Impact of income inequality on life expectancy in a highly unequal developing country: the case of Brazil

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ABSTRACT

Background Few studies have analysed the effects of income inequality on health in developing countries, particularly during economic growth, reduction of social disparities and reinforcement of the welfare and healthcare system. We evaluated the association between income inequality and life expectancy in Brazil, including the effect of social and health interventions, in the period 2000–2009.

Methods A panel dataset was created for the 27 Brazilian states over the referred time period. Multivariable linear regressions were performed using fixed-effects estimation with heteroscedasticity and serial correlation robust SEs. Models were fitted for life expectancy as a dependent variable, using the Gini index or a percentile income dispersion ratio as the main independent variable, and for demographic, socioeconomic and healthcare-related determinants as covariates.

Results The Gini index, as the other measure of income inequality, was negatively associated with life expectancy ($p<0.05$), even after adjustment for all the socioeconomic and health-related covariates. The Family Health Program, the main primary healthcare (PHC) programme of the country, was positively associated with life expectancy ($p<0.05$).

Conclusions In recent years, effective social policies have enabled Brazil to partially reduce absolute poverty and income inequality, contributing—together with PHC—to decreasing death rates in the population. Reducing income inequality may represent an important step towards improving health and increasing life expectancy, particularly in developing countries where inequalities are high.

INTRODUCTION

The relationship between income inequality and health outcomes in a society has been extensively studied over recent years; however, contradictory findings have been reported and different hypotheses have been raised in an attempt to explain this association.[1 2]

According to some authors, income distribution in the richest countries of the world acts as a proxy for the stratification of social class, representing one of the most important determinants of health.[1] In these countries, studies have shown income inequality to have an effect in reducing life expectancy (LE) beyond absolute income, and have explained this association as representing the psychosocial effects of social comparison.[3] However, some other studies—carried out with the use of multilevel statistical models—attribute this relationship to the 'concavity effect': it is the concave relationship at the individual level between income—or other variables linked to the material living standard—and health to produce a significant association between income inequality and LE at the ecological level.[4–6] Up to the present date, few studies have focused on developing countries in the belief that, particularly in deprived areas, individual income strongly determines the material living standards of a person, exerting a greater direct influence on their health than psychosocial factors.[1 7] In societies characterised by high socioeconomic inequalities, either in developing or developed countries, income inequality is usually negatively correlated with health outcomes, and some authors have proposed an explanation using both the perception of social stratification and material living standards.[8] A threshold has been proposed, suggesting that an effect on health is only detectable when inequality is high.[9]

In Brazil, which is still considered as a developing country, income inequality is among the highest in the world, ranking in the 11th position in the Gini index.[10] Nevertheless, over the past 10 years, solid economic growth and effective social policies—as the conditional cash transfer programme *Bolsa Família* (BFP)[11] and the increase in the minimum wage—have led to an improvement in socioeconomic conditions of the population and reduction of social inequalities (as shown by the decrease in the Gini index).[12 13] On the other hand, the Family Health Program (FHP), the main primary healthcare programme of the country, has widely increased in terms of coverage, contributing to the great reduction of childhood mortality.[14 15]

A few studies, mainly restricted to a local level, have attempted to evaluate the effect of income inequality on the health of the Brazilian population,[16–18] and none has used multiple inequality measures or analysed the effect of the decrease in inequality that has occurred over recent years, including social and health programmes implemented during this period.

The objective of the present study was to investigate the effect of income inequality on LE in Brazil in the period between 2000 and 2009.

METHODS

This study has a mixed ecological design, a combination of an ecological multiple-group and time-trend study design in which the Brazilian States are the unit of analysis. A panel dataset has been created using a cross-section of subjects, in this case the 27 Brazilian States, with repeated observations over time. In the present study, these consisted of yearly observations from 2000 to 2009, the period for which information was available. The dataset

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was balanced in that there were no missing values either for the subjects or the years.

Data were extracted from different information systems. LE data were obtained from the Brazilian Ministry of Health's Information System.[19] Three measures commonly used in the literature to describe income inequality were selected as the main independent variables from the database of the Brazilian Institute of Applied Economic Research (IPEA):[20 21] the Gini index and two earnings dispersion, as measured by two different percentile ratios. The Gini index is defined as the ratio of the areas on the Lorenz curve diagram; it varies from 0, reflecting complete equality, to 100, indicating complete inequality. The other two measures of inequality available in the database consist of earnings dispersion measured by percentile ratios: the ratio of the average income of the richest 10% of the population divided by the average income of the poorest 40%, and the ratio of the richest 20% divided by the poorest 20%.

