

## Effect of Brazil's Conditional Cash Transfer Programme on the new case detection rate of leprosy in children under 15 years old

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Accepted for publication 20 December 2017

### *Summary*

**Background:** Poverty and other socio-environmental determinants may contribute to the occurrence of leprosy. However, there is no previous evidence on the effectiveness of cash transfer programmes in reducing leprosy case detection among children under 15 years old.

**Objective:** This study aimed to assess the effect of the Brazilian conditional cash transfer programme (*Bolsa Família* Programme, BFP) on the reduction of new case detection rates (NCDR) of leprosy in Brazilians under 15 years old.

**Methods:** We performed a mixed ecological study with the Brazilian municipalities as units of analysis, during 2004–2015. The main independent variables were: BFP coverage of target population (poor and extremely poor families) and BFP coverage of the total population of the municipalities. Data were obtained from public databases. We included 1,120 (of 5,570) municipalities in the analysis, using fixed-effects negative binomial models for panel data, adjusted for the municipal coverages

of the Brazilian primary health care programme (Family Health Strategy, FHS) and for a set of sociodemographic covariates.

*Results:* We found an increasing trend in the median BFP coverages and a decreasing trend in the NCDR of leprosy in individuals under 15 years old. This indicator was significantly reduced in municipalities with higher BFP coverages of target population (RR = 0.75; CI 95% 0.63–0.88) and higher BFP coverages of the total population of the municipalities (RR = 0.85; CI 95% 0.79–0.93).

*Conclusions:* During the study period, BFP was associated with a reduction of the NCDR of leprosy among Brazilians aged less than 15 years old, living in municipalities with a high risk of leprosy transmission.

*Keywords:* leprosy, incidence, child, adolescent, social protection, Brazil

## Introduction

Leprosy is a chronic infectious disease caused by *M. leprae* and transmitted via the airborne route from multibacillary individuals. Due to its long incubation period (4–5 years), it is most common in adults.<sup>1</sup> However, in areas where leprosy still continues to be endemic, the high case detection among children may be associated with early exposure to the bacillus through household contact, the presence of undetected leprosy cases, active foci of transmission in the community and inefficiency of ongoing disease control programmes.<sup>1–3</sup>

According to the World Health Organization (WHO), leprosy still remains a public health problem in 14 endemic countries, which account for more than 95% of the global burden of this disease. In 2015, among 210,758 new leprosy cases reported to WHO, 18,796 (8.9%) occurred in children, mainly in India (61%), Brazil and Indonesia (10% of cases in each country).<sup>2</sup>

Zero cases of leprosy-related disability amongst newly diagnosed children is one of the most important targets of the global strategy for leprosy elimination until 2020. To reach this goal, WHO advocates for a universal health coverage with a special focus on children, along with early case detection, increasing social and financial support services, measures to fight against discrimination and the implementation of intersectoral actions for reducing social and health inequalities.<sup>4</sup>

Poverty is one of the most important social determinants of leprosy.<sup>5–7</sup> In this context, the Brazilian conditional cash transfer programme (*Bolsa Família Programme*, BFP), launched in 2003, may contribute to the control of leprosy and other poverty related diseases, enhancing children's health through compliance with health conditionalities and by improving family income.<sup>8–10</sup> However, there are still gaps in knowledge about the role of socio-environmental factors in the leprosy causal chain.<sup>1,4–7</sup>

BFP is currently the largest conditional cash transfer in the world, with nearly 13.9 million beneficiary families. Cash transfers are offered to extremely poor families (with monthly per capita income \$35 or less) and poor families (with monthly per capita income between \$35–70 and with school children or adolescents up to 17 years old or pregnant or lactating women). Depending on the household composition, monthly benefits range from \$18 to \$175 and are delivered under three conditions, namely: 1) attendance at prenatal and postnatal care visits during pregnancy; 2) up to date vaccination and nutrition of children aged 0–7 years; 3) children and youth school enrolment and a minimum school attendance of 85%.<sup>8–10</sup>

In a previous study,<sup>9</sup> an increase on BFP coverage was associated with a decrease in the annual new case detection rates (NCDR) of leprosy in Brazilians of all ages whereas the municipal coverage of the Family Health Programme (FHP) was associated with an increase on the same indicator. FHP is the main approach for delivering public primary care within the Brazilian Unified Health System (SUS).<sup>11</sup>

This study was carried out to assess the effect of the BFP on NCDR of leprosy among individuals aged less than 15 years old, residing in highly endemic Brazilian municipalities over the period from 2004–15.

