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Montoya Diaz, Maria Dolores, Dutra Teixeira, Adriano, Postali, Fernando et al. (2 more authors) (2022) Assessment of the Association between the Brazilian Family Health Strategy and Adult Mortality. Health Policy and Planning. pp. 461-471. ISSN 1460-2237

https://doi.org/10.1093/heapol/czac011

DATE: 01/2022

TITLE: ASSESSMENT OF THE ASSOCIATION BETWEEN THE BRAZILIAN FAMILY HEALTH STRATEGY AND ADULT MORTALITY

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All authors have read and approved the final manuscript.

KEYWORDS: Family health strategy (ESF); adult mortality; Datasus database; impact evaluation

JEL CLASSIFICATION: I18, C23, C26

RUNNING TITLE: BRAZILIAN PRIMARY HEALTH CARE AND MORTALITY

HIGHLIGHTS:

- 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 program is associated with 30.2% reduction in mortality.
- High-intensity exposure is associated with larger decreases in mortality over time.

WORD COUNT: 3657 WORDS

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.

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 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 paper. We are solely responsible for any errors.

FUNDING

This research 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. Maria Dolores Montoya Diaz and Fernando Postali receive Research Productivity Grants from CNPq during the elaboration of this paper. The views expressed in this publication are those of the authors and not necessarily those of the funders.

DECLARATION OF INTEREST: NONE

Assessment of the Association between the Brazilian Family Health Strategy and Adult Mortality

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 association 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 discussed 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 emphasise the role of having sufficient health teams to attend to the population.

1. 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, the 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).

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, 2016). Essentially, the program provides primary care for defined populations and is organised by geographic regions 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 program is federal, and accreditation of the Family Health Strategy (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 provides 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), hospitalisation 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, Guanais and de Souza, 2006; Macinko *et al.*, 2007; Aquino, de Oliveira and Barreto, 2009; Rasella, Aquino and Barreto, 2010; Bastos *et al.*, 2017) . More recently, Love-Koh, Mirelman and Suhrcke (2020) conclude that the impacts on inequality are small and uncertain, although the program 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, for example. As mentioned by Rasella *et al.*(2014) citing documents of 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.

2. Methods

2.1. 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 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 less than that. By 2016, 626 municipalities had 3450 or fewer residents, while 109 had less 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's 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 healthcare (Hone, Powell-Jackson, *et al.*, 2020). Formally, the coincidence period of the two programs could generate an overestimation of the ESF effects since part of the program'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, 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 program and the second without the MM-related variable). The goal is to analyse the effect of different forms of disentangling both programs.

Bolsa Família Coverage was defined as the annual total value transferred by the Bolsa Familia program 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 on the webpage (Brasil, 2020b). For the values from 2013 onwards, we can obtain information on the site (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 since 2005 (Brasil, 2020d).

2.2. Empirical Strategy

Extending the previous works that consider the programme has lagged effects on mortality (Macinko, Guanais and de Souza, 2006; Rocha and Soares, 2010; Bhalotra, Rocha and Soares, 2019), this is also an observational study. Our empirical strategy relies on a longitudinal analysis that allows heterogeneous effects according to 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:

Equation 1:

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

where $Mortality_{m,t}$ denotes the mortality rate (according to the classification of preventable conditions) for municipality m in year t, $ESF\ exposure_{m,t}^{j}$ 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.

2.2.1. 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:

Equation 2: $Mortality_{m,t} = \alpha + \sum_{k=1}^{K} \beta_k \cdot ESF\ pre-exposure_{m,t}^{k} + \sum_{j=1}^{J} \beta_j \cdot ESF\ exposure_{m,t}^{j} + \gamma \cdot X_{m,t} + \varphi_m + \mu_{m,t} + \tau_t + \varepsilon_{m,t}$

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

2.2.2. 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:

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

where $ESF\ exposure\ to\ low\ intensity_{m,t}^{l}$ 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 $ESF\ exposure\ to\ high\ intensity_{m,t}^{h}$ 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 less 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 Appendix A and columns 'Time of Exposure to the ESF' and 'ESF Coverage Measured by Available Teams' in 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.

3. Results

3.1. Main results

The descriptive statistics of the analysed variables is provided in the 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 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 divides by category: immunisable diseases; avoidable conditions; infectious gastroenteritis and complications; anaemia; nutritional deficiencies; ear, nose, and throat infections; bacterial pneumonia; asthma; and diseases of the lower airways.

The results point out that localities that have been covered by the programme for 13 years see a reduction inthe 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, corresponds 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 three years covered by the ESF, corresponding to 50.8% of the first year mortality rate associated with this condition.

3.2. 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 availabilityin 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 previous programme which confirms the aforementioned effect of ESF on mortality does not start before its local availability.

3.3. 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).At the length of time the municipalities served less 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. 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 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 of 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 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 program implementation, therefore, well before the beginning of the MM program (figures in 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 program.

4. 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, 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 among racial groups. Hone *et al.* (2020) also found that users of the program 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 program 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).

5. 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, 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 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.

