The effect of changes in educational composition on adult female mortality in Brazil

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Introduction

The last century in Brazil witnessed profound social, economic and demographic changes. Following the pioneering societies in the demographic transition, both mortality and fertility declined rapidly in Brazil after the 1940s. According to the Bureau of Census, female life expectancy at birth increased from 34.6 years in 1910 to 77.26 years in 2010 due particularly to a significant reduction in infant mortality. As expected, this process is not over yet. As life expectancy in Brazil has been below that of other Latin American countries and of the most developed societies, mortality gains will continue, mostly at adult and older ages. Explanations of the mortality transition in Brazil range from large improvements in public health, including immunization, sewage treatment and the creation of a universal public health system after 1988, to the sharp increase in income levels over the last decades.

Because Brazil is a very unequal country, mortality gains have been examined at different geographic levels, and according to the distribution of several aggregated socioeconomic variables, such as household income, GDP per capita, literacy rates, among other measures. Unfortunately, little attention has been paid to the potential effects of educational changes on life expectancy. The international literature has extensively showed that individuals with lower educational levels have higher morbidity rates and lower chances of survival than individuals with more formal education (e.g. Preston and Taubman, 1994; Goldman, 2001; Cutler and Lleras-Muney, 2006). However, in the case of Brazil, the greatest difficulty is to find reliable data to generate robust estimates that correlate individual characteristics to mortality. Brazil lacks mortality follow-up studies. In addition, conventional mortality data (death records and demographic census data) 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.

The association between educational changes and mortality gains is particularly important in Brazil, where there is a deep education transition taking place. Whereas the political discourse to improve access of children and youths to education in Brazil has been present since the country's first constitution, in 1824, public investments in education only began, in fact, more than a century latter. Accordingly, in the 1940s, only 25 percent of the children aged 5 to 14 years were enrolled in school. In this context of historical neglect, the main goal of the last decades has been to ensure universal primary schooling and eliminate illiteracy. Following the promulgation of the 1988 constitution, the national government promised larger public transfers to education. Thereafter, the Brazilian educational system has undergone major improvements in access to schooling as well as retention of students. Current data indicate that nearly all children aged 7 to 14 years attend school (Rios-Neto et al. 2010). The gross enrollment rate for the secondary education level is also high at about 80% (INEP, 2012). However, the dropout rate from upper secondary is also relatively high, as reflected in the low proportion of the students in the age group 16 to18 years old who graduates (63% in 2011) (OECD, 2013). With regard to the tertiary education level, between 1997 and 2005, Brazil experienced a significant expansion in college enrollment from 2 million to 4.5 million students, both in tuition-free public universities and more intensively, in tuition-charging private higher education institutions (INEP, 2010). According to the OECD (2011), 65 percent of Brazilian upper secondary graduates (or 34 percent of the age group) entered bachelor's-level higher education programs in 2011.

The transition in education may have affected mortality in Brazil in several different ways. For example, in the macro level, it might have reduced mortality levels indirectly through the improvement of other social and economic dimensions, including higher economic growth, and lower inequality and poverty rates. But there is also a more direct association that comes from compositional changes by education. If relative mortality risks among adults vary significantly across education levels, one should expect an increase in life expectancy that results from a more favorable relative distribution of the population by education. We hypothesize that the compositional effects on life expectancy are not trivial given the profound changes that have been documented in both mortality and education levels over the last decades. Since earlier literature on the evolution of adult life expectancy in Brazil have neglected these compositional effects, we attempt to fill this void by examining the extent to which changes in the age-specific distribution of education, between 1960 and 2010, have contributed to the decline in adult mortality among women in Brazil. Our study benefits from using new mortality estimates by education in Brazil, which have been discussed elsewhere (Perez 2010; Perez and Turra, 2009). We also speculate about further potential declines in adult mortality by comparing actual and counterfactual mortality measures under the scenario of education projected for 2040.

Methods

We measure education according to three categories: none, 1-8 years, and 9 or more years of schooling. We use census data (IPUMS 2013) to estimate the relative distribution of women by each one of these categories and 5-year age groups, for the census years during the study period (1960 to 2010). To estimate potential mortality gains from future changes in the distribution of education by age, we use the projected education distributions by age for 2040 prepared by Guimaraes (2013).

