Health Policy and Planning, **37**, 2022, 461–471
DOI: https://doi.org/10.1093/heapol/czac011
Advance access publication date: 23 February 2022
Original Article

OXFORD

Assessment of the association between the Brazilian family health strategy and adult mortality

Maria Dolores Montoya Diaz[1,*], Adriano Dutra Teixeira[2], Fernando Antonio Slaibe Postali[1], Natalia Nunes Ferreira-Batista[3] and Rodrigo Moreno-Serra[4]

[1]Departamento de Economia, FEA/USP, Universidade de São Paulo, Av. Prof. Luciano Gualberto, 908, Cidade Universitária, São Paulo 05508-900, Brazil
[2]Economics Department, Insper—Institute of Education and Research, Quata Street, 300, Vila Olimpia, São Paulo 04546-042, Brazil
[3]The Institute of Economic Research Foundation, Av. Corifeu de Azevedo Marques, 5677, Cidade Sao Francisco, São Paulo 05339-005, Brazil
[4]Centre for Health Economics, University of York, Heslington, York, YO10 5DD, UK

*Corresponding author. Departamento de Economia, FEA/USP, Universidade de São Paulo, Av. Prof. Luciano Gualberto, 908, Cidade Universitária, São Paulo 05508-900, Brazil. E-mail: madmdiaz@usp.br

Accepted on 28 January 2022

Abstract

This study aimed to analyse a wide range of related health problems that respond favourably to efficient primary care treatment among adults. We evaluate the direct impact of the Family Health Strategy (ESF) in Brazil on mortality of adults aged 25–64 years related to conditions for which access to effective primary care can reduce the likelihood of more severe outcomes. Additionally, we discuss heterogeneous effects associated with different intensities of the programme. To address these issues, we estimated a model with variation at the municipal level of the ESF expansion, including municipal-fixed effects, municipal specific trends and year-fixed effects. Our results show that a higher intensity of ESF is associated with reduced mortality by all conditions sensitive to primary care and for some diseases, especially after some years: avoidable conditions, asthma, heart failure, cerebrovascular diseases and gastrointestinal ulcer, infectious gastroenteritis and complications, diseases of the lower airways, hypertension and diabetes. As a public policy view, these results help understand how a nationwide primary care strategy can help mitigate mortality and emphasize the role of having sufficient health teams to attend to the population.

Keywords: Family Health Strategy (ESF), adult mortality, datasus database, impact evaluation

Key messages

- Long-term effects of the Family Health Strategy on adults remain largely unexplored.
- We investigated adult mortality from conditions sensitive to primary care.
- Thirteen years of exposure to the programme is associated with 30.2% reduction in mortality.
- High-intensity exposure is associated with larger decreases in mortality over time.

Introduction

Evidence indicates that the adoption of universal health coverage (UHC) produces positive results for the health of the population (Moreno-Serra and Smith, 2012; 2015). Additionally, UHC was adopted as one of the new Sustainable Development Goals and started to be incorporated as a health reform goal in several countries (Wagstaff and Neelsen, 2020). The 1988 Brazilian Constitution created the Unified Health System (SUS), which 'aims to provide comprehensive, universal preventive and curative care' (Paim *et al.*, 2011, pp. 1778).

The Family Health Program launched in December 1993, later called the Family Health Strategy (ESF), has progressively become the Brazilian nationwide initiative of primary care (Pinto and Giovanella, 2018). Essentially, the programme provides primary care for defined populations and is organized by geographic region by deploying interdisciplinary and multi-professional health care teams—composed of a physician, a nurse, a nurse assistant and four to six community health workers (Macinko and Harris, 2015).

The programme is federal, and accreditation of the ESF requires that municipal managers submit a proposal with details on the area and population to be covered, minimum actions to be developed, number and process of hiring teams, matching funds from the municipality, etc, to be approved by several agencies from all three levels of government (municipal, state and federal). After approval, the municipality starts to receive resources in proportion to the number of deployed teams. The number of accredited teams is established in the proposal. The teams are registered by each municipal health manager in the registration system (SIAB) defined by the Ministry of Health for this purpose. The deployed teams are those for which the municipality will actually receive the federal financial incentive. At this step, the Ministry of Health proceeds an analysis to evaluate if the teams comply with the rules of the programme, for example if there is any inconsistency or duplicity of professionals in the composition of the team.

The impact of ESF on several dimensions has been evaluated by a growing number of studies published by national and international journals. Macinko and Mendonça (2018) thus provide a summary of the literature regarding the impacts of ESF, considering the concepts of access, financial protection, quality of services, system efficiency, health impact and equity. On the outputs that emerge from ESF, there is specific evidence for tuberculosis mortality (de Souza *et al.*, 2018), hospitalization for diabetes mellitus (Arruda *et al.*, 2018) and due to heart failure and stroke (Cavalcante *et al.*, 2018), financial protection (Barros and Bertoldi, 2008), medicine access (Bertoldi *et al.*, 2009; Macinko and Lima Costa, 2012) and prenatal care (Andrade *et al.*, 2017). Some of the most important results include the contribution to reducing infant mortality (Moreno-Serra, 2005; Macinko *et al.*, 2006; 2007; Aquino *et al.*, 2009; Rasella *et al.*, 2010; Bastos *et al.*, 2017). More recently, Love-Koh *et al.* (2021) conclude that the impacts on inequality are small and uncertain, although the programme appears to be cost-effective.

However, to the best of our knowledge, no studies have analysed the long-term association of ESF with a wide range of related health problems that respond favourably to efficient primary care treatment among adults. Generally, published articles focused on a single health problem (e.g. hypertension or diabetes). This type of analysis is also relevant, but a broader one allows a more accurate assessment of the overall programme, favouring cost-effectiveness analyses, for example.

Conversely, the change in the Brazilian and other developing countries' demographic profile due to the ageing of the population raises the question about the association of the Family Health Program with other dimensions, such as non-communicable diseases. As mentioned by Rasella *et al.* (2014), citing documents of the Ministry of Health: 'In Brazil, the Ministry of Health has designated the Family Health Program (PSF), the main primary health care programme of the country, as the leading initiative in the national strategy for reduction of cardiovascular disease and other diseases'.

The main purpose of this study is to evaluate the association of long-term exposure of ESF with mortality related to diseases/conditions for which access to effective primary care can reduce the likelihood of more severe outcomes following Alfradique *et al.* (2009). The analysis focuses on individuals aged 25–64. Thus, the variable analysed here is adult mortality from preventable causes by primary care. In addition, we discuss a topic rarely addressed in the literature, i.e. the heterogeneous effects related to different intensities of the programme. The ESF's supply can be measured by the population per deployed team (accredited and registered) ratio. According to Andrade *et al.* (2018), the programme's coverage is related to several factors such as: population size and municipality density, coverage of private health insurance, level of economic development, among others.

