

# Effect of economic recession and impact of health and social protection expenditures on adult mortality: a longitudinal analysis of 5565 Brazilian municipalities



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## Summary

**Background** Economic recession might worsen health in low-income and middle-income countries with precarious job markets and weak social protection systems. Between 2014–16, a major economic crisis occurred in Brazil. We aimed to assess the association between economic recession and adult mortality in Brazil and to ascertain whether health and social welfare programmes in the country had a protective effect against the negative impact of this recession.

**Methods** In this longitudinal analysis, we obtained data from the Brazilian Ministry of Health, the Brazilian Institute for Geography and Statistics, the Ministry of Social Development and Fight Against Hunger, and the Information System for the Public Budget in Health to assess changes in state unemployment level and mortality among adults (aged  $\geq 15$  years) in Brazil between 2012 and 2017. Outcomes were municipal all-cause and cause-specific mortality rates for all adults and across population subgroups stratified by age, sex, and race. We used fixed-effect panel regression models with quarterly timepoints to assess the association between recession and changes in mortality. Mortality and unemployment rates were detrended using Hodrick–Prescott filters to assess cyclical variation and control for underlying trends. We tested interactions between unemployment and terciles of municipal social protection and health-care expenditure to assess whether the relationship between unemployment and mortality varied.

**Findings** Between 2012 and 2017, 7 069 242 deaths were recorded among adults (aged  $\geq 15$  years) in 5565 municipalities in Brazil. During this time period, the mean crude municipal adult mortality rate increased by 8·0% from 143·1 deaths per 100 000 in 2012 to 154·5 deaths per 100 000 in 2017. An increase in unemployment rate of 1 percentage-point was associated with a 0·50 increase per 100 000 population per rter (95% CI 0·09–0·91) in all-cause mortality, mainly due to cancer and cardiovascular disease. Between 2012 and 2017, higher unemployment accounted for 31 415 excess deaths (95% CI 29 698–33 132). All-cause mortality increased among black or mixed race (pardo) Brazilians (a 0·46 increase [95% CI 0·15–0·80]), men (0·67 [0·22–1·13]), and individuals aged 30–59 years (0·43 [0·16–0·69]) per 1 percentage-point increase in the unemployment rate. No significant association was identified between unemployment and all-cause mortality for white Brazilian, women, adolescents (aged 15–29 years), or older and retired individuals (aged  $\geq 60$  years). In municipalities with high expenditure on health and social protection programmes, no significant increases in recession-related mortality were observed.

**Interpretation** The Brazilian recession contributed to increases in mortality. However, health and social protection expenditure seemed to mitigate detrimental health effects, especially among vulnerable populations. This evidence provides support for stronger health and social protection systems globally.

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## Introduction

Evidence from high-income countries indicates that the association between economic growth and overall mortality is pro-cyclical,<sup>1–5</sup> whereby mortality decreases during economic recession. This decrease in mortality is observed despite known negative health consequences of unemployment,<sup>6,7</sup> declines in self-reported health and mental health, and increased suicide rates during recessions.<sup>1,8</sup> Decreases in overall mortality have been explained by reductions in road traffic accidents, liver disease, and cardiovascular diseases during periods of

recession.<sup>1,2</sup> A possible explanation for these reductions is that declining productivity during recessions results in less participation in harmful activities (eg, driving and alcohol consumption), reduced working hours, and increased time spent on healthy activities. However, this pro-cyclical association has been less apparent in the past two decades<sup>9</sup> and research in low-income and middle-income countries (LMICs) suggests contradictory trends to those in high-income countries.<sup>10–13</sup>

The impact of recession on health might differ in LMICs compared with high-income countries,<sup>10,11</sup> because

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For the Portuguese translation of the abstract see [Online](#) for appendix 1

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### Research in context

#### Evidence before this study

We searched MEDLINE, Embase, and Econlit using broad search terms associated with “recession” and “mortality” with no date or language restrictions. Identified studies were supplemented with studies previously known to the authors. Our search yielded more than 200 studies investigating the association between economic recession and mortality, with many also exploring the influence of social protection schemes or health-care coverage. Most studies were from high-income countries, particularly the USA and Europe. The majority of studies focused on the Great Recession of 2008. Generally, studies from high-income countries reported that overall mortality decreased during recessions, despite increases in suicides and worsening mental health. Some evidence suggested that social protection and health-care programmes contributed to reductions in economic cycle-related fluctuations in mortality.

Few studies have investigated the health effects of economic recession in low-income and middle-income countries (LMICs). Generally, the association between recession and mortality is less clear for LMICs than for high-income countries. Studies identified increases in cancer-related mortality and under-5 mortality during recession among specific populations: individuals living in poorer areas of Mexico, adults of working age in Colombia, and infants of families of lower

socioeconomic status in India. Few studies have investigated the impacts of recession across population subgroups stratified by age, sex, and race, or the potential effects of social protection and health-care programmes in LMICs.

#### Added value of this study

We used robust econometric methods to assess the association between unemployment and mortality during the 2012–16 recession in Brazil and to ascertain whether internationally recognised health and social protection programmes mitigated any negative effects. Increases in recession-related mortality increased in black or mixed race (pardo) individuals, men, and individuals of working age ( $\geq 15$  years), and social protection and health-care expenditures were shown to have important protective effects on health outcomes.

