

Effects of government programs and fertility on child mortality in the Brazilian Semi-arid region

Efeitos dos programas governamentais e da fecundidade sobre a mortalidade infantil do Semiárido brasileiro

Everlane Suane de Araújo da Silva¹, Neir Antunes Paes², Cesar Cavalcanti da Silva³

ABSTRACT It was aimed to evaluate the impact of the social programs: Bolsa Família Program and Family Health Strategy and fertility on child mortality in the Brazilian Semi-arid, during the period 2005-2010. The multivariate linear regression model of panel data with fixed effects was applied, using the Infant Mortality Rate as the dependent variable; and, as independents, the coverage of Bolsa Família and its conditionalities, coverage of the Family Health Strategy and the Fertility Rate. The public actions of the Programs, as well as the reduction of fertility levels, have greatly contributed to the decrease in infant mortality rates in the Semi-arid.

KEYWORDS Infant mortality. Government programs. Family Health Strategy. Fertility. Brazil.

RESUMO Teve-se como objetivo avaliar o impacto dos programas sociais: Programa Bolsa Família e Estratégia Saúde da Família e da fecundidade sobre a mortalidade infantil do Semiárido brasileiro, no período 2005-2010. Foi aplicado o modelo de regressão linear multivariado de dados em painel com efeitos fixos, utilizando a Taxa de Mortalidade Infantil como variável dependente; e, como independentes, as coberturas do Bolsa Família e suas condicionalidades, cobertura da Estratégia Saúde da Família e a Taxa de Fecundidade. As ações públicas dos Programas, bem como a redução dos níveis da fecundidade contribuíram sobremaneira para decréscimos nos níveis da mortalidade infantil do Semiárido.

PALAVRAS-CHAVE Mortalidade infantil. Programas governamentais. Estratégia Saúde da Família. Fertilidade. Brasil.

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Introduction

Studies related to mortality trends, particularly infant mortality, are important contributions for the monitoring of prevention actions, as they highlight existing and emerging problems, strengthening the growing need for debates and interventions in these areas. Reduction in child mortality is one of the eight Millennium Development Goals (MDGs) outlined by the United Nations (UN), in analyzing the greatest problems of the world, as child mortality is considered one of the main health indicators, reflecting the quality of life of a population, based on the level of development and access to health services.

In the period of ten years (2000-2010), the number of deaths of children under one year, in Brazil, fell from 29.7 to 15.6 for every thousand Live Births (LB), a decrease of 47.6% in the Infant Mortality Rate (IMR) of the Country¹. According to the National Monitoring Report for the MDGs 2013, Brazil has already reached the target set for the deaths of children under one year of age, surpassing the target of 15.7 deaths estimated for 2015². Nevertheless, the Country must go through a long way to reach the most developed regions of the world, which is, approximately, five deaths per thousand LB³.

Among the Brazilian regions, the largest decline in IMR from 2000 to 2010 occurred in the Northeast, from 44.7 to 18.5 deaths per thousand LB, although it is still the region with the highest levels in the Country¹. The Northeast has made significant progress in relation to the decrease in the IMR level, but still presents a pattern far from desirable. Likewise, the less developed Brazilian region, that of the Semiarid region, because it concentrates 89.5% of the geographic space in the Northeast, follows the rhythm of this region.

A drastic reduction in Brazil also occurred in relation to Total Fertility Rate (TFR) levels, when passing from 2.39 children, on

average, per woman, in 2000, to 1.87, in 2010, whose influence on infant mortality levels has been widely documented. In 2010, 29% of the Semiarid municipalities reached a TFR below the level of population replacement, reflecting a behavior of decline observed throughout the Country. Several studies have pointed out that reductions in fertility levels are related to improvements in the living conditions of the population^{4,5}. Other studies^{6,7} defend that Conditional Cash Transfer Programs can be cited as a stimulus to increase fertility, which is counter-argued by authors like Simões and Soares⁸ and Alves and Cavenaghi⁹, by justifying that the poor population covered by the Programs reduced the birth rate, independently of them.