Methods

Data

The mortality data were collected for each municipality over 1998–2018, obtained from the Mortality Information System (SIM)—a DATASUS (SUS Information Systems Department) database. The basic cause of death is coded using the International Classification of Diseases (ICD-10) depending on what was stated by the certifying physician on the death certificate. The list consists of 19 groups of diagnoses among adults, following Alfradique *et al.* (2009), as shown in Supplementary Appendix B.

The Family Health Program coverage source reports monthly the number of deployed programme teams (Brasil, 2020a). There is also a variable that estimates the programme's coverage by assuming that each team covers 3450 people. Although some papers employ this variable as ESF coverage (Silva and Powell-Jackson, 2017; Cavalcante *et al.*, 2018), there are two potential problems with this measure: firstly, nothing guarantees that each team will be effectively serving 3450 families; secondly, even if each team is able to take care of 3450 individuals, the level of care will certainly be different for a municipality with 3450 inhabitants and another with fewer than that. By 2016, 626 municipalities had 3450 or fewer residents, while 109 had fewer than 2000.

As a control variable, we include the 'Mais Médicos' (MM) coverage. MM is a federal programme created in 2012, whose goal was to fill the shortage of physicians in the Brazilian remote areas and poor municipalities—some MM physicians were also deployed to ESF. The variable was defined as the number of physicians per capita in this programme not allocated to the ESF in each municipality. There is evidence that MM was associated with a modest reduction in mortality amenable to health care (Hone and Powell-Jackson *et al.*, 2020). Formally, the coincidence period of the two programmes could generate an overestimation of the ESF effects since part of the programme's physicians were allocated to ESF teams. On the other hand, there is also evidence of a 'large-scale substitution of existing primary care doctors' (Hone and Powell-Jackson *et al.*, 2020). We also performed two exercises to assess the sensitivity of our results to changes in the definition of MM coverage (one defined as the total number of physicians per capita in this programme and the second without the MM-related variable). The goal is to analyse the effect of different forms of disentangling both programmes.

Bolsa Família Coverage was defined as the annual total value transferred by the Bolsa Familia programme to residents of each municipality in per capita values (available at Brasil, 2020f).

Municipal gross domestic product (GDP) data are available on the Brazilian Institute of Geography and Statistics—IBGE website (IBGE, 2020) in the folder 'PIB municipal', and population was obtained on the Datasus website (Brasil, 2020e) as Population Estimates from 1992 to 2018 used by the Federal Audit Court to determine the shares of the Municipal Participation Fund.

The inclusion of municipal tax revenue among the controls aims at incorporating institutional aspects related to the quality of municipalities' management that have varied over time and would be correlated with the collection of municipal taxes. The variable is defined as per capita values. Tax on urban property and land, tax on services of any kind and tax on the transfer of real estate and related rights are the three municipal taxes in Brazil. Each annual database from 1998 to 2012 is available at Brasil (2020b). For the values from 2013 onwards, we can obtain information from Brasil (2020c).

The supply of SUS hospital beds per municipality from 1998 to 2004, also defined as per capita values, was acquired through Information Access Law. It is also available on the Datasus webpage from 2005 onwards (Brasil, 2020d).

Empirical strategy

Extending the previous works that consider the programme has lagged effects on mortality (Macinko *et al.*, 2006; Rocha and Soares, 2010; Bhalotra *et al.*, 2019), this is also an observational study. Our empirical strategy relies on a longitudinal analysis that allows heterogeneous effects according to a programme's length of exposure. This framework takes into account that ESF started at specific times across regional localities in Brazil, and each municipality is submitted to a particular time of exposure into the programme. Formally, the first specification is as follows:

$$Mortality_{m,t} = \alpha + \sum_{j=1}^{J} \beta_j \cdot ESF\ exposure^{j}_{m,t} + \gamma \cdot X_{m,t} + \varphi_m + \mu_{m,t} + \tau_t + \varepsilon_{m,t} \qquad (1)$$

where $Mortality_{m,t}$ denotes the mortality rate (according to the classification of preventable conditions) for municipality m in year t, $ESF\ exposure^{j}_{m,t}$ is a binary indicator equal to one when the municipality has j years into the ESF. The matrix $X_{m,t}$ includes the collection of municipal explanatory variables, φ_m represents the municipal fixed effect, $\mu_{m,t}$ the municipal-specific trends, τ_t the fixed effect of the year, $\varepsilon_{m,t}$ the idiosyncratic error and α, β_j, γ are a set of parameters. All models are linear regressions absorbing multiple levels of fixed effects and estimations are also weighted by municipal population, and robust standard errors are computed using clusters defined by municipalities.

Robustness analysis

A robustness exercise is accomplished to encompass the potential occurrence of any previous systematic pattern in the mortality rate. The specification below introduces binary variables representative of the years previous the programme availability in every Brazilian municipality:

$$Mortality_{m,t} = \alpha + \sum_{k=1}^{K} \beta_k \cdot ESF\ pre-exposure^{k}_{m,t} + \sum_{j=1}^{J} \beta_j \cdot ESF\ exposure^{j}_{m,t} + \gamma \cdot X_{m,t} + \varphi_m + \mu_{m,t} + \tau_t + \varepsilon_{m,t} \qquad (2)$$

where $ESF\ pre-exposure^{k}_{m,t}$ designates a binary variable equal to one in case municipality m in time t is going to implement the programme in k years.

Heterogeneity analysis: intensity of the programme

Since the beginning of the programme, the Ministry of Health has recommended that each Family Health Team serves up to 3450 people. To capture heterogeneous effects due to the different intensity of ESF, we investigate the exposure time below and above this threshold for each Brazilian municipality:

$$Mortality_{m,t} = \alpha + \sum_{l=1}^{L} \beta_l \cdot ESF\ exposure\ to\ low\ intensity^{l}_{m,t} + \sum_{h=1}^{H} \delta_h \cdot ESF\ exposure\ to\ high\ intensity^{h}_{m,t} + \gamma \cdot X_{m,t} + \varphi_m + \mu_{m,t} + \tau_t + \varepsilon_{m,t} \qquad (3)$$

where $ESF\ exposure\ to\ low\ intensity^{l}_{m,t}$ denotes a binary variable equal to one on the occasion that municipality m in time t has been covered to a low intensity of the programme—so that each Family Health Team attends more than 3450 people—for l years. Similarly, the variable $ESF\ exposure\ to\ high\ intensity^{h}_{m,t}$ is binary, and it is 1 if a municipality m in a year t has been covered to a higher intensity of the programme—so that each Family Health Team attends fewer than 3450 people—for h years. Moreover, all specifications include the same fixed effects as the first specification: municipality, municipal trend, in addition to the year one.

