THE EFFECTS OF MACRO- AND INDIVIDUAL-LEVEL SOCIOECONOMIC STATUS ON CHILD MORTALITY IN BRAZIL, 1970 TO 2000

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ABSTRACT

In this paper we delineate the effects of both macro- and individual-level socioeconomic factors on child mortality in Brazil. Using 1970 through 2000 Brazilian census data we address three questions: First, did socioeconomic disparities in child mortality decline over this period of rapid but geographically uneven economic development? Second, do macro-level socioeconomic factors (measured at the state level) affect child mortality above and beyond the impact of individual-level socioeconomic factors? Third, does individual-level socioeconomic status matter more or less depending on macro-level socioeconomic context? We find declining socioeconomic disparities in child mortality in Brazil over this period. We find no evidence that macro-level socioeconomic factors affect child mortality levels above and beyond individual-level socioeconomic status, but we do find that the effects of individual-level socioeconomic factors vary as a function of macro-level socioeconomic conditions. Our findings point to the need to consider broader, macro-level socioeconomic forces in order to understand inequalities and trends in child mortality.

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Within the United States and other developed countries, researchers have observed that individuals with higher socioeconomic status benefit from lower rates of morbidity and a longer life expectancy (Robert and House 2003; Kawachi and Kennedy 2002; Antonovsky 1967; Chaplin 1924; Coombs 1941; Villerme 1840; Virchow 1848). This inverse relationship has remained remarkably stable over the past century, in spite of biomedical and public health advances that have increased overall life expectancy and quality of life (Warren and Hernandez 2007; Lynch 2003; Duncan 1996; Pappas et al. 1993; Duleep 1989).

Our paper focuses on Brazil, a developing country with considerable regional inequalities in child mortality. Research examining child mortality has found a similar trend in the SES-health relationship in both developed (Finch 2003; Lynch et al. 2001; Singh and Yu 1996) and developing countries (Sastry 2004; Hanmer, Lensink, and White 2003; Wagstaff 2000). The Brazilian context allows us to test important theoretical claims about the role of macro-level SES in determining child mortality rates and inequalities. We use Brazilian census data from the past thirty years to address three key questions: First, have socioeconomic disparities in child mortality declined? Second, do macro-level socioeconomic factors affect individual mortality above and beyond individual-level socioeconomic factors? Third, does individual-level socioeconomic status matter more or less depending on macro-level socioeconomic factors?

BACKGROUND

In response to the historically consistent inverse relationship between SES and health, scholars in public health and sociology have recently begun to emphasize the need to contextualize health inequality research within broader macro-social factors (Lutfey and Freese 2005; Mackenbach et al. 2003; Robert and House 2000; Hayward et al. 2000; Link and Phelan 1995). While public health and biomedical research has been successful in identifying individual risk factors for mortality, macro-social factors represent "social conditions" that contribute to persistent health inequalities (Link and Phelan 1995). Link and Phelan (1995) and others (Robert and House 2000) contend that risk factor epidemiology falls short because it fails to consider macro-level socioeconomic factors.

Using mortality in the United States as an example, Link and Phelan (1995) argue that social conditions—such as socioeconomic status, income and education—represent a fundamental cause driving the gradient. That is, individuals with higher SES will benefit from lower mortality rates irrespective of changing health risk factors. Link and Phelan (1995) explain that higher SES individuals have more power, prestige, knowledge and money to avoid deleterious health effects. For instance, in developed countries, obesity has replaced tuberculosis as a leading health risk factor, but individuals with higher SES still enjoy lower mortality rates. When public health and biomedical advances identify risk factors, individuals with higher SES are able to avoid them and adopt protective strategies (Link and Phelan 2000).

Evidence of long-term trends in socioeconomic status and health lend support to the "fundamental cause theory" and the argument that health inequality research needs to contextualize within macro-social factors. Previous research in the United States has found that trends in socioeconomic status measured as income (Duleep 1989; Duncan 1996; Pappas, Queen, Hadden, and Fisher 1993), education (Crimmins and Saito 2001; Lauderdale 2001; Lynch 2003; Pappas, Queen, Hadden, and Fisher 1993) and occupation (Steenland, Hu and Walker 2004) have either increased or remained steady in the latter part of the 20th century. Research in Britain tends to use social class as a measure of SES, but the results are consistent with research in the United States–trends in social class and mortality have either remained steady or increased (Antonovsky 1967; Black, Morris, Smith and Townsend 1982; Marang-van de Mheen, Smith, Hart and Gunning-Schepers 1998; Wilkinson 1986). Evidence also suggests that these trends extend to the early 20th century (Lauderdale 2001; Lynch 2003; Warren and Hernandez 2007).

Health inequality research has elaborated further the role of macro-social and individual risk factors, and has emphasized that they constitute a spectrum of influences on mortality (Berkman and Macintyre 1997; McKinley and Marceau 2000; Robert and House 2003). However, the question about the influence of macro-social factors remains: How do macro-social factors affect individual-level mortality? A central goal of our paper is to understand the roles of both macro- and individual-level SES factors for child mortality. We ask whether it is necessary to contextualize research about the SES gradient in morbidity and mortality within larger macro-social factors. More specifically, how do macro-level SES factors affect mortality, independent of individual-level SES factors? If they do not affect mortality independent of macro-level factors, do they condition individual-level SES? Quite simply, for a given individual, does their mortality depend on individual-level SES *and* the larger macro-level SES of the area in which they live?

We have three main goals for this paper. First, we document trends in the relationship between SES and child mortality from 1970 to 2000 using four Brazilian censuses. Simply, did

SES-child mortality inequalities increase, decrease or remain the same in Brazil over this time period, which was characterized by rapid but geographically uneven economic development? Our second goal is to understand the effect of macro-level SES factors and individual-level SES factors independently: do macro-level SES factors matter above and beyond individual-level SES factors? To do this, we compare states with different levels of SES, and ask whether state-level SES is associated with mortality above and beyond individual-level SES. We use mothers' individual-level SES measures, such as maternal literacy, as individual-level SES measures. Finally, we ask, do macro-level SES factors condition the effects of individual-level SES factors on child mortality?

