



ORIGINAL ARTICLE

# Reducing socioeconomic inequalities in life expectancy among municipalities: the Brazilian experience

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## Abstract

**Objectives** This study analyzed the evolution of regional and socioeconomic inequality in life expectancy (LE) at birth and the probability of living up to 40 (LU40) and up to 60 years of age (LU60) in Brazilian municipalities between 1991 and 2010.

**Methods** We analyzed data from the last three national census (1991, 2000 and 2010) computed for the 5565 Brazilian municipalities. They were divided into centiles according to the average per capita income. Poisson regression was performed to calculate the ratios between the poorest and the richest centiles.

**Results** The average LE (+ 8.8 years), LU40 [6.7 percentage points (pp)] and LU60 increased (12.2 pp) between 1991 and 2010. The ratio of LE between the 1% of richest counties and the 1% of poorest counties decreased from 1.20 in 1991 to 1.09 in 2010. While in the poorest municipalities there was a gain of around 12 years of life, among the richest this increase was around 7 years.

**Conclusions** There was a remarkable decrease in regional and socioeconomic inequality in LE, LU40 and LU60 in Brazil between 1991 and 2010.

**Keywords** Life expectancy · Socioeconomic factors · Mortality · Epidemiology · Brazil

## Introduction

Life expectancy (LE) is a key indicator for understanding the general health status of a population, and its increase during the twentieth century was one of the most remarkable achievements of societies worldwide. It is estimated that in 1900 the average life expectancy at birth in the world was around 30 years, a figure that reached 71.4 years (73.8 years for women and 69.1 years for men) in 2015 (Riley 2005; WHO 2017). A very significant increase was also observed in Brazil, where life expectancy increased almost 20 years between 1967 and 2015 (from 57.8 years to 74.7 years) (OECD 2018).

However, despite the extraordinary progress achieved, deep inequalities in life expectancy are still observed. When comparing countries around the globe, the variation in LE between the extremes is greater than 3 decades. While in 2015 in Sierra Leone life expectancy was 50.1 years, in Japan it was 83.7 years (WHO 2017). Moreover, both in high- and low-economic development countries there are important variations among socioeconomic groups in life expectancy. In many cases, like in the USA (Chetty et al. 2016), Finland (Östergren et al. 2018), South Korea (Son et al. 2012) and Russia (Murphy et al. 2006), such inequalities between richer and poorer people, or between more and less educated people, have been increasing in recent decades.

Other studies, seeking to broaden the understanding of inequalities within countries in life expectancy, have taken small urban spaces as units of analysis, such as municipalities or microregions (Dwyer-Lindgren et al. 2017; Fukuda et al. 2007). MacIntyre et al. (1993) argue that such an analytical option for urban spaces as units of analysis is powerful because they are important predictors of health,

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as or more relevant as individual characteristics, since they express both the compositional and contextual characteristics of the place of residence. In fact, studies have indicated that analyses of aggregate individuals in urban spaces have been able to express association of health outcomes with political models and micro- and macroeconomics (Barnish et al. 2018; Spiteri and von Brockdorff 2019).

Studies carried out in the United States of America (Dwyer-Lindgren et al. 2017), European Union regions (Richardson et al. 2014), Japan (Fukuda et al. 2007) and New Zealand (Pearce and Dorling 2006) used counties or other administrative spaces as units of analysis and reported an increase or stabilization of geographical inequalities in life expectancy between the 1980s and the 2000s. These results are of note because they occur in a historical moment of increasing life expectancy and of improvements in general health conditions. Mexico was an exception, since Gómez-Dantés et al. (2016) observed that the gains in life expectancy between 1990 and 2013 were more pronounced in states with high marginalization. No additional studies were identified in low-middle income countries.

