Effect of a conditional cash transfer programme on childhood mortality: a nationwide analysis of Brazilian municipalities

Davide Rasella, Rosana Aquino, Carlos A T Santos, Rômulo Paes-Sousa, Mauricio L Barreto

Summary

Background **In the past 15 years, Brazil has undergone notable social and public health changes, including a large reduction in child mortality. The *Bolsa Familia* Programme (BFP) is a widespread conditional cash transfer programme, launched in 2003, which transfers cash to poor households (maximum income US$70 per person a month) when they comply with conditions related to health and education. Transfers range from $18 to $175 per month, depending on the income and composition of the family. We aimed to assess the effect of the BFP on deaths of children younger than 5 years (under-5), overall and resulting from specific causes associated with poverty: malnutrition, diarrhoea, and lower respiratory infections.**

Methods **The study had a mixed ecological design. It covered the period from 2004–09 and included 2853 (of 5565) municipalities with death and livebirth statistics of adequate quality. We used government sources to calculate all-cause under-5 mortality rates and under-5 mortality rates for selected causes. BFP coverage was classified as low (0·0–17·1%), intermediate (17·2–32·0%), high (>32·0%), or consolidated (>32·0% and target population coverage ≥100% for at least 4 years). We did multivariable regression analyses of panel data with fixed-effects negative binomial models, adjusted for relevant social and economic covariates, and for the effect of the largest primary health-care scheme in the country (Family Health Programme).**

Findings **Under-5 mortality rate, overall and resulting from poverty-related causes, decreased as BFP coverage increased. The rate ratios (RR) for the effect of the BFP on overall under-5 mortality rate were 0·94 (95% CI 0·92–0·96) for intermediate coverage, 0·88 (0·85–0·91) for high coverage, and 0·83 (0·79–0·88) for consolidated coverage. The effect of consolidated BFP coverage was highest on under-5 mortality resulting from malnutrition (RR 0·35; 95% CI 0·24–0·50) and diarrhoea (0·47; 0·37–0·61).**

Interpretation **A conditional cash transfer programme can greatly contribute to a decrease in childhood mortality overall, and in particular for deaths attributable to poverty-related causes such as malnutrition and diarrhoea, in a large middle-income country such as Brazil.**

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Instituto de Saúde Coletiva, Federal University of Bahia, Salvador, Bahia, Brazil (D Rasella PhD, R Aquino MD, C A T Santos PhD, Prof M L Barreto MD); **Department of Exact Sciences, State University of Feira de Santana, Feira de Santana, Bahia, Brazil** (C A T Santos); **Institute of Development Studies, University of Sussex, Brighton, UK** (R Paes-Sousa MD); **and Ciência, Tecnologia e Inovação em Saúde, INCT-CITECS , Salvador, Bahia, Brazil** (Prof M L Barreto)

Correspondence to:
Prof Mauricio Barreto, Instituto de Saúde Coletiva, Universidade Federal de Bahia, Canela, 41110–040, Salvador, Bahia, Brazil
mauricio@ufba.br

Introduction

Conditional cash transfer programmes are interventions that transfer cash from governments to poor households with the requirement that parents comply with specific conditions (or conditionalities), usually focused on health and education for their children.[1] The transfer of benefits aims to promptly alleviate poverty and the conditions encourage use of existing health and education services. The first conditional cash transfer programmes were implemented in the late 1990s in Mexico and Brazil, spreading rapidly to various countries worldwide, becoming an important strategy for alleviation of poverty and reduction of inequalities in low-income and middle-income countries.[1,2]

In Brazil, the *Bolsa Familia* programme (Family Allowance, BFP), launched in 2003, merged four pre-existing national social programmes into one unique expanded programme.[3] The BFP is the world's largest conditional cash transfer programme, and its coverage has expanded greatly in the past 10 years. It reached all 5565 Brazilian municipalities and enrolled 13·4 million families in 2011, with a total budget of US$11·2 billion.[4] The cash transfers are intended for extremely poor families (with an income of less than $35 per person per month) and for other families deemed poor (with an income of between $35 and $70 per person per month) when they include children up to 17 years of age or pregnant or lactating women.[5] Poor families receive about $18 for each pregnant woman, child, or adolescent up to 17 years of age (with an upper limit for each category), whereas extremely poor families, besides receiving the same benefits, receive an additional contribution of $35 irrespective of the composition of the family. According to these criteria, benefits can range from $18 to a maximum of $175 per month. The mother (when present) must receive the monthly payment on behalf of the whole family.

A family enrolled in the BFP has to comply with specific education and health-related conditions. To meet the health conditions children younger than 7 years must be vaccinated according to the Brazilian immunisation programme schedule and must comply with health check-ups and growth monitoring according to Ministry of Health guidelines, with a frequency from one to seven times per year, depending on a child's age. Pregnant and lactating women must attend scheduled prenatal and postnatal visits and health and nutritional educational activities. When possible, health-related conditions should be met using the facilities of the main primary health care programme in Brazil, the *Programa Saúde da Família* (Family Health Programme, FHP).[6] The FHP is another large-scale national programme, implemented over the past several years. By 2011, it reached 94% of municipalities, covering 53% of the Brazilian population.[7] FHP aims to broaden access to public health services, especially in deprived areas, by offering free, community-based health care.[8]

Brazil is characterised by large social inequalities, and it has undergone substantial health and social changes in the past 15 years, including a large reduction in deaths of children younger than 5 years (under-5), enabling the country to reach the fourth Millennium Development Goal.[9,10] FHP is one of the components that has brought about the substantial decrease in under-5 mortality.[11,12] We postulate that the BFP should reduce childhood mortality by acting on social determinants of health and by stimulating health care through its conditions. Previous studies have reported the effectiveness of BFP in reducing child malnutrition,[13,14] but no studies have addressed its effect on childhood morbidity or mortality. Therefore, the objective of the present study was to assess the effect of the BFP on under-5 mortality rates in Brazilian municipalities, focussing on causes of mortality associated with poverty (such as malnutrition, diarrhoea, and lower respiratory infections) and on some of the potential intermediate mechanisms (such as vaccination, prenatal care, and admission to hospital).

