Is primary health care worth it in the long run? Evidence from Brazil

Abstract

This paper assesses whether Brazilian primary health care is worth it in the long-run by estimating the accumulated costs and benefits of its flagship, the Family Health Strategy program (ESF). We employ an alternative strategy centered on years of exposure to the program to incorporate its dynamics. We also account for the program's heterogeneity with respect to the remuneration of ESF health teams and the intensity of coverage across Brazilian municipalities, measure by the number of people assisted by each ESF team, on average. To address heterogeneity in professional earnings, this paper employs, for the first time, a dataset containing the remuneration of professionals allocated to all ESF teams nationwide. The benefits are measured by the avoided deaths and hospitalizations due to causes sensitive to primary care. Results suggest that the net monetary benefit of the program is positive on average, with an optimum time of exposure of approximately 16 years. Significant heterogeneities in cost-benefit results were found since costs outweigh benefits in localities where the coverage is low intensive. On the other hand, the benefits outweigh the costs by 22.5% on average in municipalities with high intensive coverage.

JEL classification: I15, I18, D61, C23

Keywords: Primary Health Care, Cost-Benefit Analysis, Impact Evaluation, Heterogeneous Effects

1. INTRODUCTION

The strength of primary health care (PHC) is a key element for meeting the UN Sustainable Development Goals with respect to universal health coverage (UHC). As a vehicle to attain equity in health, it eases vulnerable people's access to health care services (Hanson et al., 2022). One of the most important challenges that countries around the world face in developing UHC is how to properly fund PHC. Given deeply limited public funds, it is imperative that they are spent as efficiently and equitably as possible to maximize health benefits for the majority of people (Brundtland, 2022). At the same time, the decision to shift public funds to meet health priorities has a significant political component (Hanson et al., 2022), which results in critical dilemmas for policy-makers. In this context, assessing the costs and benefits of successful experiences in PHC around the world may reveal important lessons to guide future policies and the relevance of funding them.

The Family Health Strategy (ESF –*"Estratégia Saúde da Familia"*) is the flagship PHC program in Brazil and one of the most vital branches of its public health care system, the so-called SUS: the Brazilian Unified Health System. Created by the 1988 Federal Constitution and funded jointly by the federal government, states, and municipalities, the SUS intends to be an instrument for achieving UHC in Brazil (Castro et al., 2019; Macinko et al., 2015; Paim et al., 2011). Despite huge challenges and budgetary restraints, Brazil is a global example of striving to offer public health services as part of its social contract expressed in its constitution (Hanson et al., 2022). Access to PHC in Brazil has expanded in the last 25 years, mainly through the ESF.

The ESF is a primary healthcare model that introduced a major structural change in the healthcare system in Brazil. Before the program, the assistance model was centralized and used to rely on public hospitals, which were usually overwhelmed with emergency call attendance. The ESF program placed the decentralized local health units at the core, as they have become the gateway to the Brazilian health system. The changes in the PHC modus operandi based on ESF were able to expand access and made the community health network crucial to reallocate the resources to the health system (Bhalotra et al., 2019). Although these local health units, where patients are referred to, work as operational bases for the ESF teams, they are not exclusive to the program, once these units also are used for immunization, dental services, taking inhalations, receive basic medication, etc.

The Brazilian population is highly dependent on the SUS. According to the most recent National Health Survey, only 28.5% of the population is covered by private health insurance (including dental plans). This coverage is even lower for low-income people (2.2%) (Brazil, 2019). Access to PHC has been increasing substantially in Brazil in the last 25 years, primarily through the expansion of ESF health teams (Pinto & Giovanella, 2018). The ESF is a community-based program built around multi-professional health teams, whose standard composition is one general physician, one nurse, one nursing assistant, and some local community health workers (CHWs). In addition to establishing rapport with the community, each ESF health team has the task of monitoring a defined number of households within a specific geographic area, providing acute services, promoting health through disease prevention, monitoring comorbidity, and maternal and child care (Castro et al., 2019).

Although primary care coverage has increased through the ESF in recent years, the number of visits to doctors' offices has not risen correspondingly. In 2019, approximately 60.0% of Brazilian households were registered in the ESF (Brazil, 2019), compared to 53% in 2013, when the last national health survey was conducted. Among households registered for one year or more, 38.4% received a monthly visit from a CHW (Brazil, 2019), a decrease of 8.8 p.p. compared to 2013. The share of households registered for one year or more that never received any visit from CHW jumped from 17% in 2013 to 24% in 2019. These numbers illustrate the challenges faced by Brazilian regulators in achieving the UHC proposed by the SUS in a federated continent-dimension country.

The Brazilian constitution establishes that federal, state, and municipal governments must help to finance the SUS. Municipalities must allocate 12% of their own revenue for health, basically in primary care. In addition, municipalities receive federal transfers upon participation in specific programs, and the adoption of the ESF has been its central source of funding. Therefore, the institutional design of primary care funding in Brazil devolves to municipalities, giving them the autonomy to adopt the ESF (or not), as well spending-related decisions. However, with few exceptions, Brazilian municipalities have unstable self-generated resources, making them highly dependent on transfers from the federal government to expand ESF coverage over time.

The process of implementing ESF health teams in a municipality begins after the approval of a proposal in which a manager sets an initial number of teams linked to a specific locality and population to be covered. Once the municipality starts to receive the resources referred to these initial health teams, a funding channel with the federal government is established. The funding of new health teams is conditioned on the monthly update of the Health Information Systems by the municipality; if this does not occur within 6 months, federal government resources are withheld.

A constitutional amendment (EC95/2016) enacted in 2016 established a ceiling on federal public spending until 2036, limiting the increase in expenditures on health care to account for inflation, and consequently reducing the federal share of local health care financing. Rocha et al. (2021b), for instance, projected an annual increase of 0.71% in health financing needs relative to gross domestic product (GDP) in the coming years, reaching 10.5% in 2025. The austerity measures may have adverse consequences for the future of the ESF and its main achievements (Rasella et al., 2018, 2019)[1]. The COVID-19 pandemic has worsened the situation, as available funds for PHC may become even more restricted. In this context, a cost-benefit analysis of the ESF is indispensable. This assessment must focus on the balance of the costs and benefits for Brazilian municipalities in the long run since the program was introduced in 1998. As the program has expanded over the years, the covered population and benefits have both increased, as have its costs.

The benefits of ESF have been evaluated in the literature along several dimensions, with solid evidence that the program has helped to improve several indicators (Bastos et al., 2017b; Macinko & Mendonça, 2018), including child mortality (Aquino et al., 2009; Bhalotra et al., 2019; Guanais, 2015; Macinko et al., 2007, 2006; Rocha & Soares, 2010a), mortality from heart and cerebrovascular diseases (Rasella et al., 2014), mortality from tuberculosis (de Souza et al., 2018), and mortality from amenable diseases (Diaz et al., 2022; Hone et al., 2017). Another set of studies revealed a positive relationship between ESF coverage and reduced hospitalizations from conditions sensitive to primary care (Cavalcante et al., 2018; Ceccon et al., 2014; Macinko et al., 2011, 2010).

Few studies in the health care literature have estimated the costs of the Brazilian PHC system, and even fewer have focused on the ESF. Most of the research that calculates ESF costs is rooted in case studies that used different methodologies (Bastos et al., 2017a; Brasil, 2001; Castro et al., 2000; Costa, 2016; de Sousa Barbosa et al., 2008; Santana, 2003), resulting in different cost structures, which makes a comparison difficult. Using data from 2010, Vieira and Servo (2013a) produced the latest estimate of ESF costs from a broader perspective. Their methodology assumes a *standard* ESF health team composition, and the costs are calculated through the average remuneration of each type of professional. The drawback of these approaches is that none of them account for the heterogeneity in the formats and compositions of ESF teams across the country. Additionally, the wages and hours of pro-

[1] Rocha et al. (2021b) designed several scenarios for Brazilian health financing needs, showing that financing restrictions exogenous to the health sector (in which the EC95/2016 is one of them) impose challenges on maintaining the UHC strategy.

fessionals may vary significantly by region and municipality[2], imposing major challenges to estimate a reliable value for cost.

We performed a cost-benefit analysis of the ESF program using an alternative and more up-to-date perspective, accounting for its heterogeneity in professional remuneration and in the population assisted by ESF teams across Brazilian municipalities. The former has important impacts on team costs, whereas the latter influences the program's effectiveness. To address heterogeneous remuneration, this paper was innovative by using, for the first time, a dataset containing the remuneration of professionals allocated to all ESF teams nationwide. This information was obtained upon request based on the Brazilian Access-to-Information Law (LAI). Use of this dataset allowed for a more accurate and realistic calculation of how much each ESF team costs the public treasury, providing a standard estimate to assist municipal health managers in deciding whether to expand the ESF.

