Impact of ESF coverage on individual health: evidence from laboratory tests

Fernando Antonio Slaibe Postali [*] Maria Dolores Montoya Diaz [†]
Natalia Nunes Ferreira-Batista[‡] Adriano Dutra Teixeira[§]
Rodrigo Moreno-Serra[¶]

Resumo

O objetivo deste artigo é utilizar os resultados dos exames laboratoriais realizados pela Pesquisa Nacional de Saúde 2013 (PNS 2013) para investigar como o programa de Estratégia de Saúde na Família (ESF), o maior programa brasileiro de atenção primária, afeta a saúde individual. Uma base de dados de cross-section foi criada ligando os microdados da PNS 2013 aos resultados destes exames laboratoriais. Utilizam-se medidas de cobertura domiciliar e regional. A medida de cobertura domiciliar é estar registrado no ESF por mais de um ano e o número de visitas recebidas pelo domicílio nos doze meses anteriores. A medida de cobertura regional é dada pelo número de equipes do ESF por 10 mil habitantes implementadas na região metropolitana ou no estado. Empregamos modelos probit para estimar a relação entre a cobertura do ESF e a probabilidade de resultados laboratoriais anormais, controlando-se para a disponibilidade local de infraestrutura de saúde e um rico conjunto de características individuais e domiciliares provenientes da PNS 2013. Os resultados sugerem que a ampliação da cobertura do ESF está ligada a um decréscimo da probabilidade de resultados anormais para marcadores sanguíneos de anemia e falência renal. Hipertensão arterial, medida durante a pesquisa, parece negativamente correlacionada à cobertura do programa. Marcadores sanguíneos de colesterol e diabetes mellitus não possuem relação clara com a cobertura do ESF. A intensidade do ESF é importante para a dengue: a probabilidade de presença de anticorpos desta doença é negativamente correlacionada com o número de visitas anuais recebidas pelo domicílio, mas não correlacionado com a cobertura metropolitana.

Palavras-chaves: Atenção Primária à Saúde. Exames médicos laboratoriais. Probit. Avaliação de Impacto.

Área ANPEC: Área 12 - Economia Social e Demografia Econômica

[*]Corresponding author, Departamento de Economia - FEA/USP. E-mail:postali@usp.br
[†]Departamento de Economia - FEA/USP. E-mail: madmdiaz@usp.br
[‡]Fipe - Fipe Foundation Institute for Economic Research, Sao Paulo. E-mail: natalia.batista@fipe.org.br
[§]Institute of Economic Research , University of Sao Paulo. E-mail:adrit@usp.br
[¶]Centre for Health Economics, University of York. E-mail: rodrigo.morenoserra@york.ac.uk

Abstract

The goal of this paper is to use the laboratory blood tests carried out during the National Health Survey 2013 (PNS 2013) to investigate how the Family Health Strategy (ESF), the largest Brazilian primary care program, affects individual health. A cross-sectional dataset links the PNS 2013 survey data with the blood marker results. Both household and regional measures of coverage are used. The household measure of coverage is being registered in ESF over a year and the number of visits received in the previous twelve months. The measure of regional coverage is the number of deployed ESF teams by 10 thousand inhabitants within the Metropolitan Area or within the state. We use probit models to estimate the relationship between ESF coverage and the likelihood of abnormal laboratory test results, controlling for the local availability of health facilities and a rich set of individual and household characteristics coming from PNS 2013. The results suggest that broader ESF coverage is linked to a decrease in the likelihood of abnormal blood marker results for anemia and kidney failure. High blood pressure, measured during the survey, seems to be negatively related to the program's coverage. Blood markers for cholesterol and diabetes do not have any clear relationship with ESF coverage. The intensity of ESF coverage matters: the likelihood of the presence of Dengue's antibodies is negatively correlated with the number of ESF visits received by the household, but not with the Metropolitan ESF coverage.

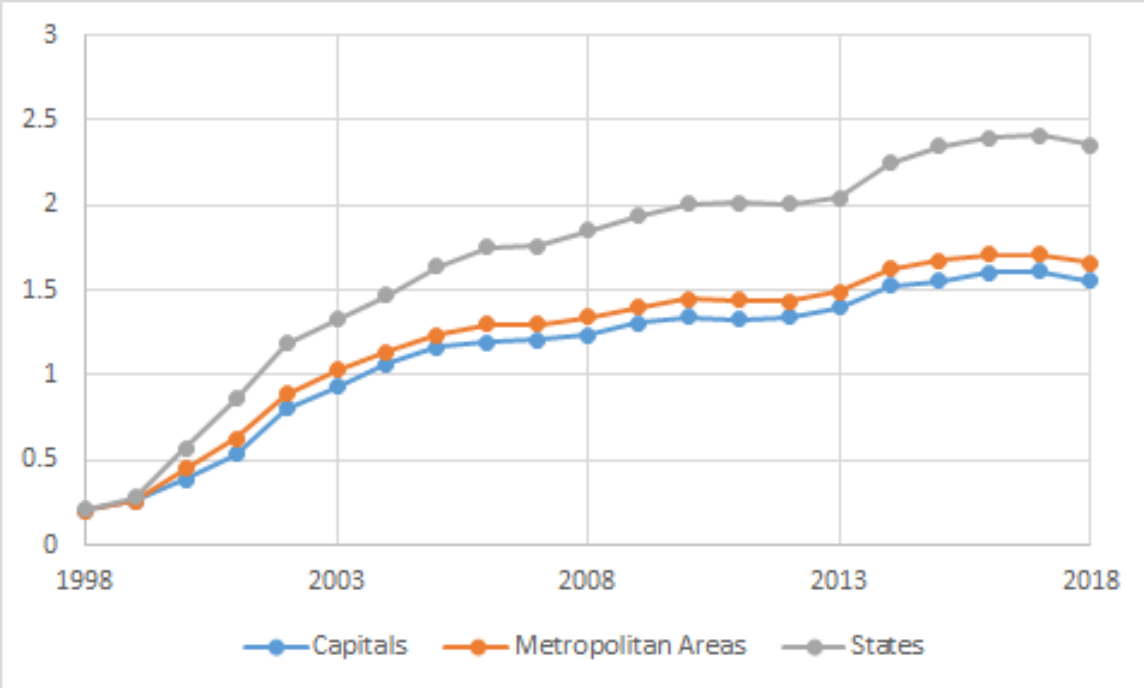
Key-words: Primary care. Clinical laboratory tests. Probit. Impact evaluation

