for the later years they accounted for considerably less. In particular, adjusting for covariates increased the concentration index by 67 percent in 1970, while in 1991 it increased the concentration index by only 29 percent. This suggests that demographic factors, living conditions, and household wealth accounted for a significantly smaller proportion of inequality in under-five mortality by mother's education over time. Mother's education appears to have emerged as perhaps the key factor underlying inequalities in under-five mortality. There were enormous improvements in mother's education over the study period. The average number of years of education for women with children increased from 3.1 in 1970, to 5.1 in 1980, to 6.4 in 1991. Although this was associated with a large decline in number of women with the lowest levels of education, it was not associated with a decline in the variance of women's years of education. Rather, it appears that there was an upward shift—and a slight spread—in the education distribution. At the same time, the adjusted decline in under-five mortality was small for women at the bottom of the education distribution and large for women at the top. Adjusted under-five mortality declined only 40 percent for illiterate women. However, for women with higher education, the adjusted decline was 75 percent. This was nearly twice as large as the decline for illiterate women, and was 50 percent higher than the unadjusted decline for these same women. Thus, not only were effects of higher levels of women's education more beneficial for their children's survival, but there was also a substantial redistribution of women up the education distribution.

5. Conclusions

In this paper I presented trends in inequality for under-five mortality in São Paulo state, Brazil, over a twenty-one year period from 1970 to 1991. There were major declines in under-five mortality for São Paulo state between 1970 and 1991. These were associated with substantial improvements in living conditions, increases in educational attainment, and other demographic and socioeconomic changes. Inequality according to household wealth underwent a clear decline over this period. Inequality according to mother's education first declined and then increased, with a net rise over the study period. When I controlled for background demographic and socioeconomic characteristics, inequalities in under-five mortality according to household wealth remained roughly constant. On the other hand, inequality according to mother's education increased substantially.

These results suggest that improvements in household sanitation and water supply, higher levels of educational attainment for women, and changes in migration patterns together accounted for the decline in wealth inequality in under-five mortality between 1970 and 1991. These changes also had the effect of keeping under-five mortality inequality by mother's education at a lower level than it otherwise would have been. Thus, social and economic development led to lower levels of mortality inequality suggesting that the disadvantaged did indeed benefit from progress over this period. Interestingly, there has been little indication that pure income or wealth inequalities have been declining in Brazil. For example, a recent study found that income inequality remained roughly constant for urban areas of the country between the 1970s and 1990s (Ferreira and Barros, 2000).

A topic of current research and policy interest is the relationship between economic growth and health inequalities according to household economic status. Contoyannis and Forster (1999) showed that no predictions can be made about the effects of income on health inequality. Wagstaff (2001) suggested, however, that existing evidence—from both cross-sectional and trend analyses—is consistent with higher average incomes being associated with higher levels of health inequality. Victora et al. (2002) contended that technological change—which generally accompanies income growth—contributes to widening health inequalities by economic status because the more advantaged tend to benefit sooner from new medical knowledge and treatments. Finally, Szreter (1997), drawing on historical evidence from Britain, argued that rapid economic growth results in worse population health, such as increasing health inequalities.

This occurs because economic growth is associated with widespread and pervasive disruption. Unless this disruption is mediated by effective social and political responses, disease and death will result.[11]

However, my results, which provide precise estimates of trends in health inequality over a far longer period than Wagstaff (2001) or Victora et al. (2002), do not support these conclusions—at least for São Paulo. In particular, the average annual growth rate in GDP per capita for Brazil was 8.5 percent between 1970 and 1980 and 2.2 percent between 1980 and 1991 (Easterly and Sewadeh, 2002). Growth was steady over the first period but there were several years with negative growth over the second period. However, wealth inequality in under-five mortality for São Paulo declined both between 1970 and 1980 and between 1980 and 1991.