#### Implications of all the available evidence

The association between economic recession and overall mortality might differ in LMICs compared with high-income countries. Our analysis and previous studies indicate that mortality might increase during recessions in LMICs, especially among at-risk populations. Thus, social protection and health-care programmes serve an important role during recessions, which warrants further prioritisation by policy makers and more detailed research.

health needs differ in LMICs, which have weaker social protection systems, and higher participation in informal and precarious employment sectors. Previous research from LMICs has often focused on the effect of recession on infant or under-5 mortality,<sup>10,14</sup> with poor understanding of adult health outcomes. Thus, the effect of recession on adults who are directly exposed to labour markets requires investigation. Additionally, aggregated impacts of economic recession might mask inequalities that exist between population groups with differential exposures to the negative effects of recession. Studies have identified countercyclical associations between unemployment and mortality (by contrast with high-income countries) in poorer areas of Mexico,<sup>12</sup> in men of working age in Colombia,<sup>11</sup> and in infants born to mothers of lower socioeconomic status in rural areas of India.<sup>13</sup> Despite evidence from high-income countries of the protective effects of health and social protection systems during recessions,<sup>2,15–17</sup> little research has been done in LMICs.

A major economic recession occurred in Brazil between March, 2014, and December, 2016, which was partly caused by a decline in commodity prices after the global economic slowdown, high interest rates and growing public debt, and a decline in consumer demand and investments. The economy contracted by nearly 8% between 2014 and 2017.<sup>18</sup> In addition to rising unemployment and poverty, declining tax revenues prompted budget cuts, which potentially undermined

the benefits of the internationally recognised health and social welfare programmes in Brazil.<sup>19,20</sup> For example, direct health system effects include increased waiting times, medicine and equipment shortages, and late payment of employee salaries.<sup>21</sup> In 2018, the Brazilian Government introduced austerity measures to restrict future public expenditures on health and education, which are predicted to have major health implications in the future.<sup>18,22,23</sup>

In Brazil, considerable health inequalities exist across the country and between population groups.<sup>24,25</sup> Different population subgroups, stratified by age, sex, and race, might be differentially affected by recession due to socioeconomic factors, labour market participation, and underlying morbidities. For example, black and mixed race (pardo) Brazilians are arguably more at risk of potential negative effects of recession on health than white Brazilians. Compared with white Brazilians, black and mixed race Brazilians are more likely to have lower educational attainment, be in informal employment, have lower incomes, rely on social protection and public health care, and access health care less frequently.<sup>25–28</sup> This study aimed to assess the association between the 2014–16 Brazilian recession and mortality in all adults and among population subgroups stratified by age, sex, and race, and to ascertain whether the internationally recognised health and social welfare programmes in Brazil protect against the effects of recession.

## Methods

### Data sources

In this longitudinal analysis, we obtained mortality statistics from the Brazilian Ministry of Health DATASUS website and population, unemployment, and municipal characteristic data from the Brazilian Institute for Geography and Statistics (IBGE; appendix 2, p 2). Data on social protection and municipal health-care expenditure were obtained from the Ministry of Social Development and Fight Against Hunger (MDS) and the Information System for the Public Budget in Health (SIOPS) (appendix 2, p 2). The period of analysis (January, 2012, to December, 2017) was based on the most recent available data for both mortality and unemployment and covered the time period before the recession.

The state unemployment rate was defined as the percentage of unemployed individuals (currently unemployed and looking for employment) relative to individuals in the workforce (all employed and unemployed individuals).<sup>29</sup> The unemployment rate was derived from the National Continuous Household Sample Survey, which surveys households across Brazil on demographic and work-related topics. The survey provides state-level, quarterly unemployment rate estimates for individuals participating in both formal and informal labour markets.

We calculated mortality rates per 100 000 population for adults (aged  $\geq 15$  years) for each municipality quarter observation. Mortality rates were calculated for all causes and for 17 selected causes of death based on WHO classifications and those likely to be affected by recession, encoded by International Classification of Diseases, 10th edition codes reported on death certificates (appendix 2, p 3). Additionally, we calculated all-cause mortality rates and mortality rates for specific causes of death, stratified by age, sex, and race. Age groups were generated using available population data and groups based on likely variation across the adult life course in underlying health risks and potential effects from unemployment: adolescents and young adults (aged 15–29 years), middle-age individuals (aged 30–59 years), and older and retired individuals (aged  $\geq 60$  years). These groupings capture the potential impacts of recession in individuals of working age and older. Racial groups were defined according to Brazilian classifications on the basis of skin colour: white, black (preto), mixed race or brown (pardo), Asian (amarelo), and indigenous. In this study, we only assessed mortality rates among black, mixed race, and white individuals since these races represent 98.5% of the Brazilian population and because mortality rate estimates are unstable for Asian and indigenous populations since the number of reported deaths is low. For our analysis, we combined black and mixed race groups, consistent with previous studies,<sup>25,30</sup> to negate misclassification across the two groups between death certificates and population estimates.

We obtained denominators for mortality rates for population subgroups based on sex, age, and race, in each

municipality from the 2010 census, and annual municipal population estimates from IBGE. Linear interpolation was used to generate quarterly population estimates to match all combinations of the age, sex, and race mortality subgroups. Mortality rates were not age standardised because fixed effects specification adjust for differences between municipalities (including age distribution differences), thus standardisation is unlikely to substantially adjust any short-term associations identified, there is limited comparison of mortality rates between areas (only within municipalities changes are estimated), and there is limited municipal-level age band data for robust standardisation.