JEL Codes: I18, C13

1 Introduction

The Family Health Strategy (ESF) is the largest Brazilian primary health care program. Launched in 1993 under the name of Family Health Program, the ESF spread gradually to the Brazilian Municipalities over the last two decades as an strategy to strengthen the basic attention in Brazil. The program is structured through health teams composed of one physician, one nurse, one auxiliary nurse, and four to six community health agents. Basically, the health agents are responsible for periodic home visits to locals to assess their general health conditions and, if necessary, the patient is referred to outpatients' clinics, called Basic Unit Health, where the rest of the team is based. The number of teams increased gradually over the last two decades, with priority to small and poor Municipalities, as Figure (1) shows. It brings the evolution of the average number of ESF teams by 10,000 inhabitants separated by States, Metropolitan Areas and Capitals in Brazil.[1]. The largest Brazilian cities (capitals) and the Metropolitan Areas both present lower coverage than the state average.

Figure 1 – Mean coverage of ESF, evolution in #teams per 10 thousand people



Most of the existing literature assesses the impact of ESF[2], finding evidence that it succeeded in reducing the infant and/or maternal mortality (MACINKO; GUANAIS; SOUZA, 2006; MACINKO et al., 2007; AQUINO; OLIVEIRA; BARRETO, 2009; ROCHA; SOARES, 2010; GUANAIS, 2015; BHALOTRA; ROCHA; SOARES, 2016), the mortality rates of some diseases and comorbidities (RASELLA et al., 2014; HONE et al., 2017; SOUZA et al., 2018; DIAZ et al., 2019) and the admission to out-patient clinics and hospitals due to primary care-sensitive conditions (MACINKO et al., 2010; MACINKO et al., 2011; CECCON; MENEGHEL; VIECILI, 2014; CAVALCANTE et al., 2018). However, there is a gap in this literature because the channels whereby ESF actions affect the individual health have never received the deserved attention.

The Brazilian Institute for Geography and Statistics (IBGE) carried out the last National Health Survey in 2013 (PNS 2013), during which a sub-sample of about 8900 individuals was submitted

[1] Source: Datasus, calculated by the authors

[2] See Bastos et al. (2017) for a systematic review of evidence.

to clinical laboratory tests (blood and urine). These laboratory tests were carried out in partnership with Osvaldo Cruz Foundation (Fiocruz), and the microdata with their results were just fully released. The new laboratory tests dataset represents an odd opportunity to contribute to the understanding of the individual channels by which ESF impact on the prevalence of some diseases.

The goal of this paper is to investigate the channels by which the ESF affects the individual health in Brazil, using the results of the laboratory tests carried out by PNS 2013. Particularly, we want to investigate whether there is any relationship between the local coverage of ESF and the blood and urinary markers of the examined individuals.

The PNS 2013 does not identify all the surveyed Municipalities, but its design allows identifying if the household is located in a Metropolitan Area or not. Therefore, among the 8900 individual test results, there is a subsample of 3840 across 21 Metropolitan Areas, allowing to evaluate if the regional density of ESF teams impact the laboratory results. Besides the household coverage (i.e., whether the tested individual is assisted by the program), we also adopt the number of deployed ESF teams by 10 thousand inhabitants within the Metropolitan Area as measure of regional coverage. We use probit models to estimate the relationship between ESF coverage and the likelihood of abnormal laboratory test results, controlling for the local availability of health facilities and a rich set of individual and household characteristics. Table 1 displays the state coverage of ESF, measured by the number of deployed teams by ten thousand inhabitants. It is possible to note how the program prioritizes the poorest Northern and Northeastern Brazilian states: whereas Distrito Federal (0.68) and São Paulo (0.92) exhibit the lowest coverage compared to the national average (2.03), Piauí (3.54), Paraíba (3.31) and Tocantins (2.84) had the highest number of teams by inhabitants in 2013. Table 1 also brings the distribution of laboratory tests across the Brazilian states, summing up 8935 exams.

Similarly, Table 2 displays the ESF coverage by Metropolitan Area, with the number of tested individuals within each one. With a few exceptions like Florianópolis (2.46) and Belo Horizonte (1.84), the same pattern of priority is seen at the Metropolitan level, with lower (higher) coverage in richer (poorer) areas. Comparing Tables 1 and 2, the average coverage of Metropolitan Areas is below the corresponding coverage of the state it is located in, which is another evidence of the strongest presence of ESF in smaller Municipalities.

Besides this introduction, this paper possesses three other sections. Section 2 describes the context of the laboratory tests carried out by PNS 2013 and their main discoveries about the health of the Brazilian people. Section 3 brings the empirical strategy and describes the data set; section 4 presents the results and the final section concludes.

Table 1 – ESF Coverage, in # Teams by ten thousand people, by State

State	**Coverage ESF 2013**	**Individuals tested**
Piauí	3.54225	347
Paraíba	3.31976	309
Tocantins	2.84126	179
Rio Grande do Norte	2.82227	288
Maranhão	2.64881	375
Sergipe	2.64798	290
Alagoas	2.44841	248
Santa Catarina	2.33813	244
Minas Gerais	2.24986	591
Ceará	2.23047	456
Acre	2.18801	384
Pernambuco	2.18168	368
Bahia	2.02137	370
Goiás	1.97005	339
Mato Grosso do Sul	1.96349	312
Mato Grosso	1.86526	231
Rondônia	1.84591	329
Paraná	1.81681	391
Roraima	1.80168	219
Amapá	1.74993	248
Espírito Santo	1.66874	156
Amazonas	1.48260	511
Rio de Janeiro	1.32848	296
Pará	1.29576	423
Rio Grande do Sul	1.29133	437
São Paulo	0.92035	470
Distrito Federal	0.68745	124
Mean/Total	2.03156	8935

Source: Calculated by the authors, based on IBGE and Ministry of Health

Table 2 – ESF Coverage, in # Teams by ten thousand people, by Metropolitan Area

Metropolitan Area	Coverage ESF 2013	Individuals tested
João Pessoa	2.68326	138
Aracaju	2.57700	83
Florianópolis	2.46805	101
Belo Horizonte	1.84460	304
Natal	1.81861	161
Recife	1.62143	232
Goiânia	1.57734	155
Fortaleza	1.52832	246
Maceió	1.41512	129
Curitiba	1.31321	181
Macapá	1.30279	185
Grande São Luís	1.29175	196
Rio de Janeiro	1.19897	200
Vale do Rio Cuiabá	1.17701	107
Belém	1.16192	256
Manaus	1.15923	386
Grande Vitória	1.00180	56
Salvador	0.84671	158
Porto Alegre	0.82021	251
São Paulo	0.81374	230
Distrito Federal and surroundings	0.68745	124
Mean/Total	1.38615	3879