Surveys¹⁰⁻¹² warn that, in order to combat infant mortality in Brazil, government intervention is necessary to minimize the disparities in income experienced by a large part of the people in this territory. In this regard, the report of the United Nations Children's Fund (Unicef), in addition to highlighting the focus on primary health care, improving maternal and newborn care, promoting breastfeeding and expanding immunization, emphasizes the creation of social protection incentives, such as income transfer programs².

The Bolsa Família Program (PBF), created in Brazil in 2003, is one of the largest direct income transfer programs in the world. The benefits are specific for families living in poverty and extreme poverty with children, young people up to the age of 17, pregnant women and breastfeeding women¹³.

The family, when joining the PBF, has some commitments. Among them is compliance with health conditionalities: children up to 7 years of age need to be vaccinated and have nutritional monitoring; and pregnant women should have prenatal¹³. The Family Health Strategy (FHS), the largest primary health care program of the Country, created in 1994, articulates with the PBF as it has a duty to guarantee access to quality health services for the lower income families. The



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parallel performance of the PBF and FHS has been pointed out as an important reducer of infant mortality¹¹.

For Shei¹², IMRs were already falling before the beginning of Bolsa Familia (2003), but the decline seems to have increased after the program was implemented. Altogether, 36 million Brazilians are out of extreme poverty due to the transfer of income¹¹.

Among the Semiarid regions of the world, Brazil is the largest in terms of size and population density, and consists of nine states, covering 1.133 municipalities¹⁴. It is the region with the most backward development indicators in the country, thus becoming one of the largest beneficiaries of government income transfer programs such as the PBF, and health care programs, such as the FHS.

It was, thus, the main objective of this study to assess the impact of government programs (PBF and FHS) and fertility on child mortality in the Brazilian Semiarid region in the period 2005-2010.

Methods

It is a longitudinal ecological study that had as a unit of analysis 1.125 municipalities of the Brazilian Semiarid region, and the data arranged in panel with annual observations from 2005 to 2010. The Ministry of National Integration, when launching the New Delimitation of the Brazilian SemiArid, defined that this region is made up of 1.133 municipalities¹⁴. The analysis excluded eight municipalities, which was justified by problems in the basic data, which made it impossible to include them (São José de Peixe, Santana do Piauí, Juazeiro do Piauí, Alvorada do Gurguéia, Bocaína, Dirceu Arcoverde, all in the state of Piauí, Quixabá, Paraíba and Severiano Melo, in Rio Grande do Norte).

The dependent variable considered for the study was IMR. The direct calculation of the indicator has not been recommended for any state of the Semiarid region using data

from vital statistics provided by the Ministry of Health or even by the Brazilian Institute of Geography and Statistics Foundation (IBGE). For this, indirect methods of estimation are used. The Atlas of Human Development in Brazil has calculated the indicator using information from the Demographic Census, making use of indirect techniques to obtain it. Once most of the Semiarid municipalities do not have reliable vital statistics, the mortality pattern of the state to which the municipality belongs is adopted. Despite the limitations related to the estimates of infant mortality provided by the Atlas, they were considered as satisfactory proxy of their levels for the municipalities¹⁵.

The databases of the Ministry of Social Development (MDS) were used to obtain the information related to the PBF. The data allowed the calculation of the independent variables: percentage of coverage of the PBF in relation to the total population of the municipality and percentage of beneficiary families of the PBF accompanied in health conditionalities¹³. For the independent variable FHS coverage, the source was the Ministry of Health¹⁶.

Through the Atlas of Human Development in Brazil, the data of the independent variable TFR¹⁵ were accessed. Other independent variables were incorporated into the analyzes due to their explanatory nature, as pointed out in other studies^{11,17-19}. They were: activity rate and percentage of mothers heads of households without complete primary education and with children under 15 years of age in the total number of heads of household. These variables were obtained from the databases of the Demographic Censuses of 2000 and 2010. However, it was necessary to obtain the annual inter census values from 2005 to 2009. The choice of the interpolation method depends on the adequacy to the data among the several existing methods, such as: linear interpolation, quadratic (degree 2 polynomial), Lagrange polynomial of degree n) and the segmented interpolation²⁰. After

preliminary inquiries, the linear model presented the most adequate to express the expected evolution of the indicators.