The ESF coverage intensity, as defined above, varies widely across municipalities and over time, as indicated in the figures in Supplementary Appendix A and columns 'Time of Exposure to the ESF' and 'ESF Coverage Measured by Available Teams' in Supplementary Appendix C.

In 2000, the municipal average exposure to the programme was half a year, and there was a little over one team per 10 000 inhabitants. In 2018, the average exposure was over 16.5 years, and there were almost 3.5 teams per 10 000 inhabitants.

Results

Main results

The descriptive statistics of the analysed variables are provided in Supplementary Appendix C. The variable adult mortality caused by all conditions sensitive to primary care presents relative stability, with the average oscillating between 3.1 and 3.7 deaths per 10 000 inhabitants by year/city during 1998–2018. On the other hand, there is a clear upward trend over the same period for the same indicator corresponding to the following causes: diabetes, kidney and urinary tract infection, epilepsy, infection of the skin and subcutaneous tissue. In the opposite direction, a downward trend, we have: avoidable conditions, cerebrovascular disease and heart failure. The graphs are in the figures of Supplementary Appendix D.

Tables 1 and 2 present our findings regarding the years of exposure to the ESF in every municipality. The main explanatory variables were binary variables that identified whether a municipality was covered 1, 2,…, 20 years into the ESF. In Table 1, the first column depicts the mortality rate due to all conditions sensitive to primary care and the following columns are divided by category: immunisable diseases; avoidable conditions; infectious gastroenteritis and complications; anaemia; nutritional deficiencies; ear, nose and throat

Table 1. Exposure to ESF and Mortality due to conditions sensitive to Primary care - Regression results for the First set of conditions

	All conditions sensitive to primary care	Immunizable diseases	Avoidable conditions	Infectious gas-troenteritis and complications	Anaemia	Nutritional deficiencies	Ear, nose and throat infections	Bacterial pneumonia	Asthma	Diseases of the lower airways
ESF year 1	−0.0739	−0.0039*	−0.0052	−0.0031	−0.0001	0.0013	−0.0009	−0.0028	0.0031	−0.0141
	(0.0675)	(0.0020)	(0.0088)	(0.0034)	(0.0005)	(0.0035)	(0.0008)	(0.0028)	(0.0026)	(0.0108)
ESF year 2	−0.1062	−0.0038	−0.0184*	−0.0022	−0.0002	0.0031	−0.0004	−0.0005	−0.0012	−0.0059
	(0.0946)	(0.0025)	(0.0104)	(0.0037)	(0.0007)	(0.0045)	(0.0010)	(0.0036)	(0.0033)	(0.0136)
ESF year 3	−0.1632	−0.0053*	−0.0152	−0.0057	−0.0001	0.0051	0.0007	0.0010	−0.0053	−0.0055
	(0.1292)	(0.0028)	(0.0129)	(0.0045)	(0.0008)	(0.0050)	(0.0012)	(0.0048)	(0.0044)	(0.0161)
ESF year 4	−0.2090	−0.0057*	−0.0187	−0.0084	0.0007	0.0060	0.0011	0.0035	−0.0045	−0.0028
	(0.1625)	(0.0034)	(0.0154)	(0.0053)	(0.0009)	(0.0061)	(0.0015)	(0.0064)	(0.0053)	(0.0217)
ESF year 5	−0.2763	−0.0061	−0.0260	−0.0070	−0.0012	0.0082	0.0022	−0.0025	−0.0085	−0.0135
	(0.2103)	(0.0042)	(0.0210)	(0.0064)	(0.0012)	(0.0073)	(0.0018)	(0.0075)	(0.0063)	(0.0249)
ESF year 6	−0.3399	−0.0085*	−0.0237	−0.0158**	−0.0005	0.0097	0.0031	−0.0025	−0.0144*	−0.0005
	(0.2479)	(0.0049)	(0.0240)	(0.0077)	(0.0014)	(0.0088)	(0.0023)	(0.0096)	(0.0078)	(0.0307)
ESF year 7	−0.4141	−0.0088	−0.0247	−0.0155*	−0.0016	0.0128	0.0023	0.0003	−0.0166*	−0.0041
	(0.3031)	(0.0058)	(0.0275)	(0.0090)	(0.0017)	(0.0105)	(0.0027)	(0.0116)	(0.0097)	(0.0362)
ESF year 8	−0.5350	−0.0110*	−0.0299	−0.0184*	−0.0016	0.0121	0.0032	−0.0035	−0.0204*	−0.0099
	(0.3506)	(0.0065)	(0.0327)	(0.0103)	(0.0021)	(0.0125)	(0.0032)	(0.0134)	(0.0112)	(0.0415)
ESF year 9	−0.6105	−0.0109	−0.0318	−0.0240**	−0.0027	0.0135	0.0041	−0.0040	−0.0209	−0.0011
	(0.4008)	(0.0076)	(0.0376)	(0.0120)	(0.0024)	(0.0141)	(0.0037)	(0.0157)	(0.0127)	(0.0485)
ESF year 10	−0.7439	−0.0141*	−0.0298	−0.0239*	−0.0025	0.0152	0.0045	−0.0073	−0.0252*	−0.0009
	(0.4652)	(0.0084)	(0.0419)	(0.0136)	(0.0026)	(0.0164)	(0.0043)	(0.0185)	(0.0144)	(0.0557)
ESF year 11	−0.8784	−0.0135	−0.0352	−0.0341**	−0.0023	0.0113	0.0052	−0.0031	−0.0285*	−0.0080
	(0.5428)	(0.0096)	(0.0493)	(0.0156)	(0.0030)	(0.0189)	(0.0049)	(0.0204)	(0.0166)	(0.0625)
ESF year 12	−1.0033	−0.0154	−0.0484	−0.0363**	−0.0031	0.0193	0.0055	−0.0020	−0.0337*	−0.0106
	(0.6128)	(0.0111)	(0.0559)	(0.0175)	(0.0034)	(0.0213)	(0.0056)	(0.0235)	(0.0188)	(0.0702)
ESF year 13	−1.1543*	−0.0153	−0.0449	−0.0376*	−0.0029	0.0215	0.0056	−0.0042	−0.0386*	−0.0185
	(0.6854)	(0.0124)	(0.0606)	(0.0198)	(0.0037)	(0.0237)	(0.0063)	(0.0264)	(0.0208)	(0.0795)
ESF year 14	−1.3111*	−0.0164	−0.0521	−0.0429**	−0.0027	0.0214	0.0062	−0.0070	−0.0438*	−0.0176
	(0.7628)	(0.0136)	(0.0680)	(0.0217)	(0.0041)	(0.0268)	(0.0071)	(0.0291)	(0.0235)	(0.0885)
ESF year 15	−1.4541*	−0.0195	−0.0494	−0.0499**	−0.0026	0.0260	0.0077	−0.0111	−0.0451*	−0.0120
	(0.8428)	(0.0152)	(0.0770)	(0.0243)	(0.0044)	(0.0296)	(0.0079)	(0.0317)	(0.0259)	(0.0983)