Source: Calculated by the authors, based on IBGE and Ministry of Health

2 National Health Survey 2013 and the laboratory tests

Up to 2008 and each five years, the Brazilian Institute for Geography and Statistics (IBGE) used to proceed a Special Supplement on Health in its Annual National Household Sample Survey (PNAD) with specific questions about the population health. From 2013 on, the Special Supplement on Health was converted in a broader and separated survey, called National Health Survey (PNS)(PINTO; De Freitas; De Figueiredo, 2018). It contains more than 700 questions grouped in 21 themes, including child health, women's and elderly health, chronic diseases, oral health, eating habits, smoking habits, physical activity, health insurance coverage, search for medical services, hospital or outpatient's clinics, household income, visits by community agents (including ESF), self assessment of health, among others (PINTO; De Freitas; De Figueiredo, 2018). The National Health Survey 2013 (PNS 2013) belongs to the Integrated System of Household Surveys, which means that its sample design is a sub-sample of the Master Sample common to the set of surveys that belong to this system.[3]

But the greatest novelty of PNS 2013 was that a sub-sample of the individuals surveyed was drawn to be submitted to laboratory exams, carried out in partnership with Osvaldo Cruz Foundation (Fiocruz). Beyond anthropometric measures (weight, height, waist circumference) and blood pressure collected during the survey, this drawn sub-group was assigned to attend a laboratory clinic to collect

[3] Souza-Júnior et al. (2015) describes the sample design of PNS 2013. The second edition of PNS should have been carried out in 2018, but it was postponed to 2019/2020. The first results are expected to be released in 2021, according to IBGE.

biological material (blood and urine). In total, 8,952 individuals had biological material collected[4]. The following laboratory tests were performed (SZWARCWALD et al., 2019a)[5]:

- Hemogram: red blood cell count (erythrogram), white blood cell count (leukogram) and platelets count. Hemogram can detect a variety of diseases and conditions, such as infections, anemia and leukemia;
- Hemoglobinopathies;
- Glycated hemoglobin/estimated average blood glucose: for diagnosis of diabetes mellitus.
- Cholesterol: Total, High-density lipoprotein (HDL) and Low-density lipoprotein (LDL);
- Serial creatinine, for diagnosis of kidney failure;
- Serology for dengue (IgG).

The excretion of potassium, salt and sodium and creatinine was estimated in the urine. Szwarcwald et al. (2019a) describes in detail the procedures to collect biological material from surveyed individuals as well as the methodology of weighting.[6]The data were weighted and made publicly available on the Oswaldo Cruz Foundation's PNS website.

At the end of 2019 *Revista Brasileira de Epidemiologia* (Brazilian Journal of Epidemiology) published a special issue (Suppl.2) with a comprehensive analysis of the prevalence of some comorbidities and diseases in the Brazilian population, based on the results of these laboratory exams. Machado et al. (2019) uses the hemoglobin results to map anemia in the Brazilian population, finding evidence of higher prevalence in elderly and low income population. Szwarcwald et al. (2019b) calculates reference values for cholesterol, glycosylated hemoglobin and creatinine, concluding for important differences between adults and elderly and between genders. Mill et al. (2019) uses the levels of sodium and creatinine excreted in the urine to estimate the salt intake, concluding that the Brazilian population ingests, on average, twice the maximum amount recommended by WHO. Malta et al. (2019a) estimate in about 10 percent the prevalence of diabetes mellitus in the adult population using the results for glycated hemoglobin; Malta et al. (2019b) finds higher prevalence of renal failure in the elderly, in women, and in less educated populations. Rosenfeld et al. (2019a) estimates in about 3.7% the prevalence of hemoglobinopathies in the Brazilian adult population. Rosenfeld et al. (2019b) calculates reference values for blood count laboratory tests in the Brazilian adult population. Malta et al. (2019c) finds a high frequency of altered cholesterol total, HDL and LDL in the Brazilian adult population, mainly among women, elderly and people with low level of education.

3 Empirical Strategy

Since the laboratory results were made available separately from the survey, it was necessary to adopt a procedure for merging both data sets, aiming to associate each laboratory result with the interviewed individual in PNS 2013 who was selected to perform the laboratory test. For this, an identification key was built based on the following information presented in both data sets: weight, height, gender, age, skin color, health self evaluation and level of education. They were complemented with specific questions (doctor appointments, nourishment and health insurance) in order to maximize the key variability and, consequently, the percentage of matches. This key proved to be highly efficient:

[4] According to Szwarcwald et al. (2019a), the number of individuals was below the expected due to logistic difficulties, which required a post-stratification procedure.

[5] See also: <ftp://ftp.ibge.gov.br/PNS//2013/> for technical notes and the methods of analysis of each exam.

[6] See also: <https://www.pns.icict.fiocruz.br/index.php?pag=coleta>. Accessed in 15th July 2020.

from the 8952 individuals tested, only 17 did not match with PNS 2013, resulting in 8935 observed exams. This means a success rate of 99.8%. Once PNS 2013 allows to identify the state and, if applicable, the Metropolitan area each surveyed household belongs to, it was possible to associate each laboratory test to the state or Metropolitan ESF coverage.

In order to estimate the relationship between ESF coverage and the individual health, a probability model is estimated, in which the dependent variable is the likelihood of abnormal laboratory test.

The probit model can be generically expressed as (1):

$$Pr(y = 1|X) = \Phi(X^T\beta) \tag{1}$$

where y is a dummy variable if the result of the individual laboratory test is out of the reference range for the corresponding blood marker; X is a vector containing the set of covariates, composed of measures of ESF coverage and β is the set of parameters to be estimated. $\Phi(.)$ is is the cumulative of the standard normal distribution. The set of covariates includes two measures of household ESF coverage and one measure of local coverage, as follows:

- Registered ESF: A dummy variable whether the household is registered at ESF over one year, according to the individual answer in PNS 2013.
- Visits ESF: The number of visits received by the household in the previous 12 months, as answered by the individual surveyed in PNS 2013[7].
- Regional coverage of ESF: The number of ESF teams deployed to the Metropolitan Area (or state) by 10 thousand inhabitants[8].