## **Materials and Methods**

A mixed ecological study was conducted, i.e. a combination of an ecological multiple-group and time-trend design,<sup>12</sup> with municipalities as units of analysis, during 2004–15. From 5,570 Brazilian municipalities, we selected 1,120 municipalities because they belong to high risk clusters for leprosy detection.<sup>9,13</sup> Leprosy cases are concentrated in a small proportion of the Brazilian population (nearly 11%), living in highly endemic areas, located in North, Northeast and Central-West regions of the country.<sup>13</sup>

The dependent variable was the annual new case detection rate (NCDR) of leprosy in individuals younger than 15 years old, calculated as the number of new leprosy cases (defined by the code A30 in the International Classification of Diseases – 10<sup>th</sup> revision) detected in people under this age group, per 100,000 inhabitants of the same age group.<sup>1</sup>

The main independent variables were two indicators of BFP coverage: 1) Coverage of the target population (poor and extremely poor), calculated by dividing the number of families enrolled in BFP by the number of eligible families for BFP, in each municipality;<sup>14</sup> 2) Coverage of the total population of the municipality, calculated by dividing the number of individuals enrolled in BFP (obtained by multiplying the number of enrolled families by the average family size) by the total population of each municipality.<sup>10</sup> Both BFP coverage indicators were categorised according to the tertiles of their distribution in: low, intermediate and high coverage.

Aiming to indicate the timeliness of leprosy case detection, we used two indicators, namely: 1) Proportion of new child cases with disability grade evaluated at the time of diagnosis; 2) Rates of new cases with Grade-2 disabilities per 100,000 children.<sup>1</sup> Disability is an umbrella term for a set of impairments, activity limitations and participation restrictions, graduated according to the severity of impairments and deformities that may affect eyes, hands and/or feet of leprosy patients.<sup>15</sup>

Based on literature review, we selected the following group of covariates as potential determinants of leprosy in Brazil: income distribution (measured by the Gini Index), illiteracy rate, unemployment rate and average number of residents per household.<sup>5–9,13,16–21</sup>

The Gini Index measures the extent to which the income distribution deviates from a perfect equal distribution, varying from 0 (perfect equality) to 1 (perfect inequality).<sup>22</sup> These covariates were dichotomised according to the median of their distribution.

Poor sanitation, unequal income distribution, overcrowding and uncontrolled urbanisation are associated with the continuity of leprosy transmission in Brazil.<sup>6,16</sup> Moreover, geographic evidences have contributed to the hypothesis of association between socio-environmental determinants and the continuation of active disease transmission.<sup>1,6,13,20</sup>

As in previous studies,<sup>9,10</sup> we also used the yearly municipal FHP coverage as a control variable in our multivariate regression models. This indicator was calculated by dividing the total number of individuals registered in the FHP by the total population of the municipality.<sup>23,24</sup>

#### DATA SOURCES

The data were obtained from different public databases: 1) New leprosy cases in individuals under 15 years of age, from Notifiable Diseases Information System (SINAN) of the Brazilian Ministry of Health,<sup>24</sup> 2) BFP coverages, from Social Information Matrix (MIS) of the Brazilian Ministry of Social Development;<sup>14</sup> 3) Population and sociodemographic variables, data from 2000 and 2010 were extracted from national demographic census databases of the Brazilian Institute of Geography and Statistics (IBGE);<sup>25</sup> 4) FHP coverages, from the Primary Care Information System (SIAB).<sup>24</sup>

Except for the census years 2000 and 2010, we used IBGE population estimates over the period 2004–12, provided by the Information Technology Department of SUS (DATASUS).<sup>24</sup> Values for 2013–15 were estimated by linear extrapolation. Regarding sociodemographic covariates, values for 2004–09 were estimated by linear interpolation and values for 2011–15 were estimated by linear extrapolation.