Between the 1990s and the 2000s, Brazil underwent profound economic and social changes, notably the stabilization of the economy, reduction of inflation, expansion of social programs and appreciation of the minimum wage, with particularly strong economic growth in more developed regions than the country's poor areas. Besides that, the country remains one of the most unequal in the world and there are no analyses that measure the regional variations in the life expectancy of the Brazilian population. It is fundamental to know if the progress achieved in recent decades was equally or evenly distributed or if, in a scenario similar to that of some countries in the Northern Hemisphere, there was an increase in the inequality of LE. In Brazil, studies on life expectancy were carried out only for specific years with larger geographical units and/or in intramunicipal spaces with smaller samples. The present study aimed to analyze the evolution of regional inequality in life expectancy at birth as well as the probability of living up to 40 and up to 60 years of age in Brazilian cities between 1991 and 2010.

## Methods

### Geographical units

The Brazilian territory covers an area equivalent to 8.5 million km<sup>2</sup>, and in 2018 it included 208 million inhabitants. The administrative division of the country encompasses five major regions (north, northeast, center-west, southeast and south), with 27 federal units within them (26 states and one federal district). In 2010, these

states contained 5565 cities, which are the smallest autonomous units of the federation.

### Estimation of health expectancy and probability of surviving to up to 40 and 60 years old

The main outcome of the present study was life expectancy at birth (average number of years that a newborn is expected to live if the probabilities of death at each age interval computed in the calendar year continue to apply). In addition, the probabilities of survival up to 40 years (SU40) and up to 60 years (SU60) were also analyzed as outcomes. The methodology proposed by Brass (1968) was used to perform the life expectancy estimation. In the cases of spatial levels with low population volumes, adaptations were made as proposed by the Center for Regional Development and Planning (CEDEPLAR), using model mortality tables (MMT). For the Brazilian cities, MMT generated for the respective states were applied. The calculations for 1991 and 2000 used as data sources the demographic census of the first year and the National Household Sample Surveys (PNAD) carried out in the 1990s. For 2010, data from the census conducted that same year were used in addition to the MMT calculated by CEDEPLAR. The calculations were made by the United Nations Development Program (UNDP) for the Atlas of Human Development in Brazil (PNUD 2013).

### Data analysis

In 2010, Brazil had 5565 cities, more than the 4491 municipalities existing in 1991. However, all 2010 municipalities had indicators calculated for the previous years. For that, a spatial compatibility was made considering the geographic space that each city of 2010 occupied in 1991 and 2000.

For each year, the mean; standard deviation; minimum and maximum values; and 5th, 50th and 95th percentiles of the three outcomes were calculated for the country as a whole. We sought to analyze not only the average increase in life expectancy in Brazilian municipalities, but also whether the dispersion of values increased or decreased in the two decades, indicating a country with more or fewer disparities.

The municipalities were then divided into centiles according to the average per capita income calculated in each of the 3 years analyzed. A crude Poisson regression analysis was conducted to assess the difference in LE, SU40 and SU60 (outcomes) according to municipalities' per capita income centiles (independent variable). The calculated ratios were reported with respective 95% confidence intervals. In addition to this measure of relative inequality, the absolute differences between the

municipalities' centiles (IC 95%) were also obtained for each outcome and year.

To verify how the years of life gained in two decades in Brazil were distributed among the cities of the country, we divided them into centiles. The increase, stabilization or decrease in the life expectancy and in the probability of survival to up to 40 and 60 years of age were calculated for the periods 1991–2000 and 2000–2010.

In all analyses, each city was weighted by its total population. All analyses were performed in the analytical package Stata 14.2.

## Results

The average life expectancy in Brazilian municipalities increased 8.8 years between 1991 and 2010 (Table 1). There was a substantial increase in the probability of surviving up to 40 [+ 6.7 percentage points (pp)] and up to 60 years of age (+ 12.2 pp). At the same time, there was a reduction in the dispersion of the values of these three outcomes, indicating a greater homogeneity of the municipal values around the average. In particular, over the 20 years analyzed there was a more substantial increase in the minimum value and 5th percentile of each outcome.

