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Impact of the Health Gym Program on hospital admissions for stroke in the state of Pernambuco, Brazil

Impacto do Programa Academia da Saúde nas internações hospitalares por acidente vascular cerebral no Estado de Pernambuco, Brasil

Impacto del Programa Academia de la Salud en los ingresos hospitalarios por accidente cerebrovascular en el estado de Pernambuco, Brasil

Flávio Renato Barros da Guarda [1,2]
Bárbara Letícia Silvestre Rodrigues [1]
Rafaela Niels da Silva [3]
Shirlley Jackllanny Martins de Faria [1,2]
Paloma Beatriz Costa Silva [1]
Redmilson Elias da Silva Júnior [1]
Daíze Kelly da Silva Feitosa [1]
Nana Kwame Anokye [4]
Peter C. Coyte [5]

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Abstract

This study aimed to evaluate the impact of the Health Gym Program (HGP) on hospital admissions for stroke in the state of Pernambuco, Brazil. This policy impact evaluation used a quasi-experimental approach consisting of a difference-in-differences estimator, weighted by propensity score matching to deal with potential confounding variables. The study comprised socioeconomic, demographic, and epidemiological data from official Brazilian databases from 2010 to 2019. The treatment group was composed of the 134 municipalities that implemented the HGP since 2011. The 51 municipalities that did not were allocated to the comparison group. The nearest neighbor algorithm (N5) was used to pair treatment and comparison group municipalities and create the weights to evaluate the average treatment effect on the treated (ATT) in the difference-in-differences estimator. In 2010, 2,771 people were hospitalized for stroke (0.51% of all hospitalizations) and in 2019, 11,542 (2%). Municipalities that implemented the HGP had 18.37% fewer hospitalizations than their counterparts in the comparison group. The program's impact in reducing hospitalization rates was incrementally greater among men (ATT: -0.1932) and those aged 71 to 80 years (ATT: -0.1911). All results were statistically significant at the 5% level. The HGP reduced hospitalization for stroke in several population groups, but primarily in those whose underlying prevalence of stroke is highest, reinforcing the importance of public investments in health promotion policies designed to encourage lifestyle changes.

Program Evaluation; Chronic Disease; Health Promotion; Propensity Score; Stroke

Correspondence
F. R. B. Guarda
Rua Cassilândia 331, bloco 1, apto. 304, Recife, PE 50740-370, Brasil.
flaviodaguarda@hotmail.com

[1] Centro Acadêmico de Vitória, Universidade Federal de Pernambuco, Vitória de Santo Antão, Brasil.
[2] Programa de Pós-graduação em Educação Física, Universidade Federal de Pernambuco, Recife, Brasil.
[3] Programa de Pós-graduação em Inovação Terapêutica, Universidade Federal de Pernambuco, Recife, Brasil.
[4] College of Medicine, Health and Life Sciences, Brunel University London, Uxbridge, U.K.
[5] Institute for Health Policy, Management and Evaluation, University of Toronto, Toronto, Canada.

Introduction

Stroke is one of the most prevalent cerebrovascular diseases and main causes of morbidity worldwide [1,2]. In 2017, 150.5 new cases of stroke were registered for each group of 100,000 people around the world. The global prevalence of stroke is higher in men and individuals over 65 years [3].

In Brazil, the prevalence of stroke per 100,000 inhabitants was 1,008.02 in 2016. This rate was higher in older people (6,816.73) and among men (1,153.94) [4]. Stroke was also the main cause of hospitalization in the circulatory system diseases subgroup in 2018 [4,5].

Health promotion interventions can reduce the incidence and costs of hospitalization and rehabilitation for stroke [6,7,8]. Thus, the Brazilian Ministry of Health has invested in public policies to reduce morbidity and, consequently, hospitalizations for chronic diseases (including stroke) [9,10]. The main device used to advance this goal has been the Health Gym Program (HGP), which contributes to health promotion by establishing public spaces, infrastructure, and qualified professionals, designed to promote health and physical activity [9].

The physical structure of the program follows standards established by the Brazilian Ministry of Health, which finances the construction of public spaces (called HGP hubs) to carry out health promotion activities. The Federal Government finances these hubs and their monthly costs. Each hub of the program is a public leisure space that also has rooms for public use, a walking and running track, and equipment for physical exercises [11].