The answers from PNS 2013 allowed to include three main sets of control variables:

- Individual characteristics: gender, age, skin color, marital status, highest educational level (dummies for complete high school or complete college), dummy if individual is covered by health insurance, dummy if the individual is smoker and dummy if the individual practices physical activity at least once a week.
- Individual health conditions: dummy for obesity (individuals with BMI $> 30kg/m^2$), waist circumference, dummies for the previous diagnosis of chronic disease, kidney failure, heart condition, diabetes, cancer and/or high blood pressure; dummy if the individual was hospitalized in the 12 months prior to the survey.
- Household characteristics: household income per capita, dummy for Bolsa Familia recipient, dummies for the presence of piped water, electric power, sanitation and/or garbage collection.

The number of hospital beds per capita was included in X with the purpose of controlling for the regional/local supply of health facilities.

It was considered that a laboratory test is abnormal when its blood marker is out of a reference range. The normal range, however, may vary slightly among different laboratories, among different medical entities and among different techniques of analysis. Table 3 summarizes the ranges used

[7] The survey asked how often a community agent or an ESF agent visited the household in the twelve months prior to the survey. The answer options were: i) monthly; ii) each two months; iii) between twice and four times a year; iv) once a year; v) never visited. The number of visits was calculated according to option chosen by the respondent.

[8] This information was gathered from Datasus.

to consider a result abnormal[9]. They were based on information from Brazilian clinical analysis laboratories and medical entities. When the sources did not indicate a consensual range, it was adopted the loosest one[10].

Table 3 – Criteria for abnormal results according to the condition

Condition	**Range for abnormality**
Leukopenia	White blood cells $< 4{,}500$ mm^3 for adults and $< 5{,}000$ mm^3 for children under 13 years old.
Leukocytosis	White blood cells $> 11{,}000$ mm^3 for adults, $> 13{,}000$ mm^3 for children between 6 and 13 yr old and $> 14{,}500$ mm^3 for children up to 6 years old.
Diabetes	Estimated average blood glucose > 126 mg/dL Glycated Hemoglobin $> 6.5\%$
High Cholesterol	Total cholesterol > 200 mg/dL in adults and > 170 mg/dL for children and teenagers under 19; LDL > 130 mg/dL in adults and > 110 mg/dL for children and teenagers under 19; HDL < 40 mg/dL
Creatinine (kidney failure)	Serum creatinine > 1.20 mg/dL
Low blood platelets	Platelets $< 150{,}000$ mm^3
Low hemoglobin (anaemia)	Hemoglobin < 14 g/dL for men and < 12 g/dL for women (< 11.5 g/dL if pregnant).
Blood pressure	Systolic blood pressure > 139 mmHg Diastolic blood pressure > 89 mmHg.
Dengue	Positive for IgG antibody

Sources: Brazilian Cardiology Society, Brazilian Diabetes Society, Brazilian, Brazilian Nephrology Society, World Health Organization, Brazilian Ministry of Health, among others. When the sources did not indicate a consensual range, it was adopted the more strict one.

Table 4 presents the proportion of abnormal results obtained in the dataset according to these criteria. Among the non-communicable conditions, the hypercholesterolemia (high total cholesterol) is the most commonly observed[11], reaching 37% of the individuals tested. On the other hand, the serological test for dengue is positive for 62.22%, which is not surprising, giving the recurrent epidemic episodes of this disease in the last decades in Brazil.

[9] The technique of analysis of each exam can be found in the PNS 2013 Exams Technical Notes, available in <ftp://ftp.ibge.gov.br/PNS//2013/>

[10] For example, the Brazilian Cardiology Society advises people to keep their blood pressure below 120 by 80 mmHg as a safe standard but, at the same time, advises them to seek medical help if the pressure exceeds 139 by 89 mmHg. The last threshold was adopted in this study. Another example is the cholesterol, whose maximum threshold for normality in adults varies from 190 to 200 mg/dL, depending on the laboratory criterion. We adopted the second one.

[11] It is important to warn that these values are not the prevalence in the Brazilian adult population, but only in the number of individuals tested. For estimates of prevalence in Brazil based on these exams, see the studies mentioned in section 2.

Table 4 – Abnormal Results in Laboratory Tests, in %

Lab test	No	Yes
Leukopenia	84.15	15.85
Leukocytosis	80.62	19.38
Blood glucose	83.12	16.88
Glycated haemoglobin	83.12	16.88
Total Cholesterol	62.99	37.01
HDL	69.01	30.99
LDL	77.61	22.39
Creatinine	83.77	16.23
Blood platelets	95.43	4.57
Low haemoglobin (anaemia)	84.00	16.00
High blood pressure	89.42	10.58
Dengue	37.78	62.22

Source: National Health Survey 2013 - Total of 8,952 lab tests

The descriptive statistics of the independent variables, separated by binary and non-binary ones, are exhibited in Tables 5 and 6 respectively. The latter also brings the proportion of individuals according to the declared skin color and according to the declared marital status. With respect to the household coverage measures, 49.34% of the surveyed individuals answered that they were registered at ESF program over one year, with an average of 3.89 visits by a ESF team or a community agent in the 12 months prior to the survey.

Table 5 – Binary control variables, in %

Categorical variable (%)	No	Yes
Register ESF	50.66	49.34
Female	41.61	58.39
Obesity	77.25	22.75
Some physical activity	1.09	98.91
Bolsa Família recipient	86.48	13.52
Health insurance	76.73	23.27
Previous diagnosis of hypertension	76.51	23.49
Previous diagnosis of diabetes	93.29	6.71
Previous diagnosis of dengue	77.22	22.78
Smoker	85.56	14.44
Previous diagnosis of cancer	98.25	1.75
Previous diagnosis of heart condition	95.50	4.50
Previous diagnosis of kidney condition	98.41	1.59
High school education	70.21	29.79
College education	89.74	10.26
Household piped water supply	26.03	73.97
Household sanitation	60.47	39.53
Household garbage collection	24.30	75.70
Household electricity power	1.42	98.58

Source: National Health Survey 2013 - Total of 8,952 lab tests

Table 6 – Descriptive statistics no binary variables

Variable	Obs.	Mean	Sd.Dev	Min	Max
Visits ESF (N)	8,952	3.89	5.11	0	12
Body Mass Index (kg/m^2)	8,856	26.57	5.10	13.11	61.35
Waist circumference (cm)	8,853	91.12	13.13	50	149.7
Age (years)	8,952	46.85	16.45	18	104
Household income per cap. (BRL/mth)	8,915	643.87	801.19	44.17	13,833.33
Married (proportion)	8,935	0.42	0.49	0	1
Separated (proportion)	8,935	0.02	0.15	0	1
Divorced (proportion)	8,935	0.05	0.21	0	1
Widow (proportion)	8,935	0.08	0.27	0	1
Single (proportion)	8,935	0.44	0.50	0	1
White skin (proportion)	8,952	0.37	0.48	0	1
Brown skin (proportion)	8,952	0.52	0.49	0	1
Black skin (proportion)	8,952	0.09	0.28	0	1
Asian skin (proportion)	8,952	0.01	0.09	0	1
Indigenous skin (proportion)	8,952	0.007	0.08	0	1

Source: PNS 2013; calculated by the authors.