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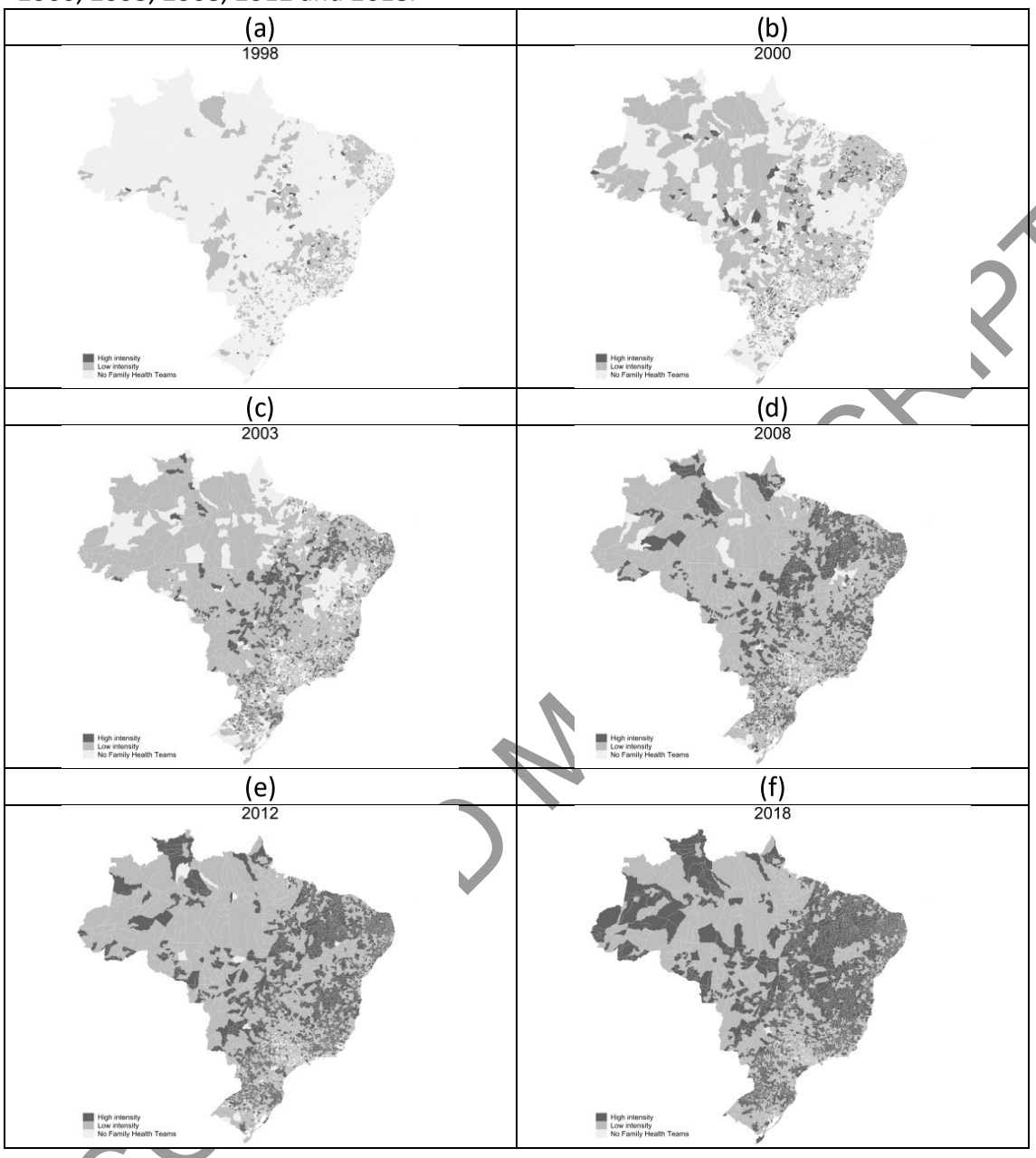
Appendices

A. Evolution of ESF Coverage for selected years

Figure A shows the evolution of ESF coverage intensity over time, measured in two categories: exposure to lower intensity defined as municipalities that served more than 3,450 people by ESF team and greater intensity, municipalities that served less than 3,450 people per team. The darker areas indicate the highest intensity of the program, and the lighter areas represent the lower intensities. The numbers show the evolution for 1998,

2000, 2003, 2008, 2012 and 2018.