Municipal mortality rates by cause of death were adjusted through reclassification of ill-defined cause of death using a published<sup>31</sup> and previously used method.<sup>25,32</sup> Adjustment involved reassigning defined cause of death for ill-defined cause of deaths on the basis of investigated death certificates that had been reclassified to non-ill-defined causes.<sup>31</sup>

Both employment and mortality rates were detrended (ie, underlying time trend removed) using Hodrick–Prescott filters (smoothing parameter of 1600 as recommended for quarterly data). These have been demonstrated as more robust than other model specifications for assessing the relationships between recession and health.<sup>33</sup>

To measure coverage of municipal social protection and health-care programmes, we obtained data on Bolsa Familia and health-care expenditure from the MDS and SIOPS. The Bolsa Familia programme is a national social protection programme that provides financial aid to nearly 14 million poor families as conditional cash transfers,<sup>20</sup> and because it is the major social protection programme in Brazil, Bolsa Familia represents a proxy for social protection coverage. Families registered with the programme receive cash benefits if conditionalities such as adhering to children’s vaccination schedules and ensuring school attendance are met. Municipal health expenditure represents local expenditure on health from public sources and is composed of funds raised by municipalities themselves through taxes and funds transferred to municipal governments from state and federal governments for programmes such as the family health strategy or operating local hospitals.

### Statistical analysis

We used panel regression methods to assess the association between recession and changes in mortality rates in Brazil between 2012 and 2017, using quarterly timepoints. The unit of observation was the municipality, which is the smallest administrative unit for aggregating mortality rates using open and accessible data. Similar to other published studies,<sup>3,15</sup> we used state-level unemployment rates as a macroeconomic proxy for economic recession. State-level is the smallest geographical unit for which regular data are available

For more on DATASUS see <http://www.datasus.gov.br>

For more on IBGE see <https://www.ibge.gov.br/en/home-eng.html>

See Online for appendix 2

For more on the MDS see <https://aplicacoes.mds.gov.br/sagi/vis/data/index.php>

For more on the SIOPS see <http://portalms.saude.gov.br/repases-financeiros/siops/indicadores>

For the National Continuous Household Sample Survey see <https://sidra.ibge.gov.br/pesquisa/pnadct/tabelas>

that captures regional variation in both the timing and depth of recession.

The modelling strategy used was based on previously published studies assessing the association between economic recession and mortality.<sup>3,9,33</sup> Panel regression models are appropriate for examining units of observation (eg, municipalities) over time and accounting for the clustered nature of the data (time periods within municipalities). We used fixed effects regression models to assess the association between unemployment and mortality rates. Fixed-effect specifications are an appropriate approach to explore trends over time, while controlling for time-invariant unobserved factors that might bias the association between unemployment and mortality (eg, geography or climate). The first equation used was:

$$M_{smq} = a_m + U_{sq}\beta + T_{sq} + q + \epsilon_{smq}$$

where  $M_{smq}$  is the mortality rate in municipality  $m$  in state  $s$  in quarter  $q$ ;  $a_m$  is the municipal fixed effect;  $U_{sq}$  is the unemployment rate for state  $s$  in quarter  $q$ ;  $T_{sq}$  is a linear state-specific time trend;  $q$  is a dummy for the quarter; and  $\epsilon_{smq}$  is the error term. In fixed-effects specifications, mean differences between municipalities are controlled for, and since only associated changes between variables within municipalities are examined, the term  $\beta$  provides an effect estimate for mean change in the municipal mortality rate per 1 percentage-point increase in the state unemployment rate.

Unemployment rate was obtained at the state level and the SEs were clustered at the state level for conservative estimates of the statistical significance.<sup>3</sup>

Additionally, all regression models were weighted by mean municipal population between 2012 and 2017 to account for the large heterogeneity in municipal population size. For analyses by cause of death, significance of p value testing was adjusted for multiple hypothesis testing.

To analyse whether the associations between changes in unemployment and changes in mortality were heterogeneous across the three terciles of health and social protection expenditure, municipalities were divided into three equal groups (terciles) on the basis of mean expenditures on health and social protection over 2012–17. The categorical tercile variables were interacted with the unemployment variables, allowing three estimates for within-municipality association between changes in unemployment and changes in mortality for the three terciles of municipalities. Municipal government health expenditure (Brazilian reais [R\$] per capita) and social protection expenditure (Bolsa Familia expenditure [R\$ per poor population]) were modelled separately. The effect estimates reported are interpreted as the mean change in the municipal mortality rate of municipalities in a specific tercile (of health or social protection expenditure) per 1 percentage-point increase in the state unemployment rate.

A three-way interaction (between unemployment, social protection terciles, and health-care expenditure terciles) was also carried out to assess further variations in these relationships. Several assumptions pertinent to this analytical approach were tested (appendix 2, pp 9–12). The main assumption is that changes in the unemployment rate are uncorrelated with unobserved factors changing at the same time, which could also affect mortality. We argue that many factors do not change that rapidly, lie on the causal pathway between recession and health (and thus should not be controlled for), or are captured by municipal time trends (which are removed using Hodrick–Prescott filters). We added the following covariates to the model to test whether other factors could mediate the associations between unemployment and mortality: municipal gross domestic product (GDP) per capita (with a 1 year lag), municipal coverage with the Family Health Strategy (ie, number of clinics per 3450 inhabitants), municipal hospital bed density, and municipal private insurance plans per capita. We also tested linear models with time trends to compare the results with detrended rates. Since state-level unemployment rates were used for our analysis, we repeated the analyses with mortality aggregated to the state level instead of the municipal level to test the robustness of our results.