With regard to the heterogeneity at the level of ESF coverage, we explored the guidelines given by the National Primary Care Policy (PNAB) to distinguish two groups of municipalities according to the proportion of their population that is registered in the program. According to the PNAB, each ESF team should be responsible for assisting approximately 3,450 people. This government "*rule of thumb*" has been in place since the program started and is normally used to estimate the ESF's coverage. The PNAB 2011 (Brazil, 2011a) established a maximum limit of 4,000 people per team but recommended an average of 3,450 per team [3]. Hence, we adopted this criterion to classify municipalities in *high* or *low intensity* if the ratio of the population to ESF health teams is below or above this threshold, respectively.

Given the character of the universal health service of the Brazilian PHC, the population to ESF health teams ratio can be seen as a measurement of PHC local supply. The underlying hypothesis is that different intensities generate different benefits with different cost-benefit ratios. On the benefits side, the assistance of more than 3,450 people per team can compromise the quality of services and affect the gains of the program. Regarding costs, more populated municipalities must deploy more health teams to serve their inhabitants; that is, they need to devote more resources to obtain the same degree of coverage to monitor

[2] An ESF team can be composed of more than one doctor. The number of each type of professional depends on the composition of equivalent working hours. For example, a team can be composed of one 40-hour doctor or two 30-hour doctors (with 40 hours per week being considered full time).

[3] The most recent PNAB (Brazil, 2017) changed this recommendation to a range from 2,000 to 3,500, but the Ministry of Health considers only the lower bound of 2,000 for financing purposes (which was previously 3,450 people)

the health of their population. As such, regarding ESF costs, the dynamics of the local market for health professionals play a relevant role in delimiting the possibilities of program's expansion within municipalities. Consequently, this affects the improvement of the population's health in the long run.

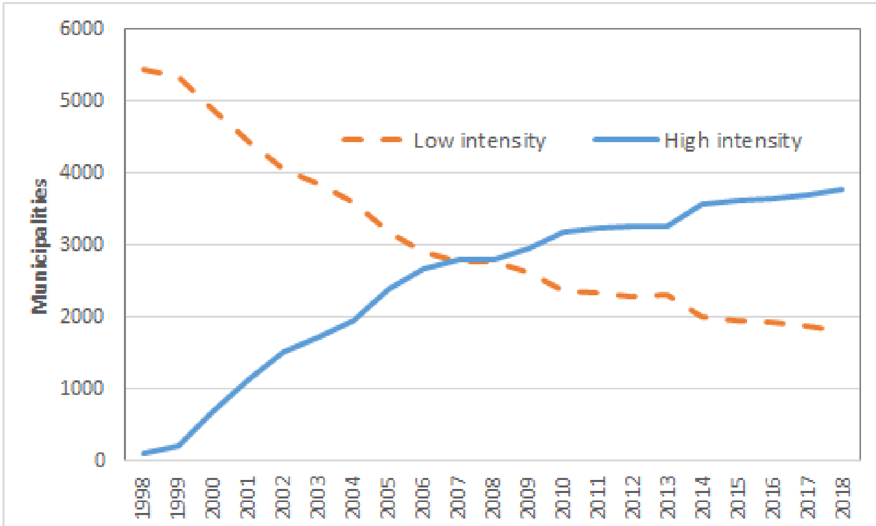

Figure 1: The distribution of Brazilian municipalities according to ESF intensity

Figure 1 shows the distribution of municipalities over time according to this criterion. In the early stages of the program, the number of municipalities with *low intensity* (i.e., a small number of deployed ESF teams relative to their population) was much higher than the quantity of municipalities classified as *high intensity*. This difference diminishes with the expansion of the ESF over time and with the growth of deployed health teams in each municipality. This process improves population welfare, as shown in the literature, regarding the impacts and benefits of the program, but it also expands the ESF's cost. The purpose of this study is to analyze the cost-benefit results of the ESF for these two groups of municipalities (*high/low intensity*) because one might expect different impacts of the program on each group at distinct costs.

Following this introduction, this paper has three more sections: Section 2 calculates the ESF's benefits, the ESF's costs and their matching, and describes the data and empirical strategy used to capture the ESF's long-term benefits. This section also outlines the strategies used to build the unique cost dataset and the approach to address the heterogeneity in the composition of ESF health teams. Section 3 presents an overview of the development of the ESF's cost and benefits by *years of exposure* to the program. The paper concludes in Section 4 with a discussion of the findings and links them to the challenges faced by Brazilian public policy in terms of primary care.

2. METHODS

We calculated the long-term costs and benefits of the ESF program using data on the expansion of its health teams since it started in 1998 (when the program's funding mechanism was established) until 2018. In sum, the progression of the number of municipalities with ESF teams over time shows the following rates: 21.2% (1,182) in 1998, 53.4% (4,523) in 2000, 81.2% (4,523) in 2003, 94.3% (5,250) in 2008, 95.4% (5,333) in 2012, and 98.4% (5,480) in 2016 (Diaz et al., 2022). However, despite its consistent expansion, the level of coverage of the ESF program varies greatly among Brazilian municipalities. In the methodology proposed here, instead of adopting a chronological approach, we calculated the costs and benefits of the ESF based on the *time of exposure* to the program in each municipality. This section describes the methodology and strategies used in this calculation.

2.1. The ESF's benefits

As the core of PHC in Brazil, one would expect the ESF to yield at least two main benefits: (1) a reduction in hospitalizations for conditions sensitive to primary care, and (2) a decrease in premature mortality from preventable diseases. Hospitalization and mortality for ambulatory care sensitive conditions (ACSCs) are health metrics that are largely exploited to investigate the access, quality, and effectiveness of health care worldwide (Caminal et al., 2004; Hossain & Laditka, 2009; Kim et al., 2019; Rocha et al., 2021a)[4]. Thus, our strategy to assess the program's benefits consists of estimating the monetary value of each avoided death or hospitalization.

The database for assessing the ESF's benefits was built from microdata on the hospitalization and mortality rates of individuals from 0 to 65 years old, aggregated by municipality and year over the period of 1998–2018, with the International Classification of Diseases (ICD-10) defined by conditions sensitive to primary care according to Alfradique et al. (2009). This resulted in 19 groups of diagnoses, as outlined in Table A.1 (Appendix A).

[4] In Brazil, the Ministry of Health carried out a study to create a list of hospitalizations for conditions sensitive to primary care, as well as a set of health conditions for which the effective application of primary care would help to mitigate the risk of hospitalization and mortality. Alfradique et al. (2009) describes the steps remaining until the completion of this classification list that was used here, as well as the diagnoses and conditions included in it.

The reason for the 65-year-old threshold is linked to the available list of conditions sensitive to primary care produced by Alfradique et al. (2009). Despite the importance to study the risk of premature deaths, there is no consensus in the literature about this concept, especially for the elderly (Hitchen et al., 2017). Life expectancy at born and the specific characteristics of each country also affect the causes of premature deaths for each age group. For these reasons, most studies treat differently the conditions sensitive to primary care according to the age groups (e.g.: Laberge et al. (2017); Magán et al. (2011)). With respect to Brazil, Alfradique et al. (2009) compile the list of conditions sensitive to primary care employed in this study, but they warn that it applies only to the population below 65 years old. To our knowledge, there are no similar studies on the population above this threshold in Brazil. Therefore, based on Alfradique et al. (2009), we've excluded the population over 65 years old, which is consistent with Brazil's life expectancy at born and with the proper list of conditions sensitive to primary care[5].

The data on hospitalizations come from the Hospital Information System of the Unified Health System (SIH-SUS) and contain the number of hospital admissions and the corresponding length of stay in days. This means that each hospitalized individual appears in the dataset according to the number of times he/she was hospitalized (e.g., if someone were admitted to the hospital twice within a year, he/she would appear twice in the dataset in that year). This database also allows one to calculate the average cost of each hospitalization using the ratio between the total value of authorized admissions (according to the unified SUS price table for procedures) and the total number of admissions (Brazil, 2021b)[6]. The data on mortality were obtained from the Mortality Information System (SIM-SUS), which contains the main cause of each death, coded according to the ICD-10 as declared by the certifying physician.

