Cardiovascular Risk Factors

# Impact of Brazil's Bolsa Família Programme on cardiovascular and all-cause mortality: a natural experiment study using the 100 Million Brazilian Cohort

Julia M Pescarini [1,2]* Desmond Campbell,[3] Leila D Amorim,[4] Ila R Falcão,[1] Andrêa JF Ferreira,[1] Mirjam Allik,[3] Richard J Shaw [3] Deborah C Malta,[5] M Sanni Ali,[2] Liam Smeeth,[2,6] Mauricio L Barreto,[1,7] Alastair Leyland [3] Peter Craig,[3†] Estela ML Aquino[7†] and Srinivasa Vittal Katikireddi [3†]

[1]Centre for Data and Knowledge Integration for Health (CIDACS), Oswaldo Cruz Foundation, Salvador, Brazil, [2]Departments of Infectious Disease Epidemiology (JMP) and Epidemiology and Population Health (LS), Faculty of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine, London, UK, [3]MRC/CSO Social & Public Health Sciences Unit, University of Glasgow, Glasgow, UK, [4]Departamento de Estatística, Instituto de Matemática e Estatística, Universidade Federal da Bahia, Salvador, Brazil, [5]Departamento materno infantil e saude pública, Universidade Federal de Minas gerais (UFMG), Belo Horizonte, Brazil, [6]Health Data Research (HDR), London, UK and [7]Instituto de Saúde Coletiva, Universidade Federal da Bahia, Salvador, Brazil

*Corresponding author. London School of Hygiene & Tropical Medicine, Keppel St, London, WC1E 7HT, UK. E-mail: julia.pescarini1@lshtm.ac.uk

[†]Co-senior authors.

## Abstract

**Background:** Cardiovascular disease (CVD) has a disproportionate effect on mortality among the poorest people. We assessed the impact on CVD and all-cause mortality of the world's largest conditional cash transfer, Brazil's Bolsa Família Programme (BFP).

**Methods:** We linked administrative data from the 100 Million Brazilian Cohort with BFP receipt and national mortality data. We followed individuals who applied for BFP between 1 January 2011 and 31 December 2015, until 31 December 2015. We used marginal structural models to estimate the effect of BFP on all-age and premature (30–69 years) CVD and all-cause mortality. We conducted stratified analyses by levels of material deprivation and access to healthcare. We checked the robustness of our findings by restricting the analysis to municipalities with better mortality data and by using alternative statistical methods.

**Results:** We studied 17 981 582 individuals, of whom 4 855 324 were aged 30–69 years. Three-quarters (76.2%) received BFP, with a mean follow-up post-award of 2.6 years. We detected 106 807 deaths by all causes, of which 60 893 were premature; and 23 389

CVD deaths, of which 15 292 were premature. BFP was associated with reductions in premature all-cause mortality [hazard ratio (HR) = 0.96, 95% CI = 0.94–0.98], premature CVD (HR = 0.96, 95% CI = 0.92–1.00) and all-age CVD (HR = 0.96, 95% CI = 0.93–1.00) but not all-age all-cause mortality (HR = 1.00, 95% CI = 0.98–1.02). In stratified and robustness analyses, BFP was consistently associated with mortality reductions for individuals living in the two most deprived quintiles.

**Conclusions:** BFP appears to have a small to null effect on premature CVD and all-cause mortality in the short term; the long-term impact remains unknown.

**Key words:** Cardiovascular disease, mortality, conditional cash transfer, Bolsa Família Programme, Family Health Strategy

---

**Key Messages**

- This is the first study to estimate the effect of a conditional cash transfer programme on cardiovascular and all-cause premature and all-ages mortality in a low- or middle-income country using individual-level data.
- The Bolsa Família Programme (BFP) was weakly and inconsistently associated with short-term cardiovascular and all-cause mortality in the general population.
- Associations between BFP and lower cardiovascular and all-cause mortality in more deprived municipalities persisted after robustness checks and should be better investigated.
- Longer follow-up, more consistent death registration in more deprived municipalities and further information on unmeasured confounding are needed to better estimate the full effects of BFP on mortality in Brazil.

## Introduction

Conditional cash transfer programmes (CCTs) are social policies that supplement incomes but also require beneficiaries to comply with conditions, such as participation in education or preventive healthcare.[1] CCTs can tackle the structural and intermediate determinants of health and promote health equity by several mechanisms,[2,3] such as by reducing poverty[4,5] and improving diet and education take-up,[6] and by contributing to women's empowerment and improved psychosocial circumstances (e.g. reduced indebtedness).[7]

In the past two decades, high rates of economic growth and the strengthening of social safety nets, such as CCTs, have played a substantial role in reducing economic and health disparities in low- and middle-income countries (LMICs).[2] The Brazilian Bolsa Família Program (BFP) was implemented in 2004[8] and is the largest and one of the oldest CCTs in the world.[6,9] BFP had been delivered to >14.6 million families as of October 2021 and has had widespread uptake among all Brazilian poor households since 2010.[10] Although BFP conditionalities focus on pregnant and breastfeeding women, children and adolescents, BFP cash benefits and conditionalities affect the entire household, as the programme has been associated with increased working hours, better jobs and higher familial income.[11–13]

Cardiovascular disease (CVD), the leading cause of death worldwide, is largely attributable to biological risk factors, such as high systolic blood pressure and high fasting plasma glucose, being overweight or obese and having an inadequate diet, that are disproportionally concentrated amongst poor individuals and those living in LMICs.[14,15] In addition to behavioural factors and co-morbidities, premature mortality (i.e. death among persons aged 30–69 years)[16] from CVD and all causes are strongly and consistently associated with low socio-economic status.[14,17] Premature mortality is one of the Sustainable Developmental Goals indicators for monitoring effective policies for disease prevention and control.[18,19] Therefore, policies aiming to reduce inequalities in CVD risk factors have great potential to reduce related deaths among the most disadvantaged populations. Nevertheless, there is limited evidence of the impact of CCTs on modifiable risk factors for CVD (e.g. tobacco and alcohol use and physical exercise) or on CVD mortality.[20,21]

In common with other CCTs, BFP may have ancillary benefits to adult health,[22] such as reducing CVD risk through short-term (e.g. poverty reduction and improved nutritional status), short- to medium-term (e.g. use of preventive health services) and long-term (e.g. improved access to education and upward social mobility) mechanisms.[23] Nevertheless, reductions in short-term CVD mortality due

to CCTs are expected to occur mainly through greater knowledge about health and nutrition and increased access to healthcare services by beneficiary families,[22] e.g. leading to the detection and treatment of adults in the family with severe CVD. We used data from the 100 Million Brazilian Cohort linked with mortality data in Brazil, a middle-income country,[24] to estimate the short-term effect of BFP on premature and all-age cardiovascular mortality. Given the high contribution of CVD to all causes of death in Brazil, we further estimated the broader effects of BFP on all-cause mortality.[23]

## Methods

We followed a pre-specified protocol for this evaluation.[23] Deviations from the original protocol are explained in the Supplementary material (available as Supplementary data at *IJE* online). The study is reported according to the reporting of studies conducted using the Template for Intervention Description and Replication (TIDieR) checklist[25] (Supplementary Table S1, available as Supplementary data at *IJE* online).

### Intervention

Since BFP implementation, eligibility for BFP and income benefits varied to adjust for inflation.[23] To be eligible for BFP, families must register with Brazil's National Registry for Social Programs 'Cadastro Único' (CadÚnico) and be extremely poor [monthly per-capita household income of ≤Brazilian Reais (BRL) 77 or USD 19 in 2015] or poor (monthly per-capita household income ≤BRL 154 or USD 39 in 2015).[26] In 2015, families with income below the extreme poverty cut-off received a fixed benefit of BRL 77 (USD 19) plus a variable benefit of BRL 35–42 (USD 9–11) per child or adolescent, or pregnant or breastfeeding woman in the household. Families with income above the extreme poverty but below the poverty cut-off received only the variable benefit.[27] Since 2011, extra benefits have been provided to families to ensure that their income is at least as high as the extreme poverty threshold after receiving BFP.[27] Further details about the intervention, such as changes in the eligibility and amount over time, as well as details about BFP implementation, are included in the TIDieR-PHP[25] reporting template (Supplementary Table S1, available as Supplementary data at *IJE* online).