This study was approved by the Human Research Ethics Committee of the Collective Health Institute, Federal University of Bahia (UFBA), Brazil, under the protocol n° 2-088-210. All data were extracted from national public domain databases.

#### STATISTICAL ANALYSIS

First, we made a descriptive analysis of trends in median values for BFP coverages, FHP coverages and sociodemographic covariates. Then, we measured the effect of BFP coverages on leprosy NCDR in individuals under 15 years old using multivariable negative binomial regression models for panel data with fixed-effects specification, crude and adjusted for sociodemographic covariates.

As the dependent variable was a rate, the Poisson distribution is the most commonly associated. However, the negative binomial distribution was used as it is useful for count data with overdispersion.<sup>26–28</sup> In order to decompose the rate in a count the logarithm of the population under 15 years old was used as an offset variable.

Two statistical models differing only in the main independent variable were defined according to the following equation:  $Y_{it} = \alpha_i + \beta \text{BFP}_{it} + \beta_n X_{nit} + u_{it}$ , where  $Y_{it}$  was the leprosy NCDR in individuals under 15 years old for the municipality  $i$  in the year  $t$ ,  $\alpha_i$  was the fixed effect for the municipality  $i$  that adjust for all unobserved time-invariant factors,  $\text{BFP}_{it}$  was the BFP coverage of target population (in the model 1) and the BFP coverage of the total population (in the model 2) for the municipality  $i$  in the year  $t$ ,  $X_{nit}$  was the value of each  $n$  covariate included in the models with the municipality  $i$  in the year  $t$ , and  $u_{it}$  was the error term.

Longitudinal panel data models were fitted by including a disturbance (or error) term ( $u_{it}$ ) and a second term ( $\alpha_i$ ) to adjust for unmeasured time-invariant characteristics of each unit of analysis, e.g. geographic, historical or sociocultural aspects of each municipality. We adopted the fixed-effect model specification based on the Hausman test, which is the most appropriate test for assessment of effects in interventions with panel data.<sup>26–28</sup>

Models with continuous and categorical variables were fitted. However, we kept the categorical models, which provided more easily interpretable effect measures. To assess the association between BFP coverage and NCDR of leprosy in individuals under 15 years, we calculated the risk ratios (RR) and their 95% confidence intervals (CI), both crude and adjusted for the FHP coverage and sociodemographic covariates, adopting municipalities with the lowest coverage as the reference category.

The goodness-of-fit of our models was assessed with the likelihood ratio test (LRT), which led us to choose the models that best fitted the data. We also estimated the The Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC), keeping the final models with the lowest AIC and BIC.

As the models with BFP coverage of target population and BFP coverage of the total population of the municipality had close AIC and BIC values, we presented both models, aiming to show the direct effect of BFP on its beneficiaries and the effect on all inhabitants of the municipality that were not enrolled in the programme (known as spillover effect).

We used the Variance Inflation Factor (VIF) to assess multicollinearity. VIF estimates for all variables included in our final models were less than 10, i.e. not suggestive of multicollinearity. We also made the same analyses including the 2,850 Brazilian municipalities that reported at least one new leprosy case in individuals under 15 years old during the study period. However, the results did not suggest an introduction of bias due to the selection of 1,120 highly endemic municipalities. The software Stata® (version 12.0) was used for database processing and analysis.

## **Results**

Over the study period, from 5,570 Brazilian municipalities 2,850 (51.2%) reported at least one new leprosy case among individuals under 15 years old. The NCDR of leprosy in this population decreased from 9.5 to 5.5 per 100,000 people (42% reduction) (Table 1). Despite this marked reduction, Brazil still remains as a “very high” endemic country, according to national parameters<sup>1</sup> (NCDR between 5.0–9.9 cases per 100,000 people under this age group).