There are a growing number of cross-country studies of inequality in under-five mortality that were reviewed above. All of these studies have drawn on survey data, which have a number of important strengths—for example, the samples and survey measures tend to be highly comparable across countries and they collect information on child health status in addition to measures of child mortality. However, they have some important weaknesses compared to census data. In particular, using census data and indirect estimation techniques provides an alternative source of information on under-five mortality that has the advantage of substantially larger sample sizes that allow considerably more statistical precision in tracking changes over time. As I have shown, census data also allow researchers to uncover historical trends in mortality inequalities.

[11] Szreter's characterization might certainly help explain São Paulo's period of rising infant and child mortality between the mid-1960s and mid-1970s.

References

Abranches, Sergio. 1995. “Crise e Mudança.” International Labor Office, Geneva.

Barros, R.P., and D.O. Sawyer. 1991. “Unequal opportunities to survive: Education and regional disparities in Brazil,” mimeographed, IPEA, Rio de Janeiro.

Bonilla-Chacin, M., and J. Hammer. 1999. “Life and death among the poorest,” Mimeo, World Bank, Washington, D.C.

Braveman, Paula, and Eleuther Tarimo. 2002. “Social inequalities in health within countries: Not only an issue for affluent nations,” *Social Science and Medicine* 54: 1621-1635.

Carvalho, J.A.M. 1974. “Regional trends in fertility and mortality in Brazil,” *Population Studies* 28: 401-421.

Carvalho, José Alberto M., and Charles H. Wood. 1978. “Mortality, income distribution, and rural-urban residence in Brazil,” *Population and Development Review* 4: 405-420.

Castilla, F.M. 1996. “Uma análise regional dos differenciais sócio-econômicos da mortalidade na infância no Brasil, 1960-80,” in *Anais do X Encontro Nacional de Estudos Populacionais*, Vol. 4, pp. 2235-2252. Belo Horizonte: ABEP.

Cleland, John, George Bicego, and Greg Fegan. 1992. “Socioeconomic inequalities in childhood mortality: The 1970s to the 1980s,” *Health Transition Review* 2: 1-18.

Contoyannis, Paul, and Martin Forster. 1999. “The distribution of health and income: A theoretical framework,” *Journal of Health Economics* 18: 605-622.

Costa, N.R., and C.M.R. Duarte. 1989. “Notas para avaliação de políticas sociais: A tendência da mortalitdade infantil nas últimas decadas,” *Dados* 32: 241-55.

Daly, H.E. 1985. “Marx and Malthus in northeast Brazil: A note on the world's largest class difference in fertility and its recent trends,” *Population Studies* 39: 329-338.

DaVanzo, Julie, and Jean-Pierre Habicht. 1986. "Infant mortality decline in Malaysia, 1946-1975: The roles of changes in variables and changes in the structure of relationships," *Demography* 23: 143-160.

Easterly, William, and Mirvat Sewadeh. 2002. "Global development network growth database," World Bank, Washington, D.C. [http://www.worldbank.org/research/growth/GDNdata.htm].

Fundação SEADE. 1993. *O novo retrato de São Paulo: Avaliação dos primeiros resultados do censo demográfico de 1991.* Second edition. São Paulo: Fundação SEADE.

Ferriera, Francisco H.G., and Ricardo Paes de Barros. 2000. "The slippery slope: Explaining the increase in extreme poverty in urban Brazil, 1976-1996." Mimeographed.

Filmer, D., and L. Pritchett. 1999. "The effect of household wealth on educational attainment: Evidence from 35 countries," *Population and Development Review* 25: 85-120.

Filmer, Deon, and Lant H. Pritchett. 2001. "Estimating wealth effects without expenditure data—or tears: An application to educational enrollments in states of India," *Demography* 38: 115-132.

Gwatkin, D.R. 2000. "Health inequalities and the health of the poor: What do we know? What can we do?" *Bulletin of the World Health Organization* 78: 3-17.

Gwatkin, D.R., S. Rutstein, K. Johnson, R.P. Pande, and A. Wagstaff. 2000. *Seocioeconomic differentials in health, nutrition, and population*. Washington, D.C.: World Bank.

Kakwani, Nanak, Adam Wagstaff, and Eddy van Doorslaer. 1997. "Socioeconomic inequalities in health: Measurement, computation, and statistical inference," *Journal of Econometrics* 77: 87-103.