This increase in life expectancy and of the probability of surviving occurred among all socioeconomic groups and regions, but it was much higher among the poorest counties. This trend led to a remarkable decrease in the relative

and absolute differences between socioeconomic status (SES) groups and regions. In 1991, the inhabitants of the 1% of richest counties lived 11.6 more years on average than those living in the 1% of poorest regions. This difference decreased to 7.1 years in 2010 (Fig. 1). The ratio between these two groups decreased from 1.20 to 1.09 (Table 2). Even more prominent was the reduction in the probability of surviving up to age 40 years. The 11.7 pp difference observed in 1991 decreased to 1.2 pp in 2010 (Fig. 1). The same pattern of inequality reduction was observed in the probability of surviving up to age 60. In 1991, the rich/poor ratio was 1.30 and in 2010 it was 1.04 (Table 2).

Figure 2 shows the number of years of life gained between 1991 and 2010 according to the income centiles of the municipalities. The mean of years gained between 1991 and 2010 was 9.4 (SD = 2.8), ranging from 3.0 to 17.0 among the 5565 municipalities. No municipality showed a decreased in life expectancy or the probability of survival up to 40 (mean = 7.7; SD = 5.0) and 60 (mean = 13.4; SD = 7.0) years old. While in the poorest municipalities there was a gain of around 12 years of life, among the richest this increase was around 7 years. The increase among the poorest municipalities was highest in the decade 2000–2010, while among the richest there was a higher increase between 1991 and 2000. A similar phenomenon was observed in the probability of surviving up to 40 and up to 60 years of age.

**Table 1** Descriptive statistics of life expectancy, probability of surviving up to ages 40 and 60

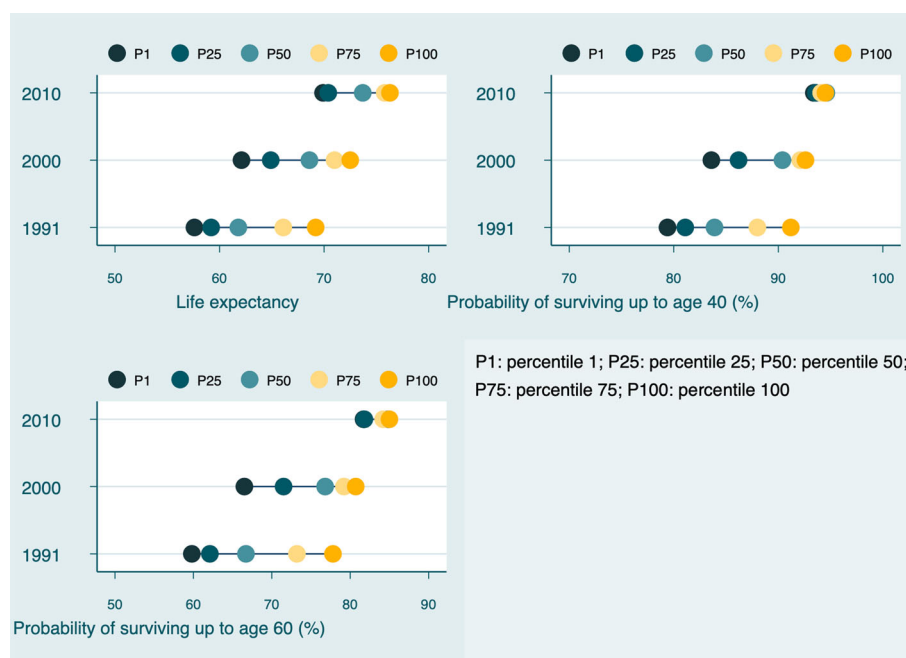
|  | Average | SD   | CV   | Min  | Max  | 5th  | 50th | 95th |
|--|---------|------|------|------|------|------|------|------|
| <i>Life expectancy (years)</i>                   |         |      |      |      |      |      |      |      |
| 1991   | 65.6    | 4.30 | 6.55 | 51.0 | 73.6 | 56.7 | 66.7 | 70.4 |
| 2000   | 69.9    | 3.52 | 5.04 | 57.5 | 77.2 | 62.8 | 70.4 | 74.1 |
| 2010   | 74.4    | 2.39 | 3.21 | 65.3 | 78.6 | 69.6 | 75.0 | 77.4 |
| <i>Probability of surviving up to age 40 (%)</i> |         |      |      |      |      |      |      |      |
| 1991   | 87.7    | 4.49 | 5.12 | 69.1 | 95.3 | 78.2 | 89.1 | 92.5 |
| 2000   | 90.8    | 2.99 | 3.29 | 78.1 | 95.7 | 84.1 | 92.0 | 93.9 |
| 2010   | 94.4    | 1.29 | 1.37 | 88.8 | 97.1 | 92.2 | 94.6 | 96.5 |
| <i>Probability of surviving up to age 60 (%)</i> |         |      |      |      |      |      |      |      |
| 1991   | 72.2    | 6.96 | 9.64 | 47.9 | 87.0 | 58.0 | 74.1 | 80.3 |
| 2000   | 78.0    | 4.69 | 6.01 | 57.3 | 87.6 | 67.9 | 79.3 | 83.5 |
| 2010   | 84.4    | 2.71 | 3.21 | 72.0 | 90.8 | 79.7 | 84.5 | 89.0 |