Table 1 shows that in the selected 1,120 municipalities, we found a reduction of 44.3% in the NCDR of leprosy in individuals under 15 years old (from 22.8 to 12.7 per 100,000 people). However, these municipalities were still categorised as ‘hyperendemic’ or ‘highly endemic’ because they still registered more than 9.9 cases per 100,000 people under this age group.

In addition to the NCDR decrease, the proportion of child new cases that had their grade of disability evaluated at the time of diagnosis increased from 84.8 to 90.5 (6.7%) and the rates of new cases with Grade-2 disability (G2D) per 100,000 children decreased from 0.52 to 0.47 (9.6% reduction).

During this study period, there was an expansion of the median BFP coverages, both of the target population (from 60.1 to 100.0%) and of the total population of the municipality (from 22.4 to 41.7%). Moreover, we observed marked improvements in socioeconomic conditions in the country and in the primary health care coverage through the FHP, mainly within the first 3 years (2004–2006). The Gini Index was reduced from 0.56 to 0.50, the illiteracy rate (from 22.0 to 15.7%), the unemployment rate (from 8.5 to 5.1%) and the average number of people per household (from 3.9 to 3.2). The FHP coverages increased by 20.1% (Table 2).

**Table 1.** New case detection rates (NCDR) of leprosy, % new cases with disabilities evaluated on diagnosis and rates of grade-2 disabilities (G2D) in people under 15 years old living in Brazil and in the highly endemic Brazilian municipalities, 2004–15

Year	New cases in the highly endemic municipalities (n = 1,120)	New cases in the Brazilian municipalities (n = 2,825)	% of the new cases in the highly endemic municipalities	NCDR* in the highly endemic municipalities	NCDR* in Brazil	% new cases with GD** evaluated on diagnosis (n = 1,028)†	Rates of new cases with G2D*** (n = 233)†
2004	2,845	4,176	68.1	22.8	9.5	84.8	0.52
2005	2,830	4,040	70.0	21.8	8.9	87.0	0.72
2006	2,486	3,534	70.3	18.8	7.7	88.5	0.62
2007	2,169	3,128	69.3	18.2	7.5	93.0	0.74
2008	2,229	3,151	70.7	18.9	7.6	87.4	0.80
2009	1,981	2,823	70.2	16.9	6.9	87.7	0.75
2010	1,775	2,554	69.5	15.8	6.7	93.8	0.59
2011	1,747	2,450	71.3	15.5	6.3	91.9	0.74
2012	1,596	2,362	67.6	14.0	6.0	91.4	0.73
2013	1,797	2,486	72.3	15.5	6.3	91.8	0.63
2014	1,730	2,430	71.2	14.8	6.1	91.6	0.55
2015	1,504	2,191	68.6	12.7	5.5	90.5	0.47

\*Leprosy new case detection rates among people under 15 years old (per 100,000 children). \*\*Grade of disability.

\*\*\*Grade 2 disability (per 100,000 children).

†Highly endemic municipalities with missing data or without child leprosy cases diagnosed with G2D were excluded. Data sources: Notifiable Diseases Information System (SINAN)/Brazilian Institute of Geography and Statistics (IBGE).

**Table 2.** Median values (interquartile range) of Bolsa Família and Family Health Programme coverages and sociodemographic covariates for the 1,120 highly endemic Brazilian municipalities, 2004–2015