Historical Demographic and Economic Trends in Brazil

Regional economic development in Brazil has been unequal since the colonial period, due in large part to the rise and fall of its primary exports (Skidmore 1984; Lovell 2000). Over the past four centuries, first the Northeast and then the Southern regions have played host to sugar, gold, diamond, and coffee export markets (Levine 1999; Lovell 2000; see Figure 1). The shift in exports altered the population structure, as the central and southern regions became the primary locations of economic development over the centuries (Skidmore 1999:21; Lovell 2000:278). By the 19th century, coffee, the final major export industry shifted southward, resulting in an unequal distribution of economic development favoring the southern regions (Skidmore 1999:50).

The trend of unequal regional economic development in Brazil continued throughout the 20th century (Skidmore 1999), as the southern regions enjoyed economic progress during the period of Brazilian industrialization. Shifting demographic trends further amplified these inequalities in economic development, as the Northeast region witnessed significant outmigration. European immigration and settlement in the Southeast states created further segregation in regional development between 1820 and 1930 (Lovell 2000).

These inequalities in regional economic development during the country's first centuries set the stage for broadening inequalities during the Brazilian population boom in the 1940s, 1950s and 1960s, a time when time fertility rates were among the highest in the world (Skidmore 1999:138). This population boom was coupled with a shift to urban life and a trend of increasingly unequal economic development. Throughout these decades, the state of São Paulo emerged as the continual economic winner and other regions remained largely underdeveloped. An economic boom followed the population boom (1968-1982), which favored the already privileged southern and central regions (Skidmore 1999:181).

Current Trends in Brazilian Economic Inequality

At the national level change or growth in economic development is typically assessed by measuring gross domestic product (Schofer, Ramirez, and Meyer 2000; Barro 1991). In early studies of economic development and mortality, Preston (1975) focused on national income per person as a measure of economic development. Regional level growth in economic development is more difficult to assess, again primarily due to lack of sufficient data to assess trends over time. Another complicating factor in research on Brazil is the unstable currency, which has changed significantly over the past fifty years. These currency changes create problems when research focuses on trends in income.

Nonetheless, some studies have attempted to assess trends in economic development in Brazil using income (Azzoni 2001; Ferreira 2000). Azzoni (2001) and Ferreira (2000) found that the Theil's inequality index—in this case a measure of income inequality between Brazilian states—dropped quickly between the mid-seventies and mid-eighties, and then leveled off. Ferreira (2000) used GDP as a measure of economic development in Brazil and found that regional shares of GDP became more equal between 1970 and 1995, but the Southeast still benefited from an uneven 57.2% of the national GDP in 1995. Population density is higher in this region, but in comparison to the regional share of GDP a smaller percent of the population resides in the Southeast (42.7%), which takes up only 10.8% of the total land area in Brazil. In contrast, 28.6% of the population lived in the Northeast in 1995, but their share of GDP was only 13.7% (Ferreira 2000).

Individual-level Risk Factors

A considerable amount of current research has focused on Brazilian SES-child mortality inequalities, and has used individual-level measures of SES. Previous research based on the Brazilian census found that indirect estimates of infant mortality rates vary by region (Victora and Barros 2001), and Brazilian epidemiological surveys have indicated that short-term trends in SES-child mortality in the 1980s and 1990s remain (Victora et al. 2000). Similar to research on the influence of individual-level SES and child mortality in the United States (Finch 2003), mother's education affects child survival (Goldani et al. 2002).

Additional research specifically focused on the state of São Paulo indicated that mother's education, and other individual-level social factors, have an effect on child mortality rates (Sastry 2004). Thomas, Strauss and Henriques (1989) found that parents' education remained a significant predictor of child mortality after controlling for household income. In a uniquely designed study, Sastry (1996) considered both the effect of individual- and household-level influences and community level influences on child survival in Brazil. The key results of this study indicate that the effect of household-level socioeconomic status characteristics vary by region (Sastry 1996: 226), and operate differently for individuals of separate socioeconomic statuses. We build on this research by considering macro-level factors at the state-level. Our research considers the effect of these macro-level factors net of individual-level factors, and considers how these macro-level factors may condition individual-level SES to affect child mortality.

Hypothesized Effect of Socioeconomic Status on Child Mortality

Brazilian economic and demographic trends over the past centuries have set the stage for the current inequalities in economic development, and previous research has documented child mortality inequalities by region. We anticipate that child mortality will be higher among the least economically developed regions. Specifically, with regard to our first question, we hypothesize that SES-child mortality inequalities will decline between 1970 and 2000, but individuals in states in the South and Southeast regions will have lower rates of child mortality compared to individuals residing in states in other regions.

Our final questions address the distinction between individual- and macro-level (state) effects on child mortality. In our second question we ask whether *state-level SES* factors are important beyond *individual-level SES* factors: does socioeconomic context matter independent of individual-level SES. We hypothesize that these state-level SES factors will influence individual child mortality rates. Finally, we ask whether individual-level SES matters more (or less) depending on macro-level SES: we hypothesize that individual-level SES will vary depending on state-level SES.

DATA

We use Brazilian census data from four time points (1970, 1980, 1991, and 2000) from the Integrated Public Use Microdata Series-International (IPUMS-International; Minnesota Population Center 2006). The Brazilian census is administered by the Instituto Brasileiro de Geografia e Estatística, and the IPUMS-International data are harmonized versions of these Brazilian census samples. For our purposes, only the 1970-2000 censuses were usable because they contain all necessary child mortality, socioeconomic status, and geographic variables in the same format for each census year. The 1970-2000 Brazilian IPUMS-International censuses are nationally representative population samples and the (unweighted) decennial IPUMS samples ranged in size from 3,001,439 to 10,136,022 individuals between 1970 and 2000. Across the four years of census data our analyses include only the 4,424,222 women aged 15-49 who have ever given birth. In Table 1, we present sample sizes and descriptive statistics about the mean number of children born and surviving for women in each region, by year. Overall, the mean number of children born and died has decreased between 1970 and 2000 within each region.