See Online for appendix

Methods

Study design

This study has a mixed ecological design, combining an ecological multiple-group design with a time-trend design. The municipality is the unit of analysis. We created a longitudinal dataset from several databases for the years 2004–09. From the 5565 Brazilian municipalities, we selected a subset that had adequate vital statistics (death and livebirth registration) during the first years of the period under study (2004–06; we assumed constant adequacy for the remaining years because of improvements in collection of vital information).[15] We assessed adequacy of mortality information according to a validated multi-dimensional criterion,[16] which took into account the value of the age-standardised mortality rate of the municipality, the ratio between registered and estimated birth rates, the percentage of poorly defined deaths, and the mean deviation of the previous two parameters for 2004–06. We obtained mortality rates by direct calculation—the number of deaths of children younger than 5 years per 1000 live-births. Groups of selected causes of mortality and admission to hospital were created by aggregation of categories from the International Classification of Diseases, 10th revision:[17] diarrhoeal diseases (A00, A01, A03, A04, A06–09), malnutrition (E40–46), lower respiratory infections (J10–18, J20–22), and external causes (V01–98). Mortality attributed to external causes (which includes transport accidents, homicides, and accidental injuries) was included as a control because no effect from either of the programmes was expected. Rates of under-5 admission to hospital were also obtained by direct calculation. A vaccination coverage index for children younger than 1 year was created with areas dichotomised into those where coverage of three main vaccines (measles, oral polio, and diphtheria-pertussis-tetanus [DPT]) was higher than 95% and those with lower coverage.

For the BFP, it is possible to concieve of two indicators of coverage. The first is coverage of the target population, calculated as the number of families enrolled in the BFP in a municipality divided by the number of eligible families (according to BFP criteria) in the same municipality.[4] The second is coverage of the total population, calculated as the number of individuals enrolled in the BFP (obtained by multiplying the number of beneficiary families by the average family size) divided by the total population of the same municipality. All models have been fitted using these two indicators (appendix p 4). We have also created a coverage indicator combining both indicators. The categories for this BFP coverage indicator were: low (BFP coverage of the total population of the municipality from 0·0% to 17·1%), intermediate (17·2–32·0%), high (>32·0%), and consolidated (BFP coverage of the total population of the municipality >32·0% and, at the same time, BFP coverage of the target population ≥100% for at least the previous 4 years). Because of the absence in the scientific literature of previous reference values, the cutoffs used for the categorisation (17·1% and 32·0%) represented the tertiles of the distribution of BFP coverage of the total population. This indicator, adjusted in the models for the percentage of the target population in the municipality, enabled us to capture the effect of programme duration and the effect of possible programme externalities (ie, positive spillover effects on programme-ineligible inhabitants) in the municipality.[2] We calculated yearly coverage of the FHP as the ratio of the total number of individuals registered in this programme to the population of the municipality, and it was categorised, for comparability reasons, as in previous studies:[11,12,15] without FHP, incipient (<30·0% of the population), intermediate (30·0–69·9% or ≥70·0% for less than the previous 4 years), and consolidated (≥70·0% for at least the previous 4 years). We selected a set of covariates recognised as determinants of under-5 mortality (all-cause and cause-specific) that were available at the municipality level: monthly income per person, proportion of total municipality population eligible for

BFP, prevalence of illiteracy among individuals older than 15 years, percentage of individuals living in households with inadequate sanitation (inadequate water supply, sewers, and garbage collection), total fertility rate, and overall rate of admissions to hospital in the municipality. We dichotomised the covariables according to the median value or, when available (as in the case of illiteracy and fertility rates), reference values.

Data sources

The data used in this study were collected from different information systems. The data sources provided by the Ministry of Health were: mortality information system (under-5 deaths), primary care information system (FHP coverage), information system on livebirths (livebirths), and outpatient information system (admissions to hospital).[7] We used the Ministry of Social Development databases to calculate BFP coverage,[4] and we used data from the Brazilian Institute of Geography and Statistics for socioeconomic variables.[18] Because data for the covariates were obtained from the 2000 and 2010 national census databases, we calculated the annual values from 2004–09 by linear interpolation.

Statistical analyses

We used conditional negative binomial regression models for panel data—consisting of a relevant number of units of analysis with repeated observations over time—with fixed-effects specification. As explained in detail in the appendix pp 7–9, to verify whether these models were actually removing the individual fixed effects,[19] we fitted models with different specifications from our dataset, including unconditional negative binomial regression models and conditional Poisson regressions with robust SEs. Conditional fixed-effects negative binomial regression models were shown to be the most appropriate for our analysis. The fixed-effects models, as with any other longitudinal or panel data models, include a second term to control for characteristics of the unit of analysis that are constant during the study period and that have not been included in the model as confounding variables, such as some geographical, historical, or sociocultural aspects of each municipality. We chose the fixed-effects model specification on the basis of the Hausman test and because it is the most appropriate test for assessment of effects in interventions with panel data.[20,21] We did goodness of fit tests with Akaike information criterion and Bayesian information criterion estimates.[19] We fitted the same models with continuous or categorised variables (appendix pp 3–4). Whereas continuous variables allow estimation of the average strength of an association along the entire range of values for a variable, categorised variables give a measure of effect that is easier to interpret, comparing defined ranges of values. Moreover, use of different levels of coverage allows verification of the existence of a gradient of effect, related—in our study—to different degrees of implementation of the interventions.[11,12,15] To assess the association between BFP or FHP coverage and mortality rates, we calculated mortality rate ratios (RRs), both crude and adjusted for covariates, using municipalities with the lowest coverage as the reference category.

To detect any interaction between the BFP and FHP with regard to the reduction of all-cause and cause-specific under-5 mortality, we created a product term between the BFP and FHP coverage—both dichotomised as consolidated or not consolidated—and fitted models with the same specification as the previous ones but with this term representing the interaction between the two programmes.

	2004	2005	2006	2007	2008	2009	Percentage change 2004–09
Mortality rate for children younger than 5 years (per 1000 livebirths)							
Overall	21·7 (14·7)	20·3 (14·5)	20·1 (14·6)	19·4 (14·8)	18·6 (15·9)	17·5 (14·7)	–19·4%
For diarrhoeal diseases	0·95 (2·93)	0·86 (2·54)	0·83 (2·67)	0·55 (2·02)	0·49 (1·96)	0·51 (2·46)	–46·3%
For malnutrition	0·55 (2·33)	0·48 (2·24)	0·36 (1·70)	0·30 (2·53)	0·20 (1·26)	0·23 (1·54)	–58·2%
For lower respiratory infections	1·15 (3·30)	0·96 (2·72)	1·07 (2·84)	0·95 (2·91)	0·98 (3·85)	0·84 (2·84)	–27·0%
For external causes	1·23 (3·29)	1·16 (3·14)	1·06 (3·17)	1·16 (3·80)	1·07 (3·70)	1·01 (3.·71)	–17·9%
BFP coverage of the municipality population (%)	17·3% (12·1)	23·0% (14·0)	28·1% (17·2)	27·8% (17·8)	25·2% (16·7)	28·3% (17·5)	63·6%
FHP coverage of the municipality population (%)	62·7% (36·7)	67·8% (34·8)	71·0% (33·4)	73·9% (32·4)	74·4% (31·3)	75·0% (30·9)	19·6%
Income per person (monthly, in BR$)	310 (126)	339 (135)	368 (145)	396 (154)	425 (164)	454 (147)	46·5%
Proportion of BFP eligible population in the municipality	27·9% (16·5)	27·8% (16·7)	27·8% (16·8)	27·7% (16·9)	26·5% (15·5)	26·3% (15·5)	–5·7%
Proportion of individuals living in households with inadequate sanitation	22·9% (16·4)	21·7% (15·8)	20·5% (15·2)	19·3% (14·7)	18·2% (14·3)	17·0% (13·9)	–25·8%
Proportion of individuals older than 15 years who are illiterate	16·9% (10·3)	16·4% (10·0)	15·9% (9·8)	15·4% (9·6)	14·9% (9·3)	14·4% (9·1)	–14·8%
Total fertility rate	2·31 (0·62)	2·27(0·63)	2·20 (0·64)	2·14 (0·65)	2·07 (0·65)	2·01 (0·67)	–13·0%
Rate of admissions to hospital (per 100 inhabitants)	4·88 (4·47)	4·69 (4·34)	4·58 (4·39)	4·46 (4·11)	4·02 (4·11)	4·04 (4·23)	–17·2%