### Study design and data sources

The 100 Million Brazilian Cohort[28] is a dynamic cohort built from the registration records of individuals applying for benefits covered by the Unified Registry for Social

Programs (CadÚnico) between 1 January 2001 and 31 December 2015, linked with BFP receipt and nationwide mortality records from the Mortality Information System.[29,30] CadÚnico is used for the administration of all federal social assistance benefits within Brazil. It includes ∼55% of the total Brazilian population and has high coverage among low-income groups.[28]

From the cohort baseline (i.e. first registration in CadÚnico), we extracted socio-economic and demographic information at the individual (i.e. age, gender, race/ethnicity and education) and household level (i.e. region of residence, urban/rural residence, house construction material, electricity, water supply, sewage, garbage collection, household density and monthly per-capita income).[28] For individuals aged <18 years, we assigned information on education as that of the household member with the highest level of education.

From the BFP database, we extracted information on the first and last date on which each household member received the benefit. We defined beneficiaries as individuals who were paid the benefit (usually a woman) or were members of a payee's household. As BFP eligibility criteria (i.e. monthly per-capita income) changed over time, we standardized household monthly per-capita income using a correction factor that adjusted the income in line with the eligibility thresholds for the year of BFP application.[23]

From the Mortality Information System Database, we extracted information on the dates and causes of death. Deaths within Brazil are subject to certification by medical professionals, with cause of death coded according to International Classification of Diseases version 10 (ICD-10).[31] Reporting rates in the Mortality Information System Database are considered high overall,[32] reaching ≥90% completeness in 93% of municipalities, though there is some variation between municipalities, with lower levels of reporting in poorer municipalities, especially in the North.

We also extracted municipality-level information on (i) material deprivation,[17] (ii) under-reporting of mortality and (iii) Family Health Strategy (FHS) coverage. Material deprivation was measured by population weighted quintiles of the Brazilian Deprivation Index (IBP)[33] for 2010, which combines the proportion of households in a given area with per-capita income ≤1/2 minimum wage, proportion of those aged ≥7 years who are illiterate and the proportion of people with inadequate housing. Quintiles of IBP are used as they provide good variation but with small risk of misclassifying a municipality. Estimates of under-reporting for premature and all-age deaths, stratified by age and gender, were extracted for 2010.[34] Coverage of the FHS,[35] a community-based primary healthcare programme aimed to expand its access and which has been previously associated with lower all-cause and CVD

mortality in Brazil,[36] was available for 2015 (i.e. midpoint year of the study period).

## Data linkage

The linkage between the 100 Million Brazilian Cohort (2001–2015) and BFP data (2004–2015) was based on a single identifier (the National Identification Number or NIS). The linkage between the cohort baseline and mortality data (2001–2015) was performed in two steps using the CIDACS-RL tool.[37] First, death records were linked based on exact matching, then unmatched records were linked using a similarity score. For both stages the matching was based on five identifiers (name, gender, year of birth, name of the mother and municipality of residency). The data set was constructed by the Centre for Data and Knowledge Integration for Health from Oswaldo Cruz Foundation,[30] de-identified and provided to the researchers for use in a safe haven without access to the internet. Details on linkage sensitivity and specificity are in the Supplementary material (available as Supplementary data at *IJE* online).

## Study population

The study population consisted of individuals who registered with the 100 Million Brazilian Cohort from 1 January 2011 to 31 December 2015 as monthly per-capita income was only available from 2011 onwards. We excluded (i) individuals who apparently died before applying to the cohort, as the anomalous dates could reflect linkage errors and[17] (ii) those who were >100 years of age at registration most likely have missing or unmatched death certificates. In addition, we excluded (iii) individuals with standardized monthly per-capita income of >BRL 300 (USD 75), so our study population was restricted to individuals who were more likely to be eligible for BFP; and (iv) individuals of Asian or Indigenous ancestry who together represented only 1.5% of the eligible population and whom we judged should not be grouped with other race/ethnicities because of their distinct characteristics. Finally, we excluded (v) individuals who applied on the last day of the follow-up (i.e. 31 December 2018) or died on the same day as they applied.

Our main analysis is related to individuals aged 30–69 years, reflecting premature mortality,[38] but we also repeated the analysis for all individuals (aged zero up to 100 years).

## Primary and secondary outcomes

Our primary outcome was CVD mortality (ICD-10 I00–I99). Secondary CVD end points included the two main CVD subtypes, namely ischaemic heart disease (I20–I25) and cerebrovascular disease (I60–I69), and all-cause mortality.

For the primary analysis (premature mortality), the number of person-years at risk (pyr) that each individual contributed to the analysis started at registration or upon reaching 30 years of age and ended at the earliest of: (i) death, (ii) 31 December 2015 or (iii) when the individual reached 70 years of age. Individuals who applied to the 100 Million Brazilian Cohort before the age of 30 years and started receiving BFP before that date were considered as exposed to BFP from the start of their risk period. For the analysis of individuals from all ages, pyr of individuals aged 0–100 years started at registration and ended at death or on 31 December 2015, whichever came first.

## Analysis

We calculated directly age-standardized rates of CVD mortality amongst recipients and non-recipients using the Brazilian 2015 official population projection as the standard[39] and estimated the 95% CIs according to Breslow and Day.[40]

We used a marginal structural model (MSM) using inverse probability of treatment weighting (IPTW) aiming to estimate the causal effect of BFP on mortality as BFP receipt is an exposure that varies over time.[41] The remaining covariates were considered fixed in time. We classified individuals as unexposed prior to BFP receipt and exposed from the date of the first receipt, so we could compare exposed and non-exposed individuals with similar probabilities of being eligible at a given point in time. First, we estimated the probability of receiving BFP (hereafter referred to as the propensity score—PS) over time using logistic regression given their baseline socio-economic and demographic characteristics (i.e. gender, age, race/ethnicity, education, urban/rural area of residency, household building material, sanitation, household crowding, region of residency and year of application). Time of follow-up was also included as a covariate to estimate the PS using a smooth function based on cubic splines (with knots at the 5th, 25th, 50th, 75th and 95th percentiles).[42] We calculated this probability up to the first month in which each individual started receiving the BFP and assumed that, once they start receiving the benefit, the probability was 1.

We used the propensity scores to derive IPTWs. Individuals' attributed weights in each month $t$ were equal to 1-PS when not receiving BFP and equal to the PS when receiving BFP. To estimate individuals' probability of treatment up to each month since the start of the follow-up, the final assigned weight was calculated by multiplying the weights cumulative over time—i.e. we multiplied the weight in the month $t$ by the 1 in month $t–1$. Finally, the

effect of BFP on mortality outcomes was estimated through the hazard ratio (HR) using pooled logistic regression with time-varying weights and cluster robust standard errors to account for individuals contributing to the analysis at multiple time points. We first obtained the effect of BFP overall and then fitted stratified models for individuals living in richer and poorer areas, measured using the IBP,[33] and those living in municipalities with different coverages of the FHS.[35] As region of residency is also a proxy of socioeconomic status; in models stratified for IBP levels, we removed it from the PS.

We considered that once individuals start receiving BFP, they are exposed for the remaining study period because (i) in our cohort, only 0.33% of people starting to receive BFP recipients stopped before the end of the follow-up;[17] (ii) once eligible to receive BFP, recipients are required to update their registry once every 2 years or every time there is any change in address or income, and if their income increases above the eligibility threshold they continue to receive benefits for up to 2 years; and (iii) ancillary benefits (i.e. increased access to the Brazilian Universal Health care system and education) are expected to continue after the end of the cash benefit (Supplementary Table S1, available as Supplementary data at *IJE* online).

We calculated the e-values to assess the sensitivity of our results to potential unmeasured confounding.[43,44] To test the robustness of our findings, we estimated the effect of BFP on mortality by (i) using time-varying Cox regression models adjusted for socio-economic and demographic covariates, (ii) weighting individuals by the inverse probability of receiving the treatment (IPTW), (iii) excluding individuals who received BFP on the same day as they applied to CadÚnico and (iv) implementing risk set matching that matches benefit recipients to non-recipient controls based on time and propensity score (further details in Supplementary File, Section 2, available as Supplementary data at *IJE* online). In addition, we used MSM to explore the potential for differential effects of BFP by conducting stratified analyses by age groups. The estimated effect of BFP on mortality could relate to poorer data quality and under-reporting of mortality among beneficiaries, which could introduce selection bias during linkage. To investigate this, we estimated the effect of BFP for individuals living in municipalities with <0.5% probability of death being underreported[34] (i.e. ~38% of studied individuals).

Analyses and visualizations were performed in STATA 16 and R Software version 3.6.0.