The Stepwise method ($p < 0.05$) was used in the selection of the independent variables to compose the multiple linear regression model. At this stage, the variables that were not significant were eliminated from the study: activity rate and percentage of mothers heads of household without complete primary education and children under 15 years of age in the total number of heads of the family.

The multiple linear regression for panel data was used to analyze the association of infant mortality with the selected variables. For the choice of the most suitable model, fixed or random effect, the Hausman specification test was performed, and the first one was chosen. In addition to the error term, panel data models with fixed effects include a second term, to control unobserved, time-invariant characteristics such as: historical, geographic and sociocultural of each Municipality. These models allow correlations between the invariable term in time and the independent variables of the model, making it generally more robust for the analysis of the results of the interventions, and are constantly used in the literature. The statistical program Stata, version 12.0, was used for data processing and analysis.

Because it was used for modeling a

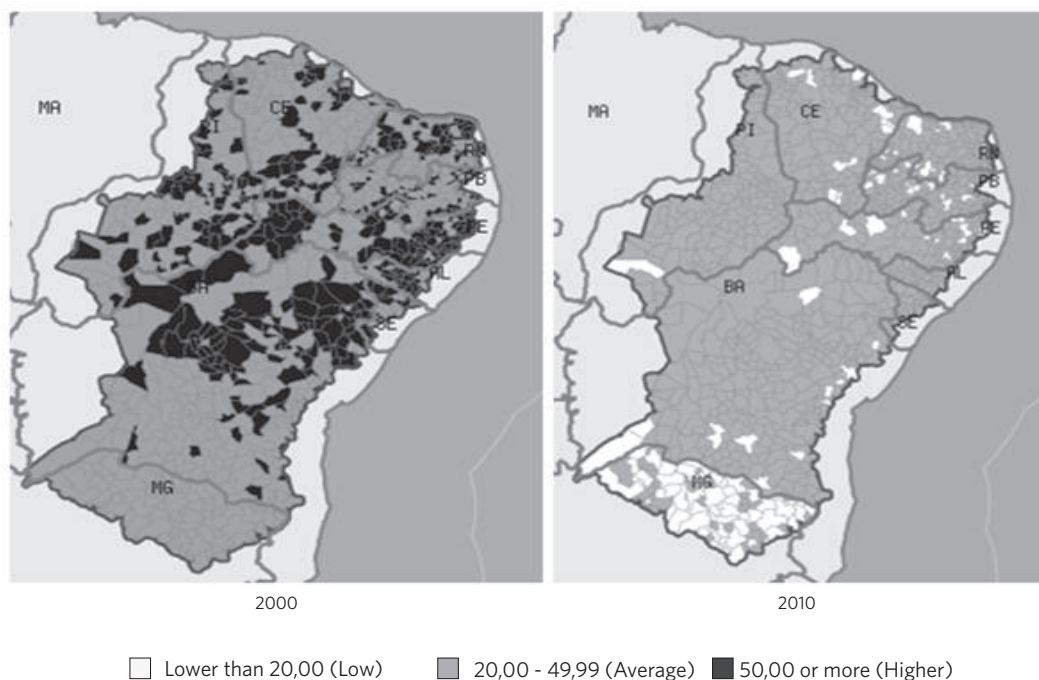
database with secondary data, freely accessible online, it is justified the absence of submission to the Brazil Platform and the subsequent referral to the Research Ethics Committee.