Data are mean (SD). Causes of death were defined according to the International Classification of Diseases, 10th revision:[17] diarrhoeal diseases (A00, A01, A03, A04, A06–09), malnutrition (E40–46), lower respiratory infections (J10–18, J20–22), and external causes (V01–98). Rate of admission to hospital was calculated as the number of admissions to hospital for all ages and all causes of one municipality divided by the total population of the same municipality and multiplied by 100. BFP=*Bolsa Familia* Programme. FHP=Family Health Programme.

Table 1: **Mortality rates and variables for selected municipalities (N=2853)**

	BFP models		FHP models		FHP and BFP (adjusted)
	Crude	Adjusted	Crude	Adjusted	
BFP population coverage					
Low (0·0–17·1%)	1·00	1·00	..	..	1·00
Intermediate (17·2–32·0%)	0·91 (0·90–0·93)	0·93 (0·91–0·95)	..	..	0·94 (0·92–0·96)
High (>32·0%)	0·82 (0·80–0·85)	0·86 (0·83–0·89)	..	..	0·88 (0·85–0·91)
Consolidated (>32·0% and TPC ≥100% for at least 4 years)	0·76 (0·72–0·80)	0·81 (0·76–0·85)	..	..	0·83 (0·79–0·88)
FHP municipality population coverage					
No FHP (0·0%)	..	..	1·00	1·00	1·00
Incipient (<30%)	..	..	0·97 (0·92–1·02)	0·98 (0·94–1·03)	0·99 (0·94–1·04)
Intermediate (≥30%)	..	..	0·89 (0·85–0·93)	0·91 (0·87–0·96)	0·93 (0·88–0·97)
Consolidated (≥70% and implemented for at least 4 years)	..	..	0·81 (0·77–0·86)	0·85 (0·80–0·90)	0·88 (0·83–0·93)
Income per person (monthly, >BR$380)*	..	0·94 (0·92–0·97)	..	0·93 (0·91–0·96)	0·95 (0·92–0·97)
Proportion of municipality population eligible for BFP* >22·4%	..	1·07 (1·02–1·11)	..	1·10 (1·06–1·15)	1·07 (1·03–1·12)
Proportion of individuals living in households with inadequate sanitation* <16·7%	..	1·10 (1·05–1·15)	..	1·11 (1·06–1·16)	1·10 (1·05–1·15)
Proportion of individuals older than 15 years who are illiterate† >11·1%	..	1·04 (1·00–1·09)	..	1·05 (1·01–1·10)	1·04 (1·00–1·08)
Total fertility rate† >2·32	..	1·08 (1·04–1·11)	..	1·08 (1·05–1·12)	1·07 (1·03–1·10)
Rate of admission to hospital (per 100 inhabitants)* >4·27	..	1·02 (0·99–1·04)	..	1·02 (0·99–1·04)	1·01 (0·99–1·04)
Number of observations	17 118	17 118	17 118	17 118	17 118
Number of municipalities	2853	2853	2853	2853	2853

Data are rate ratio (95% CI) unless otherwise specified. TPC=target population coverage. *Cutoff is median value. †Cutoff taken from Rasella and colleagues, 2010.[12]

Table 2: **Fixed-effect negative binomial models for association between under-5 mortality rates and *Bolsa Familia* Programme (BFP) and Family Health Programme (FHP) coverage**

We did a sensitivity analysis with data from all Brazilian municipalities irrespective of quality of vital information.

We used Stata (version 12.0) for database processing and analysis.

Role of the funding source

The sponsor of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

The criteria for adequate death and livebirth registration were met by 2906 municipalities. Of these, 2853 (51% of all Brazilian municipalities) had data available for all co-variates and were included in our analysis. From 2004–09, the mean under-5 mortality rate decreased by 19·4% in the studied municipalities, and among the selected causes, the greatest decrease was associated with malnutrition (58·2%; table 1). Under-5 mortality associated with external causes decreased by 17·9%. Mean BFP coverage in the municipalities exhibited some yearly variation during the study period, reaching a peak in 2009 with 28·3% coverage. Mean FHP coverage in the municipalities continually increased, reaching 75·0% in 2009. Socioeconomic conditions improved during the study period, with the mean monthly income per person increasing by 46·5% and the percentage of individuals living in households with inadequate sanitation decreasing by 25·8% (table 1).

Table 2 shows the crude and adjusted associations of under-5 mortality rate with BFP and FHP municipal coverage levels. In the analysis, both measures of BFP and FHP coverage exhibited a significant dose–response association with decreasing under-5 mortality rate, even after the adjustment for socioeconomic and demographic covariates. We indentified much the same results in models for which all the variables were imputed as continuous (appendix p 3). Table 3 shows the effect of BFP and FHP municipal coverage on selected causes of under-5 mortality. Both interventions had an effect on all selected causes except for external causes, which were used as a control. The strongest effect of the BFP was on under-5 mortality resulting from malnutrition, whereas the FHP was associated with the greatest reduction in diarrhoeal diseases and lower respiratory infections (table 3).

As shown in table 4, in multivariable models that controlled for FHP coverage and relevant covariates, the increase in BFP coverage increased vaccination coverage for measles, polio, and DPT, reduced the number of pregnant women who delivered without receiving any prenatal care, and reduced rates of under-5 admissions to hospital in a manner much the same as for the reduction in mortality rates, having the strongest effect on malnutrition and no effect on external causes.

When we included an interaction term between BFP and FHP in the models, this term was negatively associated with all mortality rates, both overall or for specific causes, but the association was significant only in the models for overall under-5 mortality rate (RR 0·95; 95% CI 0·91–0·99).