Since the establishment of ESF health teams and the program's implementation may take some time to have an impact on health outcomes (Bhalotra et al., 2019; Diaz et al., 2022; Dimitrovová et al., 2020; Rocha & Soares, 2010b), it is important to consider an empirical strategy that allows one to identify the program's immediate and lagged effects. To do so, a difference-in-differences approach that enables heterogeneous responses to length

[5] According to Alfradique et al. (2009), there is a tendency to increase the risk and length of hospitalization as age increases. Both the number of readmissions and the prevalence of comorbidities also increase, regardless of primary care. Moreover, older age can make it difficult to analyze the main cause of death, as comorbidities unrelated to primary care can also be present.

[6] The health units send the SUS's municipal or state manager's information on hospital admissions (AIH). This information is consolidated in DATASUS, containing data from most hospital admissions in Brazil.

of exposure to the program was taken while controlling for municipality-specific and year effects. This specification takes into account that ESF was implemented at different moments across various municipalities, each subject to a singular length of exposure to the program. Accordingly, the main specification is the following:

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

where $Conditions_{\,m,\,t}$ designates the mortality or number of hospitalizations for ACSCs per 10,000 inhabitants in the m-th municipality in year t and $ESF\ exposure_{\,m,\,t}^{\,j}$ denotes a dummy variable equal to one if the m-th municipality in year t had been exposed to the program for j years. φ_m represents the municipality fixed effects, τ_t is the year fixed effects, $\mu_{m,\,t}$ denotes municipality-specific year dummies, $\varepsilon_{m,\,t}$ is the idiosyncratic error term, and α, β_j, and γ denote the parameters to be estimated.

The matrix $X_{\,m,\,t}$ contains a set of municipality-level variables with the purpose of controlling for observable characteristics that may affect locals' health: (i) Bolsa Família municipal coverage, calculated as the monetary amount per capita incurred by the Bolsa Familia, the central Brazilian program of conditional cash transfer to low-income families; (ii) Mais Médicos coverage, measured as the number of physicians working on Mais Médicos solely per capita; (iii) municipal GDP per capita, to represent the income per capita of Brazilian municipalities; (iv) hospital beds per capita, defined as the supply of hospital beds held by SUS; and (v) municipal taxes per capita, defined as the municipality's own tax revenue per capita to control for institutional issues linked to the local quality of management[7]. Table 1 presents the verified effects of the period of ESF exposure on mortality and hospitalizations due to conditions sensitive to primary care, estimated with Equation (1). The key regressors are binary variables indicating whether the municipality was exposed to the ESF for $1, 2, \ldots,$ or 20 years.

The estimated coefficients suggest that for municipalities covered by the ESF for 10 years, the mortality rate for ACSCs fell by 1.07 per 10,000 inhabitants, more than similar municipalities that did not implement the program. This means a reduction of 22% relative to 1998 (4.87 per 10,000). Moreover, an average decrease of 2.97 per 10,000 people is observed in

[7]Sources: IBGE, DATASUS and FINBRA.

Table 1: Results: ESF exposure and avoidable conditions

	Preventable Mortality	Preventable Hospitalization
ESF year 1	-0.0867	-1.5028
	(0.0795)	(1.1441)
ESF year 2	-0.1605	-3.6776**
	(0.1095)	(1.8324)
ESF year 3	-0.2497*	-4.9095*
	(0.1477)	(2.6549)
ESF year 4	-0.3339*	-3.7641
	(0.1876)	(3.3872)
ESF year 5	-0.4371*	-3.4274
	(0.2440)	(4.1622)
ESF year 6	-0.5318*	-3.6659
	(0.2903)	(5.0822)
ESF year 7	-0.6422*	-4.2236
	(0.3508)	(5.9977)
ESF year 8	-0.8113**	-5.5679
	(0.4046)	(7.1165)
ESF year 9	-0.9018*	-7.5660
	(0.4661)	(8.1543)
ESF year 10	-1.0672**	-9.1676
	(0.5404)	(9.1916)
ESF year 11	-1.2317**	-10.2458
	(0.6281)	(10.4809)
ESF year 12	-1.3889*	-11.2954
	(0.7106)	(11.7277)
ESF year 13	-1.5534*	-11.1689
	(0.7949)	(13.0888)
ESF year 14	-1.7410**	-10.1907
	(0.8855)	(14.5113)
ESF year 15	-1.9042*	-9.3172
	(0.9765)	(16.0734)
ESF year 16	-2.1232**	-9.3839
	(1.0718)	(17.7638)
ESF year 17	-2.2711*	-8.0755
	(1.1654)	(19.4407)
ESF year 18	-2.5095**	-6.1085
	(1.2640)	(21.2563)
ESF year 19	-2.7329**	-2.7235
	(1.3689)	(23.2436)
ESF year 20	-2.9664**	1.8654
	(1.4826)	(25.8434)
Municipality FE	Yes	Yes
Year FE	Yes	Yes
Municipality-specific year FE	Yes	Yes
N	116707	116707

Robust standard errors clustered at the municipal level are displayed in parentheses; regressions are weighted by municipal population. Dependent variable: Deaths/hospitalizations per 10,000 inhabitants.

municipalities with 20 years of exposure, which is equivalent to 61% of the 1998 average. The estimated effect for hospitalization is -3.68 for two years of exposure to the ESF, which corresponds to 2.37% of the hospitalization rate (an average of 155.12 hospitalizations per 10,000 inhabitants in 1998) – but this effect vanishes after three years of program implementation[8].

2.1.1. Heterogeneity analysis based on program intensity across municipalities

To disentangle the heterogeneous effect of ESF intensity, Equation (1) was modified to identify the exposure time at each intensity as follows:

$$Condition_{\,m,\,t} = \alpha + \sum_{l=1}^{L} \beta_l \cdot ESF\ exposure\ to\ low\ intensity\,^{l}_{m,\,t} + \sum_{h=1}^{H} \delta_h \cdot ESF\ exposure\ to\ high\ intensity\,^{h}_{m,\,t} + \gamma \cdot X_{m,\,t} + \varphi_m + \mu_{m,\,t} + \tau_t + \varepsilon_{m,\,t} \quad (2)$$

The indicator $ESF\ exposure\ to\ low\ intensity\,^{l}_{m,\,t}$ takes a value of 1 if municipality m in year t was exposed to a low intensity of the ESF – such that each health team covers more than 3,450 people – for l year. Likewise, $ESF\ exposure\ to\ high\ intensity\,^{h}_{m,\,t}$ takes a value of 1 if municipality m in year t has been exposed to a high intensity of the ESF (3,450 or fewer people served by a team on average) for h years. All regressions control for the same abovementioned fixed effects as the main specification, including municipality fixed effects, municipality trends, and year dummies.

Figure 2 displays the estimated coefficients for preventable mortality from ACSCs with their respective 95% confidence intervals considering exposure to both high and low intensities, as defined above[9]. The estimates show that high-intensity exposure to the ESF contributes to progressive reductions in preventable mortality in the initial years of program exposure, and the effect gradually strengthens year on year. The same conclusion was not verified for low-intensity exposure. An ESF team in service of more than 3,450 people was

[8]Three robustness checks were conducted in this analysis. We first checked previous trends and found that the ESF's effect does not manifest before its implementation. Second, we checked whether our results hold within the specification without any explanatory variables from $X_{m,\,t}$. The results provide evidence that the ESF's effect is not sensitive to the inclusion of these controls. As a third exercise, we performed a placebo test to verify whether exposure to the ESF would influence specific conditions not directly linked to primary care; for example (i) thalassemia, (ii) sickle-cell disorders, and (iii) hereditary spherocytosis, which are considered inherited disorders, and we would not expect the program to have any effect on them. Indeed, the results show that exposure to the program does not have a significant effect, as expected. These estimates are available upon request.

[9]Since very few localities were exposed to the high-intensity version of the program for between 15 and 20 years, our graphs sum up such lengths of exposure as 15 years or more.

not sufficient for a municipality to sustain a significant estimate of reduced mortality in the short or long run.

Figure 3 outlines the corresponding results for avoidable hospitalizations, which were negatively associated with exposure to the program. The high- and low-intensity effects are both statistically significant, but their confidence intervals overlap. Such results do not allow us to conclude that the effect of high-intensity exposure is significantly greater than the impact of low-intensity exposure.

