Adult mortality differentials by income level in Brazil, 2010

Abstract

Despite the growing evidence on the socioeconomic health differentials in developed countries, less attention has been paid to life expectancy inequalities between social groups in developing countries largely due to poor quality of death records. This study presents the first estimates of the adult mortality gap across income quantiles by sex in Brazil and its main regions. The method employed in the paper uses death records reported at the household level in the 2010 population census to estimate age-specific mortality rates by income groups, sex and region of residence for adults aged 15 to 60. Estimated results show that the gap in life expectancy between the richest 20% and poorest 20% of individuals was 8 years for men and 7.4 years for women. The findings also indicate that the inequality of life expectancy by income varied substantially across regions and between men and women. The largest inequality in life expectancy (15.5 years) was found between the wealthiest women in the richest region of Brazil and the poorest men in the less developed region of the country.

Introduction

Despite general improvements in health conditions and a general convergence towards higher life expectancies worldwide, there are persistent socioeconomic inequalities in health conditions, which are mostly well documented in developed nations. However, much less is known about such inequalities in developing countries, where
both poverty rates and economic disparities are generally much higher\textsuperscript{11,12} and where studies have mostly focused on social inequalities in child mortality \textsuperscript{13–16}.

Improvements in life expectancy in developing countries have been explained mostly by the rapid decline in infant and child mortality. In such countries, including Brazil, there has been a convergence in the levels of infant mortality across regions in recent years \textsuperscript{17}, what suggests that future trends in life expectancy will be mostly affected by those factors that shape adult and old-age mortality. Nonetheless, despite the growing evidence on the relationship between household income and mortality and health conditions, much less is known about such relationship in developing countries including Brazil.

Only a handful of studies have analyzed the association between income levels and adult mortality or life expectancy in Brazil, an issue that seems to be of great importance since Brazil is one of the largest and richest countries in the Global South, marked by great regional disparities and ranked among the most unequal countries in terms income distribution \textsuperscript{11,12}. Previous studies in the country have mostly focused on the links between socioeconomic inequalities and health conditions related to infant and maternal mortality \textsuperscript{15,18–20} and general mortality rates by age \textsuperscript{21} and causes of deaths \textsuperscript{22}. Only three studies focused more specifically on life expectancy and have found a negative association between inequalities in income distribution and average life expectancy at birth \textsuperscript{20,23,24}. Due to the poor quality of socioeconomic information in death records in Brazil, however, these studies had to rely on ecological analyses that test for aggregate association between socioeconomic inequalities and average health conditions.
across different geographical areas and scales, including regions and states\textsuperscript{15,23}, municipalities\textsuperscript{19,24} or neighborhoods of specific cities\textsuperscript{18,20–22}.

The present study contributes to previous literature by providing the first estimates of the life expectancy gap by income groups in Brazil and its regions. To do so, this study uses information on death records reported in the 2010 Brazilian census to examine the inequalities in adult mortality by income, sex and age, showing how such inequalities vary across geographical regions of the country. We focus on adult mortality, 45q15, since we can obtain more robust estimates of mortality from the census for these age groups. Also, we assume that adulthood can be defined at age 15. At this age, there is the turning point in which declining childhood mortality risks are replaced by increased mortality risks for young adults and adults. In addition, this measure covers a substantive age range up to age 60, and avoids problems inherent in estimates of mortality at more advanced ages. All data used in this paper is publicly available and the scripts to reproduce of results of the paper in R will be publicly available once the paper is published.

The remainder of this paper comes in five parts. The next section brings a short review of the literature on socioeconomic differences in mortality and life expectancy. Section 3 presents the data sources and methods used in the analysis. Sections 4 and 5 respectively present some of the preliminary results on some concluding remarks with a discussion.

\textbf{Literature review on socioeconomic mortality differentials}
There is a consensus in the literature that higher income levels are on average associated with better health conditions and higher life expectancy at both individual and community levels\textsuperscript{3-9,10}. Nonetheless, the size as well and the trend of this life-expectancy gap between income groups over time varies substantially across countries.

The empirical evidence for more developed countries shows an increasing gap in life expectancy between income levels and socioeconomic groups in recent years\textsuperscript{25-27}. In the United States, a recent study\textsuperscript{28} found that the gap in life expectancy between the richest 1\% and poorest 1\% of individuals was 14.6 years for men and 10.1 years for women in the year 2014. Moreover, the study showed that this inequality in life expectancy had increased by approximately 2.3 and 2.9 years between 2001 and 2014, as life expectancy for the lowest income group stagnated in the period whereas it has increased in 3 years for the highest income group. Other studies in different countries including Sweden, Germany and Finland, have found similar results over the last few years\textsuperscript{9,29-31}, pointing out to how greater income inequalities are associated with lower standards of population health\textsuperscript{32}.