B. Adult Mortality from Conditions Sensitive to Primary Care - ICD 10 Definitions

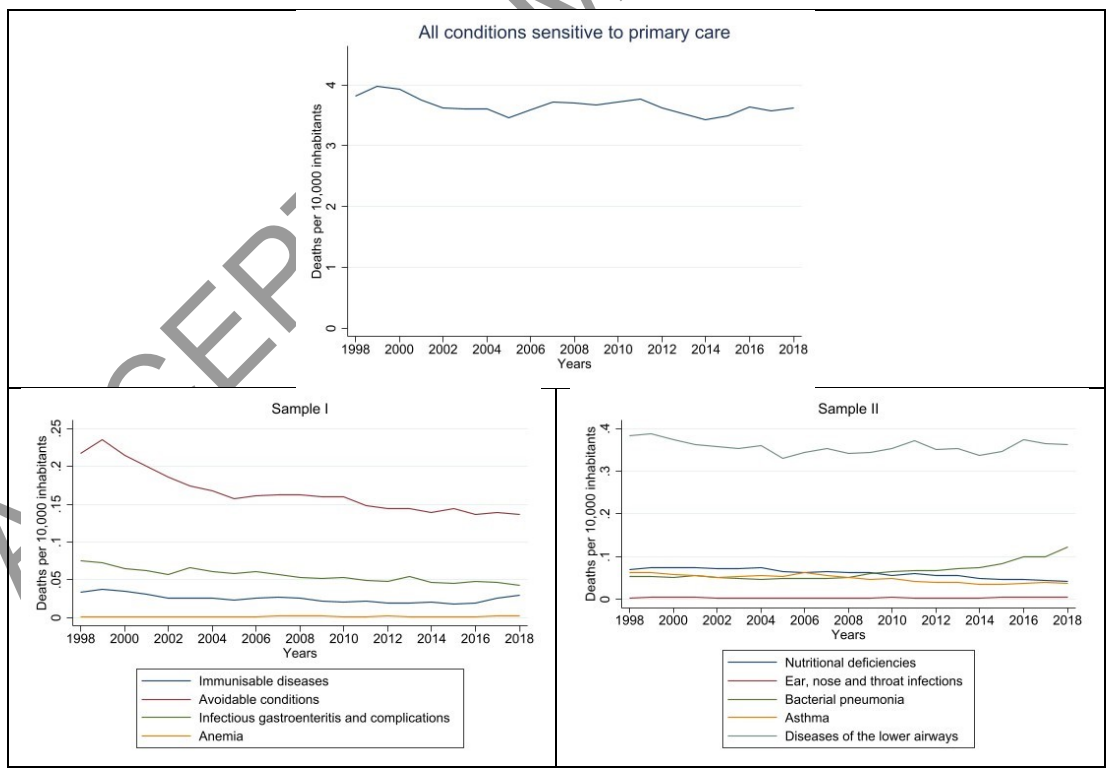
Categories:	ICDs 10
1) Immunisable diseases	A33* A34* A35* A36* A37* A95* B16* B05* B06* B26* G00.0 A17.0 A19*
2) Avoidable conditions	A15* A16* A18* A17.1-A17.9 I00-I02 A51-A53.9 B50-B54.9 B77*
3) Infectious gastroenteritis and complications	E86* A00-A09
4) Anemia	D50*
5) Nutritional deficiencies	E40/E469 E50-E64.9
6) Ear, nose and throat infections	H66* J00-J03.9 J06* J31*
7) Bacterial pneumonia	J13-J14 J15.3-J15.4 J15.8-J15.9 J18.1
8) Asthma	J45-J46.9
9) Diseases of the lower airways	J20* J21* J40-J44.9 J47*
10) Hypertension	I10-I11.9
11) Angina pectoris	I20*
12) Heart failure	I50* J81*
13) Cerebrovascular diseases	I63-I67.9 I69* G45-G46.9
14) Diabetes mellitus	E10-E14.9
15) Epilepsies	G40-G41.9
16) Kidney and urinary tract infection	N10-N12.9 N30* N34* N39.0
17) Infection of the skin and subcutaneous tissue	A46* L01-L04.9 L08*
18) Inflammatory disease of female pelvic organs	N70-N73.9 N75-N76.9
19) Gastrointestinal ulcer	K25-K28.9 K92.0 K92.1 K92.2
All conditions sensitive to primary care	**All ICDs defined above**

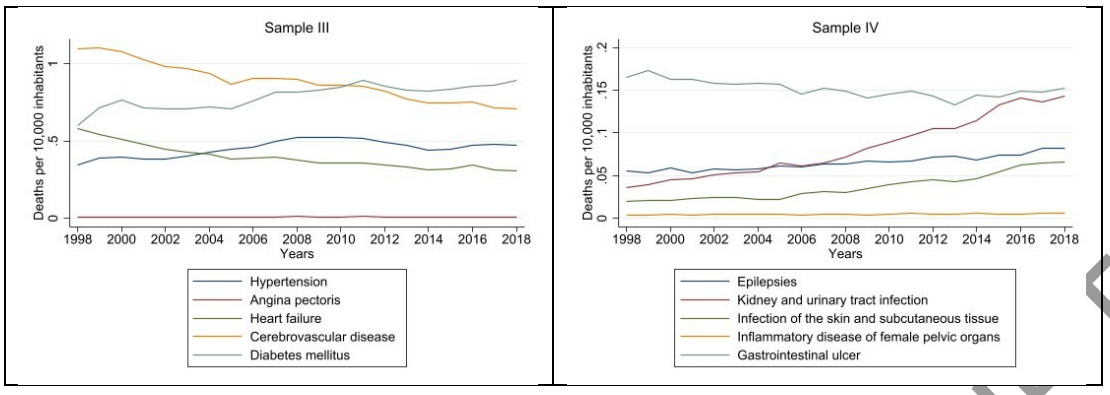
C. Descriptive Statistics

Year	Adult mortality from all conditions sensitive to primary care average # per 10,000 inhabitants by year/city	Time of exposure to the ESF average # of years	ESF Coverage measured by teams average # per 10,000 inhabitants by year/city	GDP per capita average US$	Hospital beds per capita average # by year/city	Bolsa-Familia coverage per capita average US$ by year/city	Mais Medicos coverage average # by year/city	Revenue from Municipal Taxes per capita average US$ by year/city
1998	3.13	0.00	0.317	2,843.50	0.0023	0.00	0.0000	12.78
1999	3.22	0.21	0.525	2,065.50	0.0023	0.00	0.0000	8.54