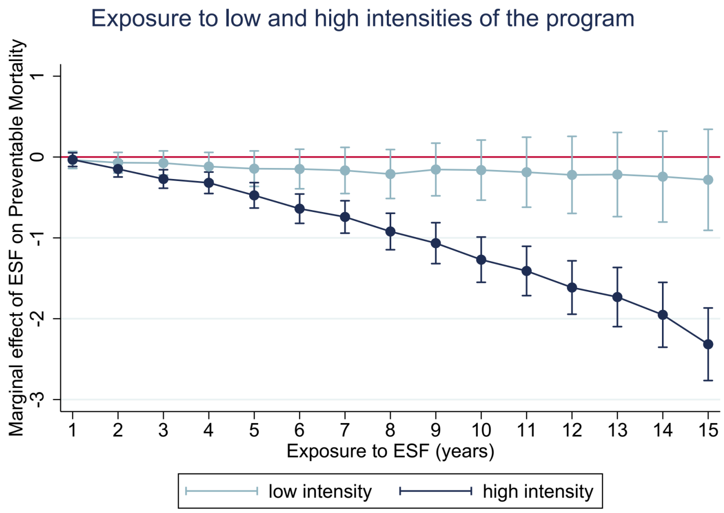

Figure 2: Marginal effect of the ESF on preventable mortality

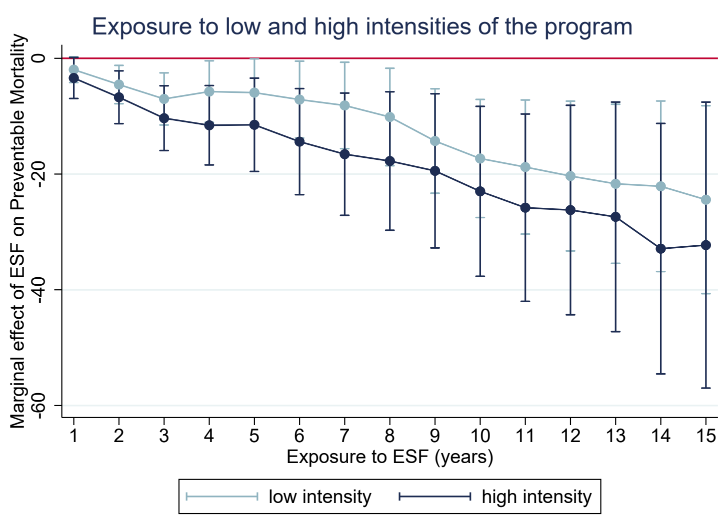

Figure 3: Marginal effect of the ESF on preventable hospitalizations

2.2. ESF costs: Heterogeneity according to program intensity

In general, the costs of the ESF program are strictly measured by expenditure on human resources for two reasons: they represent more than 70% of total costs[10], and once the costs to operate clinics and basic health units do not depend on the existence of ESF[11],those fixed costs cannot be accounted to the program. As described in the introduction, most of the studies on ESF costs focus on specific localities, so they are based on cases that poorly represent the program as a whole. The latest estimation of the ESF's overall costs employed data from 2010 and was grounded in minimal standard health team composition (Vieira and Servo, 2013a) being established as *the ideal* composition. However, neither case studies nor ideal/standard-team strategies account for the heterogeneity in the composition of health teams. This paper overcomes this limitation and accounts for ESF heterogeneity not only with respect to coverage, but also on the cost side because professional earnings vary significantly across the country. The variety of costs is due to both the definition of wages in the local labor market and the flexibility of municipal health managers to compose the health team using contracts with equivalent working hours. In this context, the computation of ESF costs is not straightforward. The following subsection describes how the dataset of costs was built. Next, we analyzed the costs of the ESF's health teams according to the program's intensity to match it with calculated benefits in Section 2.3.

2.2.1. Measuring the ESF's costs

The strategy to calculate the ESF's costs entails combining two databases: the National Health Establishments Registry (CNES) and the Annual List of Social Information (RAIS). The first contains information about health establishments, their health teams (when applicable), and health professionals. Since 2000, CNES has received information whereby each health establishment must send monthly data to the Ministry of Health, including professional personal data (e.g., age, gender, race, education level, nationality, marital status, occupation)[12], professional councils record numbers and other information), characteristics of employment connections, an establishment profile (e.g., if the health care provided is primary, medium, or high complexity, outpatient or hospital, public or private), and data for each health team (type, location, and date of implementation or cancellation)[13]. CNES

[10] See Vieira and Servo (2013a)

[11] As pointed previously, local health units are not exclusive to the ESF.

[12] According to the Brazilian Standard Occupational Classification – CBO (Brazil, 2021a).

[13] In addition to ESF health teams, the SUS includes several other kinds of health teams, such as school health teams, prison PHC health teams, mental health teams, and home care health teams. CNES infor-

is the only source that identifies public PHC establishments and provides information on workers employed on ESF teams.

The RAIS database is an administrative registry to which all establishments with or without employees report information; it contains several types of information on workers in Brazil's formal labor market, such as individual traits (e.g., age, gender, education level), type of wage contract, number of hours, remuneration and its components, indemnities or bonuses guaranteed by law, the labor contract and occupational classification for each connection). Each line in this dataset represents an employment link, so it is possible to check the remuneration of an ESF team member and whether he/she has more than one job.

The strategy to estimate the ESF program's costs and its health teams consisted of matching the CNES and RAIS datasets in 2018 using the professionals' taxpayer registry number (CPF[14]) as the individual identification key. Both identified datasets were obtained upon request in accordance with the Brazilian LAI[15]. For 2018, the full RAIS dataset reports 66.2 million employment links, including both active and inactive employment connections, on December 31st[16]. In 2018, active jobs accounted for 70.4% of all jobs, comprising 46.6 million observations, from which we only took employment links that receive payment monthly[17]; there are 43.3 million entries that include all Brazilian workers (not only health professionals).

The identified CNES database (restricted to ESF professionals) includes 472.1 thousand observations in December 2018[18]. Each ESF health professional is registered in the CNES under an occupational code that comes from the National Classification of Occupations codes (CBO) and is not exclusive to the ESF[19]. There were 1.73 million active health professionals

mation from December 2018 shows that these other types of health teams amounted to 5.8% of all health teams

[14]CPF is the Brazilian Individual Taxpayer Register, managed by the Internal Revenue Service. It is an 11-digit number whose function is to identify the individual taxpayer.

[15]Appendix B details how the Brazilian law on access to information works and how we obtained the identified datasets.

[16]Since the RAIS dataset is compiled on an annual basis, an establishment must declare whether all employment links have been settled in that year, even ones that no longer exist on December 31st. In those cases, the establishment reports the mean remuneration for the period in which the link was valid and declares that it is not active.

[17]The RAIS database has seven payment methods: monthly, biweekly, weekly, daily, hourly, by assignment, others. Since the only form of payment used by the municipalities for workers is disbursed monthly, all other options were not considered in the matching process.

[18]This number does not include professionals on oral health teams (ESFSB) because the benefits' outcomes do not account for oral health well-being; if we were to add these professionals, this database would contain 531.3 thousand observations

[19]The CBO is composed of a set of codes and titles in a hierarchical format: *large groups, main subgroups,*

(according to the selected CBO codes) on December 31st of 2018 in the RAIS dataset. From CNES, the identified individuals working on ESF health teams are matched with RAIS through their CPF to obtain remuneration. Figure 4 presents a diagram summarizing the stages of the matching process until we obtained the final sample.

For some reason, this matching process is not straightforward and has some limitations. The most relevant drawback occurs because some health professionals have more than one employment link. According to RAIS, approximately 40% of general physicians in Brazil have more than one job. The same is true for 15.4% of nurses, 13.7% of nursing technicians, and 1.4% of CHWs. When a professional has other employment links in addition to working for the ESF, he/she yields more than one entry in RAIS and CNES (but only if this additional link is in a health establishment).

To determine an accurate cost for ESF health teams, we must ensure that the remuneration we are getting from RAIS (through matching) truly corresponds to the payment for work on an ESF team. Following the path described in Figure 4, after matching the CNES and RAIS datasets (boxes (A) and (B)), we used the CBO code to check for possible mismatches among the linked sample of CNES-RAIS. This procedure assumes that the matched observation in which the health professional presents the same CBO in both datasets corresponds to the ESF employment link.

subgroups, base groups, occupations (Brazil, 2021a). In this study, we used codes at the level of *base groups* since it is the level that contains the minimum professional training to work on primary care teams. Then, the CBOs used were 2231, 2251, 2252, and 2253 for doctors, 2235 for nurses, 3222 for nursing technicians, and 5151 for CHWs.

