Measuring Educational Differences in Mortality among Women Living in Highly Unequal Societies with Defective Data: the Case of Brazil

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Abstract

Social and economic inequalities in health and mortality have been widely examined around the world. These differentials have been studied for both sexes, but the relationship among women remains more unclear. Measuring SES differentials in female mortality is even more difficult in developing countries due to the lack of reliable data. Brazil is a good example of a very unequal society where SES disparities in adult mortality remain unknown. Inspired on the orphanhood method, this study develops a new methodology that combines individual level data on the survival and the education of the mothers of participants of a household survey collected in 1996 (Living Standards Measurement Study - PPV) to examine how mortality among adult women varies by level of education in Brazil. Our results show that the differences by educational levels are not trivial at all: mortality is about two to five times higher among women with no schooling compared to women with 9+ years of schooling. We expect our method to be helpful for other countries with defective data.

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Introduction

It has been extensively showed that individuals with lower educational levels, lower income or occupational status, have lower chances of survival and higher morbidity rates than individuals with higher socioeconomic status (Preston & Taubman, 1994; Goldman, 2001; Cutler et al., 2005). This association extends across all the distribution of socioeconomic variables, also within the highest social groups, defining what researchers call as social "gradient" in health and mortality (Adler et al., 1994).

The study of the association between adult mortality and socioeconomic status (SES) is of great importance to understand the causes and consequences of health inequality. As Preston and Taubman (1994) pointed out, examining inequality is important in itself, as societies are especially interested in knowing about the distribution of wellbeing. Also, looking at health inequalities has brought clues about the origin and causes of some diseases. Finally, studying differentials of mortality by social groups allows one to identify which groups have higher risks of mortality and morbidity and define better and more focused public health policies.

In many developed countries, particularly in the U.S., a variety of studies have shown great mortality and health differences by income, education and race (Preston & Taubman, 1994; Rogers et al., 2000; Elo & Preston, 1996; Goldman, 2001; Cutler et al., 2005). Similar patterns of inequality have been found in Canada (Wolfson et al., 1993) and in Europe, where there is a great interest in occupational disparities either (Fox, 1989, Macintyre, 1997; Marmot & McDowall, 1986; Kunst et al., 1998).

Although the differentials in mortality by SES may be even more relevant in the developing world, there are other primary data quality issues that preclude us for providing any estimates of

adult mortality differentials by SES. Brazil, for example, is a country where social and income inequality is very high and persistent over time, with a long tradition of studies in this area (Barros, Foguel e Ulyssea 2007). However, we know very little about how the income and social inequalities translate into adult mortality disparities there. The greatest difficulty is to find reliable data to generate robust estimates. Unfortunately, Brazil does not have mortality follow-up studies where a socioeconomic survey is matched with death records such as those conducted in developed countries. In addition, data in Brazil (death records and demographic census) suffers from lack of information and inconsistencies in the report of socioeconomic variables. For example, death records miss, on average, almost one third of the information about education of the deceased and, certainly, missing in this case is not at random.

Despite the data issues, authors have looked for different alternatives to approach the analysis of social disparities in mortality in Brazil. One of the most prominent studies is the one from Wood and Carvalho (1988). The authors used indirect demographic methods based on infant mortality to estimate life expectancy by household income. The results show that people from higher income families can expect to live, on average, 12 years more than people living in families from the lowest income group.

Also, since Brazil is a country with large regional disparities, a great deal of studies has examined mortality differentials by region, associating the latter to a series of macroeconomic socioeconomic variables (Cerqueira & Paes, 1998; Duarte et al., 2002; Messias, 2003; Barros e Ramos, 2006; Ishitani et al., 2006). In general, these studies show that better social indicators, such as better literacy rates, higher urbanization or higher PIB per capita, are highly correlated with lower mortality rates or greater life expectancy. Wood and Carvalho (1988) find that most of the mortality differences by region are, in fact, caused by unequal distribution of income by region, since poorer people tend to live in the less developed regions of the country. A similar pattern applies to rural-urban differences. However, in the 1960s, urban areas offered higher life expectancy only for rich families. Poorer families living in rural areas had an advantage when compared to the same SES groups in the urban sectors, probably due to the less aggressive environment they were exposed to.