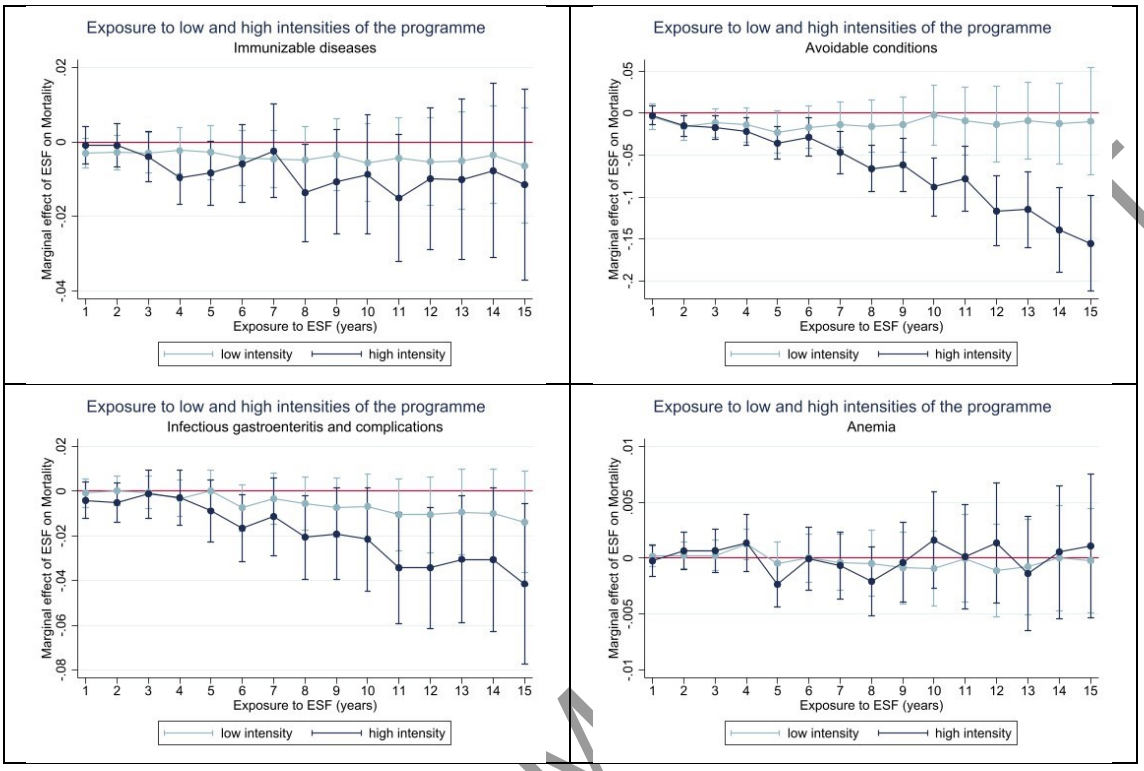
2000	3.31	0.54	1.122	2,288.00	0.0023	0.00	0.0000	11.39
2001	3.23	1.07	1.564	1,946.54	0.0023	0.00	0.0000	9.63
2002	3.20	1.75	1.898	1,833.72	0.0020	0.00	0.0000	9.12
2003	3.29	2.51	2.072	2,121.48	0.0021	0.00	0.0000	10.17
2004	3.37	3.33	2.278	2,455.60	0.0021	10.89	0.0000	12.14
2005	3.32	4.19	2.552	3,061.71	0.0018	19.28	0.0000	16.91
2006	3.48	5.10	2.725	3,763.12	0.0017	28.22	0.0000	22.76
2007	3.53	6.03	2.791	4,735.33	0.0017	36.84	0.0000	31.79
2008	3.52	6.96	2.795	5,654.93	0.0016	44.56	0.0000	37.64
2009	3.47	7.90	2.892	5,495.53	0.0016	46.42	0.0000	37.73
2010	3.58	8.85	3.015	7,159.76	0.0015	61.38	0.0000	52.84
2011	3.64	9.80	3.052	8,618.47	0.0015	76.33	0.0000	64.87
2012	3.54	10.76	3.074	8,077.65	0.0015	80.49	0.0000	59.46
2013	3.47	11.72	3.056	8,056.09	0.0014	85.11	0.0508	59.52
2014	3.30	12.68	3.308	7,932.21	0.0014	85.07	0.8053	57.96
2015	3.43	13.66	3.366	5,892.19	0.0014	60.58	0.9560	43.73
2016	3.60	14.64	3.378	6,014.23	0.0013	59.72	0.9286	42.50
2017	3.54	15.62	3.415	6,889.31	0.0013	60.57	0.8317	51.73
2018	3.70	16.61	3.473	6,336.45	0.0013	61.70	0.7320	43.84