(continued)

Table 1. (Continued)

	All conditions sensitive to primary care	Immunizable diseases	Avoidable conditions	Infectious gas-troenteritis and complications	Anaemia	Nutritional deficiencies	Ear, nose and throat infections	Bacterial pneumonia	Asthma	Diseases of the lower airways
ESF year 16	−1.6311*	−0.0190	−0.0625	−0.0478*	−0.0028	0.0285	0.0074	−0.0059	−0.0537*	−0.0161
	(0.9258)	(0.0168)	(0.0874)	(0.0267)	(0.0048)	(0.0323)	(0.0087)	(0.0356)	(0.0281)	(0.1084)
ESF year 17	−1.7775*	−0.0218	−0.0635	−0.0561*	−0.0035	0.0343	0.0084	−0.0002	−0.0586*	−0.0204
	(1.0032)	(0.0185)	(0.0956)	(0.0290)	(0.0053)	(0.0358)	(0.0095)	(0.0387)	(0.0309)	(0.1191)
ESF year 18	−1.9886*	−0.0248	−0.0758	−0.0619*	−0.0041	0.0336	0.0096	−0.0063	−0.0636*	−0.0239
	(1.0873)	(0.0206)	(0.0995)	(0.0318)	(0.0058)	(0.0390)	(0.0105)	(0.0428)	(0.0341)	(0.1280)
ESF year 19	−2.2122*	−0.0244	−0.0678	−0.0636*	−0.0044	0.0407	0.0104	0.0002	−0.0691*	−0.0377
	(1.1825)	(0.0218)	(0.1067)	(0.0346)	(0.0063)	(0.0426)	(0.0115)	(0.0469)	(0.0371)	(0.1397)
ESF year 20	−2.4515*	−0.0298	−0.0749	−0.0684*	−0.0047	0.0352	0.0117	−0.0227	−0.0735*	−0.0447
	(1.2812)	(0.0237)	(0.1174)	(0.0379)	(0.0069)	(0.0466)	(0.0124)	(0.0507)	(0.0403)	(0.1523)
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality-specific Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	116 707	116 707	116 707	116 707	116 707	116 707	116 707	116 707	116 707	116 707

Robust standard errors clustered at the municipality level are listed in parentheses; regressions weighted by population. Dependent variable: mortality rate per 10 000 per category of avoidable cause. Independent variables: dummies indicating number of years into the programme, municipality-fixed effects, year-fixed effects and municipality-specific trends. All regressions also included controls for: Bolsa Família coverage, Mais Médicos coverage, GDP per capita, municipal own tax revenue and hospital beds per capita.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

Table 2. Exposure to ESF and Mortality due to conditions sensitive to Primary care - Regression results for the Second set of conditions

	Hypertension	Angina pectoris	Heart failure	Cerebrovascular diseases	Diabetes mellitus	Epilepsies	Kidney and urinary tract infection	Infection of the skin and subcutaneous tissue	Inflammatory disease of female pelvic organs	Gastrointestinal ulcer
ESF year 1	0.0149 (0.0110)	−0.0001 (0.0014)	−0.0053 (0.0135)	−0.0381* (0.0227)	−0.0186 (0.0170)	0.0028 (0.0028)	−0.0068** (0.0033)	−0.0035 (0.0023)	0.0002 (0.0008)	0.0062 (0.0058)
ESF year 2	0.0074 (0.0137)	−0.0014 (0.0017)	−0.0021 (0.0179)	−0.0337 (0.0321)	−0.0395* (0.0235)	0.0027 (0.0037)	−0.0062* (0.0035)	−0.0053 (0.0033)	0.0003 (0.0009)	0.0012 (0.0073)
ESF year 3	−0.0012 (0.0209)	−0.0020 (0.0023)	−0.0026 (0.0226)	−0.0651 (0.0437)	−0.0458 (0.0304)	0.0013 (0.0045)	−0.0085* (0.0050)	−0.0100** (0.0050)	−0.0011 (0.0011)	0.0019 (0.0095)
ESF year 4	0.0053 (0.0254)	−0.0022 (0.0030)	−0.0274 (0.0281)	−0.0850 (0.0581)	−0.0599 (0.0378)	0.0069 (0.0051)	−0.0074 (0.0061)	−0.0104* (0.0061)	−0.0009 (0.0014)	0.0006 (0.0117)
ESF year 5	0.0047 (0.0356)	−0.0021 (0.0038)	−0.0295 (0.0341)	−0.1023 (0.0753)	−0.0776 (0.0479)	0.0024 (0.0059)	−0.0096 (0.0077)	−0.0116 (0.0077)	−0.0000 (0.0016)	0.0035 (0.0131)
ESF year 6	−0.0069 (0.0424)	−0.0026 (0.0045)	−0.0394 (0.0418)	−0.1262 (0.0871)	−0.0860 (0.0570)	0.0025 (0.0071)	−0.0119 (0.0089)	−0.0159* (0.0094)	−0.0014 (0.0020)	0.0009 (0.0164)
ESF year 7	−0.0242 (0.0522)	−0.0031 (0.0055)	−0.0591 (0.0505)	−0.1544 (0.1076)	−0.0838 (0.0679)	0.0034 (0.0085)	−0.0128 (0.0110)	−0.0206* (0.0114)	−0.0011 (0.0024)	−0.0025 (0.0202)
ESF year 8	−0.0291 (0.0602)	−0.0046 (0.0064)	−0.0689 (0.0592)	−0.1906 (0.1253)	−0.1281 (0.0816)	0.0061 (0.0097)	−0.0135 (0.0126)	−0.0222* (0.0134)	−0.0003 (0.0028)	−0.0043 (0.0236)
ESF year 9	−0.0402 (0.0707)	−0.0068 (0.0073)	−0.0820 (0.0676)	−0.2214 (0.1426)	−0.1385 (0.0941)	0.0033 (0.0113)	−0.0138 (0.0153)	−0.0287* (0.0158)	−0.0013 (0.0032)	−0.0031 (0.0270)
ESF year 10	−0.0604 (0.0846)	−0.0088 (0.0085)	−0.0832 (0.0768)	−0.2723 (0.1673)	−0.1761 (0.1072)	0.0061 (0.0131)	−0.0223 (0.0174)	−0.0336* (0.0181)	−0.0008 (0.0036)	−0.0086 (0.0310)
ESF year 11	−0.0733 (0.0990)	−0.0110 (0.0096)	−0.0957 (0.0867)	−0.3225* (0.1938)	−0.1985 (0.1260)	0.0027 (0.0148)	−0.0246 (0.0197)	−0.0382* (0.0211)	−0.0005 (0.0041)	−0.0088 (0.0353)
ESF year 12	−0.1000 (0.1133)	−0.0117 (0.0108)	−0.1059 (0.0977)	−0.3551 (0.2162)	−0.2267 (0.1442)	0.0067 (0.0168)	−0.0334 (0.0223)	−0.0427* (0.0233)	−0.0000 (0.0046)	−0.0098 (0.0392)
ESF year 13	−0.1159 (0.1283)	−0.0130 (0.0122)	−0.1338 (0.1082)	−0.4115* (0.2426)	−0.2583 (0.1631)	0.0011 (0.0187)	−0.0259 (0.0249)	−0.0449* (0.0265)	−0.0018 (0.0051)	−0.0153 (0.0440)
ESF year 14	−0.1362 (0.1436)	−0.0148 (0.0135)	−0.1503 (0.1209)	−0.4586* (0.2703)	−0.2968* (0.1796)	0.0005 (0.0207)	−0.0346 (0.0275)	−0.0528* (0.0298)	−0.0017 (0.0056)	−0.0109 (0.0490)
ESF year 15	−0.1676 (0.1594)	−0.0176 (0.0151)	−0.1769 (0.1333)	−0.4952* (0.2959)	−0.3221 (0.1993)	0.0055 (0.0231)	−0.0457 (0.0308)	−0.0573* (0.0334)	−0.0016 (0.0063)	−0.0197 (0.0542)
ESF year 16	−0.1804 (0.1767)	−0.0194 (0.0166)	−0.1853 (0.1449)	−0.5548* (0.3261)	−0.3924* (0.2179)	−0.0007 (0.0253)	−0.0448 (0.0343)	−0.0613* (0.0368)	−0.0005 (0.0069)	−0.0196 (0.0609)
ESF year 17	−0.1943 (0.1927)	−0.0217 (0.0181)	−0.2105 (0.1580)	−0.6014* (0.3567)	−0.4266* (0.2394)	−0.0006 (0.0279)	−0.0498 (0.0381)	−0.0683* (0.0408)	−0.0003 (0.0075)	−0.0226 (0.0662)
ESF year 18	−0.2273 (0.2138)	−0.0233 (0.0198)	−0.2322 (0.1728)	−0.6679* (0.3920)	−0.4703* (0.2580)	−0.0037 (0.0306)	−0.0556 (0.0423)	−0.0643 (0.0445)	−0.0009 (0.0083)	−0.0258 (0.0719)