Variables	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	% change (2004–15)
BFP* coverage of the total population of the municipality (%)	22.4 (12.5–33.7)	29.9 (17.8–43.2)	38.8 (25.7–54.0)	39.8 (25.4–54.1)	37.8 (23.9–51.1)	43.1 (28.5–55.3)	42.8 (27.9–57.0)	44.8 (27.6–60.8)	45.8 (28.7–61.4)	44.8 (27.7–60.1)	44.2 (26.8–60.8)	41.7 (24.8–56.7)	+ 86.1
BFP* coverage of the target population (%)	60.1 (41.3–72.5)	80.9 (59.8–92.7)	100.0 (89.4–100.0)	100.0 (97.9–100.0)	99.5 (94.0–100.0)	100.0 (99.6–100.0)	100.0 (100.0–100.0)	100.0 (100.0–100.0)	100.0 (99.2–100.0)	100.0 (100.0–100.0)	100.0 (99.2–100.0)	100.0 (97.3–100.0)	+ 66.4
Municipal FHP** coverage (%)	65.6 (28.4–91.6)	75.6 (42.8–94.2)	80.1 (51.2–96.6)	85.1 (60.1–99.9)	86.3 (63.0–98.6)	87.5 (65.0–98.2)	88.7 (66.8–99.3)	87.1 (65.9–98.0)	86.7 (65.7–97.8)	86.2 (66.9–97.3)	85.2 (62.5–96.8)	78.8 (60.0–93.6)	+ 20.1
Gini Index (0–1)	0.56 (0.53–0.59)	0.55 (0.52–0.59)	0.55 (0.52–0.58)	0.55 (0.51–0.58)	0.54 (0.50–0.57)	0.54 (0.50–0.57)	0.53 (0.49–0.57)	0.53 (0.48–0.57)	0.52 (0.48–0.56)	0.52 (0.47–0.56)	0.51 (0.46–0.56)	0.50 (0.45–0.56)	– 10.71
Illiteracy rate (%)	22.0 (14.9–29.9)	21.5 (14.4–29.1)	20.8 (13.9–28.4)	20.2 (13.6–27.5)	19.8 (13.2–26.8)	19.3 (12.8–26.1)	18.7 (12.4–25.4)	18.1 (11.9–24.8)	17.4 (11.3–24.1)	17.0 (10.7–23.5)	16.4 (10.4–22.8)	15.7 (9.9–22.1)	– 28.6
Unemployment rate (%)	8.5 (6.4–11.3)	8.3 (6.3–10.8)	8.1 (6.2–10.4)	7.8 (6.0–10.0)	7.5 (5.7–9.5)	7.1 (5.4–9.2)	6.7 (5.1–8.8)	6.3 (4.7–8.6)	6 (4.2–8.4)	5.6 (3.7–8.2)	5.3 (3.2–8.1)	5.1 (2.8–7.7)	– 40.0
Average number of residents per household	3.9 (3.6–4.2)	3.8 (3.5–4.2)	3.8 (3.5–4.1)	3.7 (3.4–4.1)	3.7 (3.3–4.0)	3.6 (3.3–3.9)	3.5 (3.2–3.9)	3.5 (3.2–3.8)	3.4 (3.1–3.8)	3.4 (3.1–3.7)	3.3 (3.0–3.6)	3.2 (3.0–3.6)	– 17.9

\*Bolsa Família Programme. \*\*Family Health Programme.

Data source: Notifiable Diseases Information System (SINAN)/Brazilian Institute of Geography and Statistics (IBGE)/Primary Care Information System (SIAB).

**Table 3.** Association between Bolsa Família Programme coverages and the new case detection rate (NCDR) of leprosy among people under 15 years old in Brazilian highly endemic municipalities, 2004–2015

Variables	New case detection rate of leprosy Risk Ratio (95% CI)		
	Crude model	Adjusted model*	Adjusted model**
BFP <sup>†</sup> coverage of target population (%)			
< 30	1	1	–
30–69.9	0.81 (0.69–0.96)	0.85 (0.72–1.00)	–
≥ 70	0.68 (0.58–0.80)	0.75 (0.63–0.88)	–
BFP <sup>†</sup> coverage of the total population of the municipality <sup>†</sup> (%)			
< 28.8	1	–	1
28.8–49.6	0.89 (0.83–0.94)	–	0.89 (0.84–0.94)
≥ 49.7	0.85 (0.78–0.92)	–	0.85 (0.79–0.93)
Municipal FHP <sup>††</sup> coverage (%)			
< 68.5	–	1	1
68.5–93.3	–	1.10 (1.04–1.17)	1.10 (1.04–1.17)
≥ 93.4	–	1.25 (1.15–1.35)	1.25 (1.16–1.36)
Gini Index ≥ 0.54	–	1.15 (1.07–1.23)	1.15 (1.07–1.23)
Illiteracy rate ≥ 18.7%	–	1.11 (1.02–1.20)	1.12 (1.03–1.22)
Unemployment rate ≥ 6.9%	–	1.25 (1.19–1.32)	1.27 (1.20–1.34)
Average number of residents per household ≥ 3.6	–	1.08 (1.02–1.14)	1.10 (1.04–1.16)
Number of observations	12,648	12,648	12,648
Number of municipalities <sup>†††</sup>	1,054	1,054	1,054

\*Adjusted model for BFP coverage of target population, municipal FHP coverage and sociodemographic covariates.