D. Evolution of Adult Mortality from Conditions Sensitive to Primary Care

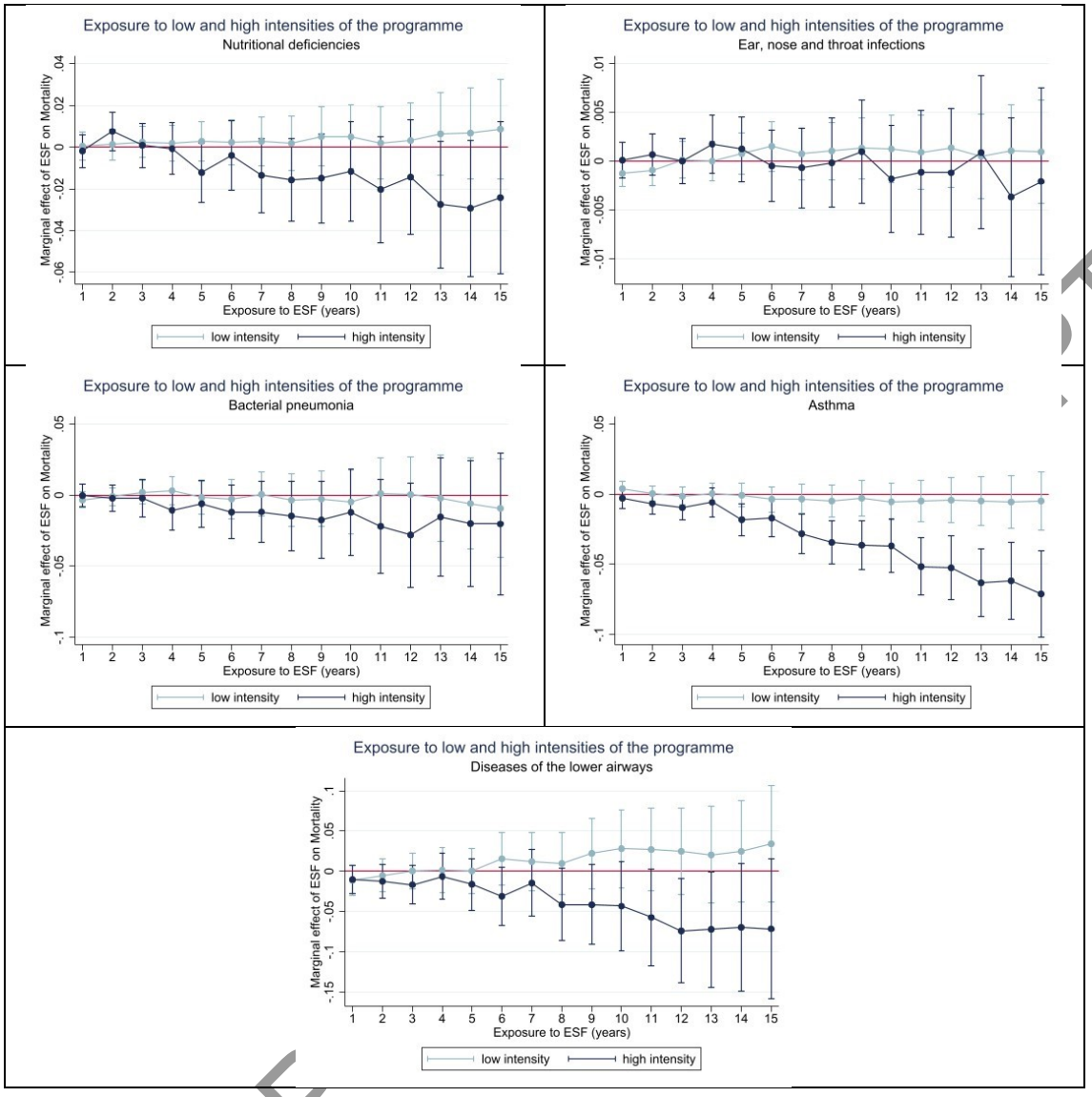




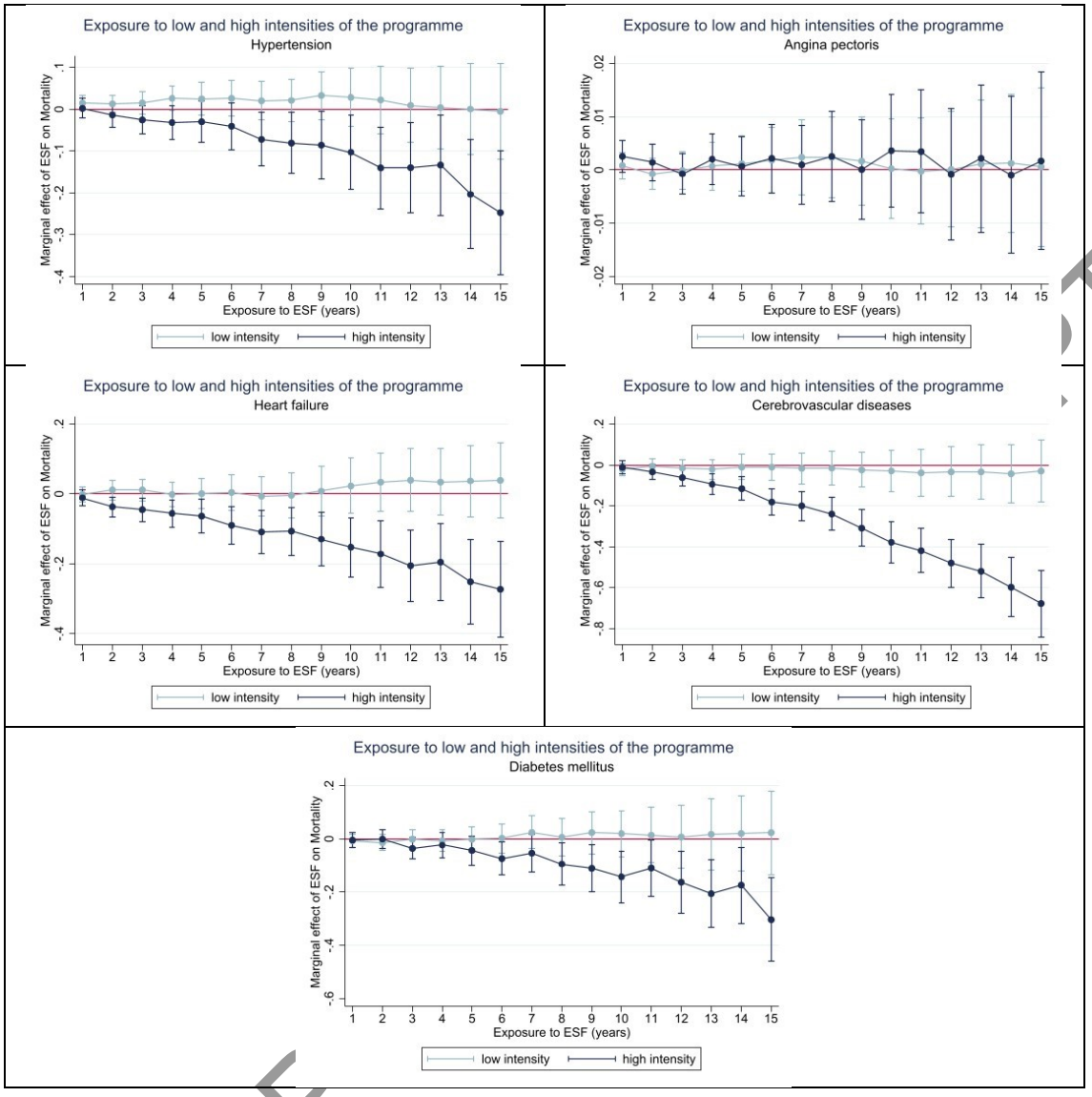
E. Heterogeneity graphs



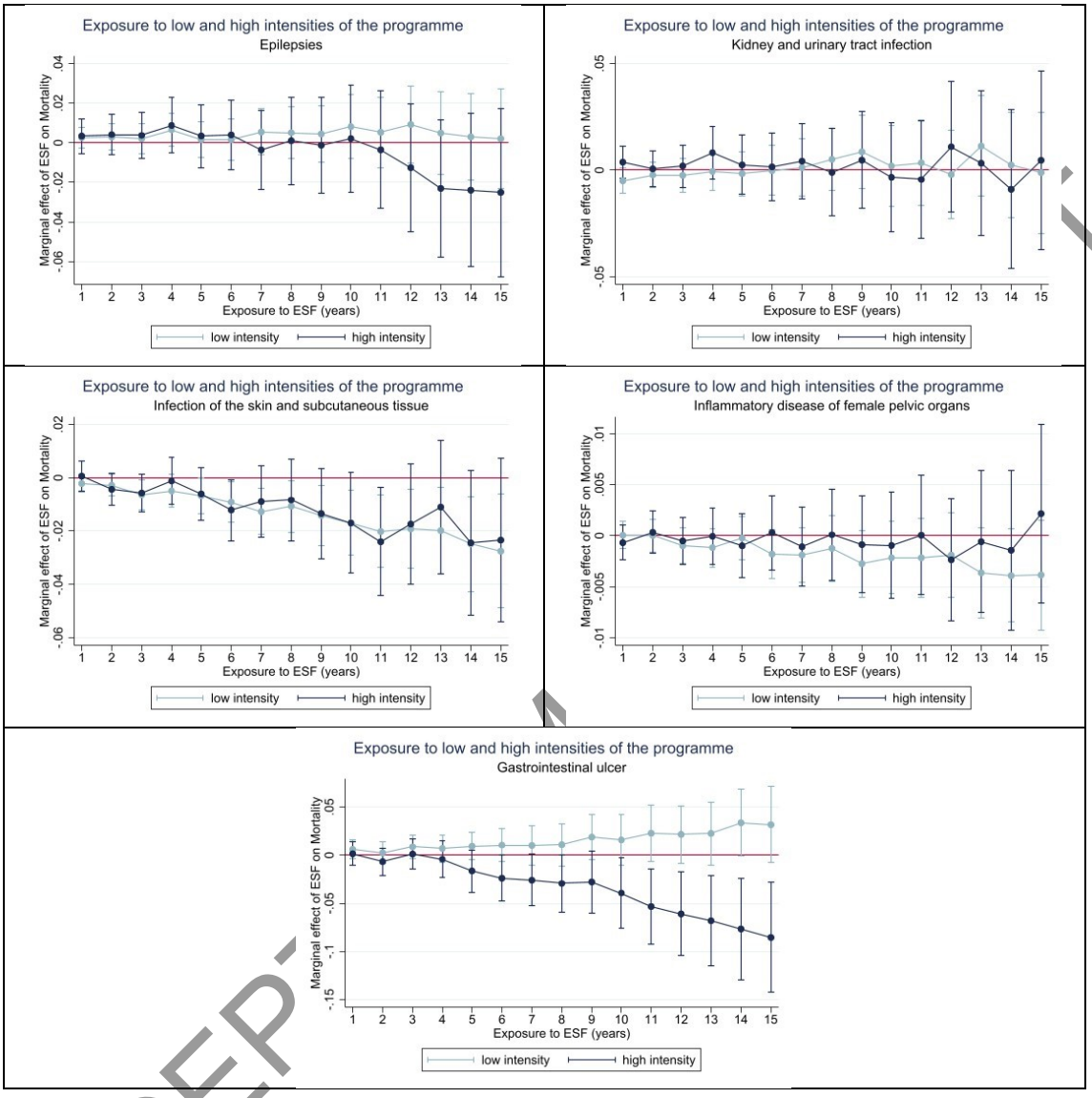
Estimates for Adult Mortality from Conditions Sensitive to Primary Care (continues)



Estimates for Adult Mortality from Conditions Sensitive to Primary Care (continues)



Estimates for Adult Mortality from Conditions Sensitive to Primary Care (continues)



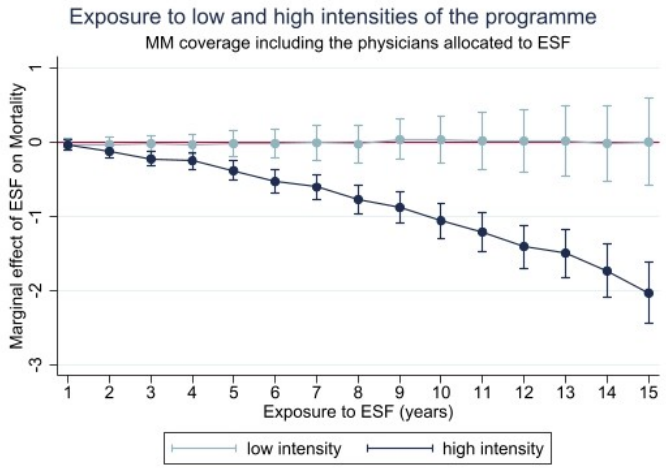
Estimates for Adult Mortality from Conditions Sensitive to Primary Care

F. Sensibility analysis for Mais Médicos control variable

Mais Médicos (MM) was a program launched in 2013 whose goal was to fill the shortage of physicians in the Brazilian remote areas and poor municipalities – some MM's physicians were also deployed to ESF. We implemented two new exercises in order to check the sensitivity of our main result to changes in the definition of MM coverage. First, we re-ran our estimation model with MM coverage now defined as total physicians per capita in this program (including those who were allocated to ESF). Second, the MM coverage is removed from the list of covariates of the regression.