The covariates selected consisted of a set of variables that, in addition to being recognised in the literature as representing determinants of LE,[22 23] were also available in the source datasets:[19 21] monthly per capita income, percentage of individuals living in poverty (according to the IPEA classification), percentage of illiterates over 15 years of age in the population, total fertility rate, urbanisation rate, percentage of individuals living in households with piped-in water supply, percentage of individuals living in households with sewerage, percentage of individuals living in households with durable material, coverage of the main programme of primary healthcare of the National Health System (FHP), number of hospital beds per 1000 inhabitants, number of diagnostic imaging instruments per 100 000 inhabitants (x-ray machine, tomography and MR) and total expenditure on health as a percentage of Gross Domestic Product. When missing, the values for some of the covariates for the years 2008 and 2009 have been obtained by linear extrapolation.

Statistical analyses

Multivariable linear regression for panel data analysis with fixed-effects estimation was used in the statistical analysis. Models were fitted using LE as the dependent variable, the Gini index or a percentile dispersion ratio as the main independent variable and the set of social and economic determinants listed previously as covariates.

In addition to the disturbance or error term, the longitudinal or panel data models include a second term to control for unobserved time-invariant characteristics, in the present case the geographical, historical or sociocultural characteristics of each State. The choice of fixed effects instead of random effects models was based on the Hausman test and on the greater robustness of the fixed effects models, which permit correlations between the unobserved time-invariant term and the explanatory variables, making them, in general, more robust for policy analysis of aggregate data.[24]

Complete regression diagnostics were performed for panel data analysis, also testing for potential heteroscedasticity and serial correlation. In the final models, we used Ordinary Least Square (OLS) estimators with heteroscedasticity and autocorrelation-robust SEs.

As sensitivity tests, various models were fitted with different specifications, including feasible generalised least squares estimators in the presence of AR (1) autocorrelation and heteroscedasticity across panels, and OLS estimators with Newey-West SEs. None of these alternative specifications affected the main conclusions reached in the final models, suggesting that the results are robust.

The Stata statistical software program V.10.1 was used in data processing and analysis.

RESULTS

A vast heterogeneity exists between values of the study variables in the different states. In 2000, monthly per capita income ranged from BR$254 in Maranhão to BR$1060 in the Federal District, while LE ranged from 63.8 years in Alagoas to 73.6 in the Federal District.

Table 1 shows the mean values and per cent changes of the dependent and independent variables: all the income inequality indicators diminished, while LE increased. The coverage of FHP increased vigorously. Changes in all the remaining variables indicate an improvement in the socioeconomic and sanitary conditions of the population.

Table 1 Mean values and SD of the selected variables for the Brazilian States (n.27)

Variable	Mean (SD) 2000	Mean (SD) 2009	Percentage of change
Population size (in millions)	6.29 (7.63)	7.09 (8.50)	12.72
Life expectancy	69.54 (2.70)	72.39 (2.31)	4.11
Gini Index	57.45 (3.20)	53.48 (3.77)	−6.91
Income ratio between the richest 10% and the poorest 40%	20.34 (4.07)	16.12 (3.96)	−20.75
Income ratio between the richest 20% and the poorest 20%	22.38 (4.48)	17.49 (4.36)	−21.85
Per capita income BR $ (monthly)	491.9 (190.7)	643.4 (240.2)	30.80
Percentage of individuals living in poverty	37.93 (16.70)	25.52 (13.06)	−32.72
Percentage of individuals living in households with piped water	78.59 (15.71)	88.39 (12.10)	12.47
Percentage of illiterates among the over 15-year-olds	15.46 (8.53)	11.52 (6.05)	−25.49
Percentage of individuals living in households with sewerage	51.96 (21.71)	67.61 (27.21)	30.12
Percentage of individuals living in households with durable material	92.93 (8.36)	96.22 (4.31)	3.54
Total fertility rate	2.62 (0.50)	1.99 (0.49)	−24.04
Urbanisation rate	76.76 (9.93)	82.17 (8.15)	7.05
Family Health Program coverage	17.35 (13.21)	60.14 (21.15)	246.7
Number of hospital beds per 1000 inhabitants	2.71 (0.72)	2.35 (0.37)	−13.28
Number of diagnostic imaging instruments per 100000 inhabitants	8.92 (3.38)	10.31 (3.76)	15.58
Total expenditure on health as percentage of GDP	4.21 (1.86)	4.76 (1.95)	13.06

GDP, Gross Domestic Product.