## Results

Our analytical cohort consisted of 17 981 582 low-income individuals, of whom 4 855 324 were aged 30–69 years for at least 1 day during follow-up (Figure 1). Among individuals aged 30–69 years, 65.5% ($n = 3\,177\,839$) received BFP at some time during the study period. Among individuals from all age groups, 76.2% ($n = 13\,705\,334$) received BFP benefits. Individuals were followed for ≤5 years (mean = 2.6, SD = 1.3), with similar follow-up among non-beneficiaries (mean = 2.6 and SD = 1.4 for both groups). BFP beneficiaries and non-beneficiaries differed systematically in all baseline demographic and socioeconomic characteristics except gender (Table 1).

Age-standardized CVD mortality was 170.4/100 000 pyr overall and higher among BFP beneficiaries (Rate = 178.8/100 000 pyr) than among non-beneficiaries (Rate = 164.5/100 000 pyr) (Table 2). The two main specific causes of CVD mortality, i.e. ischaemic heart disease (7471/23 389 or 31.9% of CVD deaths) and cerebrovascular disease mortality (6722/23 389 or 28.7%), were also higher among BFP recipients. Similarly, age-standardized all-cause mortality was higher among beneficiaries (Rate = 607.0/100 000 pyr) than among non-beneficiaries (Rate = 567.6/100 000 pyr). Mortality was generally higher among men than women, apart from cerebrovascular disease mortality, for which the rates were similar across genders (Table 2).

BFP receipt was associated with 4% lower CVD (HR = 0.96, 95% CI = 0.92–1.00) and all-cause (HR = 0.96, 95% CI = 0.94–0.98) premature mortality (Figure 2). When stratified by municipality-level deprivation, BFP receipt was associated with a lower risk of CVD premature mortality in more deprived municipalities and those where FHS had high or medium coverage (≥44%). In contrast, BFP receipt was associated with higher mortality for individuals living in less deprived municipalities (HR = 1.17, 95% CI = 1.06–1.30). Similarly, lower all-cause premature mortality among BFP recipients was found for individuals living in the most deprived municipalities (fourth quintile: HR = 0.93, 95% CI = 0.88–0.97; fifth quintile: HR = 0.82, 95% CI = 0.78–0.87). BFP receipt was associated with higher mortality for individuals living in the least deprived municipalities (first quintile: HR = 1.09, 95% CI = 1.04–1.15).

Among individuals of all ages, BFP receipt was not associated with CVD mortality (HR = 0.96, 95% CI = 0.93–1.00) or all-cause mortality (HR = 1.00, 95% CI = 0.98–1.02) (Figure 2). Similar effects on all-age mortality were found after stratifying by municipal-level deprivation (i.e. reductions among more deprived and higher mortality among less deprived) and FHS coverage. E-values for the HRs ranged between 1.16 and 1.74 for premature mortality and 1 and 1.54 for all-ages mortality, showing the highest value (E-value = 1.74) for the more deprived municipalities (i.e. IBP quintile 5) for all-cause premature mortality.
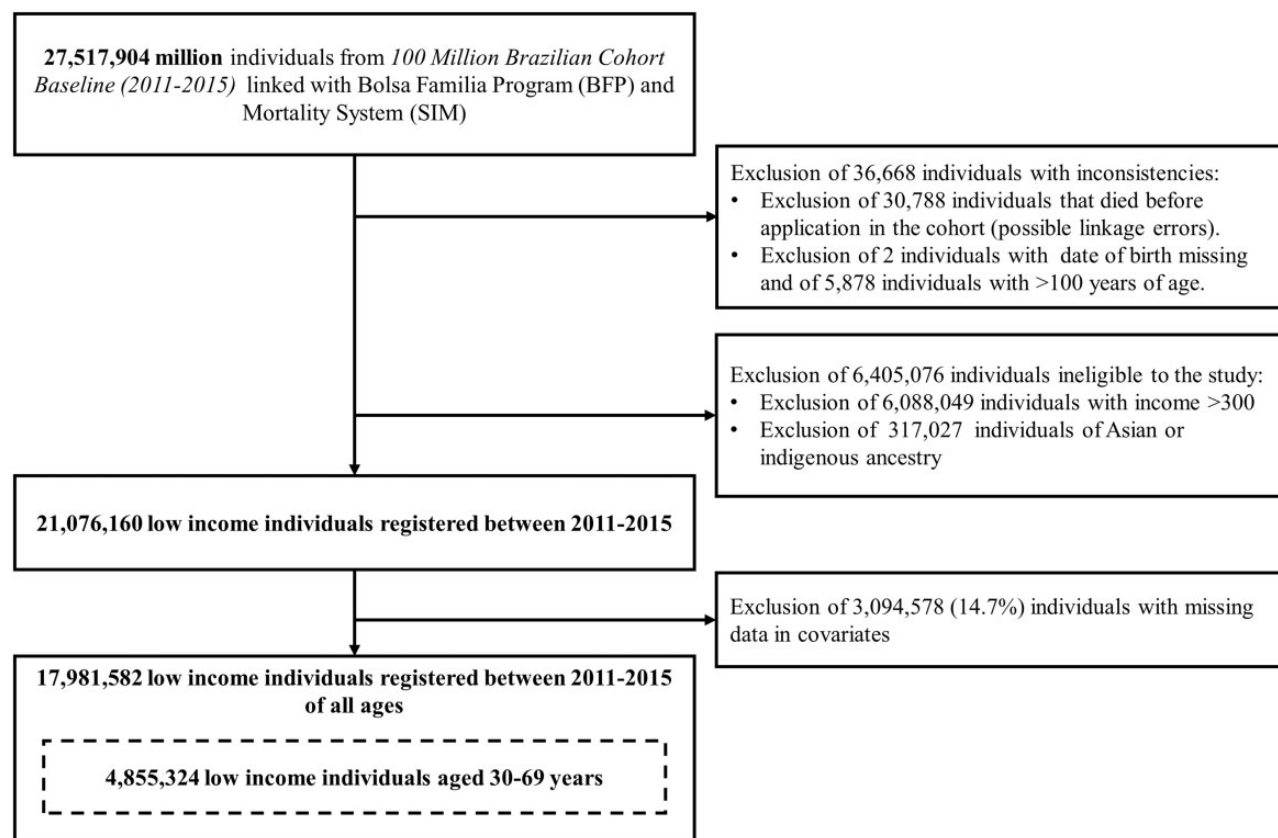
**Figure 1** Flowchart of the study population

Robustness checks using time-varying and IPTW Cox models, MSM excluding individuals who received benefit as soon as they applied to CadÚnico and risk set matching yielded inconsistent findings, suggesting a null or higher chance of mortality among BFP beneficiaries (Supplementary Table S4, available as Supplementary data at *IJE* online).

The analysis by age group showed generally similar results by age for CVD and all-cause premature mortality (Supplementary Table S5, available as Supplementary data at *IJE* online). However, for mortality among individuals of all ages, the effect estimates followed an inverted U-shaped curve with highest estimates being observed for individuals aged 50–69 years for both CVD and all-cause mortality (Supplementary Table S5, available as Supplementary data at *IJE* online). When restricting the analysis to individuals living in municipalities with less under-reporting of deaths (Supplementary Table S6, available as Supplementary data at *IJE* online), we found no consistent association between receiving BFP and lower risk of CVD or all-cause mortality, but the association between BFP receipt and lower CVD and all-cause premature mortality in more deprived municipalities persisted.

## Discussion

This is the first study to estimate the effect of a conditional cash transfer programme on cardiovascular and all-cause premature mortality in low- or middle-income countries using individual-level data. We analysed longitudinal data from >17 million low-income individuals followed for ≤5 years. We observed small to null effects of the Brazilian conditional cash transfer BFP on CVD and all-cause premature mortality, but larger and consistent mortality reductions in the areas with higher levels of deprivation.