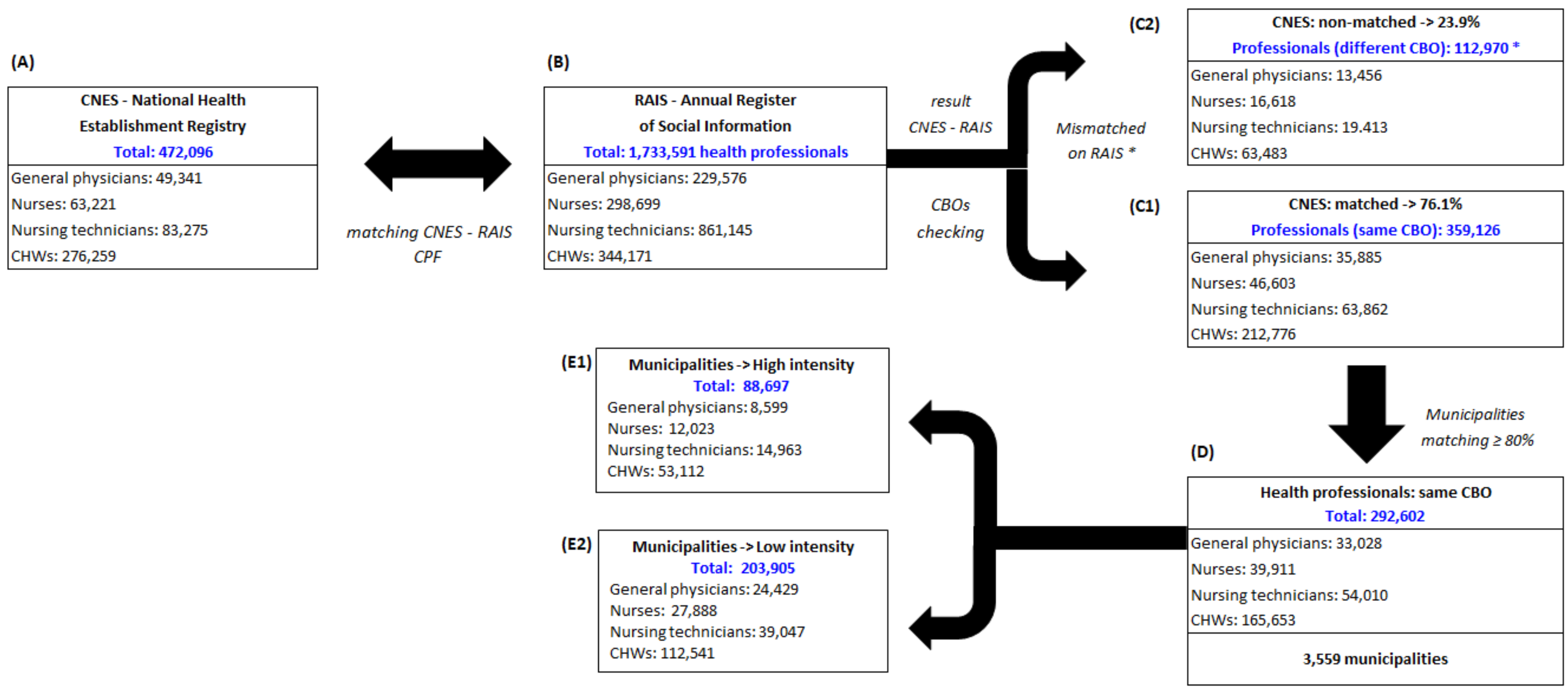

Figure 4: Process of matching the CNES-RAIS datasets

Figure 4 shows that after checking based on the CBO, we obtained the matched sample (box (C1)) that corresponds to 76.1% of all 472.1 thousand ESF workers and the mismatched sample (box (C2)) in which the ESF professional is found at RAIS with a different CBO from the one declared in CNES. The matched sample maintains the same distribution of ESF workers among the categories of professionals observed in the original CNES data[20]. The lack of pairing of 23.9% ESF professionals highlights two issues: (1) a potential *selection* of matched observations and (2) the limitation in the calculation of total ESF expenditure.

Table 2 displays the distribution of ESF professionals[21] according to the outcome obtained by the CBO check. There are three sources of CBO mismatch between CNES and RAIS: (i) missing information of the CBO in the RAIS dataset; (ii) declaration of a different CBO code in the RAIS *within* an ESF health team; and (iii) declaration of a different CBO code in the RAIS not related to an ESF health team.

Table 2: Distribution of ESF professionals from the CNES resulting from the matching process

	ESF professional (CBO from CNES)			
Results from CNES-RAIS matching (CBO check)	General physician	Nurse	Nursing technician	CHWs
Matched CBO CNES-RAIS (%)	72.7	73.7	76.7	77.0
Missing CBO information in the RAIS (%)	0.4	0.4	0.5	0.8
Mismatch within ESF's CBO (%)	1.8	7.0	5.4	1.4
Mismatch outside ESF's CBO (%)	25.0	18.9	17.4	20.7
Number of ESF professionals in the CNES	49,341	63,221	83,275	276,259

To evaluate the relevance of these sources as a potential problem of selection bias, one must note that the responsibility to fill up CNES and RAIS information comes from different administrative bodies: Whereas the CNES is declared by the managers of the health establishment, RAIS information comes from the Secretary of the Treasury (for public employees) or from the administrative-financial branch for health professionals that work in private establishments. This is why the CBO's information that comes from RAIS has less accuracy, which is reflected in the first two sources of imbalance between RAIS and CNES CBOS's codes[22], which together include 3.6% of all ESF professionals.

[20]The set of ESF professionals contains 10.5% doctors, 13.4% nurses, 17.6% nursing technicians, and more than half (58.5%) are CHWs.

[21]These professionals are defined by their CBO in the CNES dataset.

[22] Regarding the mismatch within the CBOs of ESF professionals, we identified that in the RAIS dataset,

Table 2 also indicates that the principal cause of imbalance between the CNES and RAIS refers to the incompatibility of CBOs for the same professional (20.3% of ESF professionals), which means that we found the CPF of the ESF professional, but linked it to another occupational classification, rather than the one used by the program. Importantly, the distribution of ESF professionals in this subsample is very close to the total set of ESF professionals[23]. In this subsample, except for physicians, we found that the mismatched CBO was concentrated in 3 large specific occupational groups: (i) members of the public branch, directors of organizations of public interest and of companies, managers; (ii) mid-level technicians (basically in the biological, biochemical, and health fields); and (iii) administrative service workers[24]. For these cases, we cannot assume that remuneration refers to the ESF professional.

Our goal was to calculate the costs of an ESF health team. Since we could not give up 24% of the total cost with ESF professionals, we adopted a strategy that minimizes the need to impute the remunerations that we could not obtain for the same CBO. We lined up 5,570 municipalities according to their percentage of matching and chose the threshold of 80%. Box D in Figure 4 shows that this left us with 3,559 municipalities, whose distribution is similar to the effective distribution of Brazilian municipalities across the five large regions[25].

Hence, the resulting sample is representative enough of Brazilian municipalities as a whole[26]. The data for these 3,559 municipalities with high matching rates have received the imputation for the remuneration missed according to the average wage of each professional category[27], which enabled the calculation of reliable costs for an ESF health team. This strategy differs from existing approaches in the literature on program costs because instead

some of them were listed with CBOs of another category. This happens particularly to nurses and nursing technicians, who were identified with CBOs of other professionals, inclusive ones from oral health teams, specifically dentist (CBO 2232) or dental technician (CBO 3224).

[23]The subsample of mismatched outside ESF's CBO revealed the following: 12.9% are doctors; 12.4% are nurses; 15.1% are nursing technicians; and 59.6% are CHWs.

[24]With a focus on administrative functions (CBO 4110) and public assistance representatives (4221). For ESF physicians, the divergent CBOs are concentrated in (i); (iii) and the major groups related to teaching, research, science, and arts professionals.

[25]The effective distribution of Brazilian municipalities is 8.1% in the north, 32.2% in the northeast, 29.9% in the southeast, and 8.4% in the midwest, respectively. The set of 3,559 municipalities with 80% matched is: 7.9%; 28.1%; 33.0%; 25.0%; and 6.0%.

[26]Importantly, with the exception of Palmas in the northern state of Tocantins, and Teresina in the northeastern state of Piauí, all state capitals are in the matched sample, and all of them present low intensity.