The relative mortality risks for these three educational categories are obtained from an earlier study, which was the first to estimate adult mortality by education in Brazil (Perez and Turra 2009; Perez 2010). Inspired in the orphanhood method for adult mortality, developed by Henry and Lotka and later improved by Brass and Hill, Perez and Turra (2009) combined information on mother's survival and mother's education, drawn from a household survey in Brazil (LSMS, 1996), to estimate mortality rates for different subgroups of women. The authors developed a stochastic method to randomly generate the main parameters of the model (age at maternity and age at death) and estimate the period of exposure for each respondent's mother. They then fit a Poisson regression to model the number of deaths as a function of age, education level and period of exposure. To obtain robust estimates, the authors limited the sample to women ages 30 to 70. Interaction terms between age and education proved not to be statistically significant in the models, despite earlier findings for the US and other western countries showing declining SES mortality differences by age. Also, no significant variations were found for different cohorts of women. Table 1 below summarizes the coefficients and their corresponding standard errors and relative risk ratios for the three education categories. In our study, we assume that these estimates are applicable for the entire period of analysis. We further restrict our calculation to the ages 30 to 70, in order to keep our results consistent with the original sample examined by Perez and Turra (2009).

Table 1 – Estimates from the Poisson model for the number of deaths, as a function of age, education and time of exposure, women, Brazil

Education	Coefficient	S.E.	Relative Risk Ratio
None (Reference)			1.000
1-8 years of schooling	-0.340	0.045	0.712
9 or more years of schooling	-0.772	0.115	0.462

Source: Perez (2010)

Our life tables are based on the United Nations life table model (West regional model). The corresponding level of mortality for each year is obtained by interpolating the model life table functions according to the official estimates of life expectancy at birth from the Brazilian Bureau of Census.

To estimate the proportion of deaths in a particular age and period that is attributable to changes in educational composition, we hypothetically redistribute the population at the baseline year according to distribution of women by education levels at the end of the period of analysis. We then calculate the proportional reduction in mortality that would occur under this redistribution, also known as the population attributable fraction (PAF). Our analysis follows other applications in the literature (e.g. Mehta and Change 2009; Preston and Stokes 2011), which also estimated the PAFs to measure the reduction in population mortality that would occur if exposure to specific risk factors were changed to a counterfactual level. We estimate PAFs for the female population in Brazil as

$$PAF = \frac{\sum_{i=1}^{n} RR_i - \sum_{i=1}^{n} P'RR_i}{\sum_{i=1}^{n} PRR_i}$$

where, P_i is the proportion of population at each education level in the baseline year, P'_i is the counterfactual proportion at each education level (as of as the level at the end each period of analysis), and RR_i is the relative risk of mortality at each education level. We

apply the age and period-specific sex-specific PAFs to the death rates in each baseline year to estimate what these rates would be under a scenario of education attainment observed in a later year. We then calculate life expectancy at age 30 years truncated at age 70, using the modified death rates and compared with the non-modified estimates. In addition, we calculate the probability of surviving between ages 30 and 70 under the actual and counterfactual scenarios, in order to provide an alternative measure for the effect of changes in the education profile on mortality levels.

Results

Table 2 presents the distribution of women by education and age from 1960 to 2010. The transformations in the last five decades are substantial. For example, the proportion of women aged 45 to 49 with no schooling reduced from 56% in 1960 to 4% in 2010. At the same time, there are was a sharp increase in the proportion of women with 9 years of schooling or more, who became the majority subgroup in 2010. This pattern is true for all five-year age groups, with the largest effects, as expected, among the youngest ones. The education transition has not finished yet and therefore, we expect additional changes in the education distribution over the next decades. In 2040, almost all women aged 30 to 69 are projected to have some schooling, and the largest majority of them (74 to 94%, depending on the age group) are expected to have at least 9 years of schooling. Over the entire 80 year period (1960-2040), the proportion of women with 9 years of schooling or more will have been increased from a mere 1% to levels above 90%, if the projections are correct.