All the estimations depict the same pattern, an evidence that our results remain robust to changes in the definition of Mais Médicos coverage. In addition, it is important to highlight that the effect of the high intensity of the ESF starts in the first years of the program implementation, therefore, well before the beginning of Mais Médicos. 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 program. The detailed results of these exercises are shown below.

i) Our main result from All conditions sensitive to primary care: including the ESF's physicians in the MM coverage



ii) Our main result from All conditions sensitive to primary care: without the MM coverage

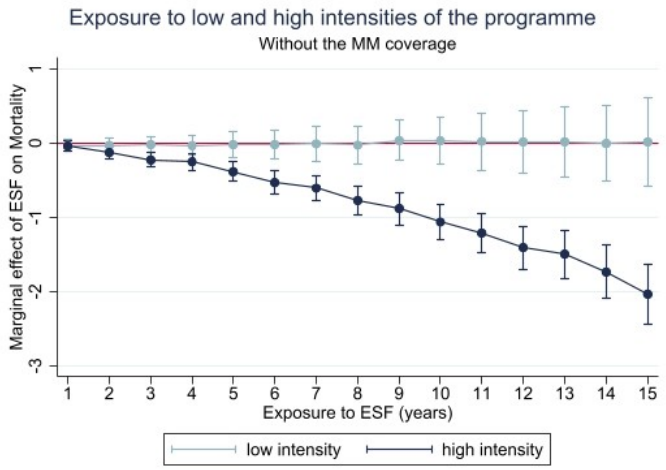


Figure 1

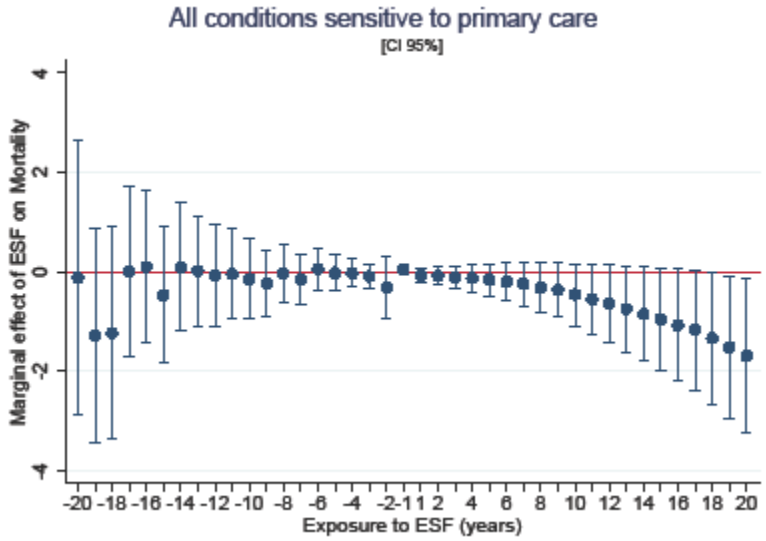


Figure 2

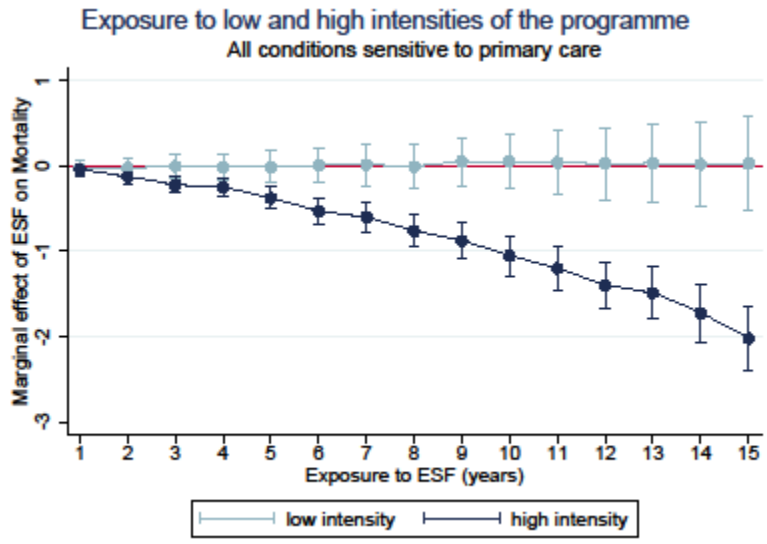


Table 1

	All conditions sensitive to primary care	Immunisable diseases	Avoidable conditions	Infectious gastroenteritis 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
	(0.21	(0.004	(0.02	(0.0064)	(0.00	(0.007	(0.00	(0.007	(0.00	(0.0

	03)	2)	10)		12)	3)	18)	5)	63)	249)
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)
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	116707	116707	116707	116707	116707	116707	116707	116707	116707	116707

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

	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	-0.0001	-0.0053	-0.0381*	-0.0186	0.0028	-0.0068**	-0.0035	0.0002	0.0062
	(0.0110)	(0.0014)	(0.0135)	(0.0227)	(0.0170)	(0.0028)	(0.0033)	(0.0023)	(0.0008)	(0.0058)
ESF year 2	0.0074	-0.0014	-0.0021	-0.0337	-0.0395*	0.0027	-0.0062*	-0.0053	0.0003	0.0012
	(0.0137)	(0.0017)	(0.0179)	(0.0321)	(0.0235)	(0.0037)	(0.0035)	(0.0033)	(0.0009)	(0.0073)