4 Results

As part of the Integrated System of Household Surveys, PNS 2013 only allows identifying the state and, if applicable, the Metropolitan Area the household is located in. Therefore, among the $8,952$ individual test results, there is a sub-sample of $3,840$ tests across 21 Metropolitan Areas. It represents an opportunity to assess not only if being assisted by an ESF team affects the individual health, but also if the regional density of ESF teams impact these laboratory results.

In order to study the effect of ESF on individual health, measured by the results of the laboratory tests, and with the purpose of checking for robustness, we grouped the estimates in four types of coverage: i) considering only household coverage, measured by registration in ESF and by the number of visits by community agents (Table 7); ii) considering only individuals tested in Metropolitan Areas with household coverage and the number of local ESF teams by 10,000 inhabitants at metropolitan level (Table 8); iii) considering all individuals tested with household coverage and the number of ESF teams by 10,000 inhabitants at state level (Table 9); iv) considering only household coverage, but with state and Metropolitan fixed effects (Table 10). Estimates (i), (ii) and (iii) use health facilities (number of hospital beds per capita within the state/Metropolitan Area where the individual test is located in) to control for the supply of health services whereas estimate (iv) replaces this variable with Metropolitan and state fixed effects.

According to Szwarcwald et al. (2019a), the final number of individuals tested was below the actually drawn, due to logistic difficulties[12], which required a post-stratification procedure. Weightings were calculated for use of the laboratory exams data set, given the post-stratification procedures by gender, age, skin color and educational level according to large region, from the total sample of the

[12] As Szwarcwald et al. (2019a, p.5) describe, "*(...) several factors caused a loss greater than 20% in the subsample of individuals indicated for laboratory tests. Among which, the following stand out: difficulty of locating the address by the hired laboratory; refusal of the selected resident to collect biological material; long time between the application of the questionnaire and the visit of the laboratory agent; and operational difficulties to transport biological material. In Brazil as a whole, laboratory tests were performed on 8,952 individuals, representing about 60% of residents interviewed individually in the initial phase of the PNS, in the sectors selected for laboratory research.*"

PNS (SZWARCWALD et al., 2019a). Fiocruz released the weights of the laboratory exams[13], which were used to weight the standard deviations of our estimates.

Results for Leukopenia and Leukocytosis: Leukopenia is a condition of low level of white blood cells in leukogram (Table 3) and suggests low immunity. Leukocytosis, on the other hand, means that the level of such cells is above the normal, which suggests the presence of bacterial infection, inflammation, or, in extreme cases, leukemia. Being registered in ESF seems negatively related with the presence of such conditions for the first three specifications, but this relationship disappears when state and Metropolitan fixed effects are introduced. Also, there is no relationship between leukopenia and leukocytosis and the density of teams within Metropolitan Areas.

Results for Diabetes Mellitus and Cholesterol: By observing the results for Diabetes Mellitus and Cholesterol in Tables 7 to 10, the ESF coverage, whether defined as household or regional coverages, does not seem to affect the likelihood of abnormal glycated hemoglobine + blood glucose (except for the coefficient of state ESF coverage, which is significant at 10%), as well as the likelihood of abnormal cholesterol and fractions, in extent that all estimated coefficients of ESF coverage are not significant.

Results for Kidney failure: The results suggest strong evidence that ESF may be effective in reducing the likelihood of kidney failure (measure by abnormal serial creatinine), once all coefficients of being registered in ESF over a year are negative and significant. The same happens with the density of ESF teams both in state and Metropolitan Areas. For instance, the marginal increase of ESF teams by 10,000 inhabitants in Metropolitan Areas reduces the likelihood of kidney failure in 3.23 p.p. (Table 8).

Results for Low blood platelets and Anaemia: Anaemia is a health condition resulting from the low presence of iron in the blood, as measured by hemoglobin. The low blood platelet count, in turn, can denote several problems, such as lack of vitamin B12, liver or spleen problems and changes in the bone marrow. Despite less robust, the results for these blood markers suggest some impact of ESF in reducing the likelihood of these conditions, depending on the specification. Being registered in ESF seems negatively correlated to low platelets, but this effect disappears in the sub-sample of Metropolitan Areas. For anaemia, the registration is also important, except in Metropolitan Areas, where the regional coverage (density of teams) seems more important.

Results for Blood pressure: The household registration in ESF seems important to reducing the likelihood of high blood pressure overall, except in the sub-sample of Metropolitan Areas, where the density of teams matters. On the other hand, the state coverage of ESF is also important, as one can observe in Table 9.

Results for Dengue: As commonly known, Brazil is an endemic country for dengue, having faced extensive epidemics in the last decades. The laboratory tests carried out by PNS 2013 assessed the reaction of IgG immunoglobulin to dengue to infer whether the individual was exposed to this virus in the past. Results allow to conclude that the intensity of visits by ESF team is important to reducing the incidence of dengue: the coefficient of the number of visits by ESF in the previous year is negative and significant for all specifications. Being registered in ESF is also important in Metropolitan Areas (Table 8) and with control for state coverage (Table 9). However, the signs of state and Metropolitan density of teams are both positive and significant, which sounds surprising, unless one imagine that the expansion of ESF teams may be guided by localities with high incidence of dengue. But this hypothesis deserve deeper investigation.