[27]Box (D) in Figure 4 shows the number of observations for the matched sample with the same CBO. The data matched with different CBOs amounted to 77,111 professionals who received the imputation of the remunerations, as follows: 5,201 general physicians; 8,042 nurses; 10,764 nursing technicians; and 53,104 CHWs. The imputation involved using the average wage of each professional category on December 31st 2018.

of assuming a standard composition of teams, we summed up all the remunerations of ESF professionals in the matched 2018 CNES-RAIS data to calculate the program's total cost in each sampled municipality, and we divided the resulting value by the number of ESF health teams. This strategy allowed us to determine the average monthly cost of an ESF health team for the full matched sample and for groups of municipalities according to program intensity, as previously defined.

2.2.2. The ESF's costs and program intensity

Table 3 summarizes the number of municipalities, the total number of ESF health teams, and the average of the matched sample according to ESF intensity. The number of municipalities in the matched sample corresponds to 65.8% of the country[28], whereas the number of ESF teams remains at 75.0% of all deployed health teams. The municipalities with high intensity predominate in the database (confirming the picture shown in Figure 1), and the majority of ESF teams are concentrated in low-intensity municipalities. There is strong closeness between the matched sample and the information for the whole country: The proportions of low- and high-intensity municipalities are 32.4% and 67.6% in Brazil, respectively, compared to 36% and 64% in the matched sample. This closeness also applies to the average health team. This similarity confirms the possibility of carrying out the analysis according to these categories of the local supply of ESF teams.

Table 3: Number of municipalities, ESF health teams, and the average ESF health team for the matched sample by ESF intensity

Level	Number of municipality	ESF health-teams number	ESF health-teams average
Total Brazil	5,407	43,705	8.1
- *Low-intensity*	1,750	24,813	14.2
- *High-intensity*	3,657	18,892	5.2
Matched sample ($\geqslant$ 80%)	3,559	32,776	9.2
- *Low-intensity*	1,281	21,037	16.4
- *High-intensity*	2,278	11,739	5.2

Figure 5 indicates that the 64% of *low-intensity* municipalities have a population with over 20 thousand inhabitants, whereas 56% of *high-intensity* municipalities have at most half

[28] Although the country has 5,570 municipalities, in 2018 there were 163 that did not implement the ESF program. For this reason, Table 3 displays a total of 5,407 municipalities.

of this size (10 thousand people). Municipality size is a key feature in the cost trajectory for two reasons: It directly affects the number of professionals needed to cover the population, and the professional wage is higher in large cities in Brazil.

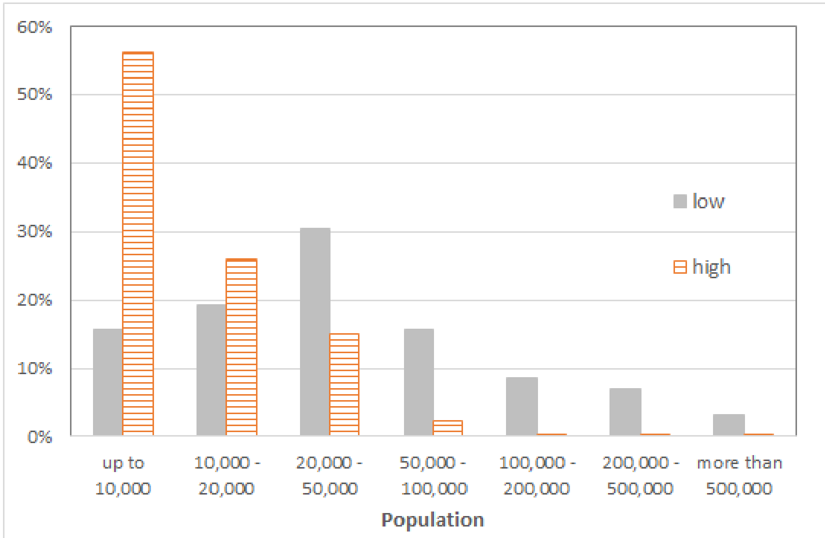

Figure 5: Municipality size by ESF intensity – 2018

The wage difference between ESF professionals from high- and low-intensity municipalities indicates the difficulty that populous municipalities face in expanding the program, despite their ability to obtain more resources by themselves. Table 4 presents the average monthly wage (in 2020 values) of each type of ESF professional from the matched sample based on the procedure described above. The calculation of social charges upon each basic remuneration follows Vieira and Servo (2013b).

Table 4: Remuneration of ESF professionals in the matched CNES-RAIS sample by program intensity

		Basic remuneration†			Including social charges ‡		
Professional	Currency§	All	Low	High	All	Low	High
Physician	BRL	11,789	12,449	10,536	15,574	16,445	13,918
	US$	2,287	2,415	2,043	3,021	3,190	2,699
Nurse	BRL	4,451	6,197	3,922	5,880	8,186	5,182
	US$	863	1,202	761	1,141	1,588	1,005
Nursing technicians	BRL	1,971	2,743	1,758	2,603	3,624	2,322
	US$	382	532	341	505	703	450
CHW	BRL	1,563	1,706	1,487	2,064	2,253	1,964
	US$	303	331	288	400	437	381

† Considering only the remuneration paid to identified professionals (CNES-RAIS) in December (active) in 2018.
‡ Following Vieira and Servo (2013b), the social charges applied to the monthly salary represent 32.1%.
§ Converted to US dollars by the commercial exchange rate for purchases at the end of 2020 (BRL 5.20/US$).
Source: Brazilian Central Bank

Table 4 indicates that the four categories of professionals on ESF health teams have higher remuneration (on average) in municipalities with low intensity: 18.2% for doctors, 58% for nurses, 56% for nursing technicians, and 14.7% for CHWs. These values in Table 4 were used to impute the wages for the portion of ESF professionals who did not obtain a match in the RAIS (different CBOs). After imputation, we obtained the average cost of an ESF health team.

Table 5: Average monthly cost of ESF health teams, by municipality intensity, in values from 2020

		All	By intensity	
Monthly cost	Currency§	Total	Low	High
Basic remuneration	BRL	44,217	46,784	26,982
	US$	8,576	9,074	5,233
Including social charges	BRL	58,411	61,802	35,643
	US$	11,329	11,987	6,913

§ Converted to US dollars by the commercial exchange rate for purchases at the end of 2020 (BRL 5.20/US$).
Source: Brazilian Central Bank

Table 5 points out that the estimated average cost of an ESF health team is BRL 58,411 (US$11,329); this value differs between groups of municipalities. The average cost is, on average, 42.3% lower in high-intensity municipalities than in low-intensity ones. This difference arises from the gap between salaries in small towns and in large cities in Brazil because the population-to-ESF team ratio is higher in the latter than in the former. This reality represents a challenge to scale up the ESF program in the most populous municipalities, thus affecting the expansion of the program's coverage and, consequently, obtaining its benefits. These three average costs for an ESF health team were used to calculate the path of the program cost from 1998 to 2018. Importantly, since the benefits are obtained according to *years of exposure*, the computation of ESF costs chronologically (year by year) is not essential to matching both.

2.3. Matching costs and benefits

This subsection evaluates the costs and benefits of the ESF program. The empirical strategy to compute the benefits of the ESF (subsection 2.1) involves reporting results by *years of exposure* to the program, which should not be interpreted in a chronological sense since different municipalities joined the ESF at different times. The rationale behind this strategy relies on the purpose of the ESF, which targets prevention and the provision of basic health, so one would expect the effects on the population to come with a lag. The results show that localities with more years of exposure to the ESF, particularly under high intensity, as previously defined, have greater benefits in terms of preventable mortality and hospitalization (see Figures 2 and 3). Therefore, it is necessary to accumulate the estimated ESF costs by *years of exposure* to the program in order to compare them with the benefits.

To perform this calculation, one assumes that the monthly costs of ESF health teams estimated in Table 5 are independent of the *years of exposure to the ESF*[29]. Then, the accumulation of ESF costs by *years of exposure* depends on the number of ESF health teams at each of these levels.

The computation is straightforward:

1. From the sample used to estimate the benefits (which includes municipal data for the 20 years of the program since its introduction in 1998), the number of ESF health teams was summed up by groups of years of exposure, whose range is 1 to 20.
2. The number of ESF health teams calculated in the previous step was accumulated according to the number of years of exposure to obtain the total number of teams linked to the benefits at each level of time of exposure.
3. For each group, the value obtained in Step 2 was multiplied by the annual cost of each

[29]In 2018, most Brazilian municipalities (76.7%) had more than 15 years of exposure; the other ones were distributed between 11 and 15 years (17.5%), 6 and 10 years (3.2%) and 1 and 5 years (1.8%). There were also 44 municipalities that did not join the ESF).

team, as calculated in the previous subsection (Table 5)[30].