Lam, David, and Deborah Levison. 1991. "Declining Inequality in Schooling in Brazil and Its Effects on Inequality in Earnings," *Journal of Development Economics* 37: 199-225.

Leser, W. 1974. “Crescimento da população e nível de saúde na cidade de São Paulo,” *Problemas Brasileiros* 16: 17-36.

Merrick, T.W. 1985. “The effect of piped water on early childhood mortality in urban Brazil, 1970 to 1976,” *Demography* 22: 1-23.

Monteiro, C.A. 1996. “O panorama da nutrição infantil nos anos 90,” Documentos para Discussão No. 1, UNICEF, Brasília.

Monteiro, C.A., and M.H.A. Benicio. 1989. “Determinants of infant mortality trends in developing countries: Some evidence from São Paulo city,” *Transactions of the Royal Society of Tropical Medicine and Hygiene* 83: 5-9.

Monteiro, C.A., M.H.A. Benicio, R. Iunes, N.C. Gouveia, J.A.A.C. Taddei and M.A.A. Cardoso. 1992. “Nutritional status of Brazilian children: Trends from 1975 to 1989,” *Bulletin of the World Health Organization* 70: 657-666.

Monteiro, C.A., H.P. Pino Zuniga, M.H.A. Benicio, and C.G. Victora. 1989. “Better prospects for child survival,” *World Health Forum* 10: 222-7.

Paim, J.S., and M.C. Costa. 1993. “Decline and unevenness of infant mortality in Salvador, Brazil, 1980-1988,” *Bulletin of the Pan American Health Organization* 27: 1-14.

Preston, Samuel H., and Michael R. Haines. 1991. *Fatal years: Child mortality in late nineteenth-century America*. Princeton, NJ: Princeton University Press.

Psacharopoulos, George, Samuel Morley, Ariel Fiszbein, Haeduck Lee, and William C. Wood. 1995. “Poverty and Income Inequality in Latin America during the 1980s,” *Review of Income and Wealth* 41: 245-64.

Sawyer, D.O. 1981. “Effects of industrialization and urbanization on mortality in developing countries: The case of Brazil,” *International Population Conference, Manila 1981*. Liège:

IUSSP.

Sawyer, D.O., R. Fernández-Castilla, and R.M. Monte-Mor. 1987. "The impact of urbanization and industrialization on mortality in Brazil," *World Health Statistics Quarterly* 40: 84-95.

Schmertmann, C.P., and D.O. Sawyer. 1996. "Migration bias in indirect estimates of regional childhood mortality levels," *Mathematical Population Studies* 6: 69-93.

Simões, Celso Cardoso da Silva, and Carlos Augusto Monteiro. 1995. "Tendência secular e diferenciais regionais da mortalidade infantile no Brasil," in Carlos Augusto Monteiro (ed.) *Velhos e novos males da saúde no Brasil*. São Paulo: Hucitec.

Simões, C.C., and L.A.P. Oliveira. 1997. "A saúde infantil no Brasil nos anos 90," manuscript, IBGE, Rio de Janeiro.

Stecklov, G., A. Bommier, and T. Boerma. 1999. "Trends in equity in child survival in developing countries: An illustrative analysis using Ugandan data," Mimeo, Carolina Population Center, Chapel Hill, NC.

Szreter, Simon. 1997. "Economic growth, disruption, deprivation, disease, and death: On the importance of the politics of public health for development," *Population and Development Review* 23: 693-728.

Szwarcwald, C.L., and E.A. Castilho. 1995. "Estimativas da mortalidade infantil no Brasil, década de oitenta," *Revista de Saúde Pública* 29: 451-462.

Trussell, James, and Samuel Preston. 1982. "Estimating the covariates of childhood mortality from retrospective reports of mothers," *Health Policy and Education* 3: 1-36.

United Nations. 1983. *Indirect techniques for demographic estimation.* Manual X. New York: United Nations

Victora, C.G., M.T. Olinto, F.C. Barros, and L.C. Nobre. 1996. "Falling diarrhoea mortality in

Northeast Brazil: Did ORT play a role?” *Health Policy and Planning* 11: 132-141.