As a measure of child mortality, we used a child mortality index (CMI; Sastry 2004) proposed by Trussell and Preston (1982), and we necessarily restrict our analysis to mothers only. The CMI is a ratio of the number of children died to the number of children born, but it corrects for changes in fertility. Thus, a lower child mortality index indicates fewer child deaths. Deriving the child mortality index is a two-step process, which involves first calculating indirect estimates of child mortality by five-year age group of mother, and then creating an individual CMI for each mother in the sample (Wood and Lovell 1990; Sastry 2004). We use information about number of children ever born and number of children surviving to produce indirect estimates of child mortality at age *a* (Brass 1975; Brass and Coale 1968; Trussell 1975):

$$q_a = k_j \times D_j$$

where D_j refers to the proportion of children dead among women in age group *j* and k_j is an age-specific multiplier[1] that depends on indices of the age pattern of fertility. Mothers' five-year age groups range from 15–19 to 45–49, and we use the Coale-Demeny West models to calculate these indirect estimates. In the next step, we calculate the child mortality index for each individual mother, which is based on the ratio of the number of children who died to the number of children born:

$$M_{ij} = \frac{D_i}{N_i \times q_{sa} / k_i}$$

where M_{ij} is the child mortality index for the *i*th mother in the *j*th group, D_i is the number of children who died for mother *i*, N_i is the number of children ever born for each mother, k_i is the coefficient for mother *i* (from previous equation), and q_{sa} is the "standard" mortality function[2] (Trussell and Preston 1982).

The mean of CMI in our pooled sample was 0.87, which closely replicates the CMI of Brazilian mothers in similar research (Wood and Lovell 1990). The bottom panel of Table 1 shows mean CMI by region and census year; these values are also depicted in the top panel of Figure 2. CMI—and this child mortality—was highest in the North and particularly in the Northeast and lowest in the South in each year. The bottom panel of Figure 2 depicts the

[1] The k_i multiplier is calculated using coefficients (a_i, b_i and c_i) based on the age pattern of mortality, and we chose to use the Coale-Demeny West model values. Therefore, k_i is calculated as $k_i = a_i + b_i(P_1/P_2) + c_i(P_2/P_3)$ where P_1, P_2 and P_3 represent the ratio of children ever born to total number of women in the three youngest five-year age groups. See Wood and Lovell (1990) for a more detailed example.
[2] Similar to Wood and Lovell (1990), we chose to use the Coale-Demeny level 19 for standard mortality function values (q_{sa}).

difference between mean CMI in each region and mean CMI in the South. Despite the fact that CMI is higher in regions other than the South and Southeast, the absolute size of those differences have been declining over time.

Socioeconomic Status

For our analysis we consider the effect of individual and state level measures of socioeconomic status on child mortality for Brazilian mothers between the ages of 15-49. We include all states with available data from 1970-2000 (n = 107 state-years[3]). At the individual-level, the IPUMS-International sample includes socioeconomic status measures such as access to a car, electricity, water supply (indoor piped water), or sewage, and ownership of a refrigerator, television, or radio. Such indicators have been used as measures of socioeconomic status in previous studies of child mortality (Razzaque, Alam, Wai and Foster 1990; Brockerhoff 1990; Guo and Grummer-Strawn 1993). These variables were used to create an individual-level socioeconomic status index, which is a summed value of access to electricity, water supply, sewage, car, and ownership of a refrigerator, television or radio ($\alpha = 0.85$). In addition to this SES index variable, we consider literacy and education level. Mothers are considered literate if they are able to both read and write. Educational-level is divided into four categories: pre-primary, primary, secondary, and post-secondary. Finally, we include an indicator of whether mothers lived in an urban or rural area.

At the individual level, we include indicators of each mother's literacy, educational attainment, SES index score, and urban/rural residence. Living in an urban environment has been shown to have varying impacts on child mortality in Brazil above and beyond household or

[3] Due to administrative reclassification, information for all states was not available for a small number of states for all four censuses between 1970 and 2000. We chose to use any available information about states.

maternal socioeconomic factors (Sastry 1997). At the state level, we have computed the mean SES index score across *all* individuals in each state within each year (not just across 15 to 49 year old mothers).

We show the distribution of the individual-level SES measures by region and year in Table 2. In each year, Brazilian mothers in the South and Southeast were more frequently literate. Mothers in the Southeast had completed more schooling and had higher SES index scores in each year. However, as shown in Table 2 literacy rates, educational attainment, and mean SES index scores increased dramatically over time in each region. What is more, as shown in the bottom panel of Figure 3, the difference between the Southeast and other regions in mean SES index scores declined over time.

Descriptively, then, three important patterns are evident: First, mothers in the South and Southeast experienced less child mortality and more advantaged socioeconomic circumstances. Second, child mortality rates declined and socioeconomic circumstances improved among women in all regions over time. Third, mean differences in child mortality and SES index scores between women in advantaged regions and other regions declined over time. These broad patterns of declining regional inequalities in child mortality and socioeconomic status are of central interest to us: Pursuant to our second and third research questions, do macro-level socioeconomic conditions affect individual-level child mortality above and beyond individual-level socioeconomic conditions?

METHOD

We address our three core research questions using a multilevel (or hierarchical) linear model.[4] Individuals – restricted to mothers in this analysis – serve as the unit of analysis for level one; at level two, the unit of analysis is state-years created by cross-classifying states by the four years in which census data were collected. As described above, our analysis sample includes 4,424,222 individuals at level one. At level two, our sample size is 107 (four time points times about 25 states in each year; the number of states differs slightly across years due to administrative reclassifications). The level one (or individual-level) model is:

$$\begin{aligned} \text{CMI} = \beta_0 &+ \beta_1(\text{Secondary}) + \beta_2(\text{Post-Secondary}) + \beta_3(\text{Literate}) \\ &+ \beta_4(\text{SES}) + \beta_5(\text{Urban}) + r \end{aligned} \tag{1}$$