(continued)

Table 2. (Continued)

	Hypertension	Angina pectoris	Heart failure	Cerebrovascular diseases	Diabetes mellitus	Epilepsies	Kidney and urinary tract infection	Infection of the skin and subcutaneous tissue	Inflammatory disease of female pelvic organs	Gastrointestinal ulcer
ESF year 19	−0.2588	−0.0254	−0.2801	−0.7445*	−0.5116*	0.0003	−0.0664	−0.0705	0.0008	−0.0403
	(0.2351)	(0.0217)	(0.1896)	(0.4262)	(0.2790)	(0.0333)	(0.0461)	(0.0486)	(0.0091)	(0.0784)
ESF year 20	−0.2877	−0.0295	−0.3000	−0.7884*	−0.5688*	0.0026	−0.0770	−0.0786	0.0006	−0.0529
	(0.2556)	(0.0236)	(0.2055)	(0.4603)	(0.3052)	(0.0363)	(0.0503)	(0.0529)	(0.0098)	(0.0850)
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality-specific Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	116 707	116 707	116 707	116 707	116 707	116 707	116 707	116 707	116 707	116 707

Robust standard errors clustered at the municipality level are listed in parentheses; regressions weighted by population. Dependent variable: mortality rate per 10 000 per category of avoidable cause. Independent variables: dummies indicating number of years into the programme, municipality-fixed effects, year-fixed effects and municipality-specific trends. All regressions also included controls for: Bolsa Família coverage, Mais Médicos coverage, GDP per capita, municipal own tax revenue and hospital beds per capita.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

infections; bacterial pneumonia; asthma; and diseases of the lower airways.

The results show that localities that have been covered by the programme for 13 years see a reduction in the mortality rate of all conditions by 1.15 per 10 000, greater than other similar localities not covered by the programme. Taking into account the average of the mortality rate from all preventable conditions (3.81 per 10 000) in the first year, this implies a decrease of 30.2% in this rate. Considering a municipality 20 years into the ESF, an accumulated effect of 2.45 is noticed, corresponding to 64% of the initial mortality rate average.

Our estimates for some categories of this general variable also reveal a negative link between programme availability and adult mortality. That is the case of infectious gastroenteritis, for which a reduction of 0.016 deaths per 10 000 is estimated for a municipality six years into the programme, which represents 21% of the 1998 average (0.075 per 10 000). Meanwhile, the estimated effect for immunisable diseases is −0.0053 for three years of exposure to ESF, which corresponds to 16% of the mortality rate due to it—but this effect vanishes after 10 years of programme implementation. A reduction of 0.0144 asthma deaths per 10 000 inhabitants is estimated for a municipality six years into the programme, equivalent to 22.8% of the asthma mortality rate from 1998 (0.063 per 10 000).

Another set of diseases is investigated in Table 2: hypertension; angina pectoris; heart failure; cerebrovascular diseases; diabetes mellitus; epilepsies; kidney and urinary tract infection; infection of the skin and subcutaneous tissue; inflammatory disease of female pelvic organs; and gastrointestinal ulcer. A decrease of 0.32 cerebrovascular deaths per 10 000 is verified for a municipality 11 years into the programme, corresponding to 29.5% of the mortality rate due to cerebrovascular diseases. Furthermore, localities covered by the programme for 14 years exhibited a drop of 0.30 per 10 000 in the diabetes mortality rate, which represents 49.6% of the 1998 average of diabetes mellitus mortality (3.81 per 10 000). Finally, a decrease of 0.01 deaths per 10 000 due to infection of the skin and subcutaneous tissue is noticed for a locality covered by the ESF for three years, corresponding to 50.8% of the first year mortality rate associated with this condition.

Robustness analysis

A fundamental issue in this framework is the potential existence of a previous trend in the verified municipal deaths from preventable causes. If that was the case, the effect of being covered by the ESF could be overestimated. Robustness analysis is carried out to check this possibility, by adding binary variables representative of the years previous to the programme availability in each municipality. If by any means our findings were explained by previous trends in adult mortality, the pre-ESF binary variables were supposed to reveal significant effects.