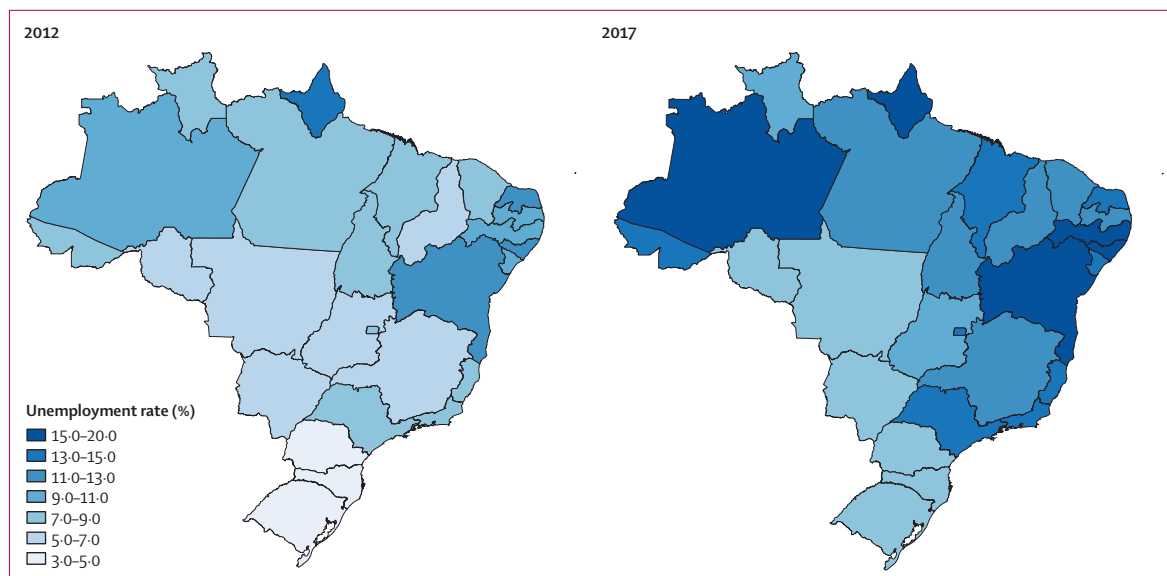
### Role of the funding source

There was no funding source for this study. The corresponding author had access to all study data and responsibility for the decision to submit the paper for publication.

	All races			Black or mixed race			White		
	Overall	Women	Men	Overall	Women	Men	Overall	Women	Men
<b>2012</b>									
15–29 years	32.2 (43.6)	14.0 (39.6)	49.7 (75.4)	33.6 (133.9)	13.2 (65.9)	52.3 (206.7)	27.3 (67.5)	13.7 (68.1)	41.0 (116.7)
29–59 years	98.8 (62.7)	65.0 (69.8)	132.4 (100.2)	98.9 (107.8)	64.1 (122.5)	132.4 (169.7)	86.4 (98.6)	60.0 (111.0)	113.5 (156.9)
≥60 years	804.6 (335.1)	719.4 (417.6)	897.6 (476.2)	677.0 (607.9)	591.6 (997.2)	768.7 (888.7)	847.8 (552.6)	780.9 (713.4)	927.1 (773.0)
All adults*	143.1 (348.1)	119.6 (88.7)	166.2 (104.6)	116.4 (116.3)	91.2 (142.2)	140.5 (169.0)	152.4 (123.2)	134.2 (145.4)	170.8 (170.4)
<b>2017</b>									
15–29 years	30.5 (41.0)	12.6 (37.9)	47.7 (70.9)	34.0 (68.6)	12.9 (71.0)	53.7 (114.0)	22.5 (58.7)	11.8 (61.9)	33.1 (98.1)
29–59 years	97.4 (61.5)	64.4 (67.9)	130.3 (98.6)	105.7 (177.3)	69.4 (255.4)	140.5 (200.2)	78.5 (93.6)	56.1 (107.3)	101.5 (146.3)
≥60 years	910.9 (76.1)	813.7 (436.7)	1016.5 (494.4)	824.1 (741.9)	715.9 (1006.7)	936.0 (1022.3)	926.3 (568.7)	855.2 (718.6)	1009.0 (812.4)
All adults*	154.5 (77.7)	130.2 (91.3)	178.4 (106.9)	133.9 (136.5)	106.2 (177.0)	160.1 (175.5)	158.3 (123.5)	142.2 (147.3)	174.5 (171.8)

Data are mean deaths per 100 000 population (SD). Data were obtained from DATASUS-SIM. Mortality rates are not age standardised and are the mean of municipal rates.\*Includes all individuals aged ≥15 years.