Steps 1–3 were carried out for the entire country and separately by sets of municipalities according to ESF intensity (low and high). Hence, we obtained three cost curves (low/high intensity and general cost) according to years of exposure to the program. In this way, we derived the estimated costs for the full period of the program (1998–2018) in 2020 values.

To compare the estimated costs with the predicted benefits of the ESF, it is necessary to monetize the reduction in hospitalizations and mortality caused by the program. With respect to the former, the gain is measured by the savings in the costs of prevented hospitalization as a consequence of the ESF according to the mean value of reimbursement by the SUS of the Hospital Admission Authorization (AIH) in 2018, calculated from the SIH-SUS dataset[31]. The value of reducing deaths, on the other hand, is calculated according to the value of a statistical life[32] (VSL) estimated by Viscusi (2020) to Brazil, whose methodology is described in Viscusi (2019).

The value of avoided hospitalizations (VH) for years of exposure i, $i = \{1, \cdots, 20\}$, and intensity j, $j = \{Low, High\}$, was calculated according to the following expression:

$$VH_{ij} = \frac{POP_{ij}}{10,000} * MEH_{ij} * DV_j * Length_j \tag{3}$$

where POP_{ij} is the population of the group of municipalities under years of exposure i and intensity j, MEH_{ij} is the marginal effect of the ESF on hospitalizations according to the years of exposure i and intensity j (Figure 3), DV_j is the daily value of hospitalizations for intensity group j, and $Length_j$ is the average length of stay calculated for intensity group j.

Likewise, the value of avoided mortality (VM) for years of exposure i, $i = \{1, \cdots, 20\}$, and intensity j, $j = \{Low, High\}$, was calculated as follows:

$$VM_{ij} = \frac{POP_{ij}}{10,000} * MEM_{ij} * VSL_{Brazil} \tag{4}$$

where POP_{ij} is the population of the group of municipalities under years of exposure i and

[30]The annual cost corresponds to the monthly value multiplied by 12 months: US$ 143,842 for the low-intensity group, US$ 82,682 for the high-intensity group, and US$ 135,949 for the full sample.

[31]http://www2.datasus.gov.br/DATASUS/index.php?area=060502

[32]According to Kniesner and Viscusi (2019), *"the value of a statistical life is the local tradeoff rate between fatality risk and money. When the tradeoff values are derived from choices in market contexts, the VSL serves as both a measure of the population's willingness to pay for risk reduction and the marginal cost of enhancing safety. Given its fundamental economic role, policy analysts have adopted the VSL as the economically correct measure of the benefit individuals receive from improvements to their health and safety"*.

intensity j, MEM_{Mij} is the marginal effect of the ESF on mortality at years of exposure i and intensity j (Figure 2), and VSL_{Brazil} is the VSL for Brazil (Viscusi, 2019, 2020).

Finally, the monetary net benefit (NB_{ij}) of the ESF for groups of years of exposure ($i = 1, \cdots, 20$) and intensities ($j = \{Low, High\}$) is given by:

$$NB_{ij} = VH_{ij} + VM_{ij} - C_{ij} \tag{5}$$

where C_{ij} is the cost of the ESF for the group of municipalities under i years of exposure and intensity j, calculated according to steps 1–3 above.

Table 6 reports the parameters used to monetize the benefits of the ESF. The daily value of hospitalizations was calculated at approximately $41, with the average length of stay varying from 4.28 in high-intensity municipalities to 6.02 in low-intensity ones. Highly complex hospital procedures are concentrated in large cities, which may explain the difference.

Table 6: Parameters to monetize the benefits of the ESF program

Factors	Intensity		Full
	Low	High	sample
Hospitalizations†			
- Daily value (US$)	41.12	41.02	41.07
- Length of stay (days)	6.02	4.28	5.47
Mortality			
- Value of a statistical life, in US$ (VSL)‡	2,877,600.00		

† Data from SIH-SUS (average of 2018), converted to US dollars according the commercial exchange rate for purchases at the end of 2020 (BRL 5.20/US$). Source: Brazilian Central Bank.
‡ From Viscusi (2019, 2020).

It is important to stress that the long-term trajectories obtained for the ESF's costs and benefits according to the *years of exposure* contain implicit assumptions that impose limitations on the final cost-benefit outcome.

On the cost side, the caveat relies on the assumption that the cost of the ESF professional in a given year does not depend on how long the municipality has been in the program (*years of exposure*). This means that any possible general equilibrium effects were not considered, i.e., the impact of ESF on the health workers' job market as a whole. Such effects would appear if health professionals' earnings were to respond to the program's expansion over time and throughout national territory. That is, one might assume that the potential increase in the demand for these types of workers as the program grows larger would not lead to imbalances in the local labor market for health professionals. This point is relevant due to the sizable shortcoming in the supply of physicians in some parts of the country (particularly the poorest states, mostly in the northern regions), as most of this labor force is concentrated in state capitals (Costa et al., 2019).

In the Brazilian context, this limitation further underscores the importance of accounting for the heterogeneity of ESF teams[33]. Additionally, as the salary data refer to the last year of the analyzed period (2018) and there may have been pressure to raise wages due to the increased demand for health professionals driven by the program over time, the calculated costs may be overestimated, since the salaries imputed for the previous years tend to be higher than those actually practiced at the time.

3. RESULTS

The trajectories of costs and benefits calculated according to the methodology previously exposed are displayed in the following figures. Figure 6 outlines the behavior of the program's accumulated costs and benefits according to the years of exposure for the full sample of municipalities. Regardless of the length of exposure, the monetary benefits outweigh the costs, and this difference reaches a maximum between 16 and 18 years from the beginning of the program.

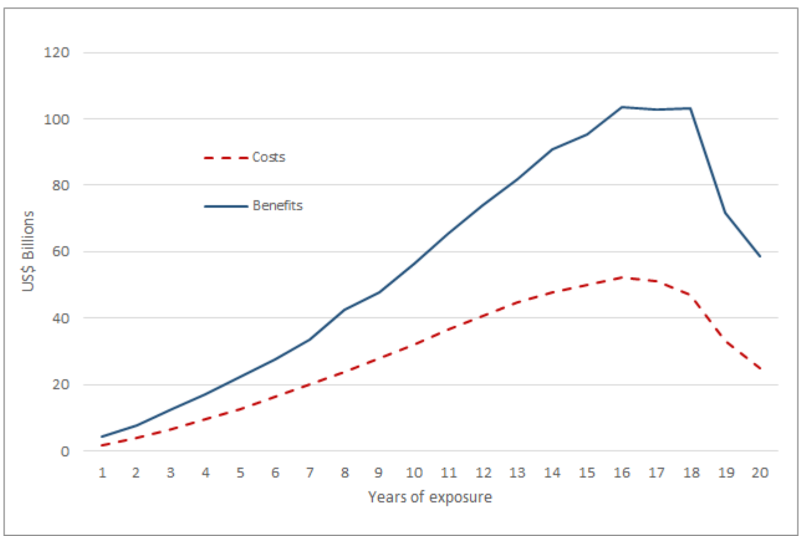

Figure 6: Costs and benefits by duration of exposure – ESF

[33]The imbalance of physicians is difficult to note given the practice of intermunicipal agreements to mutually share the full-time work of the same professionals (especially in small cities). Due to the large amount of missing data for the variable of hours worked in the CNES, it was not possible to count the equivalent hours in each municipality.

When the analysis is performed separately for municipalities with low and high ESF intensity, significant heterogeneity is observed. Figures 7 and 8 show the behavior of the program's costs and benefits for each group. For low-intensity municipalities (Figure 7), the costs outweigh the benefits regardless of the years of exposure to the program. The gap is greatest at 16 years and decreases thereafter. In contrast, for municipalities where less than 3,450 people are covered by each ESF health team (high intensity, Figure 8), the costs outweigh the benefits by up to 4 years of exposure; they even out between years 5 and 6 and after 18 years of exposure, but within this range, the benefits outweigh the costs by 22.3% on average.