Figure 1 displays the findings for this previous trends exercise on all conditions sensitive to primary care. The marginal effects of ESF exposure do not exhibit any statistical significance of previous programmes, which confirms that the aforementioned effect of ESF on mortality does not start before its local availability.

Heterogeneity analysis: intensity of the programme

Figure 2 displays our main results (coefficients with their respective 95% confidence intervals) for two programme intensities for all conditions sensitive to the primary care variable. We looked at the length of time the municipalities served over 3450 people per FHT (exposure to lower intensity) and at the length of time the municipalities served fewer than 3450 people per FHT (exposure to the higher intensity). As very few municipalities had exposure to high intensity close to 20 years, we aggregate the years of exposure to 15 years or more.

Estimates reveal that exposure to the programme's high intensity produces systematic drops in mortality in the early years, and the effect intensifies over time. The same is not true for exposure to the low intensity of the programme.

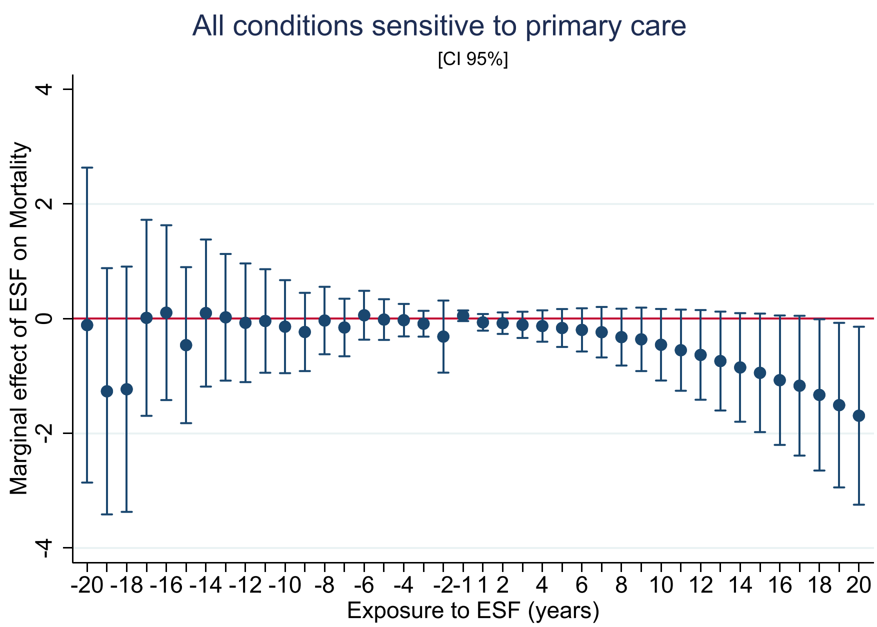

Figure 1. Exposure to ESF and Mortality due to conditions sensitive to Primary care

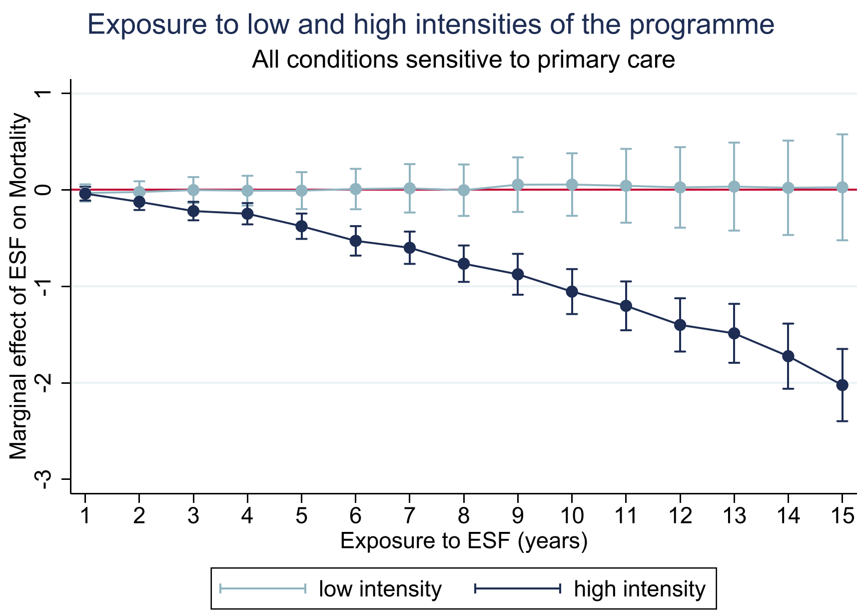

Figure 2. Exposure to high and low intensities of ESF and Mortality due to conditions sensitive to Primary care

In fact, it appears that the programme serving over 3450 people is not enough for municipalities to experience a significant effect in the short or long term for adult mortality. The results remain robust even when we use the variable exposure to the programme's sustained high (or low) intensity, defined as the exposure that remains at the high (or at the low) intensity in subsequent time periods.

By analysing the results by category (figures in Supplementary Appendix E), we notice that some diseases have effects of higher intensity fully detached from the effects of lower intensity, especially after some years. This is the case for avoidable conditions, asthma, heart failure, cerebrovascular diseases and gastrointestinal ulcer. Meanwhile, other diseases such as infectious gastroenteritis and its complications, diseases of the lower airways, hypertension and diabetes have significant effects for high intensity. Still, these effects are partly overlapping the effects seen for low intensity.

The sensitivity analysis to different MM variables depicts the same pattern found in the main analysis, and could be considered a piece of evidence showing that our results remain robust to changes in the definition of MM coverage. In addition, it is essential to highlight that the effects of the high intensity of the ESF start in the first years of the programme implementation, therefore well before the beginning of the MM programme (figures in Supplementary Appendix F). Even though the results remain similar, the main specification adopted is theoretically preferred since it was designed to isolate the effect of ESF on mortality, controlling for the impact of the MM programme.

Discussion

We investigated a wide range of related health problems to provide evidence about the effects of ESF on adult mortality. We found that a higher intensity of ESF is associated with reduced mortality by all conditions sensitive to primary care and for some diseases, especially after some years: avoidable conditions, asthma, heart failure, cerebrovascular diseases and gastrointestinal ulcer, infectious gastroenteritis and complications, diseases of the lower airways, hypertension and diabetes. For infections of the skin and subcutaneous tissue, we found some evidence of an association considering only a 10% level of significance.

By identifying links between ESF coverage and adult mortality and morbidity, our analysis provides a picture of the benefits of the Brazilian primary care strategy that is broader than, albeit consistent with, that from previous studies. For example, Hone *et al.* (2017) found a positive association between ESF expansion and better health outcomes and reduced health inequalities between racial groups. Hone and Saraceni *et al.* (2020) also found that users of the programme in the city of Rio de Janeiro 'had reduced risk of death', with greater benefits for the poorest and most vulnerable groups. Postali *et al.* (2021, p. 6) found the programme had no effect on some biomarkers, such as diabetes and cholesterol, suggesting that the 'development of diabetes and hypercholesterolemia is multifactorial, mixing environmental and genetic causes that are not addressed by the ESF. Nevertheless, although unable to mitigate both conditions, the program is effective in reducing their most serious consequences in the long run, like mortality'.