Several other studies have included aggregate variables as PIB per capita, literacy rate and quality of infrastructure at a level of neighborhood or local district in the analysis of mortality disparities in an attempt to have approximations of individual characteristics (Drummond & Barros, 1999; Silva et al., 1999; Szwarcwald et al., 1999; Paes-Souza, 2002).

Other authors have ventured in the analysis of differentials mortality at individual level using occupational status data from death records (Duncan et al., 1994; Cordeiro e Silva, 2001). These studies, however, are restricted to very small areas, and analyze only men or do not provide results for each sex since the sample sizes are too small.

In this study we try to fill the gap in the literature by presenting a new methodology to examine educational differences in mortality among women in Brazil using individual data. Extending the idea behind the orphanhood method for adult mortality, our study combines information on the survival and education of mothers, collected from the participants in the 1996 Living Standards Measurement Study (*Pesquisa sobre Padrões de Vida - PPV*). We estimate mortality rates for women at different ages and educational levels. The contribution of this study goes beyond the estimation of SES differences in mortality in a highly unequal society, as we are proposing an alternative method to estimate differences in mortality risk that could be easily applied in other populations with defective mortality data.

Methodology

Data and variables

Data for this study comes from the Living Standards Measurement Study (Pesquisa sobre Padrões de Vida - PPV). PPV provides individual and household level data from 4,940 households located in the two largest regions of Brazil (the Northeast and the Southeast, which comprise about 70% of the Brazilian population). The Brazilian Bureau of Census (IBGE) performed all stages of the survey with the technical and financial assistance of the World Bank.

The PPV collected information on education, health, economic activity, fertility, migration, interhousehold transfers and consumption. The survey also asks about the early life conditions of the participants, including the survival status of their parents at the date of interview, the parents' level of education, their occupational status, and several other demographic and SES variables. We use education as the SES measure because, as discussed before, it is easier to collect and less susceptible to errors, particularly among women. Also, it has been shown that education is related to social status in many different ways (Preston & Taubman, 1994). Educational attainment is correlated with cognitive ability, health-related behaviors, and indicates the quality and amount of access to health information. Further, education is positively associated with occupational status and income, which determines the amount of health goods and services that individuals can purchase (Lleras-Muney, 2005).

The original PPV sample includes 19.409 people of all ages. We exclude 24 individuals for whom the difference between their ages and the mothers' ages was not feasible (more than 55 years). Also, we excluded 91 respondents who were born abroad, because the meaning of educational status may vary across countries. From the 19,294 individuals included in the study, about 22.60% had deceased mothers by the date of the interview.

Mortality rates

The methodology of this study is inspired in the orphanhood method for adult mortality developed by Lotka and Henry and after improved by Brass and Hill (1973). The method relies upon a single question on the survival of the mother. The age of the respondent is used to estimate the time of exposure to the risk of mortality experienced by their mothers. This principle is extended in this study to include information on mother's education and estimate mortality rates for different educational groups of women.

We estimate mortality rates for women by ten-year age groups (20-29 through 70-79) and years of schooling according to three levels of education: No schooling, 1 to 8 years of schooling, (equivalent to primary school), and 9 or more years of schooling (equivalent to secondary school or more). 792 respondents didn't answer the question about mother's educational level. While

they represent a small fraction of the sample (4.1%), missing is not at random, and thus, we include them as a different category of education.