In Brazil, although mortality from premature CVD is high, rates declined from 294.3 to 153.9 per 100 000 inhabitants from 1990 to 2017.[45] This has been accompanied by a high prevalence of CVD risk factors, which are more prevalent among women receiving BFP (e.g. over-weight, obesity, tobacco, hypertension and diabetes).[46] Although BFP recipients have health disadvantages compared with the general Brazilian population before accounting for socio-economic status,[46] there is evidence of a positive effect of BFP receipt on the overall expenditure on food (both healthy and ultra-processed and high-caloric food)[47] and on the increased consumption and expenditure

**Table 1** Description of study population with monthly per-capita income <300 Brazilian Reais according to individuals who received Bolsa Família Programme at any point in time

| Characteristics[a] | 30 to 69 years (N = 4 855 324) | | | | | | 0–100 years (N = 17 981 582) | | | | | |
| | Non-BFP (N = 1 677 485) | | BFP (N = 3 177 839) | | | | Non-BFP (N = 4 276 248) | | BFP (N = 13 705 334) | | | |
| | N | % | N | % | SMD | | N | % | N | % | SMD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Socio-demographic characteristics** | | | | | | | | | | | |
| Gender | | | | | | | | | | | |
| 1: Men | 753 821 | 44.9 | 1 577 715 | 49.6 | 0.094 | | 2 011 476 | 47.0 | 6 686 079 | 48.8 | 0.035 |
| 2: Woman | 923 664 | 55.1 | 1 600 124 | 50.4 | | | 2 264 772 | 53.0 | 7 019 255 | 51.2 | |
| Age at entry year (years) | | | | | 0.295 | | | | | | 0.503 |
| 0–9 | – | – | – | – | | | 1 537 376 | 36.0 | 7 938 768 | 57.9 | |
| 10–19 | – | – | – | – | | | 564 209 | 13.2 | 1 500 664 | 10.9 | |
| 20–29 | – | – | – | – | | | 604 199 | 14.1 | 1 566 730 | 11.4 | |
| 30–39 | 788 781 | 47.0 | 1 885 654 | 59.3 | | | 610 547 | 14.3 | 1 363 101 | 9.9 | |
| 40–49 | 384 817 | 22.9 | 682 249 | 21.5 | | | 384 817 | 9.0 | 682 249 | 5.0 | |
| 50–59 | 316 806 | 18.9 | 437 889 | 13.8 | | | 316 806 | 7.4 | 437 889 | 3.2 | |
| 60–69 | 187 081 | 11.2 | 172 047 | 5.4 | | | 185 233 | 4.3 | 173 895 | 1.3 | |
| ≥70 | – | – | – | – | | | 73 061 | 1.7 | 42 038 | 0.3 | |
| Race/ethnicity | | | | | 0.166 | | | | | | 0.187 |
| 1: White | 673 562 | 40.2 | 1 024 016 | 32.2 | | | 1 739 260 | 40.7 | 4 359 075 | 31.8 | |
| 2: Black | 119 742 | 7.1 | 268 516 | 8.4 | | | 226 514 | 5.3 | 756 100 | 5.5 | |
| 4: Mixed/brown | 884 181 | 52.7 | 1 885 307 | 59.3 | | | 2 310 474 | 54 | 8 590 159 | 62.7 | |
| Education | | | | | 0.104 | | | | | | 0.273 |
| 0: Never went to school | 122 214 | 7.3 | 268 332 | 8.4 | | | 453 586 | 10.6 | 1 953 519 | 14.3 | |
| 1: Primary school or less (≤5 years of education) | 574 848 | 34.3 | 1 140 992 | 35.9 | | | 965 051 | 22.6 | 3 369 267 | 24.6 | |
| 2: Junior high school (≤9 years of education) | 308 298 | 18.4 | 648 500 | 20.4 | | | 828 528 | 19.4 | 3 618 895 | 26.4 | |
| 3: High school or more | 672 125 | 40.1 | 1 120 015 | 35.2 | | | 2 029 083 | 47.5 | 4 763 653 | 34.8 | |
| **Household characteristics** | | | | | | | | | | | |
| Region | | | | | 0.202 | | | | | | 0.263 |
| North | 122 200 | 7.3 | 344 912 | 10.9 | | | 377 069 | 8.8 | 1 752 349 | 12.8 | |
| Northeast | 425 988 | 25.4 | 932 245 | 29.3 | | | 1 078 001 | 25.2 | 4 496 826 | 32.8 | |
| Southeast | 739 346 | 44.1 | 1 365 194 | 43.0 | | | 1 777 195 | 41.6 | 5 183 838 | 37.8 | |
| South | 219 598 | 13.1 | 294 465 | 9.3 | | | 592 845 | 13.9 | 1 261 178 | 9.2 | |
| Central-west | 170 353 | 10.2 | 241 023 | 7.6 | | | 451 138 | 10.5 | 1 011 143 | 7.4 | |
| Area of residence | | | | | 0.110 | | | | | | 0.136 |
| 1: Urban | 1 490 072 | 88.8 | 2 705 036 | 85.1 | | | 3 792 111 | 88.7 | 11 516 822 | 84.0 | |
| 2: Rural | 187 413 | 11.2 | 472 803 | 14.9 | | | 484 137 | 11.3 | 2 188 512 | 16.0 | |

(Continued)

**Table 1** Continued

| Characteristics[a] | 30 to 69 years (N = 4 855 324) | | | | | | 0–100 years (N = 17 981 582) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Non-BFP (N = 1 677 485) | | BFP (N = 3 177 839) | | SMD | | Non-BFP (N = 4 276 248) | | BFP (N = 13 705 334) | | SMD | |
| | N | % | N | % | | | N | % | N | % | | |
| Household material | | | | | | | | | | | | |
| 1: Masonry/brick | 1 512 796 | 90.2 | 2 753 774 | 86.7 | 0.115 | | 3 820 708 | 89.3 | 11 536 906 | 84.2 | 0.171 | |
| 2: Coated or uncoated Taipa, wood, others | 50 454 | 3.0 | 149 023 | 4.7 | | | 117 671 | 2.8 | 778 256 | 5.7 | | |
| 4: Wood | 114 235 | 6.8 | 275 042 | 8.7 | | | 337 869 | 7.9 | 1 390 172 | 10.1 | | |
| Water supply | | | | | | | | | | | | |
| 1: General network distribution | 1 434 886 | 85.5 | 2 535 683 | 79.8 | 0.152 | | 3 636 402 | 85.0 | 10 666 297 | 77.8 | 0.186 | |
| 2: Well, spring or other | 242 599 | 14.5 | 642 156 | 20.2 | | | 639 846 | 15.0 | 3 039 037 | 22.2 | | |
| Sewage disposal | | | | | | | | | | | | |
| 1: Public network | 1 023 448 | 61.0 | 1 741 815 | 54.8 | 0.137 | | 2 527 127 | 59.1 | 6 914 015 | 50.4 | 0.188 | |
| 2: Septic tank | 230 175 | 13.7 | 448 559 | 14.1 | | | 607 759 | 14.2 | 2 028 978 | 14.8 | | |
| 3: Rudimentary trench, open ditch, water or others | 423 862 | 25.3 | 987 465 | 31.1 | | | 1 141 362 | 26.7 | 4 762 341 | 34.7 | | |
| Waste disposal/garbage collection | | | | | | | | | | | | |
| 1: Collected directly/indirectly | 1 521 950 | 90.7 | 2 724 790 | 85.7 | 0.155 | | 3 885 804 | 90.9 | 11 487 414 | 83.8 | 0.213 | |
| 2: Burned, buried or outdoor | 155 535 | 9.3 | 453 049 | 14.3 | | | 390 444 | 9.1 | 2 217 920 | 16.2 | | |
| Electricity | | | | | | | | | | | | |
| 1: Electric with meter | 1 496 865 | 89.2 | 2 608 592 | 82.1 | 0.223 | | 3 730 601 | 87.2 | 10 852 556 | 79.2 | 0.247 | |
| 2: Electric with community meter | 95 269 | 5.7 | 230 189 | 7.2 | | | 293 160 | 6.9 | 1 105 544 | 8.1 | | |
| 3: Informal electric lights or no electricity | 85 351 | 5.1 | 339 058 | 10.7 | | | 252 487 | 5.9 | 1 747 234 | 12.7 | | |
| Household crowding (tercile) | | | | | | | | | | | | |
| 1: ≤0.75 individuals per room | 1 099 732 | 65.6 | 1 437 185 | 45.2 | 0.492 | | 2 428 161 | 56.8 | 4 779 523 | 34.9 | 0.557 | |
| 2: 0.76–1 individuals per room | 414 965 | 24.7 | 918 666 | 28.9 | | | 1 234 841 | 28.9 | 4 023 979 | 29.4 | | |
| 3: >1 individual per room | 162 788 | 9.7 | 821 988 | 25.9 | | | 613 246 | 14.3 | 4 901 832 | 35.8 | | |
| Sanitation | | | | | | | | | | | | |
| All four components adequate | 936 265 | 55.8 | 1 501 801 | 47.3 | 0.220 | | 2 309 424 | 54.0 | 5 850 168 | 42.7 | 0.284 | |
| Three adequate | 473 010 | 28.2 | 917 198 | 28.9 | | | 1 250 480 | 29.2 | 4 149 664 | 30.3 | | |
| Two adequate | 155 409 | 9.3 | 398 203 | 12.5 | | | 417 966 | 9.8 | 1 903 635 | 13.9 | | |
| One or none adequate | 112 801 | 6.7 | 360 637 | 11.3 | | | 298 378 | 7.0 | 1 801 867 | 13.1 | | |
| Year of application | | | | | | | | | | | | |
| 2011 | 338 964 | 20.2 | 798 878 | 25.1 | 0.244 | | 661 715 | 15.5 | 2 980 612 | 21.7 | 0.276 | |
| 2012 | 496 617 | 29.6 | 993 040 | 31.2 | | | 1 078 825 | 25.2 | 3 808 703 | 27.8 | | |
| 2013 | 221 735 | 13.2 | 546 656 | 17.2 | | | 674 983 | 15.8 | 2 671 607 | 19.5 | | |
| 2014 | 365 763 | 21.8 | 522 933 | 16.5 | | | 1 039 431 | 24.3 | 2 487 230 | 18.1 | | |
| 2015 | 254 406 | 15.2 | 316 332 | 10.0 | | | 821 294 | 19.2 | 1 757 182 | 12.8 | | |