**Table 1: Mean all-cause municipal 2012 and 2017 mortality rates, for all adults and by sex, age, and race**



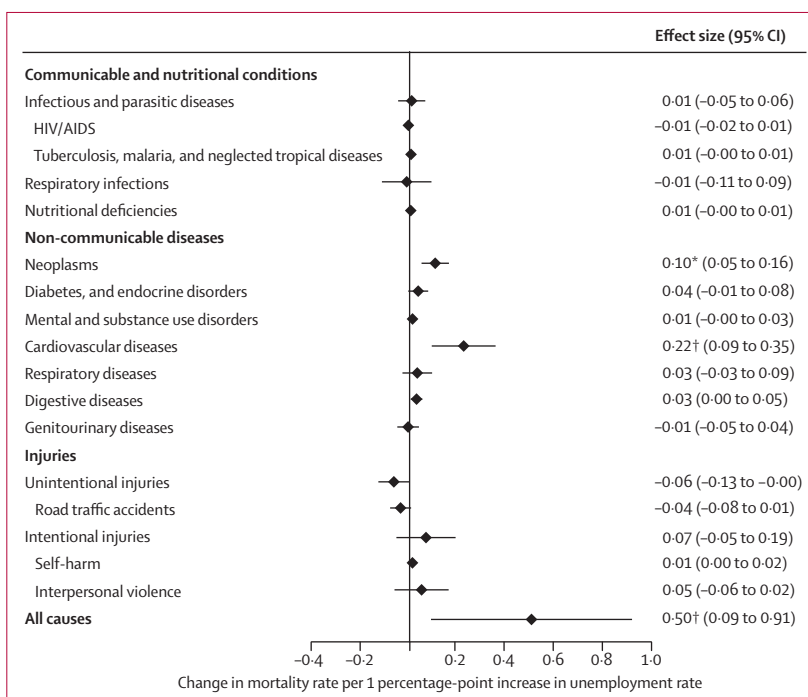
**Figure 1: Mean state unemployment rates in Brazil in 2012 and 2017**  
Data were obtained from the Brazilian Institute for Geography and Statistics (National Continuous Household Sample Survey).

**Results**

Between 2012 and 2017, 7069 242 deaths were recorded among adults (aged  $\geq 15$  years) in 5565 municipalities in Brazil (appendix 2, p 4). The 17 selected causes of death accounted for 6 621 347 (93.7%) of all 7069 242 deaths in the period. Of the 7069 242 deaths, 2 213 942 (31.3%) were due to cardiovascular diseases, 1 238 651 (17.5%) due to malignant neoplasms, 432 432 (6.1%) due to respiratory infections, 412 944 (5.8%) due to unintentional injuries, 418 897 (5.9%) due to respiratory diseases, 415 355 (5.9%) to intentional injuries, 397 653 (5.6%) due to diabetes and endocrine, blood, and immune disorders, and 379 285 (5.4%) due to digestive diseases (appendix 2, p 4). Between 2012 and 2017, the mean crude municipal adult mortality rate increased by 8.0% from 143.1 deaths per 100 000 to 154.5 1 deaths per 100 000 (table 1). Differences and divergent trends in mortality rates were identified across age, sex, and race stratifications; however, mortality rates for these subgroups were not age standardised, which precludes inference.

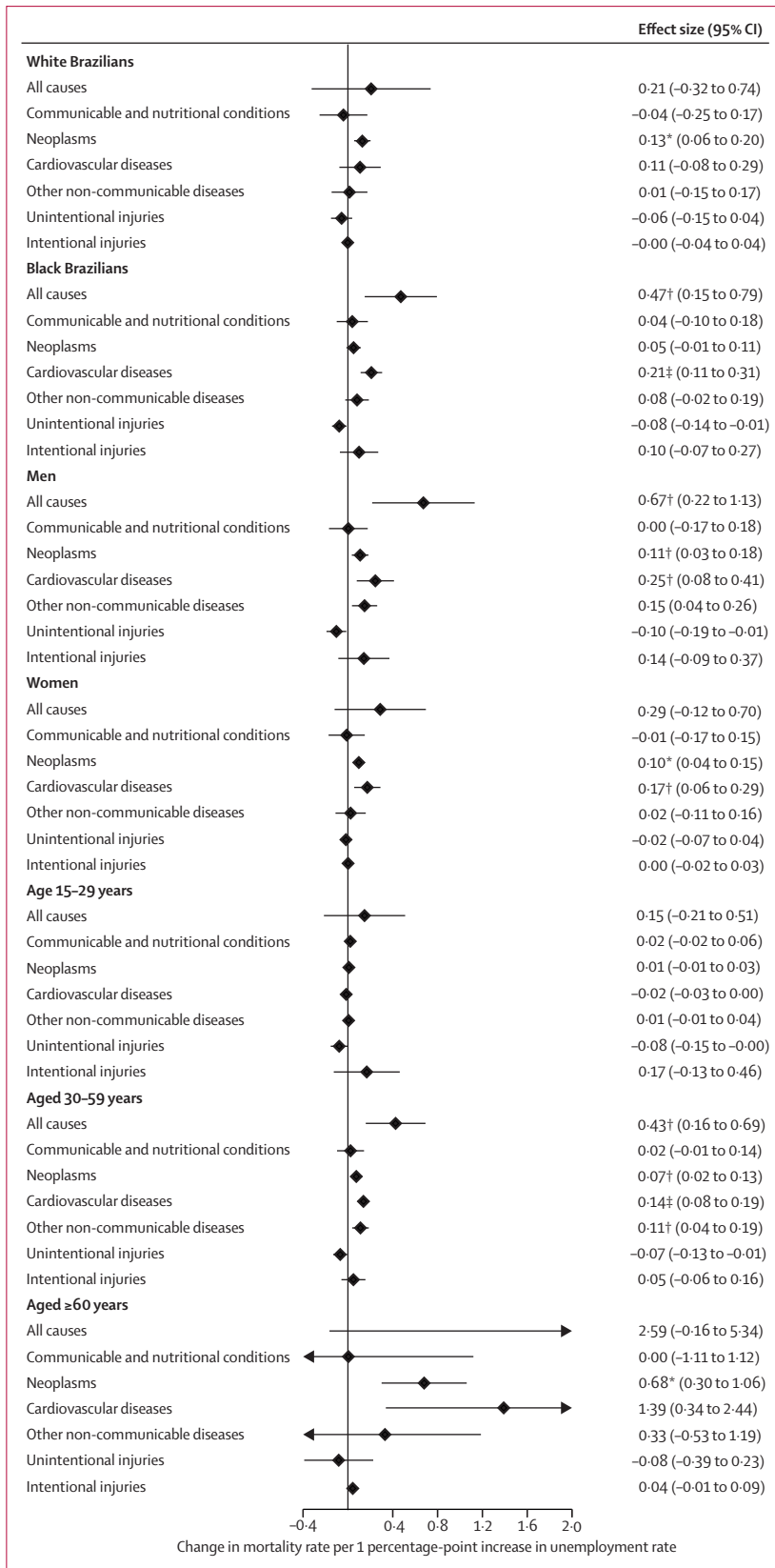
Between 2012 and 2017, the mean state unemployment rate decreased from 8.4% in the first quarter of 2012 to 6.5% in the fourth quarter of 2013, rising to 13.7% in the first quarter of 2017 (appendix 2, p 5). The state unemployment ranged from 2.7% to 18.8% across the study period. In general, states in the north and north-eastern regions of Brazil had the highest rates of unemployment and the largest increases in the unemployment rate between 2012 and 2017 (figure 1).