Results

Figure 1 shows the decline of IMR in the municipalities of the Brazilian Semiarid region when comparing the years 2000 and 2010. In 2000, 460 municipalities (41%) from all states, except Minas Gerais, had high IMRs, equal to or superior to 50 deaths of less than one year per thousand LB, as early as 2010, no municipality had an IMR at this level. Also in 2010, 119 municipalities (11%) started to have an IMR considered low (less than 20 deaths of children under one year per thousand LB), whose greatest advances were observed for the municipalities of the state of Minas Gerais. In the states of Alagoas and Sergipe, in 2010, no municipality had reached an IMR considered low. In 2010, most municipalities in the Semiarid region still had a IMR considered as average (20 to 49 per thousand), and only 39 municipalities (3%) had reached the fourth target of the Millennium Development Goals for Brazil (reduce IMR for 15.7 deaths of children under one year per thousand LB by 2015).

Table 1 shows the descriptive statistics

Figure 1. Spatial distribution of the Infant Mortality Rate indicator. Municipalities of the Brazilian Semi-Arid, 2000 and 2010



Source: Data and cartographic base: Atlas of Human Development in Brazil (UNDP/FJP/Ipea)¹⁵ and National Institute of the Semi-Arid (Insa).

(minimum, maximum, average, median and standard deviation) of the municipalities of the Brazilian Semi-arid region, for selected indicators (2005 and 2010). The descriptive measures varied during the study period.

The highest IMR (68.79), in 2005, was found for the municipality of Jucati, in the state of Pernambuco, while, in 2010, the highest value was for the municipality of Olivença, in Alagoas (45.4). The IMR average for all municipalities reduced the level by 11.1 per thousand LB over the five-year period, that is, an average annual reduction of about 2.3 deaths. The standard deviation of this indicator reduced, indicating a lower level dispersion.

The average coverage of the PBF in relation to the total population of the municipalities increased from 45.7% (2005) to 54.3% (2010). In 2005, the maximum value of the indicator was 86.4% in the municipality of Capitão Gervásio Oliveira, in Piauí. The municipality of Guaribas, in the state of Piauí, presented the highest coverage of the PBF (84.6%) in

2010. The lowest coverage of the indicator (24.3) in 2010 was observed in the municipality of Mossoró, Rio Grande do Norte.

An increase in the average number of beneficiary families of the PBF accompanied by health conditionalities was observed between 2005 and 2010, from 48.1% to 82.9%. In 2005, 255 municipalities (22.7%) of the Brazilian Semi-arid region had families enrolled in the PBF without any follow-up on health conditionalities. Already in 2010, this situation was not observed in any municipality.

The average coverage of the FHS reached 80.8% in 2005 and 91.3% in 2010. In 2005, 585 municipalities (52%) of the Semi-arid region reached universal coverage (100%), among 1.125 municipalities. In 2010, this figure increased to 768 municipalities (about 68%). On the other hand, already in 2010, the municipalities of Buritirama, Gentio do Ouro, Paripiranga and Pilão Arcado, all in the state of Bahia, still did not receive the coverage of the FHS.

The mean TFR ranged from 2.7 to 2.2

Table 1. Descriptive statistics for selected indicators. Brazilian Semi-arid, 2005 and 2010

Indicators	Minimum		Maximum		Average		Median		Standard deviation	
	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010
Child mortality rate	18,0	13,4	68,8	45,4	37,4	26,3	36,7	25,2	7,2	5,6
Coverage of the PBF ^a (%)	7,9	24,3	86,4	84,6	45,7	54,3	46,4	54,1	10,6	8,8
Coverage_Health_PBF ^b (%)	0,0	0,2	100,0	100,0	48,1	82,9	47,2	84,4	39,6	13,6
Coverage of the FHS ^c (%)	0,0	0,0	100,0	100,0	80,8	91,3	100,0	100,0	28,5	17,1
Total Fertility Rate	1,8	1,4	4,7	3,7	2,7	2,2	2,7	2,2	0,4	0,3

Source of basic data: Human Development Atlas in Brazil (UNDP/FJP/Ipea)¹⁵, Ministry of Social Development (MDS) and Ministry of Health (MS).