\*\*Adjusted model for BFP coverage of the total population of the municipality, municipal FHP coverage and sociodemographic covariates.

<sup>†</sup>Bolsa Família Programme. <sup>††</sup>Family Health Programme. <sup>†††</sup>Municipalities with missing data were excluded from this analysis.

Table 3 shows the crude and adjusted association between NCDR of leprosy in individuals under 15 years old and BFP coverages. Decrease in the NCDR was significantly associated with an increase in the BFP coverages of target population (RR = 0.75; CI 95% 0.63–0.88) and also with an increase in the BFP coverages of the total population of the municipality (RR = 0.85; CI 95% 0.79–0.93), when adjusted for the FHP coverages and for sociodemographic covariates. Thus, we verified a 10% higher reduction of leprosy NCDR associated with BFP coverages of target population when compared with the BFP coverages of the total population of the municipalities.

Regarding municipal FHP coverages, we found a 25% increase in the NCDR of leprosy in individuals under 15 years old in the municipalities with high coverages of this primary health care programme (≥ 93.4%). Finally, all sociodemographic covariates were significantly associated with the NCDR of leprosy in the study population.

## Discussion

This study brings the first evidence regarding the effect of the world's largest conditional cash transfer programme on the reduction of the NCDR of leprosy in Brazilians under 15 years

old.<sup>8</sup> This effect remained even after the adjustments for the FHP coverages and sociodemographic covariates. Moreover, both BFP coverages were significantly associated with a reduction in the NCDR of leprosy in the study population. The effect size was higher in relation to the BFP coverage of the target population in comparison with the BFP coverage of the total population of the municipality.

Our results revealed a significant protective effect of this social programme on an indicator that minimally represents leprosy incidence in a highly vulnerable population group<sup>3,29</sup> and more prone to the negative consequences of leprosy, which can be amplified by poverty. In Brazil, the NCDR of leprosy in children under 15 years is amongst the main parameters for surveillance, helping the health system monitor the epidemiological situation of this disease.

Data from 5 years before BFP was introduced in Brazil (1999–2003) showed an increase of 8.5% in the NCDR of leprosy in people less than 15 years old (from 7.30 to 7.98 per 100,000 inhabitants of this age group).<sup>1,24</sup> From 2004 onwards, the decreasing trend of this indicator was accompanied by the remarkable social progress and economical growth experienced in Brazil over the last decade.<sup>8,9</sup>

Additionally, we observed a 25% increase in the NCDR of leprosy among people under 15 years old associated with high levels of municipal FHP coverages. This finding may reflect an increased detection of previously undiagnosed cases, known as hidden prevalence. FHP may increase the early diagnosis of leprosy in children through promoting case detection activities (e.g. home visits, school surveys, health education) undertaken by the health care professionals.<sup>9,11</sup>

The increase in the proportion of new cases with evaluation of disability grade and the reduction on G2D incidence among children support the hypothesis that the FHP may have contributed to enhancing early detection and prompt treatment of cases, which reduces the transmission, occurrence of disabilities and negative social consequences due to this disease.<sup>4,9</sup> Therefore, the reduction in the NCDR in children seems not be associated with diagnosis delay or underdiagnosis.