To estimate mortality rates we first estimate the time of exposure to death for all mothers. It corresponds to the time period between the respondents' date of birth (when all mothers were necessarily alive) and the date of death for mothers who died thereafter or the date of the interview for mothers who survived. To assign a maternal age and a date of death we draw an age according to several probability functions of fertility and mortality for Brazil. One of the main problems of the orphanhood method is the assumption of constant patterns of mortality and fertility. We try to avoid potential biases caused by this assumption by using different mortality and fertility functions to generate the age at death and age at maternity according to each period of exposure.

We use discrete historical fertility functions estimated by Horta, Carvalho & Frias (2000) for Brazil to draw the maternal ages. We apply different period fertility functions according to the children's (respondents') date of birth, derived from the reported age in PPV. To assign an age at death we randomly choose ages between the maternal age and the age that the mother would have if she were alive at the time of the interview constrained by one of three distributions of probabilities of death, according to the period of exposure. When the median year of the time of exposure is before 1970, we apply the probabilities of dying from the 1965 Brazilian life table (Carvalho, 1974); when the period of exposure is between 1970 and 1980, we apply probabilities from the 1975 life table (Carvalho e Pinheiro, 1986); and when the median year of the time of exposure is after 1980, we apply the distribution from the 1985 life table (IBGE)[1]. We assume 100 years old as the highest age of survival.

Once we have all the ages assigned we have a new database in a longitudinal structure, where we have the initial date of exposure to the risk of mortality, the final date, and the age and period of each event. Like this, it is easy to calculate the number of person-years lived by each woman

[1] We work with single years of age. Because life tables were constructed in 5-years age groups we use the multipliers of Karup-King (Shryock and Siegel, 1973) to ungroup the age interval. Further, to expand the probabilities of death until age 100 we use a relational model based on the adult mortality function estimated from Himes et al. (1994).

since the date of birth of the respondent. Based in this "new" data, we use a Poisson regression to model the number of death by the time of exposure (person-years):

$$\log\left(\frac{E(deaths)}{\exp osure}\right) = \alpha + \beta_1 \cdot X \quad , \qquad (1)$$

where X is a vector of covariates that includes age and education.

However, although the assignment of the maternal age and the age of death is based on a fertility and mortality pattern, it is still at random. Therefore, to give more confidence to the results derived from the regression we estimate bootstrap coefficients drawing multiple pairs of both ages generating multiple times of exposure to death for each mother. For each set of age pairs for all mothers (maternal age and age of death) is executed a Poisson regression. The bootstrap coefficients are obtained as a mean of all coefficients from each regression. This method gives asymptotic confidence to coefficients, although it reduces the significance of the regression hypotheses.

We estimate three regression models. First, we control only for age. In the second model, we control for age and education. Finally, in the third model, we include an interaction term between age and education. Based on the coefficients of the third model, we present the estimated mortality rates by educational level for three age groups (20-29, 40-49 and 60-69).

The Poisson regression gives us the facility of estimating mortality rates derived from its coefficients controlled by the time exposure to the risk of death. The interaction model permits not only to evaluate differentials of mortality by age and by education, but also, to analyze how differentials by educational status change inside each age group, for example.

We are aware that the errors that usually affect the orphanhood method may also bias our estimates. One source of bias comes from the selection effects in infant and maternal mortality. The method assumes that there is no differential mortality among women with high fertility or with low fertility or no children, which not necessarily is true. At the same time, infant mortality

is higher among children born from mothers who have lower education, leading to an underrepresentation of low SES groups in the sample survey. On the other hand, because of differences in fertility by SES, and since we do not distinguish the siblings in our analysis, we also expect an overrepresentation of the low SES groups in the sample survey. Unfortunately, it is not clear which effect prevails.

Other possible bias of the estimates can come from declaration errors. These errors are originated when orphans report the survivorship status of their adopted mothers instead of the biological ones, or from wrong age declaration of respondents.