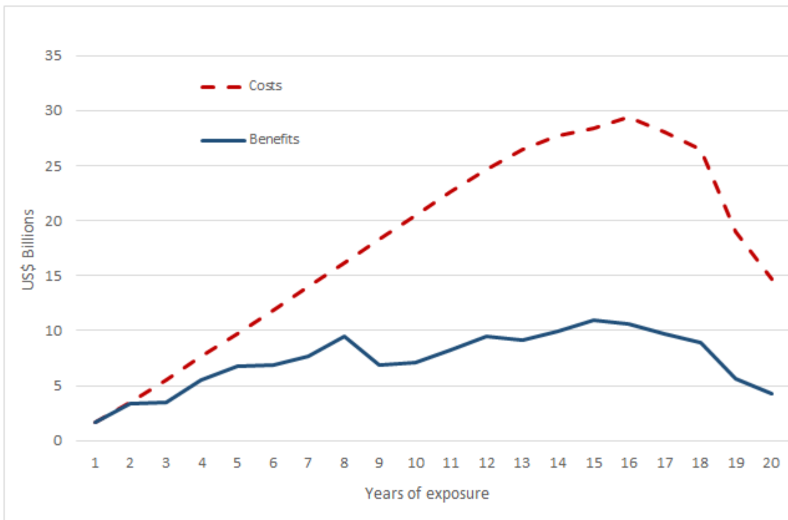

Figure 7: Costs and benefits by duration of exposure – low intensity

It is important to highlight that several municipalities changed their intensity level over time as the program expanded (as shown in Figure 1). For this reason, the evolution of costs and benefits should not be interpreted chronologically. As a municipality hires more health teams, its cost increases, but the benefit will also be greater if the municipality's coverage allows each team to cover 3,450 people or fewer. However, if the enlargement of ESF teams is insufficient to adequately serve the population, the benefits will fall short of the program's potential. The difference in cost-benefit results for the ESF in the two groups of municipalities can be attributed not only to the difference in terms of benefits, but also to the large discrepancy in the ESF's costs. Low-intensity municipalities are the most populous, paying higher wages to professionals (as seen in Table 4). Moreover, the number of ESF health teams is higher in such localities, and each team contains, on average, two more professionals than the high-intensity municipalities, i.e., one additional nurse and one additional CHW.

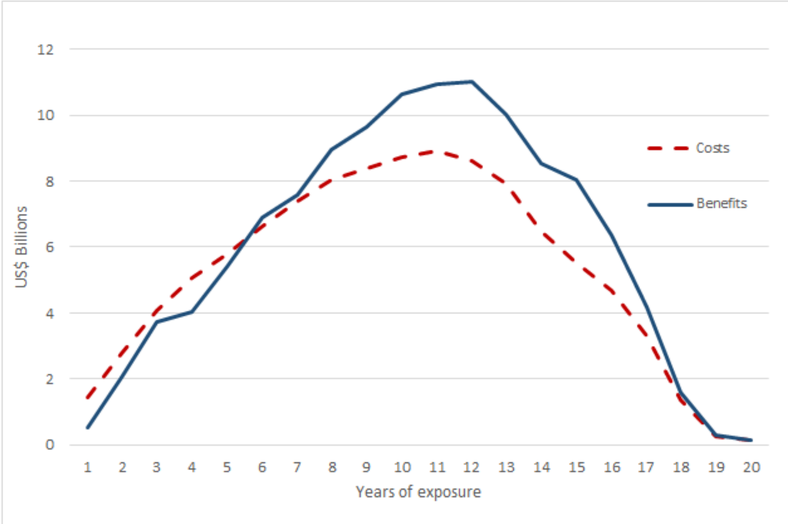

Figure 8: Costs and benefits by duration of exposure – high intensity

Despite the heterogeneity, the average result implies that the net benefit of ESF is positive, which justifies the program's expansion, mainly toward an increase in intensity, i.e., reducing the number of people covered by each health team. This strategy would increase the ESF's benefits (reducing deaths and hospitalizations) more than proportionally to its costs.

4. DISCUSSION

The ESF is the most important PHC program in Brazil and, over two decades of gradual expansion, has generated undeniable benefits in terms of reducing deaths and hospitalizations from relevant comorbidities sensitive to primary care. Notwithstanding the substantial focus on benefits, very few studies have paid attention to the costs, and even fewer have sought to complete a cost-benefit analysis of the ESF. This study fills that gap. Going beyond the costs of a "representative standard ESF team", it uses a strategy to cope with the diversity of realities in primary care throughout Brazil. The methodology is centered on "years of exposure", which made it possible to incorporate the program's dynamics to capture the accumulated benefits and costs.

This innovative procedure accounts for the program's heterogeneity along two dimensions: (1) the differences in the remuneration of ESF professionals and (2) the differences in the intensity of the program with respect to the population covered by ESF health teams across Brazilian municipalities. To the best of our knowledge, this is the first time that this strategy has been adopted to estimate the costs and benefits of the ESF, and it contributes to the understanding the program's dynamics according to the time of exposure. The supply of health teams proved to be relevant for guaranteeing benefits through reducing mortality from conditions sensitive to primary care. Thus, beyond the binary indicator of exposure to the program, the number of health teams in the population is a key element of the policy.

The results indicate that the ESF overall is a net benefit, i.e., the monetized value of the avoided deaths plus the costs saved by avoiding hospitalizations outweigh the program's costs over time. However, in detail, the ESF's cost-benefit ratio suggests that the benefits do not outweigh the costs in populous urban localities (including metropolitan areas) in which the intensity of coverage is low. On the other hand, the cost-benefit ratio implies that the benefits outweigh the costs in small cities, mainly after five years of exposure, which is a very encouraging conclusion given that such locations tend to have less developed hospital infrastructure.

This study shows that the threshold of 3,450 people per team is an important parameter when determining the ESF's cost-benefit ratio, as it directly influences the program's scale, and consequently the benefits and costs for municipalities. Although we identified substantial heterogeneity in costs and benefits, it is undeniable that the program has been very successful, on average, over the last two decades when both costs and benefits are taken into account.

Regarding public policy on primary care, the ESF intensity should be increased according to the terms defined above. Therefore, the relevant intensity heterogeneity in the dynamics of costs and benefits represents a challenge for financing the program's expansion. General incentives, or even those intended to improve local ESF health teams' productivity, could prove difficult for low-intensity municipalities.

Of course, this study has some limitations. First, on the benefits side, the outcomes were restrained to preventable hospitalizations and deaths. As a broad initiative that aims to promote health through primary care, the ESF offers other direct and indirect benefits that cannot be monetarily measured and which, consequently, were left out of this paper. There is evidence that the program also helps to improve individual biomarkers (Postali et al., 2021), self-assessed health (Ferreira-Batista et al., 2022), immunization (de Araújo Veras et al., 2020), and other preventive behaviors (Macinko et al., 2015). These are intermediate benefits whose measurement is challenging but may influence mortality and hospitalization outcomes. Second, with respect to costs, it was not possible to identify 100% of the professionals working for the ESF due to the degree of matching between the RAIS and CNES databases. Additionally, possible previous general equilibrium effects in the health job market due to the program were not taken into account, i.e., the expansion of ESF may have increased the average wage of health workers over time. Since we backwardly input the 2018 values for remuneration, the past wage values may be lower than we calculated. Joining both sides, our results underestimate the actual benefits and possibly overestimate actual past costs, which reinforces our general conclusion that the ESF pays off in the long run. Nonetheless, we believe we have taken an important step toward understanding the long-term value of primary care in a developing economy such as Brazil after years of exposure to a nationwide strategy of primary care.

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Appendix A. Premature Mortality – ICD 10 Definitions

Table A.1: Conditions sensitive to primary care – ICD 10 definitions

Categories:	ICDs 10
1) Immunizable 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**

Appendix B. Brazilian Access-to-Information Law

The data on the identified RAIS and the identified CNES were both obtained through LAI Brazil (2011b), which regulates the right to access data and information held by the public sector in Brazil, including the three federal entities. The request to assess restricted data is submitted on an integrated platform available electronically at the following address: https://www.gov.br/acessoainformacao/pt-br. The request generates a case number that is analyzed by the competent authorities. Once approved, a term of commitment is signed. Both datasets contain personal information (name and CPF) of ESF professionals, so access was granted by signing terms of confidentiality and responsibility. In these documents, researchers and institutions are committed to maintaining the confidentiality of personal data and protecting access to this information and to using it for research only.

The identified RAIS was obtained through an agreement between the Faculty of Economics, Management and Accounting/University of Sao Paulo and the Ministry of Economics. This agreement contains a confidentiality clause, according to which the faculty is forbidden from sharing the dataset and is committed to using it for research only.

The identified CNES was obtained directly from the Brazilian Ministry of Health (Process #25000.002484/2021-95) by signing a confidentiality agreement between the authors of this paper and GAAD (Data Analysis and Administration Management from the Ministry of Health). For this reason, this dataset cannot be shared.