Regression coefficients for changes in mortality associated with changes in the unemployment rate were plotted from regression models by cause of death (figure 2). A 1 percentage-point increase in the state unemployment rate was associated with a 0.50 increase



**Figure 2: Association between unemployment rate and adult mortality by cause of death**  
Effect estimates were obtained from separate fixed-effects regression models for each cause of death (n=17). All regression models included state-time effects, quarterly fixed effects, and were detrended using Hodrick-Prescott filters. Regression models were weighted by municipal population with state-clustered SEs. Effect estimates were interpreted as change in quarterly mortality rate (deaths per 100 000 population) per 1 percentage-point increase in state unemployment rate. \*p<0.0006. †p<0.003.

per 100 000 population per quarter (95% CI 0.09–0.91) in the mean municipal all-cause adult mortality rate. Therefore, the annual effect size would be 2.0 deaths per 100 000, and a mean municipal mortality rate of



143.1 per 100 000 in 2012 would result in a mean relative increase in the adult mortality rate of 1.4% per 1 percentage-point increase in unemployment. With a cumulative increase of 3.1 percentage points in the unemployment rate between 2012 and 2017, the recession was associated with a 4.3% increase in mean municipal mortality rate.

Increasing mortality was driven by increases in mortality from neoplasms (0.11 increase per 100 000 population [95% CI 0.05–0.16]) and cardiovascular diseases (0.22 [0.09–0.35]). These effect sizes were smaller than the all-cause effect size because the all-cause effect size represented an aggregate effect for all causes. Unemployment was also associated with higher mortality from digestive diseases and self-harm, but associated with lower mortality from unintentional injuries, although these differences were not statistically significant when p values were adjusted for multiple hypothesis testing. Across racial subgroups, increases in unemployment were associated with increases in all-cause mortality for black and mixed race Brazilians (0.47 increase per 100 000 [95% CI 0.15–0.80]), whereas no significant difference in mortality rate was identified for white Brazilians (figure 3). Additionally, increases in unemployment were associated with increases in mortality rates for men (0.67 increase [95% CI 0.22–1.13]) and individuals aged 30–59 years (0.43 increase [0.16–0.70]). Assuming there had been no changes in the unemployment rate between 2012 and 2017 (ie, no recession), an estimated 31415 deaths (95% CI 29 698–33 132) could have been avoided (appendix 2, p 10).

Increases in unemployment were only associated with increases in overall mortality in municipalities in the lowest terciles (0.78 increase per 100 000 population [95% CI 0.38–1.18]) and middle terciles (0.61 [0.15–1.08]) of Bolsa Familia expenditure per poor person, and in municipalities with the lowest public health expenditure per capita (0.63 increase per 100 000 population [0.24–1.02]; figure 4). These patterns were similar across population subgroups when stratified by sex and race, with increases in mortality identified among black or mixed race individuals and male individuals in municipalities in the lowest and middle terciles of Bolsa Familia and health expenditure, and increases in female mortality identified only in municipalities with the lowest Bolsa Familia and health expenditure (figure 4). A three-way interaction between social protection, health-care expenditure, and unemployment for all-cause adult

**Figure 3: Association between unemployment rate and mortality by cause of death for population subgroups**

Effect estimates obtained from separate fixed-effects regression models for causes of death. All models included state-time effects, quarterly fixed effects, and were detrended using Hodrick-Prescott filters. Regression models were weighted by municipal population and used state-clustered SEs. Effect estimates were interpreted as change in quarterly mortality rate (deaths per 100 000 population) per 1 percentage-point increase in state unemployment rate. \*p<0.0014. †p<0.007. ‡p<0.0001.