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	Diarrhoeal diseases	Malnutrition	Lower respiratory infections	External causes
BFP municipality population coverage				
Low (0·0–17·1%)	1·00	1·00	1·00	1·00
Intermediate (17·2–32·0%)	0·83 (0·74–0·92)	0·66 (0·57–0·77)	0·96 (0·88–1·05)	1·03 (0·95–1·13)
High (>32·0%)	0·68 (0·59–0·80)	0·54 (0·44–0·67)	0·94 (0·82–1·07)	0·92 (0·79–1·06)
Consolidated (>32·0% and TPC ≥100 for at least 4 years)	0·47 (0·37–0·61)	0·35 (0·24–0·50)	0·80 (0·64–0·99)	0·92 (0·72–1·16)
FHP municipality population coverage				
No FHP (0·0%)	1·00	1·00	1·00	1·00
Incipient (<30%)	0·90 (0·67–1·17)	0·88 (0·60–1·29)	0·83 (0·68–1·00)	0·95 (0·79–1·14)
Intermediate (≥30%)	0·71 (0·54–0·93)	0·72 (0·49–1·07)	0·71 (0·58–0·86)	0·87 (0·72–1·05)
Consolidate (≥70% and implemented for at least 4 years)	0·53 (0·39–0·71)	0·59 (0·38–0·91)	0·70 (0·56–0·87)	0·87 (0·70–1·08)
Number of observations	7356	5124	9894	10 776
Number of municipalities	1226	854	1649	1796

Data are rate ratio (95% CI) unless otherwise specified. Models adjusted for income per person, proportion of municipality population eligible for BFP, proportion of individuals living in households with inadequate sanitation, proportion of individuals older than 15 years who are illiterate, total fertility rate, and rate of admissions to hospital.

Table 3: **Fixed-effect negative binomial models for adjusted associations between *Bolsa Familia* Programme (BFP) and Family Health Programme (FHP) coverage and under-5 mortality rates for some relevant groups of causes**

	Measles, polio, and DPT vaccine coverage over 95% among children younger than 1 year OR* (95% CI)	Proportion of pregnant women with no prenatal visits at the moment of delivery RR† (95% CI)	Under-5 rate of admission to hospital RR‡ (95% CI)	Under-5 rate of admission to hospital for diarrhoeal diseases RR‡ (95% CI)	Under-5 rate of admission to hospital for malnutrition RR‡ (95% CI)	Under-5 rate of admission to hospital for lower respiratory infections RR‡ (95% CI)	Under-5 rate of admission to hospital for external causes RR‡ (95% CI)
BFP municipality population coverage							
Low (0·0–17·1%)	1·00	1·00	1·00	1·00	1·00	1·00	1·00
Intermediate (17·2–32·0%)	1·47 (1·29–1·68)	0·85 (0·83–0·87)	0·96 (0·95–0·97)	0·86 (0·84–0·87)	0·82 (0·76–0·87)	0·95 (0·93–0·97)	1·30 (0·85–1·99)
High (>32·0%)	1·98 (1·48–2·43)	0·66 (0·63–0·69)	0·92 (0·90–0·94)	0·80 (0·77–0·83)	0·68 (0·62–0·75)	0·88 (0·85–0·91)	1·19 (0·45–3·18)
Consolidated (>32·0% and TPC ≥100 for at least 4 years)	2·05 (1·53–2·76)	0·53 (0·48–0·57)	0·84 (0·81–0·86)	0·61 (0·57–0·65)	0·53 (0·44–0·63)	0·88 (0·83–0·93)	0·62 (0·10–3·90)
Number of observations	14 166	15 948	17 118	17 070	12 528	17 118	10 776
Number of municipalities	2361	2658	2853	2845	2088	2853	1796

OR=odds ratio. RR=rate ratio. DTP=diphtheria, tetanus, pertussis. TPC=target population coverage. FHP=Family Health Programme. *Estimated by logistic regression models adjusted for FHP coverage. †Estimated by negative binomial regression models adjusted for FHP coverage. ‡Estimated by negative binomial regression models adjusted for FHP coverage, income per person, proportion of municipality population eligible for BFP, proportion of individuals living in households with inadequate sanitation, proportion of individuals older than 15 years who are illiterate, and total fertility rate.

Table 4: **Fixed-effect models for associations between primary care indicators, rates of admission to hospital, and *Bolsa Familia* Programme (BFP) coverage**

Municipalities with adequate death and livebirth information showed a slightly lower socioeconomic status and a slightly higher BFP coverage than did those with inadequate information (data not shown). A sensitivity test, done by fitting the models with data from all Brazilian municipalities, showed slightly lower, but significant, effects of the two interventions: the effect on overall under-5 mortality of consolidated BFP coverage was RR 0·83 (95% CI 0·78–0·87) and of consolidated FHP coverage was 0·91 (0·87–0·94), while for under-5 diarrhoea mortality was 0·52 (0·41–0·66) for consolidated BFP and 0·65 (0·54–0·79) for consolidated FHP. We identified much the same results for malnutrition and respiratory infection (data not shown).

Discussion

The results of our study show that BFP had a significant role in reduction of under-5 mortality, overall and from poverty-related causes such as malnutrition and diarrhoea, in Brazilian municipalities from 2004–09. The effect was maintained even after the adjustment for socioeconomic covariables and FHP. The increase in BFP duration and in coverage of both the total and target populations strengthens the effect of the programme. The effect of the BFP was stronger when, with high municipality population coverage, full coverage of the target population of poor families was maintained for 4 years or more. With regard to factors involved in the causal chain of mortality reduction, the BFP substantially reduced rates of under-5 admission to hospital and increased vaccination coverage and prenatal visits.

Because the BFP and FHP have been implemented on a large scale over the same period in the same areas in Brazil, we had a unique opportunity to explore their joint effects. The effectiveness of the FHP in reduction of overall infant and child mortality, reducing under-5 mortality resulting from diarrhoea and lower respiratory infections, increasing vaccination coverage, and reducing admissions to hospital has already been shown.[11,12,22] However, none of these studies included the effect of the BFP in their analyses.

Several studies worldwide, summarised in reviews,[23–25] showed that conditional cash transfer programmes had positive effects on nutritional status and health outcomes of enrolled children, through the increase in the use of preventive services, immunisation coverage, and promotion of healthy behaviours (panel[23–25]). Only an econometric study[26] assessed the effect of a conditional cash transfer programme on infant mortality; the investigators reported that the Mexican conditional cash transfer programme *Progresa* was able to reduce infant mortality in rural areas.[26] Our analysis—using a different statistical approach and different mortality outcomes, excluding municipalities with inadequate vital information, using different coverage indicators, and studying the effect of BFP on the intermediate mechanisms of vaccination, prenatal care, and admissions to hospital—showed BFP to have an effect on childhood mortality.