Table 2 Fixed effect regression models for adjusted associations between life expectancy and Gini Index for the Brazilian States, 2000–2009

	Life expectancy					
	Model 1		Model 2		Model 3	
Variable	B	(95% CI)	B	(95% CI)	B	(95% CI)
Gini Index	−0.197	(−0.261 to −0.134)	−0.079	(−0.128 to −0.031)	−0.045	(−0.084 to −0.007)
Per capita income BR $ (monthly)	0.007	(0.005 to 0.010)	0.004	(0.003 to 0.006)	0.003	(0.002 to 0.005)
Percentage of individuals living in poverty	–	–	0.015	(−0.018 to 0.048)	0.006	(−0.017 to 0.028)
Percentage of illiterates among over 15 years old	–	–	−0.064	(−0.111 to −0.017)	−0.051	(−0.091 to −0.011)
Total fertility rate	–	–	−1.053	(−1.556 to −0.549)	−0.940	(−1.297 to −0.584)
Urbanisation rate			0.176	(0.081 to 0.272)	0.052	(−0.028 to 0.131)
Percentage of individuals living in households with piped water	–	–	−0.045	(−2.132 to 2.043)	−0.185	(−1.651 to 1.282)
Percentage of individuals living in households with sewerage	–	–	0.399	(−0.320 to 1.119)	0.108	(−0.559 to 0.776)
Percentage of individuals living in households with durable material	–	–	−0.011	(−0.057 to 0.035)	−0.007	(−0.040 to 0.025)
Family Health Program coverage	–	–	–	–	0.023	(0.016 to 0.030)
Number of hospital beds per 1000 inhabitants	–	–	–	–	−0.122	(−0.391 to 0.148)
Number of diagnostic imaging instruments per 100000 inhabitants	–	–	–	–	0.097	(−0.046 to 0.240)
Total expenditure on health as percentage of GDP	–	–	–	–	−0.069	(−0.222 to 0.085)
Number of observations	270		270		270	
Number of states	27		27		27	
R^2 (within)	0.677		0.872		0.907	
p Value for F test all *ui*=0	<0.001		<0.001		<0.001	

BR $, Brazilian Reais; GDP, gross domestic product.

The fixed-effect linear regression models (table 2) show a negative association between the Gini index and LE in both the crude and adjusted models. This association was statistically significant, even after controlling for the income per capita (model 1), demographic and socioeconomic variables (model 2) and healthcare-related variables (model 3). Most of the covariates had the expected direction of association with LE, but some of them did not maintain statistical significance in the final model, presumably due to the limited number of observations.

Table 3 shows the linear regression coefficient between LE and the two percentile dispersion ratios: the ratio between the richest 10% and the poorest 40% and between the richest 20% and the poorest 20%. Both show a negative and statistically significant effect, even after controlling for all the confounding

Table 3 Fixed effect regression models for adjusted associations between life expectancy and 10/40 and 20/20 income ratio for the Brazilian States, 2000–2009

	Life expectancy			
	Model 1		Model 2	
Variable	B	(95% CI)	B	(95% CI)
Income ratio between the richest 10% and the poorest 40%	−0.048	(−0.084 to −0.012)	–	–
Income ratio between the richest 20% and the poorest 20%	–	–	−0.025	(−0.049 to −0.002)
Per capita income BR $ (monthly)	0.003	(0.002 to 0.005)	0.003	(0.002 to 0.005)
Percentage of individuals living in poverty	0.005	(−0.017 to 0.028)	−0.001	(−0.022 to 0.019)
Percentage of illiterates among the over 15-year-olds	−0.048	(−0.088 to −0.008)	−0.047	(−0.088 to −0.007)
Total fertility rate	−0.931	(−1.296 to −0.566)	−0.965	(−1.332 to −0.598)
Urbanisation rate	0.056	(−0.023 to 0.135)	0.068	(−0.013 to 0.149)
Percentage of individuals living in households with piped water	−0.221	(−1.739 to 1.299)	−0.341	(−1.919 to 1.235)
Percentage of individuals living in households with sewerage	0.087	(−0.570 to 0.743)	0.058	(−0.621 to 0.737)
Percentage of individuals living in households with durable material	−0.008	(−0.039 to 0.023)	−0.013	(−0.046 to 0.020)
Family Health Program coverage	0.022	(0.016 to 0.029)	0.023	(0.016 to 0.029)
Number of hospital beds per 1000 inhabitants	−0.130	(−0.398 to 0.137)	−0.116	(−0.388 to 0.157)
Number of diagnostic imaging instruments per 100000 inhabitants	0.099	(−0.044 to 0.243)	0.106	(−0.041 to 0.254)
Total expenditure on health as percentage of GDP	−0.060	(−0.201 to 0.081)	−0.076	(−0.223 to 0.071)
Number of observations	270		270	
Number of states	27		27	
R^2 (within)	0.908		0.906	
p Value for F test all ui=0	<0.001		<0.001	