Brazilian municipalities, 1991, 2000, 2010

Values weighted by the municipalities' total population

SD standard deviation, CV coefficient of variation, Min minimum, Max maximum, 5th 5th percentile, 50th 50th percentile, 95th 95th percentile

**Fig. 1** Life expectancy, probability of surviving up to ages 40 and 60 according to municipality's per capita income centiles. Brazilian municipalities, 1991, 2000, 2010



**Table 2** Relative difference in life expectancy, probability of surviving up to ages 40 and 60 according to municipality's average income percentiles. Brazilian municipalities, 1991, 2000 and 2010

|  | Ratio (CI 95%)   |                  |                  |
|--|------------------|------------------|------------------|
|  | 1991             | 2000             | 2010             |
| <i>Life expectancy (years)</i>                   |                  |                  |                  |
| P1 (poorest municipalities)                      | 1.00             | 1.00             | 1.00             |
| P25  | 1.03 (1.00–1.06) | 1.04 (1.03–1.06) | 1.00 (1.00–1.01) |
| P50  | 1.07 (1.05–1.09) | 1.10 (1.09–1.12) | 1.05 (1.04–1.06) |
| P75  | 1.15 (1.12–1.17) | 1.14 (1.13–1.15) | 1.08 (1.07–1.10) |
| P100 (richest municipalities)                    | 1.20 (1.18–1.22) | 1.17 (1.15–1.18) | 1.09 (1.08–1.10) |
| <i>Probability of surviving up to age 40 (%)</i> |                  |                  |                  |
| P1 (poorest municipalities)                      | 1.00             | 1.00             | 1.00             |
| P25  | 1.02 (1.00–1.04) | 1.03 (1.02–1.04) | 1.00 (1.00–1.01) |
| P50  | 1.06 (1.04–1.08) | 1.08 (1.07–1.09) | 1.01 (1.00–1.02) |
| P75  | 1.11 (1.09–1.12) | 1.10 (1.09–1.11) | 1.01 (1.00–1.02) |
| P100 (richest municipalities)                    | 1.15 (1.13–1.16) | 1.11 (1.10–1.12) | 1.01 (1.00–1.02) |
| <i>Probability of surviving up to age 60 (%)</i> |                  |                  |                  |
| P1 (poorest municipalities)                      | 1.00             | 1.00             | 1.00             |
| P25  | 1.04 (0.99–1.09) | 1.07 (1.05–1.10) | 1.00 (0.99–1.02) |
| P50  | 1.11 (1.08–1.15) | 1.15 (1.14–1.17) | 1.04 (1.01–1.06) |
| P75  | 1.22 (1.19–1.26) | 1.19 (1.17–1.21) | 1.03 (1.01–1.05) |
| P100 (richest municipalities)                    | 1.30 (1.26–1.34) | 1.21 (1.19–1.23) | 1.04 (1.03–1.05) |