Victora, Cesar G., J. Patrick Vaughan, Fernando C. Barros, Anamaria C. Silva, and Elaine Tomasi. 2000. “Explaining trends in inequities: Evidence from Brazilian health studies,” *Lancet* 356: 1093-1098.

Wagstaff, Adam. 2000. “Socioeconomic inequalities in child mortality: Comparisons across nine developing countries,” *Bulletin of the World Health Organization* 78: 19-29.

Wagstaff, Adam. 2001. “Inequalities in health in developing countries: Swimming against the tide?” Mimeo, World Bank, Washington, D.C.

Wagstaff, A., and N. Nguyen. 2001. “Poverty and survival prospects of Vietnamese children under Doi Moi,” Mimeo, World Bank, Washington, D.C.

Wagstaff, A., and N. Watanabe. 2000. “Socioeconomic inequalities in child malnutrition in the developing world,” Policy Research Working Paper 2434, World Bank, Washington, D.C.

Wood, C.H. 1982. “The political economy of infant mortality in São Paulo, Brazil,” *International Journal of Health Services* 12: 215-229.

Wood, C.H., and J.A.M. Carvalho. 1988. *The demography of inequality in Brazil.* New York: Cambridge University Press.

Yunes, J. 1981. “Evolution of infant mortality and proportional infant mortality in Brazil,” *WHO Statistical Quarterly* 34: 200-219.

Zúñiga, H.P.P., and C.A. Monteiro. 1995. “Uma nova hipótese para a ascensão da mortalidade infantil da cidade de São Paulo nos anos 60,” in C.A. Monteiro (ed.) *Velhos e novos males da saúde no Brasil.* São Paulo: HUCITEC.

Table 1. Levels and inequality of under-five mortality by area for São Paulo state by year

Area	Under-five mortality		Concentration index		Sample size (mothers)
			1970		
Total	117.0	(0.36)	-0.216	(0.0023)	297,729
Urban	114.4	(0.41)	-0.238	(0.0027)	233,252
Rural	124.7	(0.78)	-0.120	(0.0047)	64,477
			1980		
Total	96.0	(0.31)	-0.163	(0.0023)	527,927
Urban	95.8	(0.33)	-0.176	(0.0025)	465,877
Rural	97.5	(0.89)	-0.098	(0.0064)	62,050
			1991		
Total	45.7	(0.21)	-0.175	(0.0036)	406,976
Urban	45.2	(0.22)	-0.163	(0.0038)	371,020
Rural	49.8	(0.72)	-0.174	(0.0110)	35,956

Source: Author's calculations based on microdata data for São Paulo state from Brazilian censuses of 1970, 1980, and 1991.

Notes: Standard errors in parentheses.
The under-five mortality rate is equal to $q(5)$ x 1,000, where $q(5)$ is an estimate of the life table probability of a child dying before age 5. The estimate of $q(5)$ is calculated from the ratio of observed to expected child deaths among women age 20-34 with one or more births and a model life table, using indirect estimation techniques. See text for details.
The concentration index is a measure of economic inequality in under-five mortality constructed using a household possessions-based wealth index. The index of household wealth is the score of a principal components analysis, with components that include the ownership of consumer durables such as a car, radio, refrigerator, and television, and the number of rooms and bedrooms in the dwelling. See text for further details.

Table 2. Levels and inequality of under-five mortality by wealth for urban areas of São Paulo state by year

	1970			1980			1991		
	Under-five mortality		Percent in category	Under-five mortality		Percent in category	Under-five mortality		Percent in category
Quintile of wealth									
1	172.4	(1.04)	20.3%	144.5	(0.84)	20.0%	66.5	(0.58)	20.0%
2	131.3	(0.96)	19.8%	106.8	(0.73)	22.3%	47.8	(0.51)	20.2%
3	102.7	(0.87)	20.1%	83.0	(0.71)	19.4%	42.3	(0.47)	20.0%
4	75.2	(0.79)	20.5%	68.8	(0.66)	20.2%	35.3	(0.44)	19.9%
5	56.0	(0.70)	19.3%	53.1	(0.65)	18.1%	30.0	(0.42)	19.8%
Total	114.4	(0.41)	100.0%	95.8	(0.33)	100.0%	45.2	(0.22)	99.90%
Ratio: min to max	3.08		1.05	2.72		1.10	2.22		1.01
Max - min	116.4			91.4			36.5		
Conc. Index	-0.208	(0.0028)		-0.176	(0.0025)		-0.163	(0.0038)	