The level two (or state-year-level) models are:

$$\begin{aligned} \beta_0 = \gamma_{00} &+ \gamma_{01}(\text{SES}) + \gamma_{02}(\text{North}) + \gamma_{03}(\text{Southeast}) + \gamma_{04}(\text{South}) + \gamma_{05}(\text{Midwest}) \\ &+ \gamma_{06}(\text{Year}) + \gamma_{07}(\text{Year* North}) + \gamma_{08}(\text{Year* Southeast}) + \gamma_{09}(\text{Year* South}) \\ &+ \gamma_{010}(\text{Year* Midwest}) + \mu_0 \end{aligned} \tag{2}$$

$$\beta_1 = \gamma_{10} + \gamma_{11}(\text{SES}) + \gamma_{12}(\text{Year}) + \mu_1 \tag{3}$$

$$\beta_2 = \gamma_{20} + \gamma_{21}(\text{SES}) + \gamma_{22}(\text{Year}) + \mu_2 \tag{4}$$

$$\beta_3 = \gamma_{30} + \gamma_{31}(\text{SES}) + \gamma_{32}(\text{Year}) + \mu_3 \tag{5}$$

$$\beta_4 = \gamma_{40} + \gamma_{41}(\text{SES}) + \gamma_{42}(\text{Year}) + \mu_4 \tag{6}$$

$$\beta_5 = \gamma_{50} + \gamma_{51}(\text{SES}) + \gamma_{52}(\text{Year}) + \mu_5 \tag{7}$$

The model specifies that a mother's CMI value is a function of (1) her own education, their own literacy, her own score on the SES index, and whether she lives in an urban area

[4] We began by running an unconstrained model to estimate the intra-class correlation (0.087), which indicates that approximately 9% of the variability of the child mortality index is associated with differences between state-years.

(Equation 1) as well as (2) the mean SES of the state-year in which she lives, the year in which she is observed, and the region of the country in which she lives (Equation 2). Note that Equation 2 allows the effects of region and year on CMI to interact, such that regional differences in CMI may change over time. The model further specifies—in Equations 3 through 7—that the individual-level effects of education, literacy, SES index and whether they lived in an urban environment vary across state years as a function of (1) the mean SES of the state-year and (2) year.

How does this model address our three research questions? First, what evidence does the model provide regarding changes over time in the association between socioeconomic status and child mortality? This question is addressed by the γ_{12}, γ_{22}, γ_{32}, and γ_{42} terms, which indicate change over time in the effects of education, literacy, and the SES index, respectively. Second, what evidence does the model provide about whether macro-level socioeconomic factors matter above and beyond individual-level socioeconomic factors? This question is addressed by the γ_{01} term, which indicates the impact of state-year means of the SES index on CMI (net of individual-level education, literacy, and SES index scores). Third, what evidence does the model provide regarding whether the effects of individual-level socioeconomic factors on CMI vary across levels of aggregate socioeconomic well-being? This question is addressed by the γ_{11}, γ_{21}, γ_{31}, and γ_{41} terms, which indicate whether the effects of education, literacy, and SES index scores, respectively, vary as a function of state-year means of the SES index.

We experimented with quadratic terms for the year variables, but found that they did not improve the fit of the model. We also experimented with adding a state-year-level measure of the proportion of individuals who were literate, but this measure was collinear with the state-year-level mean SES index. Finally, note that the model is estimated with grand-mean centering at both the individual and the state-year level.

RESULTS

Descriptive Results

The descriptive statistics we present in Table 3 provide a brief summary of the measures we use in our multilevel model. At the individual-level, there were 4,424,222 women who had at least one child. Among these mothers, the majority (60%) had completed only primary education, and 80% were literate. The mean socioeconomic index value for these mothers was 4.48 (range 1-7). At the state-level, the mean socioeconomic index value was 3.53.

In Figures 2 and 3 we show the mean CMI and SES distributions by region and year. As reported earlier, CMI decreased over time, and CMIs are the highest for the Northeast compared to other regions. Panel B in Figure 2 demonstrates that the absolute difference in child mortality between the South and other regions decreased between 1970 and 1991. In Figure 3, we show the mean SES index by region and year, which has increased over time. Again, the absolute difference in mean SES index between the South and other regions has decreased during this period.

Multilevel Model Results

The results our multilevel model described above are presented in Table 4. The terms for region (γ_{02}-γ_{05}) and year (γ_{06}) from Equation 1, along with the terms for the interaction between region and year (γ_{07}-γ_{010}) reproduce our descriptive findings above about regional differences and changes over time in CMI. Child mortality has declined over time and it is highest in the Northeast. As expected, individuals with more education, greater literacy, and higher SES index scores experience less child mortality.

How has the association between socioeconomic status and child mortality changed over time? Coefficients γ_{12}, γ_{22}, and γ_{32} are not statistically significant, which suggests that the effects of education and literacy have not changed over time. However, coefficient γ_{42}—which expresses change over time in the effect of the SES index on child mortality—is statistically significant and positive. Higher SES index scores are associated with lower child mortality, but the result for γ_{42} indicates that this effect has declined very modestly over time. We show the association between mothers' SES index and child mortality by year in Figure 4. Given the very high means of the SES index in recent years (relative to its maximum value), it may not be surprising that the SES index has become somewhat less predictive of child mortality.

Do macro-level socioeconomic factors matter for child mortality above and beyond individual-level socioeconomic factors? Coefficient γ_{01} is not statistically significant, indicating that state-year mean SES index values are not associated with child mortality above and beyond individual-level socioeconomic factors. Among mothers with equivalent educational backgrounds and SES resources, those living in areas in which average SES scores are higher experience no more or less child mortality.

Do the effects of individual-level socioeconomic factors on child mortality vary across levels of aggregate socioeconomic well-being? Coefficients γ_{31} and γ_{41} are not statistically significant, indicating that state-year mean SES levels do not condition the effects of individual-level literacy or SES index on child mortality. In contrast, coefficients γ_{11} and γ_{21} are statistically significant. Completing secondary or post-secondary education attainment is associated with lower levels of child mortality. However, this effect is smaller in magnitude as state-year mean SES index scores increase. In Figure 5, we show the relationship between completing post-secondary education and child mortality rate by year. Education certainly matters for child mortality, but it matters more in state-years in which mean SES levels are low and it matters less in state-years in which mean SES levels are high.

Discussion

We have attempted to delineate the effects of macro- and individual-level socioeconomic factors on child mortality in Brazil between 1970 and 2000. To do this, we addressed three main questions. First, have socioeconomic disparities in child mortality declined? Second, do macro-level socioeconomic factors matter above and beyond individual-level socioeconomic factors? Third, does individual-level socioeconomic status matter more or less depending on macro-level socioeconomic factors? Most, but not all, of our results support our hypotheses.