^aCoverage of the Bolsa Família Program; ^bCoverage of beneficiary families of the PBF accompanied by health conditionalities; ^cCoverage of the Family Health Strategy.

children, on average, per woman, considering the years 2005 and 2010. In 2005, the municipality of São João do Jaguaribe, in the state of Ceará, was observed the lowest TFR (1.8), and the highest (4.7) in the municipality of Canapi, in the state of Alagoas, revealing a total amplitude of 3 children, on average, per woman in the reproductive period within the Semi-arid region. For 2010, the municipality of Triunfo, in Pernambuco, presented the lowest value (1.4) for the indicator, and the highest (3.7) occurred in the city of Pureza, in Rio Grande do Norte, whose total amplitude was reduced to 2.3 children, on average, per woman.

The linear regression model (table 2) provides estimates of the parameter β , confidence interval and P-value for the variables related to government programs (PBF

and FHS) and fertility in infant mortality. According to the Hausman test, the model with random effect (H0) was rejected, that is, the fixed-effect model explained better the variations in IMR.

The linear regression with fixed effects showed a negative and statistically significant association ($p < 0.001$) between infant mortality and co-variables: Coverage of the Bolsa Família Program, Percentage of beneficiary families of the PBF accompanied by health conditionalities and Coverage of the Family Health Strategy. On the other hand, TFR was also indicated as significant ($p < 0.001$) for the reduction of IMR, but with a positive association. The fixed-effect model presented the R² (within) value of 69.2%.

Table 2. Fixed-effect regression model for the association between Infant Mortality Rate and selected indicators. Municipalities of the Brazilian Semi-arid region, 2005-2010.

Variables	β	Model		P-value
		95%		
Coverage of the PBF (%)	-0,04	-0,05 - -0,03		< 0,001
Coverage_Health_PBF (%)	-0,02	-0,02 - -0,01		< 0,001
Coverage of the FHS (%)	-0,01	-0,02 - -0,01		< 0,001
Total Fertility Rate	17,23	16,84 - 17,62		< 0,001
R ² (within)				0,692

Source: Own elaboration. Atlas of Human Development in Brazil (UNDP/FJP/Ipea)¹⁵, Ministry of Social Development (MDS) and Ministry of Health (MS).

95% CI: 95% confidence interval; β : linear regression coefficient.

Discussion

Government interventions reflect important advances related to improvements in the quality of life of people in the Brazilian Semiarid region. The fight against social inequality has been carried out with the programs of income transfer and guarantee of access of the population to the health services. These advances are reflected through the high coverage of the FHS and the PBF and are expressed in the Human Development Index of the municipalities of the Semiarid region (IDHM), where the average increased from 0.425, in 2000, to 0.591, in 2010¹⁵.

Reduction of child mortality is one of the main goals of childhood policy in the world. The impact of the socioeconomic conditions of the geographical area of reference of the newborn can be observed when the levels of IMR are verified. They fell during the period (2005-2010) in the Brazilian Semiarid, but are still considered high when compared to regions such as the South of Brazil, which, in 2010, showed an IMR of 12.6 deaths per thousand LB¹. The lowest figure observed in 2010, 13.4 deaths per thousand LB, still contrasts with that considered acceptable by the WHO, which stipulated a number of deaths of less than two digits per thousand births²¹. The decrease in the standard deviation of the values in relation to the average in the 2005-2010 period suggests a tendency of homogenization of levels throughout the Semiarid.

In the Brazilian Semiarid region, the average coverage of the PBF in relation to the total population of municipalities increased between 2005 and 2010. In 2014, approximately 3.5 million families benefited, involving a transfer of 7.1 billion reais¹³.

The coverage of the PBF has increased rapidly over the years. By the end of 2010, the PBF had reached almost 13 million families, and its pre-set target, covering 11 million Brazilian families (48,441,100 people), would have been reached since 2006^{13,22}.