ESF year 3	-0.0012	-0.0020	-0.0026	-0.0651	-0.0458	0.0013	-0.0085*	-0.0100**	-0.0011	0.0019
	(0.0209)	(0.0023)	(0.0226)	(0.0437)	(0.0304)	(0.0045)	(0.0050)	(0.0050)	(0.0011)	(0.0095)
ESF year 4	0.0053	-0.0022	-0.0274	-0.0850	-0.0599	0.0069	-0.0074	-0.0104*	-0.0009	0.0006
	(0.0254)	(0.0030)	(0.0281)	(0.0581)	(0.0378)	(0.0051)	(0.0061)	(0.0061)	(0.0014)	(0.0117)
ESF year 5	0.0047	-0.0021	-0.0295	-0.1023	-0.0776	0.0024	-0.0096	-0.0116	-0.0000	0.0035
	(0.0356)	(0.0038)	(0.0341)	(0.0753)	(0.0479)	(0.0059)	(0.0077)	(0.0077)	(0.0016)	(0.0131)
ESF year 6	-0.0069	-0.0026	-0.0394	-0.1262	-0.0860	0.0025	-0.0119	-0.0159*	-0.0014	0.0009
	(0.0424)	(0.0045)	(0.0418)	(0.0871)	(0.0570)	(0.0071)	(0.0089)	(0.0094)	(0.0020)	(0.0164)
ESF year 7	-0.0242	-0.0031	-0.0591	-0.1544	-0.0838	0.0034	-0.0128	-0.0206*	-0.0011	-0.0025
	(0.0522)	(0.0055)	(0.0505)	(0.1076)	(0.0679)	(0.0085)	(0.0110)	(0.0114)	(0.0024)	(0.0202)
ESF year 8	-0.0291	-0.0046	-0.0689	-0.1906	-0.1281	0.0061	-0.0135	-0.0222*	-0.0003	-0.0043
	(0.0602)	(0.0064)	(0.0592)	(0.1253)	(0.0816)	(0.0097)	(0.0126)	(0.0134)	(0.0028)	(0.0236)
ESF year 9	-0.0402	-0.0068	-0.0820	-0.2214	-0.1385	0.0033	-0.0138	-0.0287*	-0.0013	-0.0031
	(0.0707)	(0.0073)	(0.0676)	(0.1426)	(0.0941)	(0.0113)	(0.0153)	(0.0158)	(0.0032)	(0.0270)
ESF year 10	-0.0604	-0.0088	-0.0832	-0.2723	-0.1761	0.0061	-0.0223	-0.0336*	-0.0008	-0.0086
	(0.0846)	(0.0085)	(0.0768)	(0.1673)	(0.1072)	(0.0131)	(0.0174)	(0.0181)	(0.0036)	(0.0310)
ESF year 11	-0.0733	-0.0110	-0.0957	-0.3225*	-0.1985	0.0027	-0.0246	-0.0382*	-0.0005	-0.0088
	(0.0990)	(0.0096)	(0.0867)	(0.1938)	(0.1260)	(0.0148)	(0.0197)	(0.0211)	(0.0041)	(0.0353)
ESF year 12	-0.1000	-0.0117	-0.1059	-0.3551	-0.2267	0.0067	-0.0334	-0.0427*	-0.0000	-0.0098

	(0.1133)	(0.0108)	(0.0977)	(0.2162)	(0.1442)	(0.0168)	(0.0223)	(0.0233)	(0.0046)	(0.0392)
ESF year 13	-0.1159	-0.0130	-0.1338	-0.4115*	-0.2583	0.0011	-0.0259	-0.0449*	-0.0018	-0.0153
	(0.1283)	(0.0122)	(0.1082)	(0.2426)	(0.1631)	(0.0187)	(0.0249)	(0.0265)	(0.0051)	(0.0440)
ESF year 14	-0.1362	-0.0148	-0.1503	-0.4586*	-0.2968*	0.0005	-0.0346	-0.0528*	-0.0017	-0.0109
	(0.1436)	(0.0135)	(0.1209)	(0.2703)	(0.1796)	(0.0207)	(0.0275)	(0.0298)	(0.0056)	(0.0490)
ESF year 15	-0.1676	-0.0176	-0.1769	-0.4952*	-0.3221	0.0055	-0.0457	-0.0573*	-0.0016	-0.0197
	(0.1594)	(0.0151)	(0.1333)	(0.2959)	(0.1993)	(0.0231)	(0.0308)	(0.0334)	(0.0063)	(0.0542)
ESF year 16	-0.1804	-0.0194	-0.1853	-0.5548*	-0.3924*	-0.0007	-0.0448	-0.0613*	-0.0005	-0.0196
	(0.1767)	(0.0166)	(0.1449)	(0.3261)	(0.2179)	(0.0253)	(0.0343)	(0.0368)	(0.0069)	(0.0609)
ESF year 17	-0.1943	-0.0217	-0.2105	-0.6014*	-0.4266*	-0.0006	-0.0498	-0.0683*	-0.0003	-0.0226
	(0.1927)	(0.0181)	(0.1580)	(0.3567)	(0.2394)	(0.0279)	(0.0381)	(0.0408)	(0.0075)	(0.0662)
ESF year 18	-0.2273	-0.0233	-0.2322	-0.6679*	-0.4703*	-0.0037	-0.0556	-0.0643	-0.0009	-0.0258
	(0.2138)	(0.0198)	(0.1728)	(0.3920)	(0.2580)	(0.0306)	(0.0423)	(0.0445)	(0.0083)	(0.0719)
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
	(0.255	(0.0	(0.2	(0.4603)	(0.3	(0.03	(0.05	(0.052	(0.009	(0.0850)

	6)	236)	055)		052)	63)	03)	9)	8)	
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	116707	116707	116707	116707	116707	116707	116707	116707	116707	116707

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