Source: Author's calculations based on microdata data for São Paulo state from Brazilian censuses of 1970, 1980, and 1991.

Notes: Standard errors in parentheses.
See notes to Table 1 for information on the measures of under-five mortality and wealth and the concentration index.

Table 3. Levels and inequality of under-five mortality by mother's level of education for urban São Paulo state by year

	1970			1980			1991		
	Under-five mortality		Percent in category	Under-five mortality		Percent in category	Under-five mortality		Percent in category
Education									
Elementary or less									
Illiterate	176.6	(1.18)	15.3%	155.6	(1.20)	9.1%	98.3	(1.35)	4.8%
Literate	104.0	(0.48)	69.7%	98.5	(0.45)	55.9%	55.6	(0.39)	36.7%
Middle	68.4	(1.22)	9.0%	72.9	(0.70)	19.9%	36.5	(0.35)	33.1%
Secondary	43.7	(1.35)	5.2%	49.3	(0.89)	10.0%	22.0	(0.39)	17.8%
Higher	29.7	(2.88)	0.8%	36.9	(1.10)	5.1%	14.9	(0.49)	7.6%
Total	114.4	(0.41)	100.0%	95.8	(0.33)	100.0%	45.2	(0.22)	100.0%
Ratio: min to max	5.95		19.13	4.22		1.78	6.60		0.63
Max – min	146.9			118.7			83.4		
Conc. Index	-0.208	(0.0028)		-0.157	(0.0025)		-0.274	(0.0037)	

Source: Author's calculations based on microdata data for São Paulo state from Brazilian censuses of 1970, 1980, and 1991.

Notes: Standard errors in parentheses.
See notes to Table 1 for information about the measure of under-five mortality.
Concentration index is based on mother's years of education.

Table 4. Levels and inequality of adjusted under-five mortality by wealth quintiles for urban areas of São Paulo state by year

	1970			1980			1991		
	Under-five mortality		Percent in category	Under-five mortality		Percent in category	Under-five mortality		Percent in category
Quintile of wealth									
1	142.5	(0.87)	20.3%	115.0	(0.74)	20.0%	53.4	(0.42)	20.0%
2	125.3	(0.48)	19.8%	100.3	(0.35)	22.3%	48.1	(0.24)	20.2%
3	112.4	(0.40)	20.1%	93.1	(0.33)	19.4%	44.8	(0.22)	20.0%
4	96.8	(0.52)	20.5%	86.1	(0.41)	20.2%	41.6	(0.26)	19.9%
5	76.4	(0.81)	19.3%	74.9	(0.63)	18.1%	36.5	(0.38)	19.8%
Total	114.4	(0.41)	100.0%	95.8	(0.33)	100.0%	45.2	(0.22)	100.0%
Ratio: min to max	1.87		1.05	1.54		1.10	1.46		1.01
Max – min	66.1			40.1			16.9		
Conc. index	-0.068	(0.0024)		-0.070	(0.0025)		-0.078	(0.0037)	

Source: Author's calculations based on microdata data for São Paulo state from Brazilian censuses of 1970, 1980, and 1991.

Notes: Standard errors in parentheses.
See notes to Table 1 for information on the measures of under-five mortality and wealth.
Adjusted estimates control for covariates and set each covariate to its mean across all urban areas.
See notes to Table 5 for information on the covariates in the models.