(Continued)

**Table 1** Continued

| Characteristics[a] | 30 to 69 years (N = 4 855 324) | | | | | | 0–100 years (N = 17 981 582) | | | | | |
| | Non-BFP (N = 1 677 485) | | BFP (N = 3 177 839) | | SMD | | Non-BFP (N = 4 276 248) | | BFP (N = 13 705 334) | | SMD |
| | N | % | N | % | | | N | % | N | % | |
| Per-capita income (BRL) | | | | | | | | | | | |
| 0–50 | 590 974 | 13.8 | 6 428 385 | 46.9 | <0.001 | | 165 441 | 9.9 | 1 324 976 | 41.7 | <0.001 |
| 50–150 | 812 395 | 19.0 | 6 015 398 | 43.9 | | | 313 201 | 18.7 | 1 454 021 | 45.8 | |
| 150–300 | 2 872 879 | 67.2 | 1 261 551 | 9.2 | | | 1 198 843 | 71.5 | 398 842 | 12.6 | |

SMD, standardized mean difference prior weighting or matching; BFP, Bolsa Família Programme; BRL, Brazilian Reais.
[a]Distribution excluding missing data.

**Table 2** All-cause, cardiovascular, ischaemic heart disease and cerebrovascular disease age-standardized mortality rates overall and by Bolsa Família Programme receipt, 2011–2015

| All age groups | Overall (N = 17 981 582) | | | Non-BFP (N = 4 276 248) | | | BFP (N = 13 705 334) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Events | Person-years at risk | Age-standardized rate[a,b] (95% CI)[c] | Events | Person-years at risk | Age-standardized rate[a,b] (95% CI)[c] | Events | Person-years at risk | Age-standardized rate[a,b] (95% CI)[c] |
| CVD mortality | 23 389 | 47 869 832 | 170.4 (170.4–170.4) | 12 195 | 15 144 018 | 164.5 (164.5–164.5) | 11 194 | 32 731 881 | 178.8 (178.8–178.8) |
| Men | 13 352 | 22 973 212 | 177.1 (177.1–177.1) | 6644 | 6 974 914 | 177.3 (177.3–177.3) | 6708 | 16 001 934 | 178.6 (178.6–178.6) |
| Women | 10 037 | 24 896 620 | 162.3 (162.3–162.3) | 5551 | 8 169 104 | 154.9 (154.9–154.9) | 4486 | 16 729 947 | 174.4 (174.3–174.4) |
| Ischaemic heart disease mortality | 7471 | 47 869 832 | 52.7 (52.7–52.7) | 3858 | 15 144 018 | 50.7 (50.7–50.7) | 3613 | 32 731 881 | 55.2 (55.1–55.2) |
| Men | 4738 | 22 973 212 | 60.9 (60.9–60.9) | 2347 | 6 974 914 | 61.6 (61.6–61.6) | 2391 | 16 001 934 | 60.5 (60.5–60.5) |
| Women | 2733 | 24 896 620 | 43.7 (43.7–43.7) | 1511 | 8 169 104 | 41.5 (41.5–41.5) | 1222 | 16 729 947 | 46.8 (46.8–46.8) |
| Cerebrovascular disease mortality | 6722 | 47 869 832 | 52.6 (52.5–52.6) | 3552 | 15 144 018 | 50.0 (50.0–50.0) | 3170 | 32 731 881 | 56.5 (56.5–56.5) |
| Men | 3675 | 22 973 212 | 52.8 (52.8–52.8) | 1862 | 6 974 914 | 51.8 (51.8–51.8) | 1813 | 16 001 934 | 54.5 (54.5–54.5) |
| Women | 3047 | 24 896 620 | 51.6 (51.6–51.6) | 1690 | 8 169 104 | 48.4 (48.4–48.4) | 1357 | 16 729 947 | 57.2 (57.2–57.2) |
| All-cause mortality | 106 807 | 47 869 832 | 585.5 (585.5–585.5) | 48 332 | 15 144 018 | 567.6 (567.6–567.6) | 58 475 | 32 731 881 | 607.0 (606.9–607.0) |
| Men | 65 045 | 22 973 212 | 670.3 (670.3–670.3) | 28 083 | 6 974 914 | 672.2 (672.2–672.2) | 36 962 | 16 001 934 | 668.7 (668.6–668.7) |
| Women | 41 762 | 24 896 620 | 507.7 (507.7–507.7) | 20 249 | 8 169 104 | 487.7 (487.7–487.8) | 21 513 | 16 729 947 | 539.9 (539.9–539.9) |

BFP, Bolsa Família Programme; CVD, cardiovascular disease.

[a]Rates were calculated considering the treatment to vary over time (i.e. follow-up time for individuals exposed to BFP were calculated separately before the intervention and allocated to the non-BFP group and later allocated to the BFP group).

[b]The mortality rates were standardized by age (in 5-year age groups) using 2015 Brazilian population. Data available at http://tabnet.datasus.gov.br/cgi/deftohtm.exe?popsvs/cnv/popbr.def.

[c]The 95% CI estimates take into account the method described by Breslow and Day to calculate the standard error and assume that the numbers of events in each age group follow a Poisson distribution.[42]
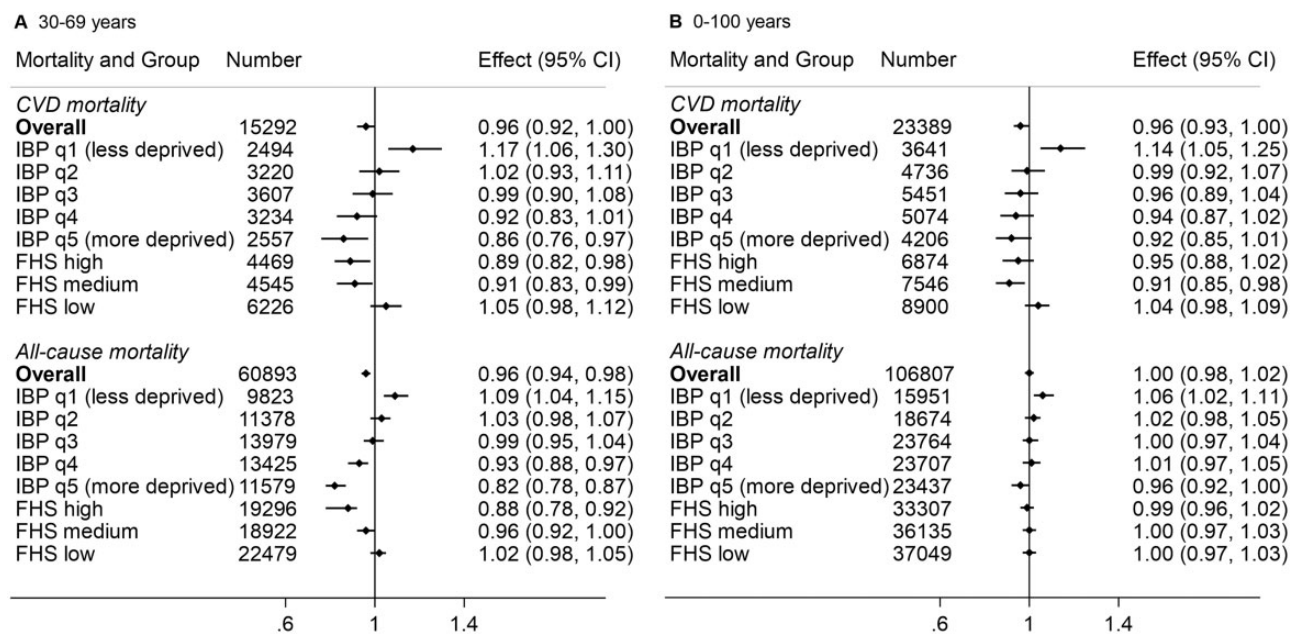
**A** 30–69 years