BR $, Brazilian Reais; GDP, Gross Domestic Product.

variables. Among the controlling variables, FHP showed a positive and statistically significant association with LE.

DISCUSSION

The present results show that income inequality in the 27 Brazilian states (measured by three different indicators: the Gini index, the ratio of the average income of the richest 10% of the population divided by the average income of the poorest 40% and the ratio of the richest 20% divided by the poorest 20%) is negatively associated with LE in adjusted models.

The negative association between LE and the Gini index in Brazil confirmed the results of a previous cross-sectional study,[16] but—differently from that study—our findings indicate a significant negative association even after controlling for the illiteracy rate and other covariates, including healthcare-related variables, presumably because of the use of a more complete panel dataset instead of a simple cross-sectional dataset.

Considering the curvilinear relationship between income and mortality, and presuming that the richest 10% and 20% have reasonably similar health conditions,[25] the greater effect of the ratio of the richest 10% to the poorest 40% compared with the ratio of the richest 20% to the poorest 20% may suggest that in the poorest 40% of the population, and not only in the extremely poor 20%, income still exerts a strong effect on health.[20]

The greater decrease in the two measures of income inequality in comparison with the Gini index, and data about the reduction of absolute poverty observed here and elsewhere,[21] are evidence that in Brazil an improvement has been occurring in the distribution of income through a decrease in the number of impoverished individuals rather than a more generalised redistribution of income.[12]

In our adjusted models, the percentage of individuals living in poverty was not showing the expected sign and significance because of its high correlation with the per capita income (Pearson R^2 <–0.8) and its multicollinearity (Variance Inflation Factor >10). When the income per capita was removed from the adjusted model, the variable coefficient turned negative and statistically significant. Considering that the presence of this variable does not affect the strength, sign or significance of the other covariates, it has been maintained in the final adjusted models for theoretical reasons.

Different hypotheses may be used to explain the effect of income distribution on health outcomes in Brazil. Considering that a great number of people still live in extreme poverty, either in rural or in urban areas, and considering the high value of the Gini index and of the percentile dispersion ratios, a proportion of the marginal relationship between income inequality measures and LE may be explained by the concavity effect, also known as the statistical artefact hypothesis.[4 6 26] According to this hypothesis, the ecological association between income inequality and health is a statistical artefact due to the non-linear relationship between individual income and mortality. Income, as a proxy of an individual's material living conditions, would represent one of the major determinants of health, even in the richest countries.

Considering the wide stratification of social class in the Brazilian population, an important part of the marginal effect may be explained by the contextual hypothesis.[1 27] In countries with a medium-high per capita income and LE, the major determinant of health would no longer be absolute income, but rather relative income. As a proxy of class differentiation, income inequality is socially corrosive, leading to more violence, higher homicide rates, lower social capital and increased chronic stress. It has to be considered that homicides and violence-related morbidity and mortality still represent a huge public-health problem in Brazil, even if there are some signs of decline.[28] Several studies have shown that more-equal societies usually have a higher LE, lower infant mortality, lower homicide rates and lower rates of cardiac and respiratory diseases.[29] Some authors have shown that in countries in which inequality is extremely high, even using an explicit modelling of the income artefact effect, such an effect could explain only up to half the association between inequality and health, indicating that contextual factors could explain the remaining effect.[8] A recent meta-analysis of all the multilevel studies conducted on the association between income distribution and health confirmed the adverse effect of income inequality on health even after controlling for the statistical artefact effect, demonstrating that the impact of the contextual factors on population could be relevant.[9] These effects were evident only in countries with a Gini index higher than 30, as was the case in Brazil.