Table 2 - Distribution of Education by Age, Year, and Educational Category, Women, Brazil

Age and Education Groups	1960	1970	1980	1990	2000	2010	2040
30-34							
No schooling	0.45	0.38	0.25	0.13	0.06	0.03	0.00
1-8 years of schooling	0.52	0.55	0.59	0.58	0.56	0.36	0.06
9 years of schooling or more	0.03	0.06	0.17	0.28	0.38	0.61	0.94
35-39							
No schooling	0.52	0.42	0.30	0.17	0.07	0.05	0.00
1-8 years of schooling	0.47	0.53	0.58	0.59	0.57	0.44	0.06
9 years of schooling or more	0.02	0.05	0.12	0.24	0.36	0.52	0.93
40-44							
No schooling	0.56	0.45	0.34	0.23	0.10	0.07	0.00
1-8 years of schooling	0.43	0.50	0.57	0.58	0.59	0.48	0.07
9 years of schooling or more	0.01	0.04	0.09	0.19	0.32	0.47	0.92
45-49							
No schooling	0.58	0.50	0.38	0.28	0.13	0.09	0.00
1-8 years of schooling	0.41	0.46	0.55	0.58	0.59	0.51	0.07
9 years of schooling or more	0.01	0.04	0.07	0.14	0.27	0.43	0.92
50-54							
No schooling	0.63	0.55	0.42	0.33	0.19	0.12	0.01
1-8 years of schooling	0.36	0.42	0.52	0.57	0.60	0.55	0.08
9 years of schooling or more	0.01	0.04	0.06	0.11	0.21	0.37	0.92
55-59							
No schooling	0.65	0.57	0.48	0.38	0.25	0.18	0.01
1-8 years of schooling	0.34	0.40	0.47	0.54	0.60	0.57	0.11
9 years of schooling or more	0.01	0.03	0.05	0.08	0.16	0.30	0.88
60-64							
No schooling	0.69	0.62	0.53	0.42	0.29	0.24	0.01
1-8 years of schooling	0.30	0.36	0.42	0.51	0.59	0.59	0.16
9 years of schooling or more	0.01	0.03	0.04	0.07	0.12	0.23	0.82
65-69							
No schooling	0.69	0.62	0.59	0.48	0.35	0.30	0.01
1-8 years of schooling	0.31	0.35	0.37	0.46	0.56	0.62	0.26
9 years of schooling or more	0.01	0.02	0.04	0.06	0.10	0.17	0.74

Source: Demographic Census, 1960 to 2000 (IPUMS) and 2010 (IBGE); 2040 (Guimaraes 2013)

Fractions of all-cause mortality attributable to compositional changes in education by age are presented in Table 3. Confidence intervals reflect uncertainty in the risk ratios. We show the PAFs for the two main periods of analysis: 1960-2010 and 2010-2040. The fractions for each decade are available upon request. Since we used the same mortality risk ratios for all age groups and time periods, differences in the PAFs depend mostly on the proportion of women in each educational level. Between 1960 and 2010, the fraction of deaths attributable to compositional changes in education are

lower at higher ages since improvements in education have affected more the younger cohorts. This pattern will probably change from 2010 to 2040 as the distribution of education gains becomes more concentrated at the higher age groups.

Table 3 - Estimated Proportion of All-Cause Female Mortality Attributable to Compositional Change in Education, Brazil

	1960-2010		2010-2040	
Age Group	PAF	C.I. (95%)	PAF	C.I. (95%)
30-34	0.317	(0.235 , 0.392)	0.135	(0.097 , 0.174)
35-39	0.306	(0.224 , 0.380)	0.171	(0.125 , 0.217)
40-44	0.294	(0.213 , 0.367)	0.196	(0.146 , 0.245)
45-49	0.278	(0.199 , 0.349)	0.221	(0.166 , 0.275)
50-54	0.259	(0.182 , 0.328)	0.253	(0.193 , 0.311)
55-59	0.216	(0.144 , 0.280)	0.292	(0.226 , 0.355)
60-64	0.173	(0.107 , 0.232)	0.322	(0.254 , 0.386)
65-69	0.115	(0.056 , 0.168)	0.347	(0.278 , 0.412)

Note. CI = confidence interval; PAF = population attributable fraction. The 95% CIs for PAFs incorporate uncertainty in the relative risks of mortality.