Results

Table 1 shows, as an example, the number of deaths and person-years lived by age and level of education for women, after one draw of maternal age and age of death for each mother. As expected, crude death rates increase with age and decrease at higher levels of education. Mothers with missing information on education have the highest mortality rate. Indeed because mother's death may help children forget about her SES status, we would expect a relatively larger number of deaths among the mothers of those who could not remember the mothers' education. We must emphasize however, that missing cases represents only about 4% of the whole sample size, including the deceased and the survivors.

Table 1: Number of deaths, person-years and mortality rates by age and years of schooling, for women in Brazil, 1996.

	Deaths	Person-years	Mortality rates (x1000)
Age			
20-29	127	62324	2.04
30-39	340	117471	2.89
40-49	566	111909	5.06
50-59	802	79925	10.03
60-69	940	47931	19.61
70-79	951	22158	42.92
Years of schooling			
0	2056	190749	10.78
1-8	1173	190723	6.15
9 or over	114	37248	3.06
missing	383	22997	16.65

Source: PPV 1996

Table 2 shows the bootstrap regression coefficients from the Poisson models. In the first model, which controls only for age, all age groups are statistically significant ($p<0.001$) and, as expected, positively related to deaths. Based on the regression coefficients by age groups of this model we estimate a life expectancy at age 20 of 53.0 years and of 48.42 and 57.13 years from both limits of the 95% confidence interval. These results are compared to previous estimates of life expectancy from year 1970, the median year of death in our sample. Carvalho (1974) estimated a life expectancy at age 20 of 49.19 years applying indirect methods based in infant mortality estimates for the year of 1965 and for the Southeast and Northeast region. Our results, controlling only for age, can be considered quite accurate, as the previous estimate of life expectancy is included inside the confidence interval of our estimates, although the confidence interval is quite large, due to the bootstrap method.

In the second Poisson regression model (Table 2), we add educational levels, which are all statistically significant ($p<0.001$). The coefficients for age groups are now slightly smaller, implying that part of the age effect is related to the fact that younger people are more educated. There is clearly a negative relation between education and number of deaths, controlling for age and time of exposure. Again, the missing category shows the highest mortality rates.

In the third model (Table 2) we include interaction effects between age and educational groups, since we want to examine whether education effects are different inside each age group. Not all coefficients for the interaction terms are statistically significant, although they are jointly significant in the majority of the Poisson regressions (results not presented). The coefficients for the interaction terms are positive and increase with age and educational level, which suggests that educational differences in mortality are lower at older ages. This pattern confirms previous studies that claim both selection and protection effects at higher ages.

Table 3 presents mortality rates calculated from the coefficients of the third model (Table 2). Not surprisingly, mortality rates among those with less education are higher than among those with higher levels of education. What is a surprising result is the level of this differential that arrives to more than five times for women who are 20 to 29 years old. The educational disparities are therefore, substantial among women in Brazil. The ratio between mortality rates for women without any education and those with 9 years of schooling decreases substantially with age, although it is still large among old women (1.89 at ages 60-69). Those women with missing information in educational level present the highest rates among all age groups, although its differential with the lowest educational group is bigger among the youngest women. Confidence intervals show that data present a great variability, but it is due in great part because the survey it is not so large. Another problem is that the application of the bootstrap method to estimate the Poisson coefficients include some Poisson regressions that are completely outliers and increase greatly the mean standard deviation.

Table 2: Coefficients from Poisson Regressions of number of deaths by age and education for women in Brazil, 1996