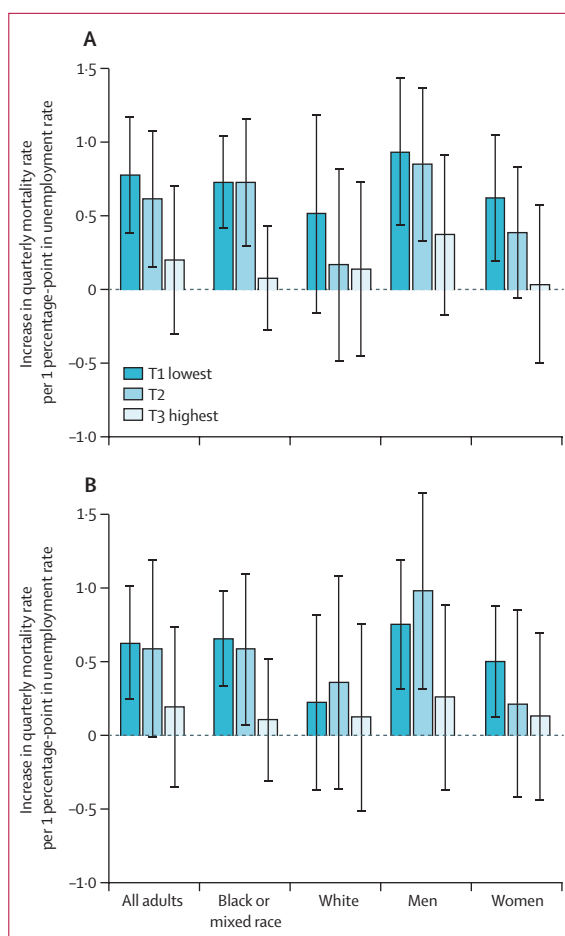
mortality showed that increases in mortality associated with unemployment were found in municipalities that did not have the highest social protection or health-care expenditure (appendix 2, p 9).

The findings of analyses using alternative time specifications, variables that had not been detrended, non-weighted variables, and state-level aggregation were concordant, suggesting that the model specification was robust (appendix 2, pp 11–12). Additionally, inclusion of time-dependent variables (GDP per capita, Family Health Strategy Coverage, hospital beds density, and private insurance plan coverage) in the model yielded similar effect sizes for unemployment and mortality suggesting the negative effects of recession were not mediated through short-term changes in these variables.

## Discussion

This study finds that the 2012–16 economic recession in Brazil was countercyclically associated with adult mortality. Increases in unemployment between 2012 and 2017 were associated with more than 30 000 additional deaths, mainly from cancer and cardiovascular disease. The largest increases in mortality were observed in black and mixed race populations, men, and individuals aged 30–59 years. Considering that these populations generally have poorer health than women and white Brazilians, it is likely the economic recession increased existing health inequalities. Municipalities with higher expenditures on health and social protection programmes had lower or no unemployment-associated increases in mortality.

The countercyclical association identified between recession and mortality contradicts the associations identified in many studies done in high-income countries,<sup>1–5,16</sup> however, other Latin American studies have shown increases in overall mortality during recession, especially in the poorest areas.<sup>10–12</sup> This difference could result from multiple factors. Similar to many other Latin American and middle-income countries, sizeable health and socioeconomic inequalities exist in Brazil, which has weaker health-care and social protection systems and more precarious job markets than high-income countries.<sup>34</sup> Thus, the level of exposure to the negative effects of recession and unemployment might be higher in Brazilian populations than individuals in high-income countries.<sup>6</sup> In 2017, 37·3 million Brazilians (40·8% of the labour force) were employed in informal jobs, earning on average 48·5% of the income of individuals employed in formal jobs.<sup>26</sup> Lower income, greater risk of poverty-related poor health, and increased psychosocial stress could have contributed to increases in mortality during recession.<sup>16–8</sup> Unemployment has known negative health effects. The finding that mortality increased to a greater extent among black and mixed race Brazilians than white Brazilians during the 2014–16 recession is concordant with previous evidence that black and mixed race Brazilians are more likely to be in



**Figure 4: Associations between unemployment and all-cause mortality in all adults and population subgroups by municipal social protection and health-care expenditure**

Associations between unemployment, mortality, and Bolsa Familia expenditure (A) and health-care expenditure (B). Effect estimates were obtained from separate fixed-effects regression models with separate unemployment variables for each of the three tertiles of municipalities. Tertiles were based on Bolsa Familia expenditure per poor person and public health expenditure per capita. Plotted coefficients were interpreted as change in quarterly mortality rate (deaths per 100 000 population) per 1 percentage-point increase in state unemployment rate in municipalities of that tertile. All regression models include quarter fixed effects, and were detrended using Hodrick–Prescott filters. Regression models were weighted by municipal population and used state-clustered SEs. T=tertile.