The large magnitude of the effect of the BFP that we identified can be explained by the fact that the number of under-5 deaths from a small number of extremely poor families constitutes a high proportion of all under-5 deaths in the municipalities. The proportion reaches almost 100% for poverty-related causes of mortality, such as malnutrition or diarrhoea. A mathematical demonstration and a broader discussion of how this association operates are available in the appendix pp 5–6. Moreover, to understand how the relatively small amount of money provided by the BFP can have an effect on beneficiaries' health, it has to be remembered that this amount is proportional to the economic vulnerability of the families, and that the association between income and health is non-linear:[28] even a small amount of money, given to extremely poor families, can have an effect on child health, increasing survival.

BFP, like other conditional cash transfer programmes, can affect child survival through different mechanisms (figure), largely centred on income improvement and health conditions: an increased income can increase access to food and other health-related goods, and health-related conditions can improve access to health services.[25] A strong association exists between child undernutrition and child survival—as levels of child undernutrition increase so does the risk of death, especially from diarrhoea and measles.[29] Research has already shown that poor families enrolled in the BFP increased food expenditures and improved food security in their households.[30] Overall, Brazil has seen a substantial decrease in child undernutrition during the past decade, particularly among poor families.[9] The contribution of the BFP to this process has been shown in a few studies,[13,14] in which children from BFP beneficiary families were more likely to be better nourished than were those from non-beneficiary families. The money allowance from the BFP could likewise reduce the household poverty burden, improving living conditions and removing or reducing barriers to accessing health care, not only for children, but also the rest of the family.[31]

Another important explanation for the effect of the BFP on child survival is associated with the health-related conditions, which include prenatal care, postnatal care, and health and nutrition education activities for mothers, in addition to a regular vaccination schedule and routine check-ups for growth and development for children younger than 7 years. Maternal knowledge and education are some of the strongest determinants of child health, improving nutrition, hygiene practices, and care-seeking for illnesses.[31] Even when there is conflicting evidence as to whether monitoring of child growth is effective in itself, such monitoring can provide an entry point for preventive and curative health-care services and can reduce the scarcity of contact with the health system, an important determinant of child survival in developing countries.[32] As shown in our study, the BFP increases prenatal care and

Panel: Research in context

Systematic review

We searched PubMed, Science Direct, Popline, and Embase with the terms "conditional cash transfer" and "bolsa familia". Searches were not restricted by language or date; the last search was done in June, 2012. We used the reference lists of selected reports to identify other relevant studies.

In a comprehensive systematic review[23] of the effect of conditional cash transfer programmes on general health outcomes, positive effects of such programmes were identified for child nutritional status and child morbidity. An increased use of general health care and preventive services in children and pregnant women was also reported.[24] A programme theory framework has been proposed to explain the effects of conditional cash transfer on health,[25] suggesting that the quality of the health services providing conditions is a crucial factor in the effectiveness of such programmes. With regard to the effect of conditional cash transfer programmes on mortality, we identified only one research report, which showed a reduction of infant mortality rates in Mexico, attributed to the effect of the conditional cash transfer programme *Progresa*,[26] probably because it increases access to health care for hard-to-reach segments of the population in both rural and urban areas.[27] However, limitations in the study design and the absence of analysis of some intermediate mechanisms that could explain this mortality reduction—including health-care supply—emphasised the necessity of a broader and more rigorous study of the effect on child mortality of a larger conditional cash transfer programme, such as *Bolsa Familia* in Brazil.

Interpretation

The results of our study show that a large-scale conditional cash transfer programme, combined with an effective primary health-care system, can strongly reduce childhood mortality, from poverty-related causes and overall. Mechanisms include effects on social determinants of health and increased use of preventive services in children and pregnant women through programme conditions.

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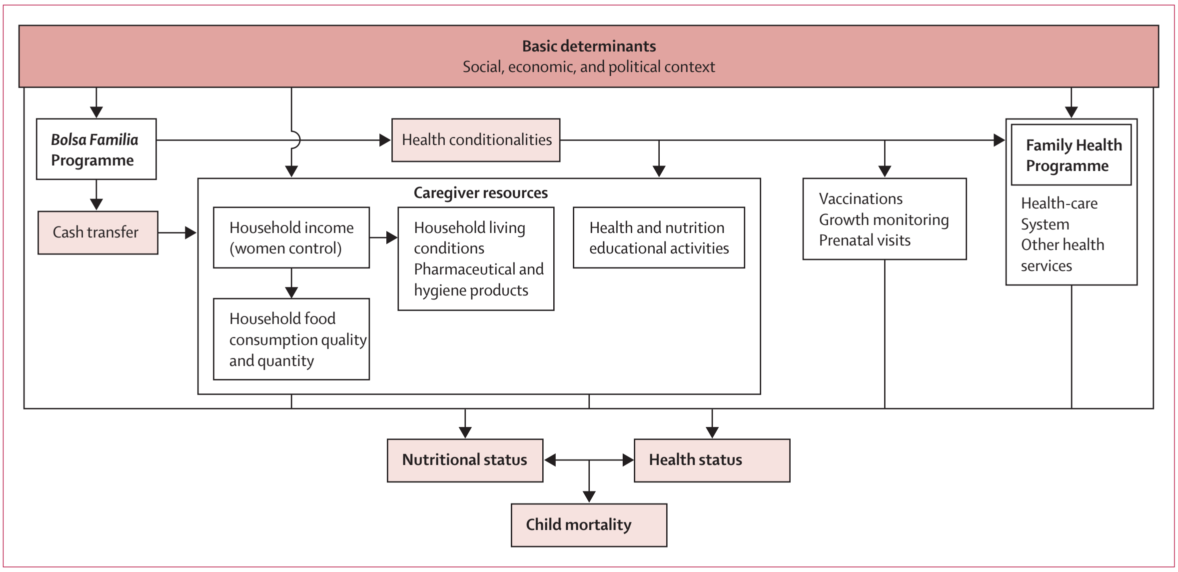

Figure: **Mechanisms linking the *Bolsa Familia* Programme and the Family Health Programme to child nutritional and health outcomes**

vaccination coverage. These interventions are effective for prevention of child mortality.[33]

Even if implementation and coverage of the FHP is not affected by the presence of the BFP, according to the Ministry of Health, the FHP is the strategy of choice to help BFP beneficiaries meet health conditions, and to help them with their health needs.[6] Unlike the BFP, which has a specific target population, the FHP has the objective of covering all the population of the municipality, offering comprehensive primary health care free of charge.[8] When BFP beneficiaries are under an FHP catchment area, the FHP team has the formal responsibility to deliver all services linked to the conditions, and community health workers should undertake home visits and actively monitor the completion of conditions.[6] Compliance with health conditions depends on monitoring and on barriers to accessing services.[1,25] The FHP increases access to health care,[15,34] which, according to our results, strengthens the effect of the BFP on FHP beneficiaries compared with BFP beneficiaries who are assisted by traditional health facilities, which are generally more distant and do not undertake community involvement activities and home visits.[3]

We identified a strong effect of the BFP on rates of under-5 admissions to hospital, both overall and for specific causes, which could be explained by two different mechanisms: decreasing the incidence of the diseases by affecting social determinants of health; or by increasing early contacts with the health-care system, thereby reducing the number of severe cases of illness needing admission to hospital.[25] One of the strengths of our study is that we used a measurement of the intensity of the intervention (the coverage of the BFP) that is specifically linked to the population group that accounts for a large proportion of the outcome (deaths from poverty-related causes), thus reducing the plausibility that the outcomes of interest are coming from the group of people not exposed to the intervention (ie, ecological fallacies).