In one of the pioneer studies on mortality differentials in Brazil, Wood and Carvalho\textsuperscript{33} used census information on infant and child mortality and model life tables to estimate mortality differentials by sub-population groups in the 1970s. They found large differences across socioeconomic groups by educational attainment and regions. In 1970, individuals from families with higher income had life expectancy at birth 12 higher than low-income families. Recent research\textsuperscript{15,34} found that regional inequalities in maternal and child health in Brazil have decreased over the past decades, noting how the persistent regional inequalities in health conditions are revealing of the regional development
disparities observed in the country. Soares \(^2\) on the other hand analyzes the relationship between income and life expectancy aggregated at the municipality level in Brazil in 1970 and 2000 (Figure 1 updates the results of Soares \(^2\) with data of 2010). The author shows that the pattern and evolution of life expectancy inequalities across municipalities in Brazil has been different from what is observed in other countries. He shows that life expectancy income gradient is less steep in Brazil and inequality in life expectancy is lower. In addition to that, inequalities between municipalities in terms of both income and life expectancy have decreased between 1970 and 2010.

Figure 1 – Relationship between live expectancy and income across municipalities. Brazil, 1991-2010.

Despite the contributions of the reviewed literature on socioeconomic mortality differentials in Brazil, these studies have been largely focused on infant and maternal
mortality, circumscribed to specific cities or based on aggregated data at the regional\state\national level to compare differentials in mortality or life expectancy between rich and poor areas. As such, previous studies in the country fall short in providing results that cover health inequalities among overall adult population or that are representative of the country as a whole and its regional inequalities without incurring in ecological fallacy.

More recently, other researchers have proposed alternative methods and approaches to study mortality differentials by educational attainment in Brazil, finding significant differences across educational groups\textsuperscript{36,37}. For example, work by Silva and colleagues\textsuperscript{37} find that life expectancy of men with complete higher education in Brazil was 4.37 years higher than the average national male population, and 6.27 years higher than the male population with less than complete primary education. They also show marked regional disparities, particularly pronounced when comparing the poorest and richest regions of Brazil, Northeast and Southeast regions respectively.

In sum, little is known about life expectancy inequality by income levels in developing countries. Studies in more developed economies show that life expectancy gaps have increased over the last few years. In some cases, the gaps have increased because life expectancy for the lowest income groups have stagnated\textsuperscript{38}. We aim to contribute to this discussion by estimating and discussing the life expectancy inequalities in a middle-income country characterized by large income inequality.

**Methods**
As in other developing countries, socioeconomic information of death records are of poor quality in Brazil, with issues of underreporting of education level and lack of income information of the deceased. To work around this problem, this paper uses information on household mortality recently incorporated into the 2010 Brazilian population census. Since the 1990s, a growing number of countries have also added questions on recent household mortality to their population censuses, including Bolivia, Burkina Faso, Cameroon, Guinea, Haiti, Panama, Tanzania, Vietnam, Benin, Madagascar, Zimbabwe, among others. The 2010 Brazilian census asked for all households whether someone living in that household died in the previous 12 months. In the case there was a reported death in the household, it was asked the sex and age of the deceased.

These data are analyzed through a simple two-step method, similar to the method previously used by Silva et al. In the first step, evaluation methods are applied to the household mortality records in order to check their quality and to adjust the numbers of reported deaths, allowing for more accurate estimates of mortality levels. A recent study, estimated the completeness of death counts enumeration in the census at 80% for females and 85% for males. In this paper, we evaluate the quality of mortality data reported in the census at the regional level to correct for such underreported records. In the second step of the method, household mortality records (including age and sex of the deceased) are linked to household information such as income per-capita and place of residence. This simple method allows one to estimate age-specific mortality rates by income quantile, sex and region of residence in Brazil, which in turn were used to compute life tables. The two steps and their caveats are detailed below.
Coverage of Reported Deaths

The demographic literature has developed several methods based upon equations of population dynamics to evaluate the coverage of reported deaths relative to populations. The death distribution methods (DDM) are commonly used to estimate adult mortality in a non-stable population\textsuperscript{41,42,43}. A stable population is one in which the birth and death rates are unchanging over a long period of time. The DDM methods compare the distribution of deaths by age with the age distribution of the living and provide age patterns of mortality in a defined reference period. There are two major approaches: the General Growth Balance Methods, and the Synthetic Extinct Generation method.