With regard to our first question, our descriptive and multi-level models indicate that the Northeast region has the highest child mortality index in comparison to the other regions. Indeed, our descriptive results indicate increasing disparities in CMI in the North and Northeast compared to the South. Given the history of unequal regional economic development, we expected these regional disparities in child mortality. When we considered the impact of our SES measures on these CMI trends, we found that the effect of education and literacy on CMI did not change over time; however, we did find that the effect of SES index has declined slightly over the thirty year span. Over this period, mean SES index in each region has increased steadily (see Figure 3), which may explain why our SES index has less of an effect on CMI over time.

Our next result, which addressed our second question, contradicted our hypothesis. We found that the macro-level state-year mean SES index was not associated with individual CMI after controlling for individual-level SES. This result did not support our hypothesis that macro-level SES matters above and beyond individual-level SES. For mothers of the same individual-level SES, the state- or macro-level SES is not associated with their child mortality index. These results indicate that macro-social factors, measured as state-level SES, do not drive child mortality alone.

In our final results, we find that the mean state-level SES index does condition the effect of maternal education on child mortality. We find that having more education seems to matter most when mothers live among others with fewer economic resources. One interpretation is that people with less education experience less child mortality if they live in areas in which there is more general prosperity and, perhaps, better developed public health systems and greater access to health care service. In any case, these results make clear that the benefits that mothers accrue from their own education are conditioned by the macro-socioeconomic circumstances surrounding them.

There are a few limitations with our study. Our measure of SES at the macro-social level, mean SES index, may not be the best measure of macro-level socioeconomic status. Indeed, macro-level education measures may be associated with child mortality. Ideally, we would like to use income as an additional measure of socioeconomic status, but changes in the Brazilian currency do not allow these comparisons over time. Two final limitations involve changing fertility patterns and child mortality in Brazil between 1970 and 2000, within regions. Table 1 shows that women have and lose fewer children over time and these rates vary between regions. One assumption of the child mortality index (Sastry 2004) is that fertility rates and child mortality have been constant in the recent past. We cannot be as confident about the changing child mortality rates between 1970 and 2000, and we note this as a violation of the assumption of our indirect estimate of child mortality.

Conclusion

A substantial amount of research has documented the inverse relationship between socioeconomic status and health (Robert and House 2003; Kawachi and Kennedy 2002; Antonovsky 1967; Chaplin 1924; Coombs 1941; Villerme 1840; Virchow 1848), measured in a variety of ways over long periods of time. In response, health inequality researchers have sought to explain this long-term trend by contextualizing research within broader socioeconomic factors (Link and Phelan 1995). In this paper we attempt to distinguish between the effects of macro- and individual-level SES on child mortality.

Our results indicate that child mortality has declined in all regions, but the South and Southeast have consistently lower child mortality indices. As expected, regions with lower economic development had higher rates of child mortality. However, in contrast to our hypothesis, macro-level SES did not affect CMI above and beyond individual-level SES. This finding may be due, in part, to our conceptualization of SES at the macro-level. Still, when we considered whether individual-level education varied by state-level SES, we found that maternal education matters more when the mean state-level SES is lower.

Our attempt to delineate the effects of macro- and individual-level socioeconomic factors on child mortality has produced mixed results. At the regional-level, we found declining inequalities in child mortality over time. At the state-level, we found that macro-level SES does not affect child mortality among mothers of with same individual-level SES. Nevertheless, we did find that the effect of individual-level education varies by macro-level SES. Taken together, these results indicate that it is important to distinguish between the effects of macro- and individual-level socioeconomic factors on child mortality.

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Table 1. Sample Size and Child Birth/Death Rates, by Region and Year

	North		Northeast		Southeast		South		Midwest	
	$\bar{x}$ or %	(s.d.)	$\bar{x}$ or %	(s.d.)	$\bar{x}$ or %	(s.d.)	$\bar{x}$ or %	(s.d.)	$\bar{x}$ or %	(s.d.)
Sample Size										
1970		25,322		197,983		304,775		124,987		37,469
1980		43,150		249,043		428,081		158,535		60,525
1991		80,575		330,813		562,166		211,600		90,517
2000		108,291		340,302		702,016		249,438		118,636
Children Ever Born										
1970	5.01	(3.31)	5.42	(3.82)	4.10	(2.99)	4.33	(3.04)	4.64	(3.17)
1980	4.35	(3.02)	4.84	(3.56)	3.36	(2.55)	3.49	(2.59)	3.94	(2.81)
1991	3.86	(2.77)	3.97	(3.04)	2.76	(1.91)	2.74	(1.92)	3.01	(2.06)
2000	3.10	(2.24)	2.86	(2.12)	2.36	(1.48)	2.35	(1.46)	2.47	(1.50)
Children Surviving										
1970	4.20	(2.70)	4.15	(2.82)	3.51	(2.42)	3.81	(2.58)	4.01	(2.64)
1980	3.90	(2.67)	3.93	(2.78)	3.03	(2.22)	3.20	(2.31)	3.54	(2.46)
1991	3.53	(2.40)	3.42	(2.41)	2.58	(1.67)	2.57	(1.70)	2.79	(1.80)
2000	2.93	(2.03)	2.62	(1.78)	2.27	(1.36)	2.27	(1.37)	2.37	(1.38)
Child Mortality Index [a]										
1970	1.74	(2.87)	2.42	(3.36)	1.36	(2.64)	1.20	(2.47)	1.40	(2.62)
1980	1.15	(2.84)	1.97	(3.43)	1.05	(2.82)	0.86	(2.47)	1.06	(2.69)
1991	0.77	(1.88)	1.18	(2.36)	0.52	(1.62)	0.48	(1.57)	0.59	(1.72)
2000	0.49	(1.74)	0.65	(1.99)	0.32	(1.46)	0.28	(1.36)	0.34	(1.48)

Note: Sample restricted to women between the ages of 15 and 49 who have given birth to at lest one child and who had no missing data on variables in analyses. See text for description of measures. Figures based on weighted data.

[a] As described in the text, the child mortality index can only be computed for women who have given birth to at least one child.