[13] For a detailed description of the post-stratification procedure and how the weights were calculated, see Szwarcwald et al. (2019a, p.5-6)

Table 7 – Results for Household coverage in 2013 - controlled for state health facilities

	Leukopenia	Leukocytosis	Diabetes	Cholesterol	Kidney failure	Low blood platelets	Anaemia	Blood pressure	Dengue
Registered ESF	-0.0192**	-0.0186**	-0.00847	0.00287	-0.0188***	-0.0137**	-0.0216**	-0.0162**	-0.0142
	(0.00979)	(0.00941)	(0.00707)	(0.00597)	(0.00717)	(0.00565)	(0.00982)	(0.00797)	(0.0125)
Visits ESF	0.00180*	0.000266	4.54e-05	-0.000382	0.000118	0.00141***	-0.000893	-0.000432	-0.00301**
	(0.000947)	(0.000911)	(0.000683)	(0.000582)	(0.000702)	(0.000528)	(0.000975)	(0.000785)	(0.00122)
Health facilities	-0.00404***	-0.0143***	-0.00794***	-0.000729	-0.00883***	-0.00103	0.000204	0.00262***	-0.0143***
	(0.00121)	(0.00116)	(0.000883)	(0.000759)	(0.000894)	(0.000667)	(0.00123)	(0.00100)	(0.00156)

* p<0.1; ** p<0.05; *** p<0.01. Weighted standard deviations in parentheses. Probit marginal effects. Dependent variable: likelihood of abnormal result. Register ESF is a dummy variable whether the household is registered in ESF over a year. Visits ESF is the number of visits by ESF team or community agent in the previous 12 months. Number of hospital beds per capita within the state used as proxy for the supply of health facilities. Results controlled for individual characteristics (gender, age, skin color, marital status, educational level), individual health conditions (obesity, waist measure, previous diagnosis of chronic diseases, kidney condition, heart condition, diabetes, cancer, high blood pressure, hospitalized in the previous 12 months), household characteristics (presence of piped water, electric power, sanitation, garbage collection, household income per capita), covered by health insurance, Bolsa Familia recipient, sport practitioner, smoker. 8831 individuals tested.

Table 8 – Results for Metropolitan ESF coverage in 2013 - controlled for Metropolitan health facilities

	Leukopenia	Leukocytosis	Diabetes	Cholesterol	Kidney failure	Low blood platelets	Anaemia	Blood pressure	Dengue
Metropolitan ESF Coverage	0.00889	-0.0160	-0.00341	-0.00447	-0.0323***	0.00706	-0.0607***	-0.0302***	0.173***
	(0.0102)	(0.0108)	(0.00872)	(0.00779)	(0.00918)	(0.00600)	(0.0122)	(0.00991)	(0.0141)
Registered ESF	-0.0203*	-0.0209*	-0.0103	-0.00515	-0.0232**	-0.0107	-0.00766	-0.0129	-0.0448***
	(0.0118)	(0.0119)	(0.00968)	(0.00870)	(0.00976)	(0.00700)	(0.0137)	(0.0107)	(0.0167)
Visits ESF	-0.000878	0.000526	-7.67e-05	-0.000101	0.00138	-0.000176	0.00173	0.000883	-0.00438**
	(0.00137)	(0.00135)	(0.00107)	(0.000980)	(0.00110)	(0.000798)	(0.00155)	(0.00117)	(0.00189)
Health facilities	-0.000688	-0.00592***	-0.00493***	-0.000433	-0.00614***	-6.36e-05	0.00592***	-0.000553	0.0151***
	(0.00125)	(0.00124)	(0.00104)	(0.000951)	(0.00101)	(0.000711)	(0.00145)	(0.00117)	(0.00171)

* p<0.1; ** p<0.05; *** p<0.01. Weighted standard deviations in parentheses. Probit marginal effects. Dependent variable: likelihood of abnormal result. Metropolitan ESF coverage measured by the number of ESF teams by 10,000 inhabitants. Register ESF is a dummy variable whether the household is registered in ESF over a year. Visits ESF is the number of visits by ESF team or community agent in the previous 12 months. Number of hospital beds per capita within the Metropolitan Area used as proxy for supply of health facilities. Results controlled for individual characteristics (gender, age, skin color, marital status, educational level), individual health conditions (obesity, waist measure, previous diagnosis of chronic diseases, kidney condition, heart condition, diabetes, cancer, high blood pressure, hospitalized in the previous 12 months), household characteristics (presence of piped water, electric power, sanitation, garbage collection, household income per capita), covered by health insurance, Bolsa Familia recipient, sport practitioner, smoker. 3840 individuals tested.

Table 9 – Results for State ESF coverage in 2013 - controlled for state health facilites

	Leukopenia	Leukocytosis	Diabetes	Cholesterol	Kidney failure	Low blood platelets	Anaemia	Blood pressure	Dengue
State ESF Coverage	0.0226***	0.00114	-0.00771*	0.00484	-0.0162***	-7.07e-05	0.00337	-0.0161***	0.169***
	(0.00618)	(0.00590)	(0.00458)	(0.00390)	(0.00463)	(0.00344)	(0.00636)	(0.00528)	(0.00756)
Registered ESF	-0.0209**	-0.0187**	-0.00780	0.00236	-0.0174**	-0.0137**	-0.0218**	-0.0148*	-0.0281**
	(0.00980)	(0.00942)	(0.00708)	(0.00599)	(0.00717)	(0.00566)	(0.00983)	(0.00797)	(0.0122)
Visits ESF	0.00151	0.000251	0.000139	-0.000447	0.000326	0.00141***	-0.000940	-0.000211	-0.00529***
	(0.000949)	(0.000914)	(0.000685)	(0.000585)	(0.000704)	(0.000529)	(0.000979)	(0.000787)	(0.00120)
Health facilities	-0.00329***	-0.0142***	-0.00815***	-0.000552	-0.00921***	-0.00103	0.000328	0.00197*	-0.00717***
	(0.00123)	(0.00117)	(0.000891)	(0.000774)	(0.000900)	(0.000674)	(0.00125)	(0.00102)	(0.00155)

* p<0.1; ** p<0.05; *** p<0.01. Weighted standard deviations in parentheses. Probit marginal effects. Dependent variable: likelihood of abnormal result. State ESF coverage measured by the number of ESF teams by 10,000 inhabitants. Register ESF is a dummy variable whether the household is registered in ESF over a year. Visits ESF is the number of visits by ESF team or community agent in the previous 12 months. Number of hospital beds per capita within the state used as proxy for supply of health facilities. Results controlled for individual characteristics (gender, age, skin color, marital status, educational level), individual health conditions (obesity, waist measure, previous diagnosis of chronic diseases, kidney condition, heart condition, diabetes, cancer, high blood pressure, hospitalized in the previous 12 months), household characteristics (presence of piped water, electric power, sanitation, garbage collection, household income per capita), covered by health insurance, Bolsa Familia recipient, sport practitioner, smoker. 8831 individuals tested.