Hill and colleagues\textsuperscript{42} suggest that the combination of GGB and SEG methods may be more robust than the application of the two methods separately. The adjusted method consists of applying GGB to obtain estimates of the change in the population enumeration ($k_1/k_2$), and use this ratio to adjust the coverage of both census, and then apply the SEG method using the adjusted population for the coverage of mortality data. These mortality corrections have been applied to the data using the DDM library in R\textsuperscript{44}. We present estimates for the adjustment factor and a summary measure of adult mortality for males and females in Brazil and its regions in Table 1. For the sake of space, we only present the results based on the Benneth-Horiuchi adjusted method. The results indicate that the quality of death registration in Brazil is higher in more developed regions of the country (South and Southeast) and lower in those less developed (North and Northeast). The adjustment factor in the South and Southeast is very close to 1, indicating close to 100% completeness, dispensing additional adjustments in the recorded death counts. In
the Northeast and North, we find much lower completeness and it is necessary to adjust
the enumeration of death counts to obtain the corrected number of deaths, for both males
and females. Table 1 also draws attention to the large differences in mortality levels
between adult men and women and between regions. Male adult mortality is higher for
all regions (and states – results not shown), but they are particularly higher in the less
developed areas of the country. We find that probability of death for males between ages
15 and 60 in the northeast is close to 30% compared to 18% in the South. For females,
the difference is smaller. In the Northeast it is 14% compared to 9% in the Southeast.

Table 1 - Summary of Estimates of coverage and summary measure of adult
mortality, 45q15, and obtained by using the Benneth-Horiuchi Adjusted Method,
Brazil, 2010

<table>
<thead>
<tr>
<th>Regions</th>
<th>Adjustment Factors</th>
<th>Adult Mortality (45q15)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>North</td>
<td>1.18</td>
<td>1.08</td>
</tr>
<tr>
<td>Northeast</td>
<td>1.28</td>
<td>1.18</td>
</tr>
<tr>
<td>Mid-West</td>
<td>0.95</td>
<td>1.06</td>
</tr>
<tr>
<td>Southeast</td>
<td>1.07</td>
<td>1.06</td>
</tr>
<tr>
<td>South</td>
<td>1.02</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Source: author’s estimates with 2010 Population Census (IBGE).

Mortality levels by income groups.
The second step is to associate information on household mortality records (including age and sex of the deceased) with information on household income and place of residence. Households were classified into deciles or quintiles of household income per-capita, depending on the geographic scale of analysis. Thus, this method is grounded on the assumption that mortality patterns do not differ significantly between individuals of the same household. This seems a reasonable assumption to the extent that members of the same household tend to share a number of physical resources, financial and social capital, access to health resources, as well as, eating habits and genetic factors.

**Methodological Caveats**

A few methodological caveats warrant a careful interpretation of the results. First, census data on household mortality imply that deaths in single-person households are likely to be omitted. This is likely to be the most important limitation of this method, single-person households represented 12% of all households in Brazil in 2010 and they were largely composed by middle-aged women with lower-middle income. This is the most important methodological limitation and it is likely to generate life expectancy estimates that underestimate. Additionally, we assume the same adjustment factor for all income quantiles when correcting the coverage of reported deaths. One could argue that the level of enumeration completeness would be lower for low income groups, but we assume that all groups would report at the same level for methodological simplicity. As a consequence, if there were differences of enumeration across the income distribution, our estimates would be underestimating the mortality differentials across income groups. Furthermore, we used only one adjustment factor across all age groups, which assumes the same degree of completeness of death records for all ages. If the coverage of infant
mortality records is worse than in the adult age, probably this difference is higher in the lower income groups. If that is the case, this would imply again that our method would be underestimating the mortality differentials across income groups.

Lastly, a third limitation of the method presented here is that it does not incorporate the contribution of the deceased person to the total household income. However, this would only become an issue in those situations when the income loss due to death of one of the household members would radically lower the relative position of the household in the overall income distribution. In any case, this effect of this methodological limitation would be, if any, to underestimate the inequalities in life expectancy by income groups. Overall, the limitations of the method would in the worst-case scenario generate more conservative estimates of inequality in life expectancy by income levels.

**Results**

We find large differences in life expectancy and mortality rates by income in Brazil. Figure 2 shows the life expectancy gap between low- and high-income groups at different ages by sex. The gap in life expectancy between the richest 10% and poorest 10% of individuals was almost 11 years for men and 9.6 years for women. As observed in other countries, these life expectancy inequalities by income decline with age. Observed gaps are much greater for those aged 30 and less compared to those aged 60 and above. Similarly, we find that female life expectancy is greater than male life expectancy at all ages, but the gender gap declines with age.
As it can be seen in figure 3, these gaps in life expectancy arise due to generalized inequalities in mortality levels across all ages. Despite remarkable improvements in reducing infant mortality over the last decades\textsuperscript{15}, we still observe important inequalities in infant mortality for both sexes, confirming for the national level what previous studies had previously found for specific municipalities and states of the country\textsuperscript{13,34,45–47}. Contrary to men, for whom mortality differentials by income become higher at young adult-hood (between 15 and 25 years), for women these differentials only become at a later stage after 50 years old.
Furthermore, the observed general health inequalities present considerable regional differences. Figure 4 shows regional variations in the average life expectancy at birth by sex comparing the top and bottom income groups. Inequalities in life expectancy vary substantially, being particularly acute when comparing high-income women and low-income men living respectively in richest and poorest areas of the country. On the whole, the largest life-expectancy gap (16 years) is observed between females at the top income group in the richest region of Brazil (Southeast) and males at the lowest income group in the poorest part of the country (Northeast).