Examining the results as a whole, the ESF strategy, on average, is linked to reduced mortality for a wide set of primary care-sensitive conditions. Further research is needed, however, to better understand why the relationship between ESF expansion and the evolution of some diseases that are sensitive to the quality of primary care has been more limited. To this end, a useful focus for future studies is an in-depth evaluation of treatment processes and pathways within the ESF strategy, particularly the care pathways to treat chronic non-communicable diseases (NCDs). A recent report has identified gaps between what is expressed in the guidelines for the management of NCDs in Brazil and what is actually implemented in primary care at the municipal level (Eleone *et al.*, 2021).

The first limitation of this work is that it is an observational study, which does not necessarily allow for causal interpretations, but rather associations between programme coverage and results. Another limitation stems from the use of data from death certificates, which depend on the quality of reporting and completion that are done in a completely decentralized manner. There has been some concern about this issue since the mid-1980s, leading to the elaboration of manuals for the standardization of death registries and considerable improvement in the quality of data (Queiroz *et al.*, 2017; Teixeira *et al.*, 2019).

Conclusion

Primary care is the backbone of SUS, and the ESF is a fundamental component of the system's structure. In 2018, Brazil had already linked approximately 44 000 teams and over 300 000 professionals.

Before the coronavirus (COVID-19) pandemic emerged, the Ministry of Health proposed a change in the funding structure of primary healthcare and in the assistance provided by family health teams and basic health units. Essentially, the proposal would transfer resources to municipalities conditional on the quality of system user registration and some performance and treatment quality indicators, including pregnant women and women's health, child health, chronic diseases and tuberculosis.

Information on the programme's success in some dimensions and the need for improvement in others is crucial for planning the actions and priorities to be adopted in this future funding structure. Improvements will be needed worldwide in the face of future challenges regarding the underway demographic changes, together with the health and socioeconomic changes resulting from the COVID-19 pandemic.

Supplementary data

Supplementary data are available at *Health Policy and Planning* online.

Funding

This work was supported by the National Institute for Health Research (NIHR) (NIHR Global Health Econometrics & Economics Group) using UK aid from the UK Government [grant number ABX 16/137/90] and by Fipe – Fundação Instituto de Pesquisas Econômicas. M.D.M.D. and F.A.S.P. received Research Productivity Grants from CNPq during the elaboration of this article. The views expressed in this publication are those of the authors and not necessarily those of the funders.

Acknowledgements

The authors are grateful to Marc Suhrcke, Ijeoma Edoka and several seminar participants at GHE2 iHEA 2019 Organised Session and 2019 Annual Meeting for their valuable comments, and to Matheus Valentim de Barros, Guilherme Jardinetti Araujo and Gabriela Soares de Faria for excellent research assistance. We also thank two anonymous referees for their careful reading of the manuscript and helpful comments and suggestions that have helped improve the article. We are solely responsible for any errors.

Author contributions

M.D.M.D.: Conception or design of the work, Data collection, Data analysis and interpretation, Drafting the article, Critical revision of the article.
A.D.T.: Conception or design of the work, Data collection, Data analysis and interpretation, Drafting the article, Critical revision of the article.
F.A.S.P.: Conception or design of the work, Data analysis and interpretation, Critical revision of the article.
N.N.F.B.: Conception or design of the work, Data analysis and interpretation, Critical revision of the article.
R.M.S.: Conception or design of the work, Data analysis and interpretation, Critical revision of the article.

Ethical approval. Ethical approval for this type of study is not required by Brazilian legislation (Resolution 510, of April 7, 2016), which establishes that studies that use information in the public domain or obtained from the Access to Information Law will not be registered or evaluated by the Research Ethics Committee.

Conflict of interest statement. None declared.

References

Alfradique ME, Bonolo PDF, Dourado I *et al.* 2009. Internações por condições sensíveis à atenção primária: a construção da lista brasileira como ferramenta para medir o desempenho do sistema de saúde (Projeto ICSAP – Brasil). *Cadernos de Saúde Pública* **25**: 1337–49.

Andrade MV, Noronha KVMS, Queiroz-Barbosa AC *et al.* 2017. Family health strategy and equity in prenatal care: a population based cross-sectional study in Minas Gerais, Brazil. *International Journal for Equity in Health* **16**: 24.

Andrade MV, Coelho AQ, Xavier-Neto M *et al.* 2018. Brazil's Family Health Strategy: factors associated with programme uptake and coverage expansion over 15 years (1998–2012). *Health Policy and Planning* **33**: 368–80.

Aquino R, de Oliveira NF, Barreto ML. 2009. Impact of the Family Health Program on infant mortality in Brazilian municipalities. *American Journal of Public Health* **99**: 87–93.

Arruda GOD, Schmidt DB, Marcon SS *et al.* 2018. Hospitalizations for diabetes mellitus and the Family Health Strategy, Paraná, Brazil, 2000–2012. *Ciência & Saúde Coletiva* **23**: 543–52.

Barros AJ, Bertoldi AD. 2008. Out-of-pocket health expenditure in a population covered by the Family Health Program in Brazil. *International Journal of Epidemiology* **37**: 758–65.

Bastos ML, Menzies D, Hone T *et al.* 2017. The impact of the Brazilian family health strategy on selected primary care sensitive conditions: a systematic review. *PLoS One* **12**: e0182336.

Bertoldi AD, de Barros AJD, Wagner A *et al.* 2009. Medicine access and utilization in a population covered by primary health care in Brazil. *Health Policy* **89**: 295–302.

Bhalotra S, Rocha R, Soares RR. 2019. *Does Universalization of Health Work? Evidence from Health Systems Restructuring and Maternal and Child Health in Brazil.* IZA Discussion Paper. https://ssrn.com/abstract=3390099, accessed 15 January 2021.

Brasil. 2020a. *Ministério da Saúde.* e-Gestor AB. https://egestorab.saude.gov.br/paginas/acessoPublico/relatorios/relHistoricoCoberturaAB.xhtml, accessed 26 January 2021.

Brasil. 2020b. *Ministério da Economia, FINBRA – Dados Contábeis dos Municípios – 1989 a 2012-2013 01 01.* Tesouro Transparente. https://www.tesourotransparente.gov.br/publicacoes/finbra-dados-contabeis-dos-municipios-1989-a-2012/2012/26, accessed 26 January 2021.