Another strength of our study was the selection of municipalities with vital information of adequate quality, which improved the study's internal validity, although this selection might limit the generalisability of the results. However, the sensitivity analysis done with all Brazilian municipalities gave much the same effect estimates, suggesting that our findings are robust. In some of the models for selected causes of mortality, the number of observations varied for statistical reasons; municipalities with the same values for the outcome (in this case, 0 deaths) over the entire 6-year period were not included in the model fitting because of a limitation of the fixed-effects model algorithms.[19,20] However, by comparing the covariate values of the municipalities included in each model with those that were excluded, we identified much the same values, and the estimates of the random effects models (which included all 2853 municipalities in the model fitting) did not affect the sign, significance, or main conclusions reached with the fixed-effects models; the random-effects RR for consolidated BFP coverage was 0·75 for mortality from diarrhoea and 0·61 for mortality from malnutrition. Possible bias introduced by use of crude interpolation rather than more complex estimation techniques was limited by variable categorisation, which can reduce fluctuations that are artificially introduced by the method.

We did not included a variable representing time in the models because the mortality RR, comparing two or more groups of coverage exposed to the same mortality time trend, allowed us to control for secular trends.[11,12] The introduction of a time variable in the models would have constituted an over-specification problem, as confirmed by the sensitivity analyses. The fact that these models were not affected by secular mortality trends was suggested by the estimates of the effect of BFP and FHP on under-5 mortality attributed to external causes: although mortality from external causes was decreasing during the study period, neither programme showed an effect of reduction on mortality from such causes. One limitation of the study was that fixed-effects models can control only for selection bias associated with unmeasured time-constant characteristics of the municipalities.[21] However, we used a wide set of covariates and showed no effects of either programme on mortality from external causes, suggesting that other possible sources of selection bias or confounding were controlled.

The results of our study provide evidence that a multisectoral approach, combining a large-scale conditional cash transfer programme, with the potential to act on important social health determinants, and effective primary health care, capable of attending basic health demands of the same population and of attending conditions imposed by the conditional cash transfer programme, can substantially reduce childhood mortality from poverty-related causes in a large middle-income country such as Brazil.

Contributors

MLB, DR, and RA designed the original study in discussion with RP-S. DR collected data. DR and CATS did the data analysis and DR wrote a first draft of the report. All authors contributed to data interpretation and to the review of the report.

Conflicts of interest

We declare that we have no conflicts of interest.

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Supplementary appendix

Supplement to: Rasella D, Aquino R, Santos CAT; Paes-Sousa R, Barreto ML. Effect of a conditional cash transfer programme on childhood mortality: analysis of nationwide data of Brazilian municipalities.

1. Multivariate Models for the Association of Under-five Mortality Rates with Different *Bolsa Familia* Program Coverage Indicators

Two different yearly coverages of the Bolsa Familia Program (BFP) were considered: BFP coverage of the target population (TP) and BFP coverage of the total population of the municipality. The TP coverage was calculated as the number of families enrolled in the BFP program in the municipality divided by the number of eligible families (according to the BFP criteria) in the same municipality.[1] The second was the BFP coverage over the total population, calculated as the number of individuals enrolled in the BFP (obtained multiplying the number of beneficiary families per the average family size) over the total population of the same municipality.

Different models have been fitted using these two indicators as continuous or categorized variables. While continuous variable allow to estimate the existence of an association along the entire range of values of a variable, categorized variables gives an easily interpretable measure of effect. Moreover the use of different levels of coverage allow to verify the existence of a gradient of effect, related to different degrees of implementation of the interventions.[2,3]

Multivariable negative binomial models with all variables expressed as continuous variables were fitted and the results are shown in Table S1.

In order to obtain models with categorized variables, the BFP coverage of the total population of the municipality, much like the FHP program, was grouped as follows: low coverage (coverage of <70.0%), intermediate coverage (coverage of 70,0% to 99.9%), and high coverage (coverage of ≥ 100.0%). BFP coverage of the total population of the municipality was calculated as the sum of people receiving benefits from the BFP over the total population of the same municipality, and – in the absence of any literature reference for this kind of coverage - was classified according to terciles of the distribution: low coverage (first tercile, from 0.0% to 17.1%), intermediate coverage (second tercile, from 17.2% to 32.0%) and high coverage (third tercile, higher than 32.0%).

Multivariable negative binomial models with categorized variables were fitted as described in the methods section of the article (Table S2).

The BFP has a high targeting accuracy compared to CCTs of others countries [4] and it has been shown that even families mistakenly included in the program are often poor or low income.[5] The fact that the municipality population coverage, controlled for the TP percentage, seems to have a slightly higher effect than the Bolsa Familia TP coverage could be explained by the inclusion in this indicator of low income, but not eligible, families, and by the effects of the program's externalities.[6]

TABLE S1. Fixed-Effect Negative Binomial Models for the Association Between Under-five Mortality Rates and BFP Coverage, Expressed as Continuous Variables: Brazil, 2004–2009

Variables	Under-fives mortality rate, RR (95%CI)			
	Crude	Adjusted	Crude	Adjusted
BFP coverage of TP	0.997 (0.997-0.998)*	0.999 (0.999-0.999)*	-	-
BFP municipality population coverage	-	-	0.992 (0.991-0.993)*	0.997 (0.996-0.999)*
FHP population coverage	-	0.999 (0.999-0.999)*	-	0.999 (0.999-0.999)*
Per capita income (monthly)	-	0.999 (0.999-0.999)*	-	0.999 (0.999-0.999)*
Percentage of target poor population	-	1.005 (1.002-1.009)*	-	1.007 (1.003-1.010)*
Percentage of individuals living in households with inadequate sanitation	-	1.010 (1.007-1.013)*	-	1.007 (1.004-1.011)*
Percentage of illiterates among individuals over 15 years old (inverse)**	-	1.191 (1.070-1.325)*	-	1.159 (1.040-1.291)*
Total fertility rate	-	1.048 (1.002-1.096)*	-	1.041 (0.996-1.088)
Hospitalization rate (per 100 inhabitants)	-	0.997 (0.991-1.003)	-	0.997 (0.991-1.003)
No. of observations	17118	17118	17118	17118
No. of counties	2853	2853	2853	2853