| Mortality and Group | Number | Effect (95% CI) |
|---|---|---|
| *CVD mortality* | | |
| **Overall** | 15292 | 0.96 (0.92, 1.00) |
| IBP q1 (less deprived) | 2494 | 1.17 (1.06, 1.30) |
| IBP q2 | 3220 | 1.02 (0.93, 1.11) |
| IBP q3 | 3607 | 0.99 (0.90, 1.08) |
| IBP q4 | 3234 | 0.92 (0.83, 1.01) |
| IBP q5 (more deprived) | 2557 | 0.86 (0.76, 0.97) |
| FHS high | 4469 | 0.89 (0.82, 0.98) |
| FHS medium | 4545 | 0.91 (0.83, 0.99) |
| FHS low | 6226 | 1.05 (0.98, 1.12) |
| *All-cause mortality* | | |
| **Overall** | 60893 | 0.96 (0.94, 0.98) |
| IBP q1 (less deprived) | 9823 | 1.09 (1.04, 1.15) |
| IBP q2 | 11378 | 1.03 (0.98, 1.07) |
| IBP q3 | 13979 | 0.99 (0.95, 1.04) |
| IBP q4 | 13425 | 0.93 (0.88, 0.97) |
| IBP q5 (more deprived) | 11579 | 0.82 (0.78, 0.87) |
| FHS high | 19296 | 0.88 (0.78, 0.92) |
| FHS medium | 18922 | 0.96 (0.92, 1.00) |
| FHS low | 22479 | 1.02 (0.98, 1.05) |

**B** 0–100 years

| Mortality and Group | Number | Effect (95% CI) |
|---|---|---|
| *CVD mortality* | | |
| **Overall** | 23389 | 0.96 (0.93, 1.00) |
| IBP q1 (less deprived) | 3641 | 1.14 (1.05, 1.25) |
| IBP q2 | 4736 | 0.99 (0.92, 1.07) |
| IBP q3 | 5451 | 0.96 (0.89, 1.04) |
| IBP q4 | 5074 | 0.94 (0.87, 1.02) |
| IBP q5 (more deprived) | 4206 | 0.92 (0.85, 1.01) |
| FHS high | 6874 | 0.95 (0.88, 1.02) |
| FHS medium | 7546 | 0.91 (0.85, 0.98) |
| FHS low | 8900 | 1.04 (0.98, 1.09) |
| *All-cause mortality* | | |
| **Overall** | 106807 | 1.00 (0.98, 1.02) |
| IBP q1 (less deprived) | 15951 | 1.06 (1.02, 1.11) |
| IBP q2 | 18674 | 1.02 (0.98, 1.05) |
| IBP q3 | 23764 | 1.00 (0.97, 1.04) |
| IBP q4 | 23707 | 1.01 (0.97, 1.05) |
| IBP q5 (more deprived) | 23437 | 0.96 (0.92, 1.00) |
| FHS high | 33307 | 0.99 (0.96, 1.02) |
| FHS medium | 36135 | 1.00 (0.97, 1.03) |
| FHS low | 37049 | 1.00 (0.97, 1.03) |

**Figure 2** Estimation of the marginal structural model effect of Bolsa Família Programme receipt on cardiovascular and all-cause mortality for individuals living in municipalities with high-low material deprivation and high-low coverage of the Family Health Strategy IBP, Brazilian Deprivation Index (divided into quintiles); FHS, Family Health Strategy (divided into terciles); CVD, cardiovascular diseases; q1, quintile 1; q2, quintile 2; q3, quintile 3; q4, quintile 4; q5: quintile 5. For the 30–69 years age group, 709 premature all-cause mortality and 180 CVD premature mortality missing values for IBP levels and 196 premature all-cause mortality and 52 CVD premature mortality missing values for FHS coverage. For the 0–100 years age group, 1274 all-cause mortality and 280 CVD mortality missing values for IBP levels and 316 all-cause mortality and 69 CVD mortality missing values for FHS coverage. For the 30–69 years age group, FHS coverage is divided into terciles of high (≥83%), medium (44–83%) or low coverage (≤44%). For the 0–100 years age group, FHS coverage is divided into terciles of high (≥87%), medium (44–87%) or low coverage (≤44%).

on healthy foods (i.e. fresh or minimally processed food).[48,49]

The consistent estimates for the effect of BFP receipt on lower CVD and all-cause premature mortality in more deprived municipalities in Brazil could be explained by higher homogeneity of individuals' socio-economic characteristics, which could lead to lower unmeasured confounders. In addition, in the most vulnerable municipalities, the lower prices per calorie of natural products and cooking ingredients in the poorest and rural regions of Brazil could translate into a higher purchasing power.[49,50] Conversely, income transfers in wealthier and larger municipalities, which have greater availability and consumption of ultra-processed and caloric food, may exacerbate being overweight and obesity, which are important risk factors for non-communicable diseases.[4,5,51] In theory, these mechanisms could lead to overall null effects when looking at the effect of BFP receipt in a large and heterogeneous country like Brazil.

The null association between BFP and CVD premature mortality after accounting for under-reporting, especially in places with lower FHS coverage, may also indicate improved mortality registration among families that are enrolled in both BFP and FHS programmes. The BFP health conditionalities might encourage uptake of health checks and nutrition education and surveillance among all household members, as seen by increased tuberculosis and leprosy cure rates among BFP beneficiaries in Brazil.[52,53] A previous study with the CCT Pregressa in Mexico found that adults from beneficiary families that participated in the programme for 3.5–5 years had a lower prevalence of obesity and hypertension compared with non-beneficiaries.[54] Adults, especially women, are more likely to attend health services during conditionality check-ups and can benefit from contact with health professionals, being monitored or diagnosed for co-morbidities such as hypertension or obesity.[22,54] The majority of BFP beneficiary families are monitored by the FHS, which provides an interdisciplinary healthcare team that contributes to improved access to the health system.[55] Monitoring of health conditionalities could also help in improving access to the health system, contribute to the adoption of healthy eating and physical activity behaviours, promote early CVD diagnosis and increase access to antihypertensive medications of adults.[23,36,55] The increased coverage of FHS in Brazil in the last decade, especially in smaller and poorer municipalities,[56] has also been associated with improved follow-up of chronic conditions and infectious diseases, as well as the reduction in hospitalization rates across Brazil.[36,55,57] Nevertheless, the effectiveness of social interventions on the socio-economic determinants of health and health

outcomes are largely dependent on other factors, such as political will, macro-economic stability, household dynamics and community acceptance.[58]

Our study took advantage of a large sample size with rich socio-economic data of CadÚnico linked with nation-wide mortality data to provide a unique opportunity to evaluate the short-term effect of BFP receipt on all-cause and CVD mortality among the poorest individuals of Brazil. However, our study also has limitations. First, we used secondary administrative data whose quality varies across regions. As poor data quality can increase information bias arising in the linkage process, we repeated our analysis restricted to municipalities with better mortality data and found a consistent association of BFP receipt on lower CVD and all-cause mortality among individuals living in the two most deprived municipality quintiles and in municipalities with higher coverage of FHS. Second, due to the impossibility of applying a fuzzy regression discontinuity design, we used the MSM developed by Robins,[41] given that this is the most well-described causal method that can be used to deal with time-varying variables such as BFP receipt and survival. However, robustness checks using different statistical methods found inconsistent associations between receiving BFP and mortality. Although risk set matching might have accounted for municipal variations in BFP implementation or other unmeasured confounders, individuals who received BFP straight away (i.e. in the first few days after applying to CadÚnico) were unlikely to be matched due to their low propensity scores obtained in the Cox regression model, suggesting that such individuals were systematically different from those who received BFP later. Third, for a causal interpretation of the effect of BFP on mortality, MSM assumes no unmeasured confounding. In our analysis, we were able to control for many socio-demographic confounders, including age, but we were unable to control for the main behavioural risk factors for CVD premature mortality (i.e. excess bodyweight, unhealthy diet, tobacco, harmful use of alcohol, hypertension and physical inactivity)[17] or access to secondary or tertiary care. However, by stratifying by municipal-level deprivation, we possibly have accounted for some variations in the tobacco and alcohol consumption,[59,60] as well as in availability and access to hospital beds. In addition, controlling for behavioural risk factors, which we were unable to do, is not necessarily appropriate as they lie on the causal pathway between socio-economic factors and CVD. Although small, the e-values obtained in our estimates suggested a null effect of BFP in the presence of unmeasured confounders. However, interpreting e-values depends on the measured confounders that were accounted for in the analysis—in our case, we accounted for multiple socio-economic confounders. In addition, we must consider that e-values are less useful in the presence of multiple, possibly interacting unmeasured confounders, which could be the case for socio-economic and behavioural factors.[43,61]

Fourth, as income data from CadÚnico were poorly recorded before 2011, we were only able to study new applicants to BFP from 2011 onwards and to follow individuals for ≤5 years. Thus the data only allowed investigation of short-term effects of BFP. Longer follow-up might be needed to assess the full effect of BFP receipt on all-cause and CVD mortality.