Table 4 presents the impact on life expectancy at age 30, truncated at age 70, and on the survival probability between ages 30 and 70, that are implied by the estimates of deaths attributable to compositional changes in education. Between 1960 and 2010, the actual female life expectancy at age 30 increased 5.04 years, from 33.17 to 38.21. Reallocating women in 1960 to the education levels as of 2010 would increase life expectancy in 1960 to 34.74. Therefore, an estimated 1.57 years (95% CI = 1.10, 2.00) are attributable to changes in distribution of women by education; about 31% of the actual gains. Not surprising, we also estimate an important effect on the survival probability. Over the 1960-2010 period, about 28 women out of 100 were saved between ages 30 and 70 because of actual mortality declines (the survival probability increased from 0.53 to 0.81). About 7 of these women were saved because of the

compositional changes in education alone (95% CI = 5%, 10%). Table 4 also shows the effects for each decade, with larger effects on life expectancy and survival probability at the most recent ones.

We can expect further improvements in mortality levels from 2010 to 2040 because of compositional changes. Reallocating women in 2010 to the projected education levels as of 2040 would increase truncated life expectancy at age 30 to 38.66; representing another 0.45 years of life. Also, another 5 out of 100 women will be saved because of the compositional changes in education alone. There are a few reasons for the effects in the 2010-2040 period to be relatively smaller than those for 1960 - 2010. First, it is a shorter period of time. Second, compared to 1960, in 2010 there was less room for improvements in the distribution of education. Third, in 2010 mortality rates were significantly lower than in 1960. Therefore, a similar relative reduction in the mortality rate translates into smaller absolute changes in the number of persons year lived in 2010 compared to 1960. Finally, most of future changes in the education profile of women will occur in the tertiary education level, which has not been explicitly accounted for in our study.

Table 4 - Truncated female life expectancy at age 30 and conditional survival probability with and without all-cause mortality attributable to changes in the age distribution of education, Brazil

Period		${}_{40}e_{30}$					
t_1	t_2	Actual t_1	Actual t_2	Life expectancy estimated in t_1 with the distribution of education as of t_2	Actual Difference	Difference explained by changes in education	(95% CI)
		(1)	(2)	(3)	(1-2)	(1-3)	
1960	2010	33.17	38.21	34.74	5.04	1.57	(1.10 , 2.00)
1960	1970	33.17	34.56	33.51	1.39	0.34	(0.24 , 0.44)
1970	1980	34.56	35.53	34.83	0.97	0.27	(0.19 , 0.35)
1980	1990	35.53	36.57	35.80	1.04	0.27	(0.19 , 0.34)
1990	2000	36.57	37.50	36.84	0.93	0.26	(0.18 , 0.34)
2000	2010	37.50	38.21	37.57	0.71	0.07	(0.02 , 0.11)
2010	2040	38.21		38.66		0.45	(0.35 , 0.45)
		l_{70}/l_{30}					
t_1	t_2	Actual t_1	Actual t_2	Survival probability estimated in t_1 with the distribution of education as of t_2	Actual Difference	Difference explained by changes in education	(95% CI)
		(1)	(2)	(3)	(1-2)	(1-3)	
1960	2010	0.53	0.81	0.60	0.28	0.07	(0.05 , 0.10)
1960	1970	0.53	0.60	0.54	0.06	0.01	(0.01 , 0.02)
1970	1980	0.60	0.64	0.61	0.05	0.01	(0.01 , 0.02)
1980	1990	0.64	0.70	0.66	0.06	0.02	(0.01 , 0.02)
1990	2000	0.70	0.76	0.72	0.06	0.02	(0.01 , 0.02)
2000	2010	0.76	0.81	0.76	0.05	0.00	(0.00 , 0.00)
2010	2040	0.81		0.87		0.05	(0.04 , 0.06)

Note: Life expectancy at age 30 is truncated at age 70.

Discussion

In this article we provide the plausible pure effects of compositional changes in the distribution of education on adult mortality. As we showed in our simulations, life expectancy at age 30, truncated at 70, would have been 31% lower in 1960 if the distribution of education were similar to the one in 2010. Between 1960 and 2010, about a quarter of lives saved from ages 30 to 70 were due to more favorable distribution patterns. New mortality gains are expected in future, although they tend to

be relatively lower, compared to 1960-2010, with the diminishing marginal improvements in the distribution of education by age.