* P value < 0.05
** Illiteracy rate has been transformed into its scaled inverse because caused collinearity problems to the model (VIF>6)

TABLE S2. Fixed-Effect Negative Binomial Models for the Association Between Under-five Mortality Rates and BFP Coverage, Expressed as Categorized Variables: Brazil, 2004–2009

Variables	Under-fives mortality rate, RR (95%CI)			
	Crude	Adjusted	Crude	Adjusted
BFP coverage of TP				
Low (<70%)	1	1	-	-
Intermediate (70.0% to 99.9%)	0.92 (0.90-0.93)	0.93 (0.92-0.94)	-	-
High (>=100.0%)	0.88 (0.86-0.89)	0.90 (0.89-0.92)	-	-
BFP municipality population coverage				
Low (0.0% to 17.1%)	-	-	1	1
Intermediate (17.2% to 32.0%)	-	-	0.91 (0.89-0.93)	0.94 (0.92-0.96)
High (>32.0%)	-	-	0.82 (0.79-0.84)	0.87 (0.84-0.90)
FHP population coverage				
No FHP (0.0%)	-	1	-	1
Incipient (<30%)	-	0.99 (0.95-1.04)	-	0.99 (0.95-1.04)
Intermediate (>= 30%)	-	0.94 (0.90-0.99)	-	0.93 (0.89-0.98)
Consolidate (>= 70% and time of implementation in the municipality of 4 years or longer)	-	0.91 (0.87-0.96)		0.90 (0.86-0.95)
Per capita income (monthly) > 380 BR	-	0.96 (0.93-0.98)	-	0.94 (0.92-0.97)
Percentage of target poor population> 22.4		1.07 (1.02-1.11)		1.07 (1.03-1.12)
Percentage of individuals living in households with inadequate sanitation <16.7		1.10 (1.05-1.15)		1.11 (1.06-1.16)
Percentage of illiterates among individuals over 15 years old >11.1%		1.05 (1.00-1.09)		1.05 (1.00-1.09)
Total fertility rate > 2.32		1.05 (1.01-1.08)		1.06 (1.02-1.09)
Hospitalization rate (per 100 inhabitants) > 4.27		1.01 (0.98-1.04)		1.02 (0.99-1.05)
No. of observations	17118	17118	17118	17118
No. of counties	2853	2853	2853	2853

2. Estimating the percentage of deaths from vulnerable segments of the population

Considering the unit of analysis of an ecological study, for example a county, divided into two different population groups with different mortality rates (MR), with MR_p being the MR of the poorest part of the population, and MR_r being the MR of the rest of the population, the Rate Ratio (RR) is: $RR = MR_p / MR_r$. If we consider the deaths from the poorest group (D_p) over the population of the poorest group (P_p) and the deaths from the rest of the population (D_r) over the rest of the population (P_r), We can obtain the total deaths in the county (D_{tot}) and the total population (P_{tot}) from the following equations:

$$MR_p = RR \times MR_r$$

$$D_p / P_p = RR \times D_r / P_r$$

$$D_p = RR \times (D_{tot} - D_p) \times P_p / P_r$$

$$D_p \times (1 + RR \times P_p / P_r) = RR \times P_p \times D_{tot} / P_r$$

$$D_p = RR \times P_p \times D_{tot} / [P_p \times (RR-1) + P_{tot}]$$

$$D_p = K_p \times D_{tot}$$

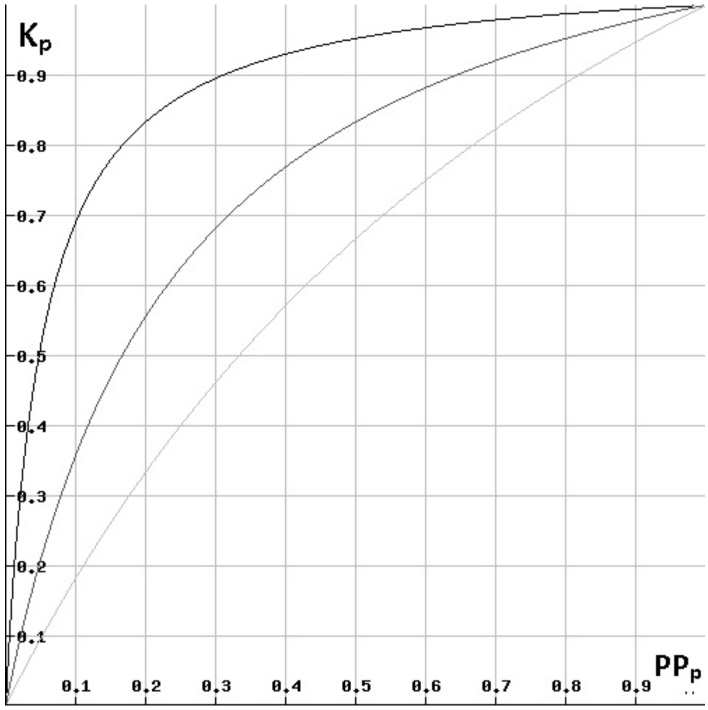
K_p represents the proportion of deaths that come from the poorest segment of the county's population, and depends on the Mortality Rate Ratio between the two population groups and the proportion of poor people over the total population of the county (PP_p) according to the following equation:

$$K_p = RR \times PP_p / [PP_p \times (RR-1) + 1]$$

Considering different values of Mortality Rate Ratios, the proportion of deaths that come from the poorest part of the population has a curvilinear relationship with the proportion of poor people in the county (FIGURE S1).

If we consider an under-five mortality rate ratio (RR) of 2.3,[7] in a county with 30% poor people the proportion of under-five deaths attributable to them will be 50%. In the case of segments of the population in extreme poverty the RR, and consequently the proportion of deaths attributable to them, will be considerably higher. The RR for specific causes,[8] especially poverty-related causes such as malnutrition or diarrhea, can be so high that the deaths attributable to extremely poor people reach almost the totality of the deaths for this specific cause in the county, as shown in the figure.

FIGURE S1: Proportion of deaths coming from the poorest part of the population (K_p) as function of the proportion of poor people in the county (PP_p) and according to different values of mortality rate ratio (RR).



Light grey: RR=2; Dark grey: RR=5; Black: RR=20

3. Negative binomial regression models with fixed effect specifications in impact evaluations

Negative Binomial Models

Negative binomial (NB) regression models are used when the outcome to be analyzed is a count data and the Poisson model assumption that the mean is equal to the variance does not hold, usually because the data are *overdispersed*.[9] The standard negative binomial regression model can be derived either as a Poisson-gamma mixture model or as a member of exponential distributions used as a basis for generalized linear models.