Brasil. 2020c. *Ministério da Economia, Siconfi - Secretaria do Tesouro Nacional (STN) – Versão: 2.0 Contas Anuais*. https://siconfi.tesouro.gov.br/siconfi/index.jsf;jsessionid=bwg3m2MTtKSDT2rLsT5z75Uo.node1, accessed 26 January 2021.

Brasil. 2020d. *Ministério da Saúde, CNES – Recursos Físicos – Hospitalar – Leitos de internação – Brasil* [data set]. http://tabnet.datasus.gov.br/cgi/deftohtm.exe?cnes/cnv/leiintbr.def, accessed 26 January 2021.

Brasil. 2020e. *Ministério da Saúde, População Residente – Estimativas para o TCU – Brasil*. http://tabnet.datasus.gov.br/cgi/deftohtm.exe?ibge/cnv/poptbr.def, asccessed 26 January 2021.

Brasil. 2020f. *Ministério Desenvolvimento Social, Bolsa Família – MI Social – Conjuntos de dados – Portal Brasileiro de Dados Abertos*. https://dados.gov.br/dataset/bolsa-familia-misocial, accessed 26 January 2021.

Cavalcante DDFB, Brizon VSC, Probst LF *et al.* 2018. Did the Family Health Strategy have an impact on indicators of hospitalizations for stroke and heart failure? Longitudinal study in Brazil: 1998–2013. *PLoS One* **13**: e0198428.

da Silva EN, Powell-Jackson T. 2017. Does expanding primary healthcare improve hospital efficiency? Evidence from a panel analysis of avoidable hospitalisations in 5506 municipalities in Brazil, 2000–2014. *BMJ Global Health* **2**: e000242.

de Souza RA, Nery JS, Rasella D *et al.* 2018. Family health and conditional cash transfer in Brazil and its effect on tuberculosis mortality. *The International Journal of Tuberculosis and Lung Disease* **22**: 1300–6.

Eleone A, Aguillar A, Leal F *et al.* 2021. *Linhas de Cuidado de Doenças Crônicas Não Transmissíveis na Atenção Primária à Saúde*. https://ieps.org.br/wp-content/uploads/2021/07/Panorama_IEPS_02.pdf, accessed 15 August 2021.

Hone T, Powell-Jackson T *et al.* 2020. Impact of the Programa Mais médicos (more doctors Programme) on primary care doctor supply and amenable mortality: quasi-experimental study of 5565 Brazilian municipalities. *BMC Health Services Research* **20**: 1–11.

Hone T, Rasella D, Barreto ML, Majeed A, Millett C. 2017. Association between expansion of primary healthcare and racial inequalities in mortality amenable to primary care in Brazil: a national longitudinal analysis. *PLoS Medicine* **14**: e1002306.

Hone T, Saraceni V, Medina-Coeli C *et al.* 2020. Primary healthcare expansion and mortality in Brazil's urban poor: a cohort analysis of 1.2 million adults. *PLoS Medicine* **17**: e1003357.

IBGE. 2020. *Downloads*. IBGE. https://www.ibge.gov.br/estatisticas/downloads-estatisticas.html, accessed 26 January 2021.

Love-Koh J, Mirelman A, Suhrcke M. 2021. Equity and economic evaluation of system-level health interventions: a case study of Brazil's Family Health Program. *Health Policy and Planning* **36**: 229–38.

Macinko J, de Souza MDFM, Guanais FC *et al.* 2007. Going to scale with community-based primary care: an analysis of the Family Health Program and infant mortality in Brazil, 1999–2004. *Social Science & Medicine* **65**: 2070–80.

Macinko J, Guanais FC, de Souza MDFM. 2006. Evaluation of the impact of the Family Health Program on infant mortality in Brazil, 1990–2002. *Journal of Epidemiology and Community Health* **60**: 13–9.

Macinko J, Harris MJ. 2015. Brazil's Family Health Strategy — delivering community-based primary care in a universal health system. *Massachusetts Medical Society* **372**: 2177–81.

Macinko J, Lima Costa MF. 2012. Access to, use of and satisfaction with health services among adults enrolled in Brazil's Family Health Strategy: evidence from the 2008 National Household Survey. *Tropical Medicine & International Health* **17**: 36–42.

Macinko J, Mendonça CS. 2018. Estratégia Saúde da Família, um forte modelo de Atenção Primária à Saúde que traz resultados. *Saúde em Debate* **42**: 18–37.

Moreno-Serra RA. 2005. Uma avaliação empírica do impacto do programa saúde da família sobre a saúde infantil no estado de São Paulo. In: *Prêmio em Economia da Saúde: 1ºPrêmio Nacional, 2004: Coletânea Premiada*. 79–112.

Moreno-Serra R, Smith PC. 2012. Does progress towards universal health coverage improve population health? *The Lancet* **380**: 917–23.

Moreno-Serra R, Smith PC. 2015. Broader health coverage is good for the nation's health: evidence from country level panel data. *Journal of the Royal Statistical Society: Series A (Statistics in Society)* **178**: 101–24.

Paim J, Travassos C, Almeida C *et al.* 2011. The Brazilian health system: history, advances, and challenges. *The Lancet* **377**: 1778–97.

Pinto LF, Giovanella L. 2018. Do Programa à Estratégia Saúde da Família: expansão do acesso e redução das internações por condições sensíveis à atenção básica (ICSAB) [The Family Health Strategy : expanding access and reducing hospitalizations due to ambulatory care sensitive condit]. *Ciencia & Saude Coletiva* **23**: 1903–14.

Postali FAS, Diaz MDM, Ferreira-Batista NN *et al.* 2021. Primary care coverage and individual health: evidence from a likelihood model using biomarkers in Brazil. *BMC Health Services Research* **21**: 1–8.

Queiroz BL, Freire FHMDA, Gonzaga MR *et al.* 2017. Completeness of death-count coverage and adult mortality (45aq15) for Brazilian states from 1980 to 2010. *Revista Brasileira de Epidemiologia* **20**: 21–33.

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

Rasella D, Aquino R, Barreto ML. 2010. Impact of the Family Health Program on the quality of vital information and reduction of child unattended deaths in Brazil: an ecological longitudinal study. *BMC Public Health* **10**: 380.

Rocha R, Soares RR. 2010. Evaluating the impact of community based health interventions: evidence from Brazil's Family Health Program. *Health Economics* **19**: 126–58.

Teixeira RA, Naghavi M, Guimarães MDC *et al.* 2019. Quality of cause-of-death data in Brazil: garbage codes among registered deaths in 2000 and 2015. *Revista Brasileira de Epidemiologia* **22**: e19002.

Wagstaff A, Neelsen S. 2020. A comprehensive assessment of universal health coverage in 111 countries: a retrospective observational study. *The Lancet Global Health* **8**: e39–49.