Table 2. Individual-Level Literacy, Educational Attainment, and SES by Region and Year

	North		Northeast		Southeast		South		Midwest	
	$\bar{x}$ or %	(s.d.)	$\bar{x}$ or %	(s.d.)	$\bar{x}$ or %	(s.d.)	$\bar{x}$ or %	(s.d.)	$\bar{x}$ or %	(s.d.)
% Literate (vs. Not Literate)										
1970	58.7%		41.8%		71.4%		71.3%		59.4%	
1980	69.1%		53.2%		81.8%		83.2%		73.5%	
1991	77.9%		67.0%		90.3%		91.1%		86.4%	
2000	90.1%		85.5%		95.4%		95.8%		94.1%	
% Completing Secondary or Post-Secondary Education (vs. Pre-Primary or Primary Education)										
1970	2.6%		2.1%		5.8%		3.4%		3.2%	
1980	8.9%		8.1%		12.7%		10.3%		11.3%	
1991	16.9%		17.4%		23.5%		20.5%		23.3%	
2000	29.9%		29.9%		33.8%		30.8%		33.3%	
Mean Individual-Level Socioeconomic Index Score										
1970	1.30	(1.78)	1.04	(1.71)	3.38	(2.42)	2.23	(2.16)	1.55	(2.00)
1980	2.56	(2.28)	2.32	(2.18)	4.89	(2.02)	4.14	(2.25)	3.16	(2.33)
1991	3.25	(2.26)	3.32	(2.19)	5.55	(1.47)	5.23	(1.63)	4.56	(1.88)
2000	4.47	(1.89)	5.04	(1.42)	6.07	(0.94)	5.91	(1.07)	5.41	(1.24)

Note: Sample restricted to women between the ages of 15 and 49 who have given birth to at lest one child and who had no missing data on variables in analyses. See text for description of measures. Figures based on weighted data.

Table 3. Descriptive Statistics for Measures Used in Multivariate Models

	Min.	Max.	$\bar{x}$ or p	Std. Dev.
Individual-Level Variables (n = 4,424,222)				
Child Mortality Index	0.00	18.28	0.87	(2.30)
Pre-Primary or Primary Education (Proportion)	0.00	1.00	0.80	
Secondary Education (Proportion)	0.00	1.00	0.15	
Post-Secondary Education (Proportion)	0.00	1.00	0.05	
Literate (Proportion)	0.00	1.00	0.81	
Urban Resident	0.00	1.00	0.77	
Socioeconomic Index	0.00	7.00	4.48	(2.28)
State-Level Variables (n=107)				
Socioeconomic Index	0.52	6.24	3.53	(1.57)
Region: North (Proportion)	0.00	1.00	0.24	
Region: Northeast (Proportion)	0.00	1.00	0.35	
Region: Southeast (Proportion)	0.00	1.00	0.16	
Region: South (Proportion)	0.00	1.00	0.11	
Region: Midwest (Proportion)	0.00	1.00	0.14	
Year (0=1970, 30=2000)	0.00	30.00	15.39	(11.31)
Year x Region: North	0.00	30.00	3.90	(8.88)
Year x Region: Northeast	0.00	30.00	5.22	(9.78)
Year x Region: Southeast	0.00	30.00	2.28	(7.01)
Year x Region: South	0.00	30.00	1.71	(6.15)
Year x Region: Midwest	0.00	30.00	2.28	(7.01)

Table 4. Results from Multilevel Model of Child Mortality Index

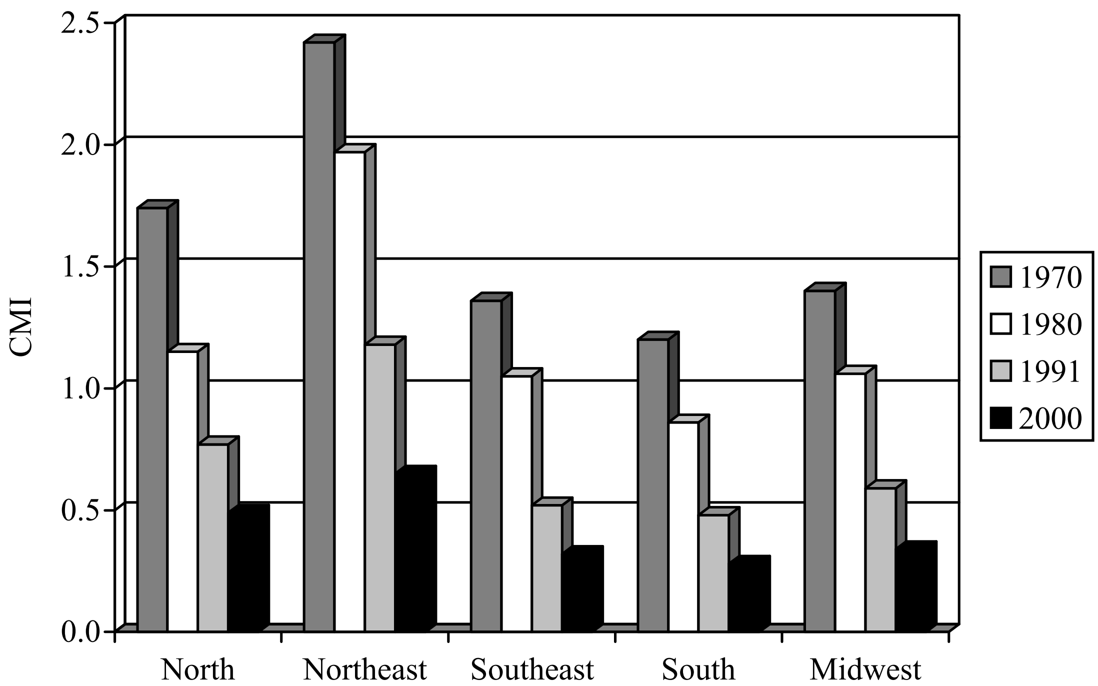
	b	|b/s.e.|	
Equations for Education Slopes ($\beta_{1\text{-}2}$)			
Pre-Primary or Primary Education	(Ref. Category)		
Secondary Education (γ_{10})	-0.34	(19.94)	**
Socioeconomic Index (γ_{11})	0.07	(5.90)	**
Year (0=1970, 30=2000) (γ_{12})	0.00	(0.79)	
Post-Secondary Education (γ_{20})	-0.42	(24.30)	**
Socioeconomic Index (γ_{21})	0.10	(8.09)	**
Year (0=1970, 30=2000) (γ_{22})	0.00	(0.20)	
Equation for Literacy Slope (β_3)			
Literate (γ_{30})	-0.50	(32.16)	**
Socioeconomic Index (γ_{31})	-0.01	(0.46)	
Year (0=1970, 30=2000) (γ_{32})	0.00	(1.26)	
Equation for Socioeconomic Status Slope (β_4)			
Socioeconomic Index (γ_{40})	-0.10	(22.91)	**
Socioeconomic Index (γ_{41})	0.00	(1.15)	
Year (0=1970, 30=2000) (γ_{42})	0.00	(6.66)	**
Equation for Urban Residence (β_5)			
Urban (γ_{50})	0.29	(20.21)	**
Socioeconomic Index (γ_{51})	-0.04	(3.49)	**
Year (0=1970, 30=2000) (γ_{52})	-0.01	(7.39)	**
Equation for Intercept (β_0)			
Intercept (γ_{00})	0.95	(52.51)	**
Socioeconomic Index (γ_{01})	-0.01	(0.67)	
Region: North (γ_{02})	-0.13	(1.73)	
Region: Northeast	(Ref. Category)		
Region: Southeast (γ_{03})	-0.42	(5.76)	**
Region: South (γ_{04})	-0.51	(7.02)	**
Region: Midwest (γ_{05})	-0.33	(5.16)	**
Year (0=1970, 30=2000) (γ_{06})	-0.03	(9.42)	**
Year x Region: North (γ_{07})	0.00	(0.33)	
Year x Region: Northeast	(Ref. Category)		
Year x Region: Southeast (γ_{08})	0.01	(2.94)	**
Year x Region: South (γ_{09})	0.01	(3.67)	**
Year x Region: Midwest (γ_{010})	0.01	(2.50)	*