		Model 1		Model 2		Model 3	
		Coef	S. E.	Coef	S. E.	Coef	S. E.
Age	20-29	-	-	-	-	-	-
	30-39	0.600	0.130 ***	0.571	0.130 ***	0.507	0.185 **
	40-49	1.257	0.123 ***	1.185	0.123 ***	1.045	0.175 ***
	50-59	1.935	0.121 ***	1.839	0.121 ***	1.679	0.172 ***
	60-69	2.691	0.119 ***	2.578	0.120 ***	2.420	0.170 ***
	70-79	3.500	0.119 ***	3.372	0.119 ***	3.215	0.169 ***
Years of schooling	no schooling	-	-	-	-	-	-
	1-8			-0.371	0.037 ***	-0.869	0.264 **
	9 e mais			-0.824	0.097 ***	-2.537	50.406
	missing			0.367	0.057 ***	1.072	0.342 **
Age*Schooling	30-39*1-8 y. schooling					0.226	0.298
	30-39*9+ y. schooling					0.942	50.497
	30-39*missing					-0.260	0.392
	40-49*1-8 y. schooling					0.430	0.282
	40-49*9+ y. schooling					1.484	50.452
	40-49*missing					-0.485	0.372
	50-59*1-8 y. schooling					0.518	0.277 *
	50-59*9+ y. schooling					1.790	50.438
	50-59*missing					-0.672	0.365 *
	60-69*1-8 y. schooling					0.557	0.274 *
	60-69*9+ y. schooling					1.901	50.432
	60-69*missing					-0.830	0.360 *
	70-79*1-8 y. schooling					0.581	0.273 *
	70-79*9+ y. schooling					1.992	50.432
	70-79*missing					-0.905	0.359 *
Constant		-6.638	0.115 ***	-6.401	0.117 ***	-6.255	0.164 ***

*** P<0.001, **P<0.01, *P<0.1

Source: PPV 1996

Table 3: Mortality rates by age group and educational level (x1000) for adult women in Brazil.

Age	Education (years of schooling)	Rates	Confidence Interval (95%)	
20-29	0	1.92	1.39	1627
	1-8	0.81	0.35	3559
	9 or over	0.15	0.00	>5000
	missing	5.61	2.08	4479
Ratio 0/9 or over		12.64		
40-49	0	5.46	2.81	2735
	1-8	3.52	0.62	>5000
	9 or over	1.91	0.00	>5000
	missing	9.83	1.25	>5000
Ratio 0/9 or over		2.86		
60-69	0	21.61	11.22	2692
	1-8	15.82	2.86	>5000
	9 or over	11.45	0.00	>5000
	missing	27.52	3.61	>5000
Ratio 0/9 or over		1.89		

Source: PPV 1996

Final considerations

In this article, we estimate mortality rates among adult women using information on the survival and education of mothers from respondents of a household survey in Brazil. Our study applies a methodology that has its roots on the traditional orphanhood method for adult mortality, allowing us not only to estimate female mortality rates by level of education at the individual level for the first time in Brazil, but also to analyze how these differentials vary by age and education simultaneously. We believe this method could be applied in other countries that face the same data quality issues. It is particularly useful to measure differentials in female mortality since the

information on the survival of the mothers is known to be superior to the information on the survival of the fathers (United Nations, 1983).

First of all, our results can be considered quite reliable since they agree with previous estimates of other specific mortality rates by age estimated for Brazil, even when all the estimations are based in indirect methodologies. Moreover, our results agree with the international literature in showing larger mortality rates for women with lower education demonstrating that the differences by educational levels for adult women are not trivial at all in Brazil: mortality is about two to twelve times higher among the lowest educational group compared to the highest one. The differences reduce substantially at higher ages, suggesting that protection or selection effects may also operate among Brazilian women. The large educational differences in female mortality in Brazil contrast with results for other countries. For example, in the US, Pappas et al. (1993), Feldman et al. (1989) and Preston and Elo (1995) estimated death rates for those with the highest education levels to be around 20% to 60% lower than for those with the lowest educational levels. In the case of Europe (Kunst et al., 2004) differences in mortality between opposite educational groups were around 40% only.

Our results certainly call the attention for the harsher face of socioeconomic disparities in Brazil. Ignoring educational differences in adult mortality seems to be unacceptable in a country so unequal. Combining this type of information with that of changes in the distribution of educational level among women will make possible to predict how public policies that promote the expansion of education will affect the general level in mortality.

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