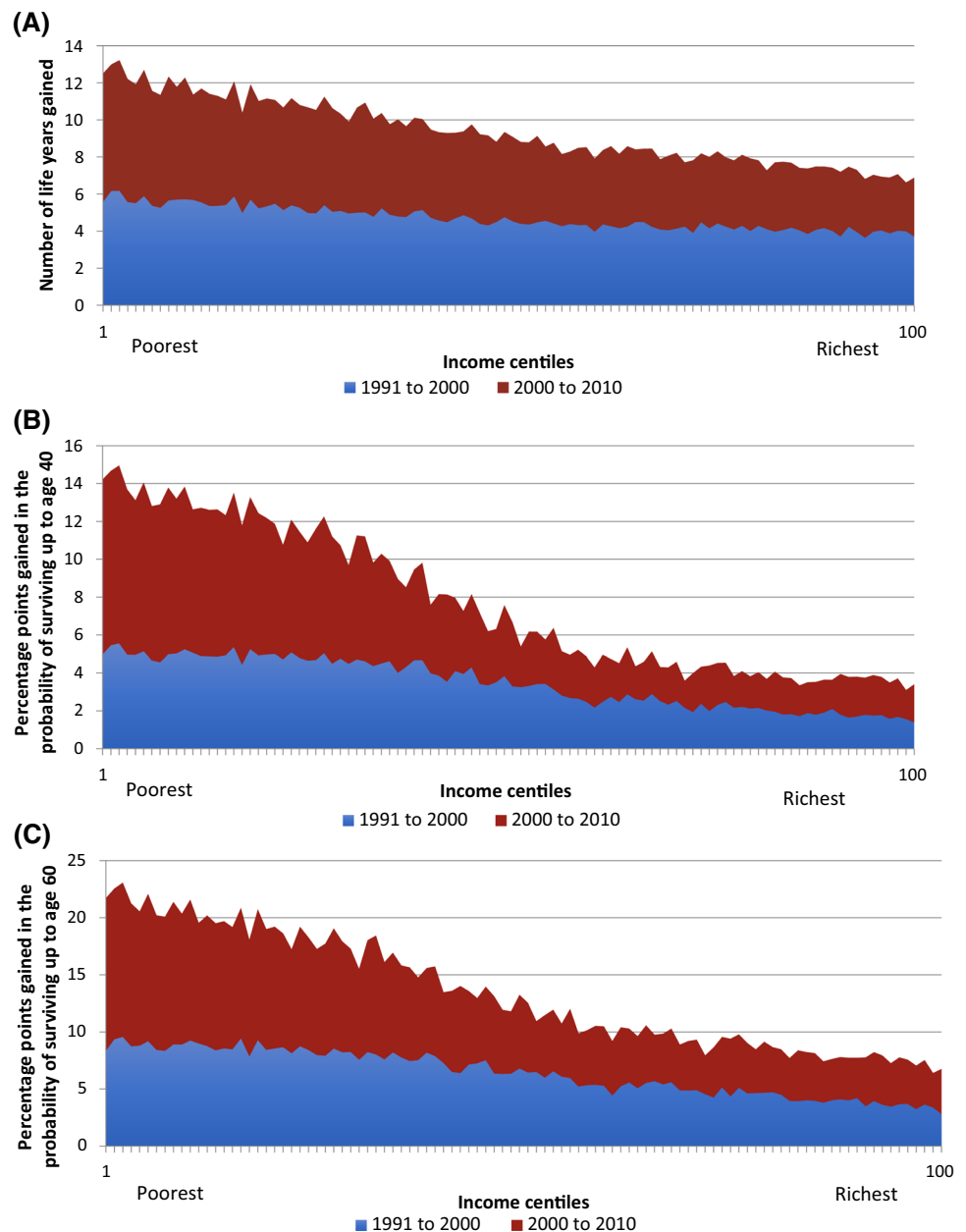
CI confidence interval, P1 percentile 1 of municipality's average income, P25 percentile 25, P50 percentile 50, P75 percentile 75, P100 percentile 100