Despite these limitations, our study adds to the limited body of evidence on the effects of CCTs on CVD mortality in LMICs. A previous analysis of the Progresa CCT scheme using municipal-level data on Mexican elders (≥65 years) found that receipt was associated with a 4% reduction in elderly all-cause mortality but not associated with CVD mortality in the same group.[20] In contrast, another ecological study using a similar difference-in-difference approach but assessing the Mexican non-conditional pension scheme '70 y Más' targeting elders found, on average, a 5% increase in all-cause mortality among recipients, driven by increases in deaths related to CVD in more economically disadvantaged communities.[21]

## Conclusions

Social protection has been associated with improved access to healthcare and health outcomes among individuals residing in LMICs[4,62] and constitutes a viable policy option for poverty reduction.[63] By following millions of Brazilians (nearly 34 million people as in 2015 in CadÚnico[23]) for ≤5 years, we found weak evidence that BFP receipt might lead to small reductions in premature and all-age CVD mortality in the short term across the entire country. Beneficial effects seem strongest for populations living in more deprived municipalities. Future research should seek to identify the longer-term effects of participation in CCTs on cardiovascular and all-cause adult mortality and, if present, the mechanisms by which those effects occur.

## Ethics approval

## Data availability

The data underlying this article will be shared on reasonable request to CIDACS Fiocruz and after ethical approval.

## Supplementary data

Supplementary data are available at *IJE* online.

## Author contributions

J.M.P., P.C., L.D.A., S.A., M.L.B., A.L., E.M.L.A., M.A. and S.V.K. have contributed to the conception and design of the study; J.M.P., D.C. and M.A. performed the analysis. J.M.P., P.C., L.D.A., D.C., I.R.F., A.J.F.F., L.S., R.J.S., D.C.M. and M.A. contributed to the analysis and interpretation of the results. J.M.P. and I.R.F. wrote the first draft of the manuscript. All authors have contributed to the manuscript revision, and have read and approved the submitted version.

## Funding

## Conflict of interest

None declared.

## References

1. Morgan L, Stanton ME, Higgs ES *et al.* Financial incentives and maternal health: where do we go from here? *J Health Popul Nutr* 2013;**31**:8–22.
2. Fiszbein A, Schady N. *Conditional Cash Transfers: Reducing Present and Future Poverty: Research Report.* Washington, DC: World Bank, 2009.
3. Owusu-Addo E, Renzaho AMN, Smith BJ. Cash transfers and the social determinants of health: a conceptual framework. *Health Promot Int* 2019;**34**:e106–18.
4. Lagarde M, Haines A, Palmer N. The impact of conditional cash transfers on health outcomes and use of health services in low and middle income countries. *Cochrane Database Syst Rev* 2009;**2009**:CD008137.
5. Leroy JL, Gadsden P, Rodríguez-Ramírez S, de Cossío TG, Cash and in-kind transfers in poor rural communities in Mexico increase household fruit, vegetable, and micronutrient consumption but also lead to excess energy consumption. *J Nutr* 2010;**140**:612–17.
6. World Bank. *The State of Social Safety Nets 2015.* Washington, DC: World Bank, 2015.
7. Leite TH, Moraes CLd, Marques ES, Caetano R, Braga JU, Reichenheim ME. Women economic empowerment via cash transfer and microcredit programs is enough to decrease intimate partner violence: evidence from a systematic review. *Cad Saúde Pública* 2019;**35**:e00174818.
8. Santos LMP, Paes-Sousa R, Miazagi E, Silva TF, Fonseca AMMd, *The Brazilian Experience with Conditional Cash Transfers Cash Transfers: A Successful Way to Reduce Successful Way to Reduce Inequity and to Improve Health Inequity and to Improve Health and to Improve Health World Conference on Social Determinants of Health.* Rio De Janeiro: World Health Organization, 2011.
9. Van Stolk C, Patil S. *Evaluating Conditional Cash Transfer Programmes: The Case of Bolsa Familia.* Santa Monica, CA: RAND Corporation, 2015.
10. Secretaria de Avaliação e Gestão da Informação—SAGI. Quantidade de Famílias beneficiadas pelo Bolsa Família, Estimativa de Famílias Pobres—Censo IBGE 2010, Percentual de cobertura das Famílias beneficiárias do PBF. 2021. https://aplicacoes.mds.gov.br/sagi/vis/data3/data-explorer.php# (15 May 2021, date last accessed).
11. Cabral CS, Lopes AG, Lopes JM, Vianna RPdT. Segurança alimentar, renda e Programa Bolsa Família: estudo de coorte em municípios do interior da Paraíba, Brasil, 2005-2011. *Cad Saúde Pública* 2014;**30**:393–402.
12. Barbosa A, Corseuil CHL. Conditional cash transfer and informality in Brazil. *IZA J Labor Develop* 2014;**3**:37.
13. Nazareno LA. O programa bolsa família e o mercado de trabalho informal: uma análise de impacto da ação Brasil carinhoso. *Econ Aplic* 2016;**20**:457–71.
14. Mallinson PAC, Luhar S, Williamson E, Barreto ML, Kinra S. Socioeconomic position and cardiovascular mortality in 63 million adults from Brazil. *Heart* 2021;**107**:822–27.
15. Murray CJL, Aravkin AY, Zheng P *et al.* Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet* 2020;**396**:1223–49.
16. (WHO) WHO. Premature mortality from noncommunicable disease. 2022. https://www.who.int/data/gho/indicator-metadata-registry/imr-details/3411 (10 October 2021, date last accessed).
17. Stringhini S, Carmeli C, Jokela M *et al.* Socioeconomic status and the 25×25 risk factors as determinants of premature mortality: a multicohort study and meta-analysis of 1·7 million men and women. *Lancet* 2017;**389**:1229–37.
18. Nations U. *Transforming Our World: The 2030 Agenda for Sustainable Development.* New York: United Nations, Department of Economic and Social Affairs, 2015.
19. Ordunez P, Prieto-Lara E, Pinheiro Gawryszewski V, Hennis AJM, Cooper RS. Premature mortality from cardiovascular disease in the Americas—will the goal of a decline of '25% by 2025' be met? *PLoS ONE* 2015;**10**:e0141685.
20. Barham T, Rowberry J. Living longer: the effect of the Mexican conditional cash transfer program on elderly mortality. *J Dev Econ* 2013;**105**:226–36.

21. Feeney K. *Cash Transfers and Adult Mortality: Evidence from Pension Policies*. Berkeley, CA: University of California, 2017.

22. Behrman JR, Parker SW. Is health of the aging improved by conditional cash transfer programs? Evidence from Mexico. *Demography* 2013;**50**:1363–86.

23. Pescarini JM, Craig P, Allik M *et al.* Evaluating the impact of the Bolsa Familia conditional cash transfer program on premature cardiovascular and all-cause mortality using the 100 million Brazilian cohort: a natural experiment study protocol. *BMJ Open* 2020;**10**:e039658.

24. World Bank. World Bank Country and Lending Groups. World Bank GNI per capita Operational. 2022. http://databank.world bank.org/data/download/site-content/OGHIST.xlsx (10 October 2021, date last accessed).

25. Campbell M, Katikireddi SV, Hoffmann T, Armstrong R, Waters E, Craig P. TIDieR-PHP: a reporting guideline for population health and policy interventions. *BMJ* 2018;**361**:k1079.