In the last decade, Brazil and other countries with a high leprosy burden (such as India, Bangladesh, Indonesia, Myanmar and some African countries) introduced conditional cash transfer (CCT) programmes, based on income transfers conditioned to certain requirements in health and education.<sup>30,31</sup> Recent studies showed that CCTs may improve the health status of children and adolescents by increasing family income and, consequently, allowing families to provide better nutrition and living conditions for their children.<sup>30–33</sup>

Evidence also shows that CCT programmes are positively related to children's health, even if they do not require the attendance with certain obligations (or conditionalities) by the recipients.<sup>33,34</sup> These programmes were designed not only to move people out of extreme poverty, but also to break the inter-generational transmission of poverty by investing in the human capital of children through improving access to health care, the quantity and quality of food consumption and childhood education.<sup>30,31</sup>

CCTs also have impact by increasing vaccination coverage and encouraging beneficiaries to adopt healthy behaviours.<sup>33,34</sup> The Brazilian CCT also showed an association with a decrease in infant mortality and low birth weight, besides the increase in attendance by pregnant women at prenatal check-ups and in school attendance by children and adolescents.<sup>10,31</sup>

Only one previous study<sup>9</sup> found an association between high BFP coverages of the total population of the municipalities ( $\geq 48.11\%$ ) and a 15% reduction on the NCDR of leprosy in all Brazilian population, during 2004–11. A high effect size (21% reduction) was found when

the BFP coverages of the total population of the municipalities were combined with a BFP coverage of target population higher or equal than 100% for at least 4 years.

Our results showed a 25% reduction on the NCDR of leprosy in people less than 15 years old associated with high BFP coverages of target population ( $\geq 70\%$ ), covering a longer time-period. Thus, we decided to show individually the results with each BFP coverage indicator.

In our study, through negative binomial regression models for panel data we analysed a time series of 12 years for each high leprosy-endemic municipality. Panel data also allowed us to analyse repeated measures over time, assuming its degree of dependency. This robust approach, widely used in econometrics, is more rigorous than a cross-sectional analysis and is suitable for impact evaluations of social interventions, such as CCT programmes.<sup>26–28</sup>

The inclusion criteria of the municipalities in our analysis were supported by evidence that previously elucidated the spatial distribution of leprosy cases in the Brazilian territory.<sup>13</sup> As leprosy is concentrated in high-risk geographical areas of the country, with neighbouring municipalities forming clusters, we decided to keep only these municipalities in our analyses because they have more impact on the disease transmission. Actions and investments in leprosy control, including social support to leprosy patients, may be focused in these highly endemic areas.

As our analyses used aggregate data, we may not extrapolate our findings to individuals, under the risk of committing an ecological fallacy. Association measures generated by ecological analyses may be less or more accurate than data from studies conducted on individual basis.<sup>12</sup> The use of national leprosy surveillance data may also represent a limitation of our study, due to problems commonly associated with the quality of secondary data, among them, data completeness and under-reporting of cases. Therefore, caution is required in the interpretation of this study's findings.

However, this study provided reliable evidence that an intersectoral approach, including income transfers and other social protection strategies, along with an effective primary health care system may be associated with an improvement in leprosy control among children living in endemic countries, such as Brazil.

## Conclusions

CCT programmes are amongst the most important social protection strategies currently in place worldwide and might act on the social determinants of leprosy and other poverty-related diseases. For this reason, they should be enhanced by national governments, along with social inclusion policies and implementation of actions aimed to reducing illiteracy, unemployment and childhood undernutrition.

Considering the spatial distribution pattern of leprosy in the country, the Brazilian Ministry of Health should implement disease control strategies focused on the municipalities with high risk of leprosy transmission, ensuring access to social protection interventions aimed to protect children, adolescents and other vulnerable population groups.

Since Brazil is among the 14 countries with a high leprosy burden, that together account for most of cases reported worldwide, the strengthening of social support policies for leprosy patients, in conjunction with more investments in scientific research, development of new prevention approaches and establishment of international partnerships are urgently needed. Despite leprosy still being a neglected disease, its elimination requires collective efforts and integrated actions.

## Acknowledgements

We would like to thank Joney Ribeiro Gonçalves for the grammatical review of this manuscript.

## Funding

This study was supported by the National Council for Scientific and Technological Development (CNPq), Brazil, under the process n° 404030/2012-2.

## Contributors

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