## Discussion

Between 1991 and 2010, Brazil managed to significantly reduce the municipal differences in life expectancy and the probability of living up to 40 and 60 years of age. The

reduction in inequalities occurred throughout the analyzed period, but was more pronounced in the 2000–2010 decade. This achievement occurred in parallel with the continuous improvement of the life expectancy in the national average.

**Fig. 2** Number of life years gained (a), of percentage points gained in the probability of surviving up to age 40 (b) and 60 (c) according to per capita income centiles. Brazilian municipalities, 1991, 2000 and 2010



In addition, it was observed that the indicators were better in 2010 compared to 2000 and 1991 in all income centiles.

Improved indicators of life expectancy and survival have been reported in countries all over the world. In the second half of the twentieth century, globally, life expectancy increased by 3 years every decade, except in the 1990s (WHO 2016). From 2000 to 2015, the average gain was slightly higher, reaching 5 years. As a result, the overall life expectancy was 71.4 years in 2015, 3 years less than the figure observed in the present study for Brazil in 2010. The main drivers of this advance were the increase in schooling, income and sanitation; improvements in nutrition; and advances in medicine (Oeppen and Vaupel 2002).

In short, it is a reflection of the organization of the governments/societies, improvements in general living conditions, investments in research and expansion of democracy.

In addition, the inequality in life expectancy among the richest and poorest regions of the planet has been reduced. For instance, when analyzing all the world regions, it was observed that the highest increase in life expectancy between 2000 and 2015 occurred in the African continent (WHO 2016). With this, the gap between African and European life expectancy narrowed by 4.9 years in the period. However, by 2015 the absolute difference in life expectancy between the richest and poorest countries was still impressive at 17.5 years, which should reach

approximately 13 or 14 by 2030 (WHO 2016). Another negative point is that in some countries it is precisely the wealthiest groups and/or regions that have had the greatest gains in life expectancy. With this, the last decades of the twentieth century and the first years of the twenty-first century have been marked by the stabilization or increase in inequalities within some countries (Dwyer-Lindgren et al. 2017).

During the period analyzed in the present study, Brazil underwent profound economic changes, and its social policies may have impacted on the results found. In the health sector, the Federal Constitution of 1988 established that health would become a right of every person and that the government would be responsible for the health of its citizens. Based on those principles, the Unified Health System (SUS) was created and became the largest public and universal health system in the world. Since then, the healthcare delivery was decentralized to the municipal-level, decision that has impacted on the scale-up of primary healthcare coverage and may have effects on health outcomes at local levels. Despite difficulties in fulfilling its original aims, SUS has greatly expanded access to more complex levels of healthcare as well, providing services from immunizations to pharmaceutical inputs and transplants (Paim et al. 2011). Several studies have reported that the expansion of primary care promoted by SUS is associated with fewer deaths from preventable causes (Hone et al. 2017a), fewer infant deaths (Guanais 2015), fewer unnecessary hospitalizations (Macinko et al. 2010) and reduction in the racial inequalities in mortality amenable to primary care (Hone et al. 2017b).

Among economic policies, in the mid-1990s Brazil succeeded in promoting the stabilization of the economy and reducing inflation, which was the highest in the world between 1960 and 1995 (Neri 2007). This allowed the improvement of social indicators based on per capita income and contributed to the reduction of poverty, especially in rural areas (from 63.7% in 1992 to 54.3% in 2002). It also gave greater predictability to governments, companies and families to plan and execute their budgets, allowing progress in the implementation of social policies (Neri 2007).