26. Secretaria de Avaliação e Gestão da Informação—SAGI. Quantidade de Famílias beneficiadas pelo Bolsa Família, Estimativa de Famílias Pobres—Censo IBGE 2010, Percentual de cobertura das Famílias beneficiárias do PBF. 2020. https://apli cacoes.mds.gov.br/sagi/vis/data3/data-explorer.php# (15 November 2021, date last accessed).

27. Campello T, Neri MCO. *Programa Bolsa Família Uma Década de Inclusão e Cidadania*. Brasília: Ipea, 2013.

28. Barreto ML, Ichihara MY, Pescarini JM *et al.* Cohort Profile: The 100 Million Brazilian Cohort. *Int J Epidemiol* 2022;**51**: e27–38.

29. de Sousa Silva F, Christine de Sousa Queiroz R, dos Remédios Freitas Carvalho Branco M *et al.* Bolsa Família program and incomplete childhood vaccination in two Brazilian cohorts. *Rev Saude Publ* 2020;**54**:1–14.

30. Barreto ML, Ichihara MY, Almeida BA *et al.* The Center for Data and Knowledge Integration for Health (CIDACS): an experience of linking health and social data in Brazil. *Int J Popul Data Sci* 2019;**4**:1140.

31. World Health Organization. *International Statistical Classification of Diseases and Related Health Problems: tenth Revision*, 2nd edn. Geneva: WHO, 2004.

32. Costa LFL, de Mesquita Silva Montenegro M, Rabello Neto DL *et al.* Estimating completeness of national and subnational death reporting in Brazil: application of record linkage methods. *Popul Health Metr* 2020;**18**:22.

33. Allik M, Ramos D, Agranonik M *et al.* *Developing a Small-area Deprivation Measure for Brazil*. Technical Report. University of Glasgow, 2020.

34. Gonzaga MR, Schmertmann CP. Estimating age- and sex-specific mortality rates for small areas with TOPALS regression: an application to Brazil in 2010. *Rev Bras Estud Popul* 2016;**33**: 629–52.

35. Brasil. Ministério da Saúde. Secretaria de Atenção Primária à Saúde (SAPS). Cobertura da Atenção Básica. 2017. https://eges torab.saude.gov.br/paginas/acessoPublico/relatorios/relHistorico CoberturaAB.xhtml (10 November 2021, date last accessed).

36. Rasella D, Harhay MO, Pamponet ML, Aquino R, Barreto ML. Impact of primary health care on mortality from heart and cerebrovascular diseases in Brazil: a nationwide analysis of longitudinal data. *BMJ* 2014;**349**:g4014.

37. Barbosa GCG, Ali MS, Araujo B *et al.* CIDACS-RL: a novel indexing search and scoring-based record linkage system for huge datasets with high accuracy and scalability. *BMC Med Inform Decis Mak* 2020;**20**:289.

38. World Health Organization. The Global Health Observatory. Premature mortality from noncommunicable disease. https:// www.who.int/data/gho/indicator-metadata-registry/imr-details/ 3411 (4 February 2022, date last accessed).

39. Saúde/SVS/DASNT/CGIAE Md. População residente—estudo de estimativas populacionais por município, idade e sexo 2000– 2020—Brasil. 2021. http://tabnet.datasus.gov.br/cgi/deftohtm. exe?popsvs/cnv/popbr.def (1 March 2021, date last accessed).

40. Breslow NE, Day N. *Statistical Methods in Cancer Research: The Design and Analysis of Cohort Studies*. Lyon: IARCPress, 1987.

41. Robins JM, Hernán MÁ, Brumback B. Marginal structural models and causal inference in epidemiology. *Epidemiology* 2000; **11**:550–60.

42. Fewell Z, Hernán MA, Wolfe F, Tilling K, Choi H, Sterne JAC. Controlling for time-dependent confounding using marginal structural models. *Stata J* 2004;**4**:402–20.

43. VanderWeele TJ, Ding P. Sensitivity analysis in observational research: introducing the e-value. *Ann Intern Med* 2017;**167**: 268–74.

44. Mathur MB, Ding P, Riddell CA, VanderWeele TJ. Web site and R package for computing e-values. *Epidemiology* 2018;**29**:e45–47.

45. Malta DC, Duncan BB, Schmidt MI *et al.* Trends in mortality due to non-communicable diseases in the Brazilian adult population: national and subnational estimates and projections for 2030. *Popul Health Metr* 2020;**18**:16.

46. Bernal RTI, Felisbino-Mendes MS, Carvalho QH *et al.* Indicators of chronic noncommunicable diseases in women of reproductive age that are beneficiaries and non-beneficiaries of Bolsa Família. *Rev Bras Epidemiol* 2019;**22**(Suppl 02): E190012.Supl.2.

47. de Bem Lignani J, Sichieri R, Burlandy L, Salles-Costa R. Changes in food consumption among the Programa Bolsa Família participant families in Brazil. *Public Health Nutr* 2011; **14**:785–92.

48. Ferrario MN. The impacts on family consumption of the Bolsa Família subsidy programme. *CEPAL Review* 2014;**2014**: 147–63.

49. Sperandio N, Rodrigues CT, Franceschini SCC, Priore SE. The impact of the Bolsa Família program on food consumption: a comparative study of the southeast and northeast regions of Brazil. *Cien Saude Colet* 2017;**22**:1771–80.

50. Claro RM, Maia EG, Costa BVdL, Diniz DP. Food prices in Brazil: prefer cooking to ultra-processed foods. *Cad Saude Publica* 2016;**32**:e00104715.

51. Forde I, Chandola T, Garcia S, Marmot MG, Attanasio O. The impact of cash transfers to poor women in Colombia on BMI and obesity: prospective cohort study. *Int J Obes* 2012;**36**: 1209–14.

52. Pescarini JM, Williamson E, Nery JS *et al.* Effect of a conditional cash transfer programme on leprosy treatment adherence and cure in patients from the nationwide 100 Million Brazilian Cohort: a quasi-experimental study. *Lancet Infect Dis* 2020;**20**: 618–27.

53. Oliosi JGN, Reis-Santos B, Locatelli RL *et al*. Effect of the Bolsa Familia Programme on the outcome of tuberculosis treatment: a prospective cohort study. *The Lancet Global Health* 2019;**7**: e219–26.

54. Fernald LC, Hou X, Gertler PJ. Oportunidades program participation and body mass index, blood pressure, and self-reported health in Mexican adults. *Prev Chronic Dis* 2008;**5**:A81.

55. Macinko J, Harris MJ. Brazil's family health strategy–delivering community-based primary care in a universal health system. *N Engl J Med* 2015;**372**:2177–81.

56. do Rosário Costa N. The Family Health Strategy: primary health care and the challenge of Brazilian metropolises. *Cien Saude Colet* 2016;**21**:1389–98.

57. Jesus GS, Pescarini JM, Silva AF *et al*. The effect of primary health care on tuberculosis in a nationwide cohort of 7·3 million Brazilian people: a quasi-experimental study. *Lancet Glob Health* 2022;**10**:e390–97.

58. Owusu-Addo E, Renzaho AMN, Smith BJ. The impact of cash transfers on social determinants of health and health inequalities in sub-Saharan Africa: a systematic review. *Health Policy Plan* 2018;**33**:675–96.

59. Ministério da Saúde Secretaria de Vigilância em Saúde (ed). *Vigitel Brasil 2019: Vigilância de Fatores de Risco e Proteção Para Doenças Crônicas Por Inquérito Telefônico*. Brasília: Ministério da Saúde, 2019.

60. Araujo FG, Velasquez-Melendez G, Felisbino-Mendes MS. Prevalence trends of overweight, obesity, diabetes and hypertension among Brazilian women of reproductive age based on sociodemographic characteristics. *Health Care Women Int* 2019;**40**:386–406.

61. Trinquart L, Erlinger AL, Petersen JM, Fox M, Galea S. Applying the E value to assess the robustness of epidemiologic fields of inquiry to unmeasured confounding. *Am J Epidemiol* 2019;**188**:1174–80.

62. Pullar J, Allen L, Townsend N *et al*. The impact of poverty reduction and development interventions on non-communicable diseases and their behavioural risk factors in low and lower-middle income countries: a systematic review. *PLoS ONE* 2018;**13**: e0193378.

63. World Health Organization. *Closing the Gap in a Generation: Health Equity through Action on the Social Determinants of Health: Final Report of the Commission on Social Determinants of Health*. Geneva: World Health Organization, 2008.