Table 10 – Results for Household coverage in 2013 - controlled for State and Metropolitan dummies

	Leukopenia	Leukocytosis	Diabetes	Cholesterol	Kidney failure	Low blood platelets	Anaemia	Blood pressure	Dengue
Registered ESF	-0.0141	-0.00394	-0.00248	0.00297	-0.0121*	-0.0141**	-0.0135	-0.0174**	0.0212*
	(0.00988)	(0.00923)	(0.00704)	(0.00607)	(0.00709)	(0.00574)	(0.00990)	(0.00810)	(0.0110)
Visits ESF	0.000666	-5.92e-05	0.000462	-0.000330	0.000688	0.00126**	-0.000239	-0.000598	-0.00298***
	(0.000965)	(0.000902)	(0.000688)	(0.000600)	(0.000702)	(0.000542)	(0.000994)	(0.000808)	(0.00107)
Metropolitan Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

* p<0.1; ** p<0.05; *** p<0.01. Weighted standard deviations in parentheses. Probit marginal effects. Dependent variable: likelihood of abnormal result. Register ESF is a dummy variable whether the household is registered in ESF over a year. Visits ESF is the number of visits by ESF team or community agent in the previous 12 months. Controlled for fixed effects of State and Metropolitan Region. Results controlled for individual characteristics (gender, age, skin color, marital status, educational level), individual health conditions (obesity, waist measure, previous diagnosis of chronic diseases, kidney condition, heart condition, diabetes, cancer, high blood pressure, hospitalized in the previous 12 months), household characteristics (presence of piped water, electric power, sanitation, garbage collection, household income per capita), covered by health insurance, Bolsa Familia recipient, sport practitioner, smoker. 8831 individuals tested.

5 Concluding Remarks

The National Health Survey 2013 brought the novelty of laboratory tests for a sub-sample of individuals, resulting in a rich data set that allows us to dig deeper into the channels whereby primary care coverage expansions may affect health. The purpose of this paper was to shed a first light in this theme, which has not received attention in the existing literature. Despite the simplicity of the empirical strategy, to our knowledge it is the first time that these lab tests results are used to measure the effectiveness of primary care in Brazil.

The overall results reveal a complex picture, with different impacts according to the type of coverage, the intensity of care and the region. Registering in ESF seems important for the effectiveness of the program in reducing the likelihood of anaemia, kidney failure, high blood pressure and dengue, but regional density of teams in Metropolitan Areas affects only kidney failure. For dengue, the intensity of care, measured as the yearly number of visits by a ESF team, is more important than the regional coverage at state and at Metropolitan levels. This result indicates that the expansion of primary care is a good strategy to reduce dengue cases. The fact that diabetes mellitus and abnormal cholesterol seem not sensitive to ESF coverage, whether household or regional, suggests that the ESF should reassess its strategy toward addressing non-communicable metabolic diseases, whose prevalence will likely increase in the coming years as a consequence of population ageing.

Unfortunately, the sample design pf PNS 2013 does not allow to identify all the municipalities where the data were collected, but only the Federation Unit and the Metropolitan Region, if applicable. For a more refined study of the relationship between the density of ESF teams and the effects on individual health, it would be necessary to identify the location of each household, but for that, authorization from IBGE would be necessary. This is an interesting next step for this research. Despite this limitation, this paper contributed to a first investigation and could shed light on important policy priorities for primary health care in Brazil.

Acknowledgements

The authors acknowledge financial support from National Institute for Health Research grant for Global Health Econometrics and Economics Group (GHE2) and from Fipe - Fundacao Instituto de Pesquisas Economicas. Fernando Postali and Maria Dolores Montoya Diaz have received a CNPq Research Productivity Grant during the elaboration of this paper. Adriano Dutra Teixeira receive CNPq PhD Grant. We are grateful to Matheus Valentim de Barros and to Guilherme Jardinetti Araujo for excellent research assistance. We are solely responsible for any errors.

References

AQUINO, R.; OLIVEIRA, N. F. de; BARRETO, M. L. Impact of the Family Health Program on Infant Mortality in Brazilian Municipalities. *American Journal of Public Health*, American Public Health Association, v. 99, n. 1, p. 87–93, jan 2009. ISSN 0090-0036. Disponível em: <https://doi.org/10.2105/AJPH.2007.127480>. Citado na página 3.

BASTOS, M. L. et al. The impact of the Brazilian family health strategy on selected primary care sensitive conditions: A systematic review. *PLOS ONE*, Public Library of Science, v. 12, n. 8, p. e0182336, aug 2017. ISSN 1932-6203. Disponível em: <http://dx.plos.org/10.1371/journal.pone.0182336>. Citado na página 3.

BHALOTRA, S.; ROCHA, R.; SOARES, R. R. Does Universalization of Health Work? Evidence from Health Systems Restructuring and Maternal and Child Health in Brazil. *Institute for Social & Economic Research*, 2016. Citado na página 3.

CAVALCANTE, D. d. F. B. et al. Did the Family Health Strategy have an impact on indicators of hospitalizations for stroke and heart failure? Longitudinal study in Brazil: 1998-2013. *PLOS ONE*, Public Library of Science, v. 13, n. 6, p. e0198428, jun 2018. ISSN 1932-6203. Disponível em: <https://dx.plos.org/10.1371/journal.pone.0198428>. Citado na página 3.

CECCON, R. F.; MENEGHEL, S. N.; VIECILI, P. R. N. Hospitalization due to conditions sensitive to primary care and expansion of the Family Health Program in Brazil: an ecological study. *Revista Brasileira de Epidemiologia*, Associação Brasileira de Pós -Graduação em Saúde Coletiva, v. 17, n. 4, p. 968–977, dec 2014. ISSN 1415-790X. Disponível em: <http://www.scielo.br/scielo.php?script=sci{_}arttext{&}pid=S1415-790X2014000400968{&}lng=e>. Citado na página 3.

DIAZ, M. D. M. et al. *Primary health care coverage in Brazil: Assessment of the Family Health Program impacts on mortality at municipality level*. [S.l.], 2019. Disponível em: <http://www.repec.eae.fea.usp.br/documentos/Diaz_Teixeira_Postali_Batista_Serra_42WP.pdf>. Citado na página 3.