informal employment than white Brazilians (46·9% vs 33·7%<sup>26</sup>), have lower incomes than white Brazilians employed in the same role,<sup>26</sup> are at higher risk of falling into poverty, and have a greater need for investment in health and social protection programmes.<sup>25,27</sup> In the USA, evidence also shows the health of men, black individuals, and Hispanic individuals, and individuals with lower education is most affected by economic recession.<sup>35</sup>

The 2014–16 economic crisis in Brazil has had a negative effect on health-care access,<sup>18,21,36</sup> which might partly explain our findings. During the recession, delays in paying medical staff, medicine shortages, and clinic closures were widely reported.<sup>21,36</sup> Assessment of the

long-term trends in health-care funding and changes in health service availability following the recession will be an important area for future research when data become available. Notably, increases in unemployment were not associated with increases in mortality in municipalities with higher health-care and social protection spending, which is consistent with research from North America and Europe. Evidence from the 2008 recession across European countries has highlighted the importance of social protection expenditure in negating recession-related mortality.<sup>2,15</sup> Evidence also suggests that universal health coverage and social protection expenditures are important for reducing the harmful effects of unemployment on mortality.<sup>16,17</sup>

The association between increased mortality from neoplasms and unemployment might be surprising, but is concordant with global studies,<sup>9</sup> which argue that declining income and socioeconomic status increase barriers to accessing care.<sup>17</sup> However, increases in cardiovascular diseases mortality contrasts with the findings of studies from high-income countries.<sup>1-3,5</sup> The mechanisms that contribute to decreases in cardiovascular diseases mortality during recession in high-income countries are unclear, but are possibly due to declining working hours, increased time spent on healthy activities, and less participation in unhealthy behaviours (ie, drinking, smoking, and unhealthy diets).<sup>12,16</sup> In Brazil, similar to other middle-income countries, these pathways might be less important since precarious employment can reduce an individual's ability to purchase medicines, unemployment might result in the loss of private insurance, healthy and unhealthy behaviours might be less linked to the economic cycle than in high-income countries, and health service inadequacies (eg, delays in providing medicines<sup>21,36</sup>) are likely to also be greater. The decreases in unintentional injury mortality (majority road traffic injuries) associated with higher unemployment in black and mixed race individuals, men, and individuals of working age is consistent with studies from Europe,<sup>2,37</sup> and generally explained by reduced car use during recession.

Our study has key limitations. First, challenges with regard to data quality and processing exist. Mortality and ill-defined mortality are under-reported in Brazil. However, under-reporting was corrected for during the analysis by adjusting for municipal fixed effects (ie, only assessing changes within municipalities), and therefore any changes in reporting are unlikely to be correlated with changes in unemployment. Furthermore, mortality rates were based on interpolated and extrapolated population and demographic distribution estimates. Mortality rates were not age standardised due to the small age-strata when examining rates across racial groups and the use of Hodrick–Prescott filters (which remove underlying trends including gradual ageing of the population). Biases might have been present, but we argue that they would have been small since the fixed-effects approach used assessed the exogenous

fluctuation in economic activity and controlled for municipal fixed effects. State-level unemployment was used as an indicator of recession and assumes similar changes in unemployment across all municipalities in a state. This assumption masks municipal variation in unemployment rates, which would allow more accurate estimates of local recession effects. Although this is not ideal, these were the most granular data available and quarterly subnational data on unemployment are rarely available for many middle-income countries. Compared with national-level data, state-level unemployment rates allow regional variations to be exploited in the analytical strategy and better reflect proximity of an individual to the effects of recession. The unemployment data might also be limited by the fact that data were collected from reported employment status and do not reflect nuances of the labour market such as moving from formal to informal employment.

Second, any causal claim must be restricted considering that these analyses only examined associations within municipalities over time. Although trends and patterns were identified, determining causal pathways between recession and mortality in Brazil requires more research.

Third, although fixed-effects regression methods are robust and frequently used, these models rely on the assumption that unobserved variables associated with unemployment and mortality are time-invariant and not part of the causal pathway. Furthermore, the approach to examining heterogeneous effects of unemployment does not adjust for all multiple municipality characteristics, and considering that it is likely that a correlation exists between these factors (eg, wealthier municipalities are likely to spend more on health care), judicious interpretation is necessary. Autocorrelation and heteroscedasticity might also be present in these models, but these factors were controlled for by using cluster robust SEs.

The 2012–16 recession in Brazil has most likely contributed to the observed increases in mortality. Black and mixed race Brazilians, men, and individuals of working age were most negatively affected, indicating that the recession might contribute to worsening of health conditions in these groups and thus widening of existing health inequalities. However, no significant increases in recession-related mortality were identified in areas with higher expenditure on health and social protection programmes. These findings are likely to be generalisable to other LMICs as many have sizeable inequalities, precarious job markets, and limited safety nets to protect individuals from the negative effects of economic recession. Our findings underline the importance of nationally appropriate social protection systems to protect at-risk populations from the adverse health impacts of economic recessions in LMICs.

#### Contributors

TH, DR, and CM conceptualised the study. TH, DR and RR contributed to the literature search. TH compiled data, analysed data, produced the



figures and tables, and wrote the original draft of the manuscript. AM provided statistical guidance and input on the analysis and edited early drafts of the manuscript. All authors contributed to subsequent drafts of the manuscript and provided critical interpretation of the results and approved the manuscript for publication.

#### Declaration of interests

We declare no competing interests.

#### Data sharing

All data used in this study are publicly available from the sources listed in appendix 2.

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