The NB regression can be used with longitudinal or panel data, where the same unit of analysis has repeated observations over a period of time.[10] In this case, in addition to the disturbance or error term, panel data models include a second term to control for unobserved time-invariant characteristics of the unit of analysis, or panel. According to how this term is estimated, the models can be distinguished in fixed effects or random effects models. From a statistical point of view, the choice between fixed-effects and random-effects models is based on the Hausman specification test.[10,11]

Fixed Effects Models in Impact Evaluations

In impact evaluations fixed effects (FE) models are usually preferred because they permit correlations between the unobserved time-invariant term and the explanatory variables.[12] In our case the time-invariant term could represent unobserved characteristics of the municipality such as geographical, historical, socio-cultural or socio-economic characteristics that did not change during the period of the study. In fixed effects models, but not in random ones, those characteristics could be correlated with the treatment variables, such as the BFP or FHP coverage. If for example these interventions were implemented with priority in remote and poor areas with higher mortality rates, and variables linked to those characteristics were not included in the model, the estimates of the intervention effects could suffer from selection bias. Fixed effects models allow to control for this selection bias because the fixed effect term of the equation represents these unobserved time-invariant characteristics of the panel.[12]

The Regression Model

The regression model to be estimated was as follows:

$$Y_{it} = \alpha_i + \beta_1 BFP_{it} + \beta_2 FHP_{it} + \beta_n X_{nit} + u_{it}$$

Where Y_{it} was the mortality rate for the municipality *i* in year *t*, α_i is the fixed effect for the municipality *i* that captures all unobserved time-invariant factors, BFP_{it} is the Bolsa Familia Program coverage for the municipality *i* in the year *t*, FHP_{it} the Family Health Program coverage for the municipality *i* in the year *t*, X_{nit} was the value of each *n* covariate of the model with in the municipality *i* in the year *t,* and u_{it} was the error.

A variable representing time was not included in the model because the mortality rate ratio, comparing two or more groups of coverage exposed to the same mortality time trend, allowed us to control for secular trends.[2,3] Introduced in the models a time variable would have represented an over-specification problem, as confirmed by sensitivity analyses that have been performed. The fact that these models control for secular trends was confirmed by the estimates of the BFP and FHP effect on U5MR due to external causes: despite this group of causes presented a decreasing mortality in the studied period the coverage of the two programs, which had increased in the same period, did not show any effect on it.

Fixed Effects Negative Binomial Models

Fixed effects negative binomial (FENB) models may be estimated in two ways, unconditionally or conditionally.[13] Conditional models are usually preferred and implemented in the classical statistical software packages because they can adjust for a large number of panels without creating dummy slopes for each panel, that is extremely time and computing memory consuming if the number of panels is large. However it has been shown that the conditional maximum likelihood estimator of the FENB does not necessarily remove the individual fixed effects in count panel data, this happens only in specific conditions.[13,14]

Different solutions have been proposed. According to the literature the more appropriate - even if time-consuming - is the fitting of unconditional FENB scaling its standard error (SE) by the Person Chi2 or the deviance dispersion.[9,13,15]

As it is shown in TABLE S3, in order to verify the robustness of our analysis, we fitted the panel data models related to all-causes under-five mortality rate using three different model specifications: 1- Conditional FENB, 2- Unconditional FENB with scaled SE, 3- conditional FE Poisson with robust SE.

The estimated effects of BFP and FHP (and of the covariates) are almost identical in all these models. The values of the Akaike information criterion (AIC) and Bayesian information criterion (BIC), that due to their formula was possible to calculate only for the models 1 and 3, suggest that the conditional FENB is the models that better fits the data.

The same comparison of model specifications have been performed for all the other mortality outcomes of the study: conditional FENB models show similar effect estimates but better AIC and BIC that Poisson models with robust SE, on the other hand unconditional FENB models have problems of convergence in some outcomes - probably due to the high number of parameters calculated - but when convergent show similar values to the conditional FENB.

Considering that the negative binomial regression is the model that better fit our *overdispersed* mortality data, that the fixed effects is an important specification for impact evaluation analysis, and that the conditional FENB demonstrated to behave in our models - comparing its estimates with the unconditional FENB and Poisson regressions - as true fixed effects models, we decided to use for the analysis of our panel dataset models with conditional FENB specifications.

TABLE S3: Fixed effects Regression Models for the Association Between Under-five Mortality Rates (U5MR) and BFP Coverage with Different Model Specifications: Brazil, 2004–2009

Variables	U5MR, RR (95%CI)		
	1. Conditional FENB	2. Unconditional FENB with scaled SE*[a]	3. Conditional FE Poisson with Robust SE
BFP population coverage			
Low (0.0% to 17.1%)	1	1	1
Intermediate (17.2% to 32.0%)	0.94 (0.92-0.96)	0.95 (0.93-0.97)	0.94 (0.91-0.97)
High (>32.0%)	0.88 (0.85-0.91)	0.89 (0.85-0.92)	0.88 (0.84-0.92)
Consolidate (>32.0% and TP coverage>=100% for 4 years or longer)	0.83 (0.79-0.88)	0.84 (0.79-0.89)	0.84 (0.78-0.89)
FHP municipality population coverage			
No FHP (0.0%)	1	1	1
Incipient (<30%)	0.99 (0.94-1.04)	0.98 (0.93-1.03)	0.99 (0.94-1.04)
Intermediate (>= 30%)	0.93 (0.88-0.97)	0.94 (0.89-0.98)	0.93 (0.88-0.98)
Consolidate (>= 70% and time of implementation in the municipality of 4 years or longer)	0.88 (0.83-0.93)	0.88 (0.83-0.94)	0.87 (0.82-0.93)
Per capita income (monthly) > 380 BR$	0.95 (0.92-0.97)	0.94 (0.92-0.97)	0.94 (0.91-0.98)
Percentage of TP > 22.4%	1.07 (1.03-1.12)	1.07 (1.01-1.13)	1.07 (1.02-1.13)
Percentage of individuals living in households with inadequate sanitation <16.7%	1.10 (1.05-1.15)	1.10 (1.05-1.15)	1.09 (1.04-1.15)
Percentage of illiterates among individuals over 15 years old >11.1%	1.04 (1.00-1.08)	1.04 (1.00-1.09)	1.04 (0.99-1.09)
Total fertility rate > 2.32	1.07 (1.03-1.10)	1.07 (1.04-1.11)	1.07 (1.03-1.11)
Hospitalization rate (per 100 inhabitants) > 4.27	1.01 (0.99-1.04)	1.00 (0.97-1.03)	1.01 (0.97-1.06)
No. of observations	17118	17118	17118
No. of counties	2853	2853	2853
AIC	52,962	*[b]	53,070
BIC	53,063		53,163

*[a] SE scaled by the Pearson chi-square statistic divided by the residual degrees of freedom, scaling by deviance statistics gave similar results
*[b] Not possible to be estimated according to the AIC and BIC formula;
FENB: Fixed Effects Negative Binomial,
FE: Fixed Effects

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