Brazil is considered one of the greatest emerging economies in the world; however, it remains one of the countries in which income inequality is higher and where the Human Development Index is relatively low compared with countries with a similar per capita GDP.[10] In recent years, contrary to the increasing trend of the 20th century, a reduction in income inequality and in absolute poverty has occurred in the country.[21] BFP, which was launched in 2003 and considered to be the largest conditional cash transfer in the world, showed during the last years high targeting results to the poorest strata of the population.[11] A recent study suggests that this countrywide welfare programme could be one of the factors responsible for the improvement of socioeconomic conditions and reduction of income inequalities in the Brazilian population.[13]

FHP was adopted on a national basis in 1994 and represented a strategy to focus the model of care towards primary healthcare and to increase the National Health System coverage, especially for deprived areas (such as rural communities and urban slums).[30] In recent years, FHP has experienced a dramatic expansion, being present by the end of 2008 in 94% of the Brazilian municipalities.[31] The effect of FHP on LE has never been shown in the literature, but it is plausible considering that previous studies have demonstrated its strong impact on the infant and under-five mortality and in the reduction of ambulatory care-sensitive hospitalisations among adults.[14 15 32] It has to be considered that primary healthcare programmes such as FHP are considered an effective strategy for the reduction of the burden of chronic diseases in adults even in developing countries.[33] In addition to exerting a significant effect on mortality, some authors argue that primary healthcare may partially attenuate the adverse effects of income inequality.[34]

Some authors suggest that income inequality can exert its influence on mortality risk with a lag period, depending on the country, historical period, unit of analysis and level of income inequality.[35] In our study, we have not investigated the lagged effects of income inequality because of the relatively short period of time considered. Only the period 2000–2009 has been analysed because of the need to use better LE estimates, derived from mortality information of better quality,[36] and because the previous decade was characterised by a different income inequality trend and a different socioeconomic context.[12 21] It has to be considered that, as discussed above, income inequality not only exerts its effects promoting the development of chronic diseases, but also it can reduce infant mortality and homicide rates in a shorter period of time.[29] Moreover, there is an increasing body of evidence that socioeconomic changes, as well as effective health and welfare interventions, can reduce death rates in the population—even for

chronic diseases—in a short period of time, and do not necessarily require decades to show an impact.[37]

The main strength of the present study lies in its use of panel data analysis instead of classical cross-sectional data to demonstrate the association between income inequality and health. Panel data allow differences among the subjects to be modelled, in addition to providing stronger evidence for causal inference compared with purely cross-sectional data.[24]

The main disadvantage in the use of the Gini index is that it does not capture where the inequality occurs, and two very different distributions of income may result in the same Gini index (a high Gini index could be the consequence of a number of extremely rich individuals or a number of extremely poor individuals).[20] But we take advantage of also have used as an alternative to the Gini index—the earnings dispersions measured by percentile ratios—obtaining comparable results. These measures are easily interpretable and permit comprehension with respect to which section of the income spectrum may be more important for health; however, they do not measure inequality throughout society as a whole.

One of the main limitations of this study is the possibility of ecological fallacy: it is impossible to determine exactly the exposure of those people who experienced the outcome, since the only information available is at an aggregate level. However, considering that income inequality is an intrinsically aggregate measure, and that its effect is not confined to the poor but extends to the most affluent classes, it is reasonable to assume that it is an exposure that is shared in different ways by each member of the society.[29]

Understanding the importance and the effects of reducing socioeconomic inequalities, and in particular income inequality, in developing countries is an important political goal. Inequality is prejudicial not only from a social or economical point of view, but also for the health conditions of a population. In recent years, Brazil, one of the countries with the worst income distribution in the world, has succeeded in decreasing its socioeconomic inequalities and improving the health of the population through effective social and health policies, showing a possible way forward for other developing countries.

What is already known on this subject?

- Income inequality represents an important determinant of health in high-income countries, but few studies have analysed its effects in developing countries.
- There are no evidences on the effect of a strong and rapid reduction of income inequality, driven by economic growth and effective social policies, on income inequality and life expectancy in developing countries.

What this study adds?

- The reduction of income inequality, measured with longitudinal data and different inequality indicators, can increase life expectancy even in fast-growing and high unequal developing countries like Brazil.
- The reduction of income inequality, together with an effective primary healthcare, can have a relevant impact on life expectancy in these countries.

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