With regard to the methodological limitations of our study, one should note, first, that as in any counterfactual analysis, we are isolating only one source of effect out of many other that may have affected mortality levels, including the indirect effects of education on mortality rates. Accordingly, our results revealed that adult mortality declines happened mainly because of significantly lower mortality risks across all education groups. Out of the total lives saved, three quarters were due to improvements in mortality levels, regardless of changes in the distribution of women by education. In addition, we measured only the first order effects of composition changes. We did not take into consideration any inter-relations of education with mortality levels. We believe such feedback effects exist, however.

Lack of detailed mortality estimates limited the precision of our decompositions. In Brazil, as in many other countries, the mortality gradient by education is probably not restricted to certain education levels. Since we were not able to break down the distribution of women into smaller education groups, including the tertiary, we expect our estimates to be underestimated, and the true upper limit of the composition effects to future mortality gains to be probably higher.

Finally, we assumed the relative mortality risks by education to be fixed over time. Improvements in the education profile of the Brazilian population are too recent for its implications to be totally known. Education mobility may have modified the population composition with respect to other observable and unobservable characteristics, affecting mortality variance within the education groups and thus, the longevity returns for each additional year of schooling. This a central question for

anyone interested on understanding adult mortality differentials in Brazil and its implications for past and future longevity gains.

References

Cutlear, D. M., Lleras-Muney, A. 2006. Education and health: evaluating theories and evidence. NBER Working Paper No. 12352.

Goldman, N. 2001.Social inequalities in health, disentangling the underlying mechanisms. Annals New York Academy of Sciences.

Guimaraes, R.R.M. 2013. Education projections using age-period-cohort models: classical and bayesian approaches. PhD dissertation presented at the Graduate Group in Demography, Cedeplar, Brazil.

Guimaraes, R. R. M.; Rios Neto, E.L.G.; Pimenta, P.S.F.; Moraes, T.A. 2010. Análise da evolução de indicadores educacionais no Brasil: 1981 a 2008. Working paper. Belo Horizonte: Cedeplar, UFMG.

INEP. 2012. Sinopse Estatística Da Educação Superior 2010-2012. Brasilia: Instituto Nacional de Estudos e Pesquisas Educacionais.

INEP. 2012. Sinopse Estatística Da Educação Superior 2010-2012. Brasilia: Instituto Nacional de Estudos e Pesquisas Educacionais.

Mehta, N.K.; Change, V.W. 2009. Mortality attributable to obesity among middle-aged adults in the United States. Demography, 46(4):851-872.

OECD. 2011. *Education at a Glance 2011*: OECD Indicators. Paris: OECD Publishing.

OECD. 2013. *Education at a Glance, 2013*: OECD Indicators. Paris: OECD Publishing.

Perez, E.R. 2010. Adult mortality estimates by education level in Brazil. Ph.D. Dissertation, Graduate Program in Demography, Cedeplar, UFMG, Brazil.

Perez, E.R., Turra, C.M. 2009. Measuring educational differences in mortality among women living in highly uneqal societies with defective data: the case of Brazil. Paper presented at the XXVI IUSSP International Population Conference in Marrakesh.

Preston, S.H., Stokes, A.M. 2011.Contribution of obesity to international differences in life expectancy. American Journal of Public Health. 101(11):2137-2143.

Preston, S. H., Taubman, P. 1994. Socieconomic differences in adult mortality and health status. In: Martin, L.G., Preston, S.H., Demography of aging, ed. National Academy Press. Washington, DC, p. 279-318.

Rios-Neto, E.; Guimaraes., R.R.M. 2010. The demography of education in Brazil: inequality of educational opportunities based on Grade Progression Probability (1986-2008).” *Vienna Yearbook of Population Research* 8: 283–312.

Rios-Neto, E., R. Guimaraes, P. Pimenta, and T. Moraes. 2010. “Análise Da Evolução de Indicadores Educacionais No Brasil: 1981 a 2008”. Working Paper 386. Belo Horizonte: Cedeplar, Universidade Federal de Minas Gerais. http://econpapers.repec.org/RePEc:cdp:texdis:td386.