Table 5. Levels and inequality of adjusted under-five mortality by mother's level of education for urban areas of São Paulo state by year

	1970			1980			1991		
	Under-five mortality		Percent in category	Under-five mortality		Percent in category	Under-five mortality		Percent in category
Education									
Elementary or less									
Illiterate	147.8	(1.31)	15.3%	133.1	(1.42)	9.1%	88.0	(1.20)	4.8%
Literate	106.7	(0.49)	69.7%	97.1	(0.43)	55.9%	52.8	(0.34)	36.7%
Middle	100.6	(1.22)	9.0%	79.0	(0.69)	19.9%	38.7	(0.37)	33.1%
Secondary	93.8	(1.54)	5.2%	70.7	(0.94)	10.0%	27.3	(0.48)	17.8%
Higher	85.6	(3.64)	0.8%	69.1	(1.31)	5.1%	21.6	(0.72)	7.6%
Total	114.4	(0.41)	100.0%	95.8	(0.33)	100.0%	45.2	(0.22)	100.0%
Ratio: min to max	1.73		19.13	1.93		1.78	4.07		0.63
Max – min	62.2			64.0			66.4		
Conc. Index	-0.068	(0.0028)		-0.086	(0.0024)		-0.194	(0.0036)	

Source: Author's calculations based on microdata data for São Paulo state from Brazilian censuses of 1970, 1980, and 1991.

Notes: Standard errors in parentheses.
See notes to Table 1 for information about the measure of under-five mortality.
Adjusted estimates control for covariates and set each covariate to its mean across all urban areas.
See notes to Table 5 for information on the covariates in the models.
Concentration index is based on mother's years of education.

Figure 1. Infant mortality rate for São Paulo state, 1894-1998

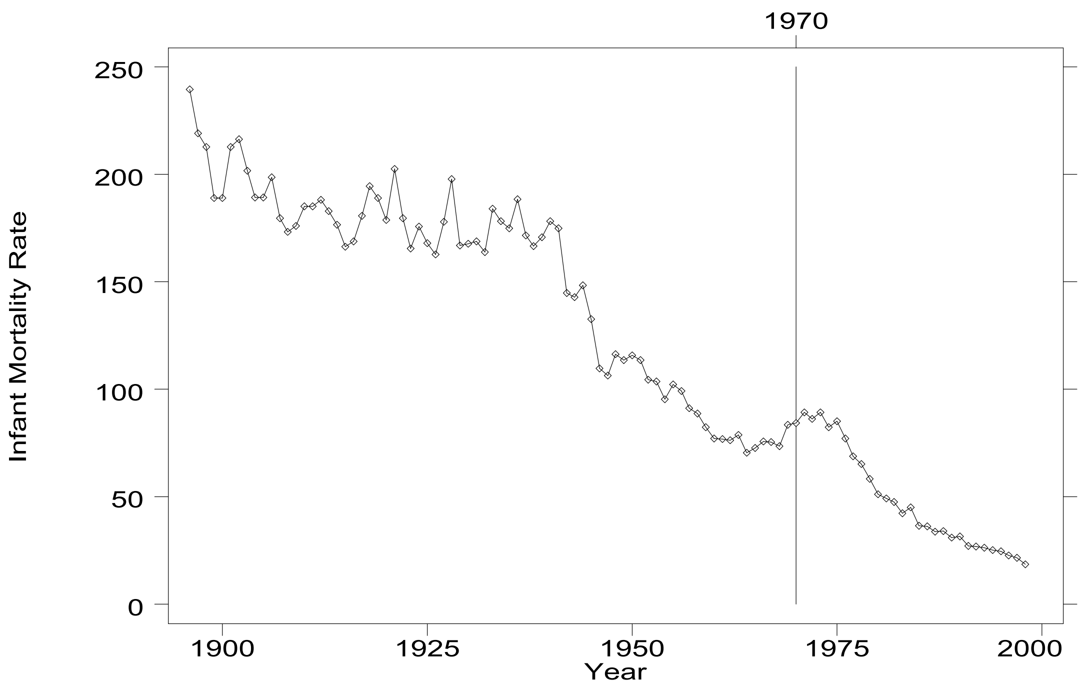

Figure 2. Concentration curve deviations for under-five mortality by wealth for São Paulo state in 1970, 1980, and 1991