Note: ** = p < 0.01; * = p < 0.05. All variables are grand-mean centered.

Figure 1. Map of Brazilian Regions

Figure 2. Child Mortality Index (CMI) in Brazil, 1970-2000, by Region and Year

Panel A: Mean CMI by Region and Year



Panel B: Difference in CMI for Each Region and CMI for the South, by Year

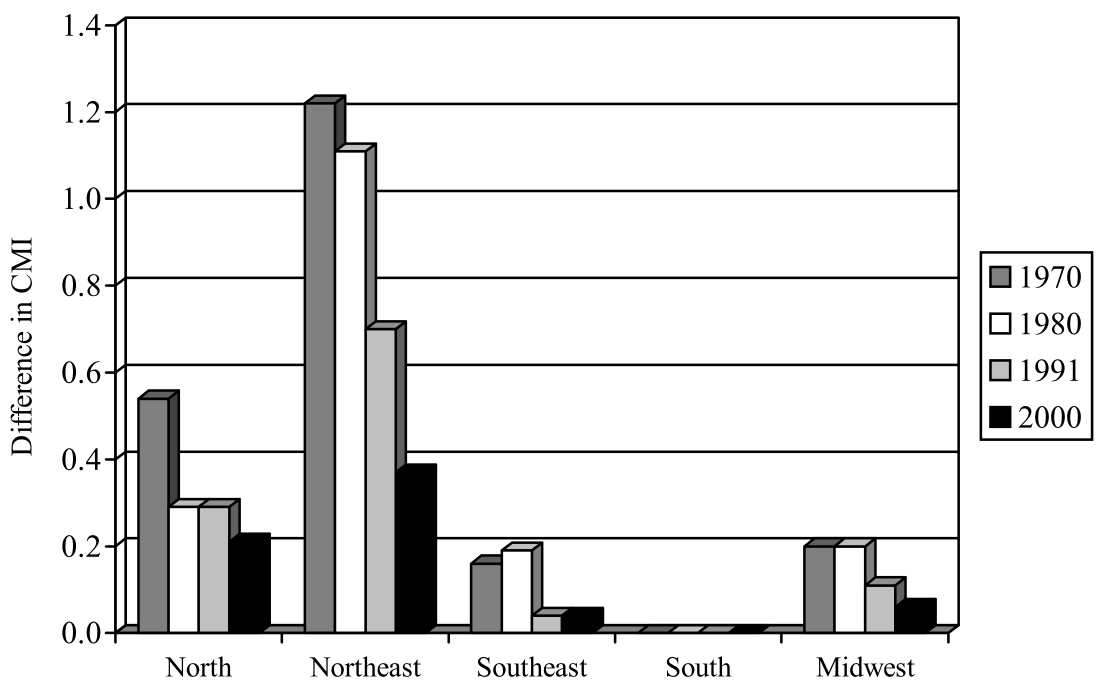
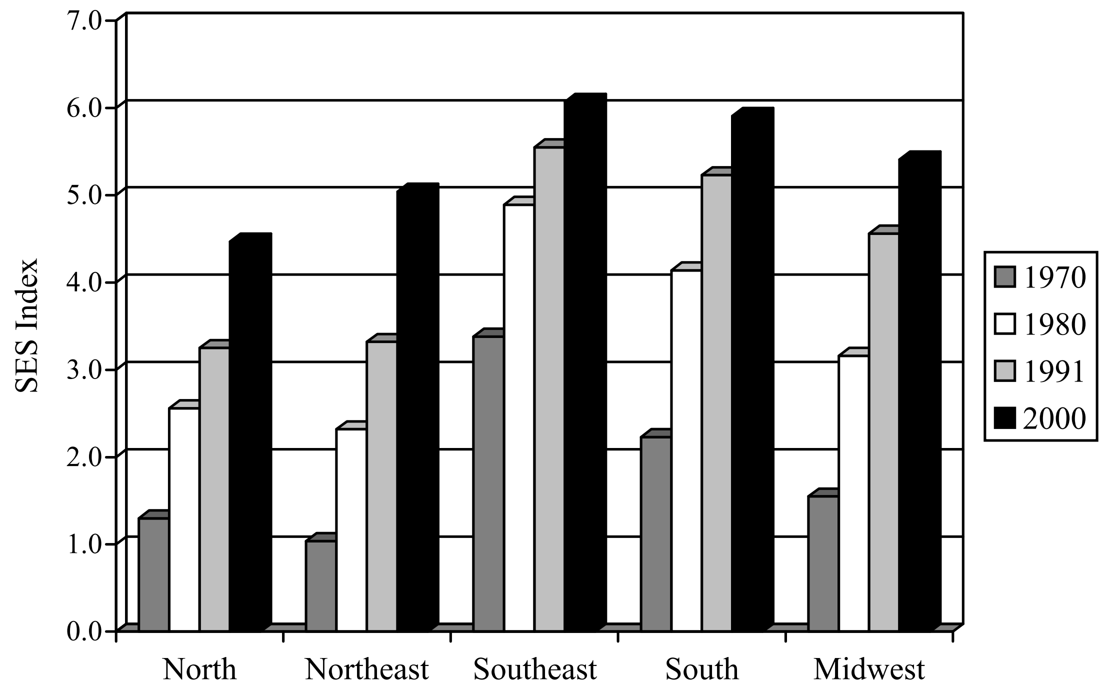