Additionally, life expectancy gaps by income vary considerably across the regions of the country. Higher life-expectancy inequalities between the rich and the poor are found in the less developed regions of Brazil, what reflect higher disparities in access to health care, sanitation, clean water and education. The largest differences were found amongst women in the less developed Northeast region, where women in the poorest fifth
are expected to live 11.4 years less than their richest counterparts. For men, we observed the greatest difference between income groups (9.1 years) in the mid-west and northeast parts of the country. In contrast, the difference between top and low-income groups in the Southeast region was much smaller, 5 years, among women. To put into perspective, in Canada, the gap in life expectancy at birth between the 20% riches and the 20% poorest women was of only 2.2 years in 2007. For men, this gap was only 4.4 years, which is probably a reflex of a much better functioning public health system in one of the countries with lowest incomes inequalities in world (source: Statscan).

**Figure 4. Life expectancy at birth by sex and income group. Brazil and its regions, 2010**

Source: author’s estimates with 2010 Population Census (IBGE).
There are also large gender differences that vary regionally. In general, we observe that life-expectancy inequalities between men and women are larger amongst low-income groups in every region, with exception of the two poorest regions in the country (Northeast and North), what reflect the poor conditions of access to health services in both of these regions.

Figure 5 shows the log mortality rates by income level for males and females for each of the five regions of the country. We observe that male mortality is higher than females’ and particularly higher among young adults. We also find that young adult mortality rates for the lowest income groups are higher compared to the top income. The majority of deaths at this age groups are related to external causes of deaths, which have found to be largely dependent on household socioeconomic status and local social conditions. Figure 5 shows estimates of life expectancy by sex, regions and age, with results that are very similar to the trends observed in mortality rates.

A general lesson taken from these charts is that health and mortality inequalities start to manifest in early age, particularly for men at the age of 15. Despite the obvious fact that children do not choose the families or regions of the country they are born into, the results presented here show that the natural lottery of life does have an important bearing on the individuals’ life chances.

Figure 5. Life expectancy by age, sex and income group. Brazil and regions, 2010
Source: author’s estimates with 2010 Population Census (IBGE).
Concluding remarks

This study adds to the literature on socioeconomic inequalities in health by presenting the first estimates of the life expectancy gap by income level in Brazil. Despite general improvements in health conditions of the Brazilian population over recent decades, this study has found that income mortality differentials are still a pervasive characteristic of the country, supporting previous evidence on the important role of earnings as lifelong social determinant of health.

The average life expectancy gap between high- and low-income groups in Brazil is of 8 years for men and 7.4 years for women, comparable to inequalities observed in the USA and other developed countries\(^1\),\(^{25}\). The study has also found that life expectancy gap by income varies substantially across regions and between men and women, with the largest inequality of 15.5 years being observed between the wealthiest women in the richest region of Brazil and the poorest men in the less developed region of the country.

As widely acknowledged, health inequalities are largely shaped by social determinants to health related to inequities in access to health care, sanitation, environment conditions, clean water and education\(^{31,49,50}\) in combination to variations in individual behavior and psychosocial dispositions detrimental to health, which are consistently related low socioeconomic status\(^4,51\). It lies beyond the scope of this study to measure the importance of each of these components in explaining the size of the life expectancy gap between rich and poor in Brazil. This identification, however, is crucial for further discussions on such how inequalities are likely to change in the coming years and what policy measures should be used to address them. It seems reasonable to expect though that the existence of a public and free healthcare system with universal and yet
heterogeneous coverage in the territory might play a role in attenuating income and regional health inequalities.

For future studies, the methodology used in this study could be applied to estimate the life expectancy inequalities of other a growing number of countries in Latin America, sub-Saharan Africa and Asia that have also added questions on recent household mortality to their population censuses. Future studies would also be welcomed to overcome the limitations of the methodology used in this study, for example, by calculating separate adjustment factors of reported deaths for each income group, age intervals and at more fine grained spatial scale, which would allow for more accurate estimates at the national and local levels. For now, these preliminary results should be taken with a grain of salt since the methodological limitations involved in this study tend underestimate the inequalities in life expectancy between rich and poor people. If that is the case, however, public authorities in Brazil should treat the picture of inequalities in health conditions presented by this study even more seriously.

References