The conditionalities of the PBF target the

most vulnerable population groups to preventive health care, with important effects on the health of children and pregnant women. To that end, the PBF sought support from existing service networks, such as the Family Health Strategy, to meet beneficiary health conditionalities. The average number of beneficiary families of the PBF accompanied by health conditionalities showed a significant increase in the comparison between 2005 (next year to the implementation of the PBF) and 2010 (already seven years after the Program was in existence). In 2010, the FHS already reached universality (100%) for most municipalities in the Brazilian Semiarid region. Nevertheless, some municipalities presented coverage of 0%. However, it should be noted that there was an important advance, with the average coverage of the indicator increasing from 80.8% in 2005 to 91.3% in 2010, and that the performance of health professionals is paramount in the monitoring of families participating in the exercise of conditionalities, in order to facilitate their access to actions and health services. Carvalho, Almeida and Jaime²³ point out the need for a compromise between all the social actors involved.

Studies emphasize that managers must provide means to adequately fulfill the conditionalities imposed on program beneficiaries, since the use of public social services depends on the ability of the Country to attend to demand^{10-12,24}.

The negative and significant association revealed by the linear regression model with fixed effects between infant mortality and covariates – Coverage of the Bolsa Família Program, Percentage of beneficiary families of the PBF accompanied by health conditionalities and Coverage of the Family Health Strategy – corroborated the effects found between government programs and IMR, obtained in other longitudinal studies^{10,11}.

The decrease in TFR was also indicated as a determinant for the reduction of IMR, since a smaller number of children provides better care and greater perspectives for the children. The TFR behavior is associated

with the transformations experienced by the Brazilian population in the so-called 'demographic transition', in which the rapid fall in fertility levels determined the population size and the new national configuration in terms of age structure.

There is a belief that the beneficiary families of the PBF would have more children, however, it is not confirmed by some authors^{6,25}. Arguments in this sense show that women beneficiaries of PBF have increased the use of contraceptive methods, which has contributed to the decline of fertility⁶.

The TFR average of the Semiarid region declined when comparing 2005 and 2010. Thus, the level of fertility followed the same trend of decline observed for Brazil. In 2010, the average TFR of the Semiarid region was 2.2 children per woman, a level very close to that of population replacement, which was 2.1. Some municipalities in the Semiarid region reached a TFR equivalent to that of states such as São Paulo (1.66), Rio de Janeiro (1.68) and Santa Catarina (1.71). The municipalities of Triunfo and Frei Miguelinho, both in the state of Pernambuco (1.4) and Brumado, Bahia (1.5), for example, already presented levels below the replacement and made possible a comparison with TFR of developed countries, such as Italy (1.4), Japan (1.4) and Spain (1.5), thus breaking barriers never recorded for two decades for any municipality.

The R^2 (within) of the fixed effects model was considered satisfactory, being explained by 69.2% of the internal association between IMR and co-variables. It is revealing to explore the joint effects of public interventions, especially in the Semiarid region. In this sense, it is possible to highlight the importance of using panel data to evaluate the association between government programs and health, as an alternative to the use of classic cross-sectional data. In this way, causal inference obtains stronger evidence when panel data are used in relation to transversal ones.

Conclusions

The results obtained evidenced that the public actions of the PBF and the FHS, as well as the reduction of the fertility levels, contributed greatly with decreases in the infant mortality rates of the Brazilian Semiarid region. The PBF, by establishing conditionalities that are attributions of the FHS, depends a lot on it for its success. To maintain the reduction of IMR, constant government interventions are necessary, among them, measures that minimize the income disparities experienced by the population. Increases in the income of people and, especially, their better distribution are essential to combat infant mortality.

Statistical evidence has detected the importance of public actions that aim to help combat two major problems in the Country: poverty and high levels of infant mortality. It is emphasized that programs with conditionalities in their composition have a potential on the social determinants of health and primary health care, and it should be highlighted that it is the responsibility of public managers to provide for the maintenance of the means for the beneficiaries to adequately meet the requirements imposed by these conditionalities.

It is highlighted the unprecedented approach of this study when investigating the relationship between the actions of the governmental programs (FHS and PBF) on child mortality, specifically for the Semiarid region of Brazil.

Collaborators

Everlane Suane de Araújo da Silva and Neir Antunes Paes participated in the design, analysis of data, writing of the manuscript and discussion of the results. Cesar Cavalcanti da Silva performed the critical review of the manuscript. All authors participated in the approval of the final version of the text. ■

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