Figure 3. Socioeconomic Status (SES) Index in Brazil, 1970-2000, by Region and Year

Panel A: Mean SES Index by Region and Year



Panel B: Difference in SES Index for Each Region and SES Index for the South, by Year

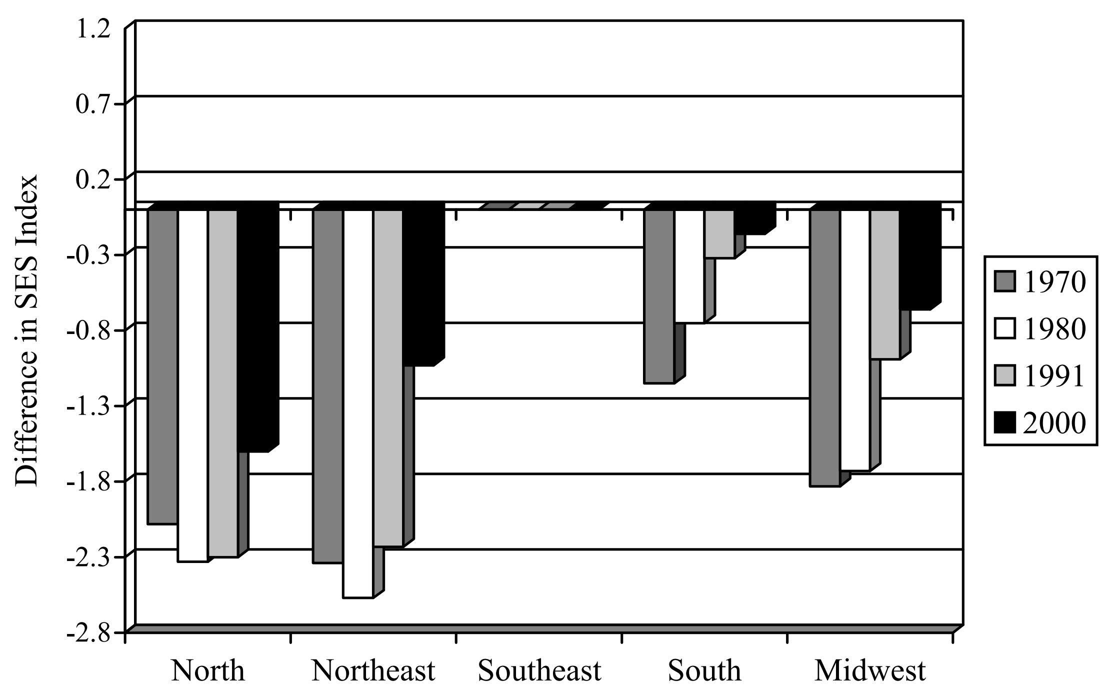


Figure 4. Individual-Level SES and Child Mortality by Year

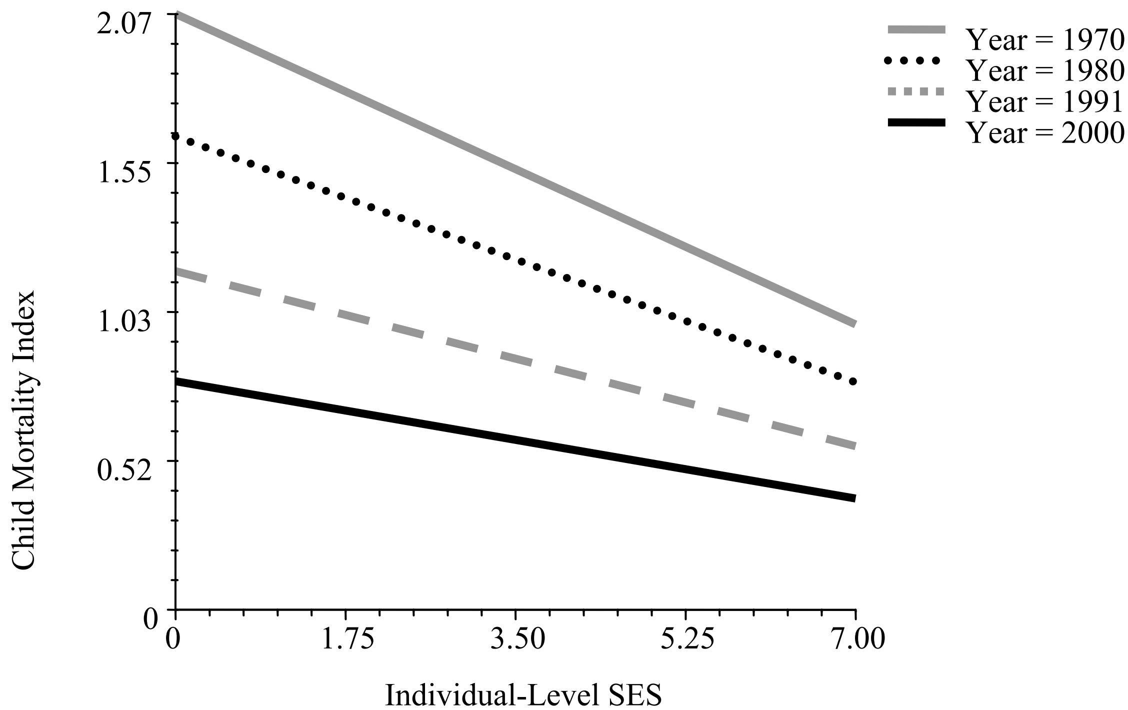


Figure 5. Post-Secondary Education and Child Mortality by Mean State-Year SES