Since the 2000s, social programs have expanded, unemployment rates have declined, GDP growth has increased, and there has been intense appreciation of the minimum wage. The unemployment rate decreased from 12.3% in 2002 to 5.5% in 2012, with an average annual reduction of 5.2% between 2004 and 2010 (Pochman 2010; Wiesebron 2014). In spite of the 2008 world economic crisis, the Brazilian average GDP grew 4.2% between 2004 and 2010, more than double the observed value between 1999 and 2003 (1.9%) (Serrano and Summa 2012). According to Melo et al. (2012), in 1995 the process was

begun of increasing the real value of the minimum wage. Almost two decades later, in 2012, the minimum wage was 789.4% higher. Over the same period, the consumer price index reached 270.7%, showing a significant nominal increase in the minimum wage.

Brazil has also implemented many successful social programs. The most important is the Bolsa Família (BF), a conditional cash transfer program. Using approximately 0.5% of the national GDP, the federal government transfers cash to poor households when they comply with certain education and health conditions. Studies have shown that the BF coverage is associated with higher availability of fresh foods in households (Martins and Monteiro 2016), reduction in tuberculosis and leprosy incidence (Nery et al. 2014, 2017), increase in children's visits to health centers for preventive services (Shei et al. 2014) and decrease in childhood mortality (Rasella et al. 2013).

Finally, during the last decades, an increase in the educational level and sanitation has been described in Brazil (Brasil 2010). Both have strong impact on health indicators, particularly in child health. These socioeconomic initiatives and achievements, helped by the commodities boom in the 2000s, have helped Brazil to reduce its social inequality, mainly due to gains in income and educational level within the poorest population. While between 1985 and the mid-1990s, the Gini coefficient increased 4.1 percentage points (pp), between 1998 and 2009 it decreased 5.4 pp (Lustig et al. 2012).

The pro-poor policies helped to stimulate the economy all over the country, but the deepest impact was observed in the poor regions (Vaitsman and Paes-Sousa 2007). This movement is in addition to other governmental initiatives that occurred during the second half of the twentieth century in order to develop the poorest regions of Brazil, which contributed to the reduction of social differences between more and less rich counties, states and regions. Infant mortality, which has a large impact on estimates of life expectancy, for example, decreased by 52.4% in Brazil between 1980 and 2010. In the Northeast region, which concentrates some of the country's poorest municipalities, the reduction reached 74.0%, while in the South, which is richer, the oscillation was − 35.8% (Brasil 2013).

One last point that must be considered is that the poorest centile in 2010 is richer and wealthier than the poorest centile in 1991. Also, it is important to highlight that the present study analyzed aggregate municipal data, and it is not possible to evaluate the evolution of inequality among population groups. In addition, given the existence of spatial levels with low population volumes, the estimates used in this study needed to be calculated by applying states MMT to the municipalities. Nonetheless, the data are collected in national censuses, and the estimates are solid



and part of the official documents of the United Nations Development Program.

In a country marked by centuries of deep social and economic inequalities between people as well as between regions, mitigating differences must be permanently on the agenda of policy makers. Despite the advances observed in recent decades, there is still a long way for Brazil to overcome its inequalities. So, of particular concern are the recently published data showing an increase in maternal mortality and infant mortality in 2016 after decades of steady decline (dos Reis 2018). The reduction in public investments in social policies has been pointed out as responsible for this new scenario. A nationwide microsimulation study reported that fiscal austerity measures in Brazil can be responsible for an additional 19,732 under-five deaths and 123,549 under-five hospitalizations over the period between 2017 and 2030, which could be avoided with the maintenance of the current levels of social protection provided by the BF and SUS primary healthcare (Rasella et al. 2018). Political and economic crisis, along with austerity policies, may impact deeply mainly on the poorest municipalities and most vulnerable population, worsening structural problems and disparities in the country (Massuda et al. 2018). Thus, it will be crucial to monitor the evolution of inequalities in health indicators, such as life expectancy, in Brazil in the coming years.

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## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** This article does not contain any studies with human participants performed by any of the authors.

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