GUANAIS, F. C. The Combined Effects of the Expansion of Primary Health Care and Conditional Cash Transfers on Infant Mortality in Brazil, 1998–2010. *American Journal of Public Health*, American Public Health Association, v. 105, n. S4, p. S593–S599, aug 2015. ISSN 0090-0036. Disponível em: <https://doi.org/10.2105/AJPH.2013.301452r>. Citado na página 3.

HONE, T. et al. Large reductions in amenable mortality associated with Brazil's primary care expansion and strong health governance. *Health Affairs*, v. 36, n. 1, p. 149–158, 2017. ISSN 0278-2715. Citado na página 3.

MACHADO, . A. E. et al. Prevalence of anemia in Brazilian adults and elderly. *Revista Brasileira de Epidemiologia*, scielo, v. 22, 00 2019. ISSN 1415-790X. Disponível em: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1415-790X2019000300404&nrm=iso>. Citado na página 7.

MACINKO, J. et al. Going to scale with community-based primary care: An analysis of the family health program and infant mortality in Brazil, 1999–2004. *Social Science & Medicine*, Pergamon, v. 65, n. 10, p. 2070–2080, nov 2007. ISSN 0277-9536. Disponível em: <https://www.sciencedirect.com/science/article/pii/S0277953607003553>. Citado na página 3.

MACINKO, J. et al. Major expansion of primary care in Brazil linked to decline in unnecessary hospitalization. *Health Affairs*, v. 29, n. 12, p. 2149–2160, 2010. ISSN 0278-2715. Citado na página 3.

MACINKO, J.; GUANAIS, F. C.; SOUZA, M. d. F. M. de. Evaluation of the impact of the Family Health Program on infant mortality in Brazil, 1990–2002. *Journal of epidemiology and community health*, BMJ Publishing Group Ltd, v. 60, n. 1, p. 13–19, 2006. Citado na página 3.

MACINKO, J. et al. The Influence of Primary Care and Hospital Supply on Ambulatory Care–Sensitive Hospitalizations Among Adults in Brazil, 1999–2007. *American Journal of Public Health*, American Public Health Association, v. 101, n. 10, p. 1963–1970, oct 2011. ISSN 0090-0036. Disponível em: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3222340/>. Citado na página 3.

MALTA, D. C. et al. Prevalence of diabetes mellitus as determined by glycated hemoglobin in the Brazilian adult population, National Health Survey. *Revista Brasileira de Epidemiologia*, scielo, v. 22, 00 2019. ISSN 1415-790X. Citado na página 7.

MALTA, D. C. et al. Evaluation of renal function in the Brazilian adult population, according to laboratory criteria from the National Health Survey. *Revista Brasileira de Epidemiologia*, scielo, v. 22, 00 2019. ISSN 1415-790X. Citado na página 7.

MALTA, D. C. et al. Prevalence of altered total cholesterol and fractions in the Brazilian adult population: National Health Survey. *Revista Brasileira de Epidemiologia*, scielo, v. 22, 00 2019. ISSN 1415-790X. Citado na página 7.

MILL, J. A. G. et al. Estimation of salt intake in the Brazilian population: results from the 2013 National Health Survey. *Revista Brasileira de Epidemiologia*, scielo, v. 22, 00 2019. ISSN 1415-790X. Citado na página 7.

PINTO, L. F.; De Freitas, M. P. S.; De Figueiredo, A. W. S. National information and population survey systems: Selected contributions from the ministry of health and the IBGE for analysis of Brazilian state capitals over the past 30 years. *Ciencia e Saude Coletiva*, Associacao Brasileira de Pos - Graduacao em Saude Coletiva, v. 23, n. 6, p. 1859–1870, jun 2018. ISSN 16784561. Citado na página 6.

RASELLA, D. et al. Impact of primary health care on mortality from heart and cerebrovascular diseases in Brazil: a nationwide analysis of longitudinal data. *BMJ : British Medical Journal*, v. 349, jul 2014. Disponível em: <http://www.bmj.com/content/349/bmj.g4014.abstract>. Citado na página 3.

ROCHA, R.; SOARES, R. R. Evaluating the impact of community based health interventions: evidence from Brazil's Family Health Program. *Health Economics*, Wiley Online Library, v. 19, n. S1, p. 126–158, 2010. Citado na página 3.

ROSENFELD, L. G. A. et al. Prevalence of hemoglobinopathies in the Brazilian adult population: National Health Survey 2014-2015. *Revista Brasileira de Epidemiologia*, scielo, v. 22, 00 2019. ISSN 1415-790X. Citado na página 7.

ROSENFELD, L. G. A. et al. Reference values for blood count laboratory tests in the Brazilian adult population, National Health Survey. *Revista Brasileira de Epidemiologia*, scielo, v. 22, 00 2019. ISSN 1415-790X. Citado na página 7.

SOUZA-JÚNIOR, P. R. B. de et al. Desenho da amostra da Pesquisa Nacional de Saúde 2013. *Epidemiologia e Serviços de Saúde*, v. 24, n. 2, p. 207–216, 2015. ISSN 1679-4974. Disponível em: <http://www.iec.pa.gov.br/template{_}doi{_}ess.php?doi=10.5123/S1679-49742015000200003{&}scielo=S2237-96222015>. Citado na página 6.

SOUZA, R. A. de et al. Family health and conditional cash transfer in Brazil and its effect on tuberculosis mortality. *The International Journal of Tuberculosis and Lung Disease*, v. 22, n. 11, p. 1300–1306, nov 2018. ISSN 1027-3719. Disponível em: <http://www.ingentaconnect.com/content/10.5588/ijtld.17.0907>. Citado na página 3.

SZWARCWALD, C. A. L. et al. Laboratory exams of the National Health Survey: methodology of sampling, data collection and analysis. *Revista Brasileira de Epidemiologia*, scielo, v. 22, 00 2019. ISSN 1415-790X. Disponível em: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1415-790X2019000300402&nrm=iso>. Citado 3 vezes nas páginas 7, 11 e 12.

SZWARCWALD, C. A. L. et al. Reference values for laboratory tests of cholesterol, glycosylated hemoglobin and creatinine of the Brazilian adult population. *Revista Brasileira de Epidemiologia*, scielo, v. 22, 00 2019. ISSN 1415-790X. Citado na página 7.