The program guidelines establish that the HGP activities can be developed by nurses, nutritionists, physical therapists, psychologists, and physical education professionals, among other professionals [11]. The program's actions include encouraging healthy eating habits, health education activities on many topics, activities focused on changing health risk behaviors (smoking, alcohol use, and stress control), encouraging the autonomous practice of physical activities, and offering exercises guided by physical education professionals (walking, running, gym and dance classes, and resistance training) [12,13].

Evidence shows that health promotion programs developed within the scope of primary health care can reduce the incidence of stroke cases [7,14,15]. Thus, the health promotion actions encouraged by the HGP can reduce the population's exposure to modifiable risk factors for strokes, such as obesity, dyslipidemia, smoking, hypertension, and physical inactivity [9,10].

The state of Pernambuco, Brazil, has 267 HGP hubs in 134 municipalities since 2011, representing 9.66% of hubs countrywide, which places it as the second Brazilian state with the most program hubs implemented [16].

The adoption of a physically active lifestyle reduces the risk of stroke development [7] and evidence showed the effectiveness of the HGP in increasing the population's physical activity level [17] and reducing mortality from arterial hypertension in Pernambuco [18]. Still, few studies on the impact of HGP on health indicators exist, and it is still unknown how this program can mitigate hospitalizations for stroke and other chronic diseases.

This study aims to evaluate the impact of the HGP on hospitalization rates for stroke in the state of Pernambuco.

Methods

This study adopts a quasi-experimental approach that combines difference-in-differences (DD) with propensity score matching (PSM), herein referred to as double difference matching (DDM) [19,20,21].

The study used annual panel data from 2007 (four years before the implementation of the HGP) to 2019 (eight years after its implementation) for all 185 municipalities in Pernambuco. The 2,405 observations focus on the population over 40 years of age, and derive from many official databases, including the Brazilian Health Informatics Department (DATASUS), the Brazilian Institute of Geography and Statistics (IBGE), the Information System on Public Budgets for Health (SIOPS), and the Brazilian National Institute for Educational Studies and Research (INEP).

The 185 municipalities in Pernambuco were dichotomized into two groups. The treatment group comprised 134 municipalities that implemented the HGP since 2011; and the comparison group comprised 51 municipalities that never implemented the program over the study period.

The effectiveness of the HGP was measured as the difference in the percentage of hospitalizations for stroke in the period after the implementation of HGP (2011 to 2019) compared to equivalent figures for the pre-treatment period (2007 to 2010) after controlling for covariates.

The main outcome variable used in this study was the natural logarithm of hospitalization for stroke. Potential confounding variables were selected based on the Andersen and Newman healthcare utilization model [22]. This conceptual framework is widely used to evaluate health service use in many contexts [22], including in Brazil [12]. This framework privileges three main factors as instrumental in driving health service use: predisposing factors (such as sex and age), enabling factors (such as socioeconomic status), and needs-based factors (such as health status and comorbid conditions). This study considered sex and the proportion of individuals in different age groups as predisposing factors. The number of physicians and gross domestic product (GDP) per capita were used as enabling factors. The number of hospitalizations for hypertension and the number of people with excess weight (overweight and obesity) per each inhabitant in the municipalities were used as needs-based factors.

The covariates used in this study were identified based on scientific evidence about the possible confounding effects that they may have on the relationship between risk exposure and the outcome of interest in Brazil. Thus, the epidemiological model that guided the selection of explanatory variables used as reference a set of studies that point to factors associated with hospitalizations for circulatory system and cerebrovascular diseases and stroke in the Brazilian population [23].

The analysis model used a set of covariates that constitute the municipalities' socioeconomic, demographic, and health aspects. Socioeconomic variables were annual total health expenditure, GDP per capita, and the proportion of federal social benefits for a highly poor population per 10,000 inhabitants. Demographic variables included the general population by municipality, proportion of residents for each age group (41 to 50, 51 to 60, 61 to 70, 71 to 80, and 81 years and over) per 1,000 inhabitants, and high school pass rate. The variables related to the health aspects were the availability of hospital beds for every 10,000 inhabitants, proportion of people with excess weight per inhabitants, number of physicians, and number of hospitalizations for stroke.

Data analysis

Descriptive statistics (frequencies, means, and standard deviations) were used to characterize and evaluate differences between the socioeconomic, demographic, and epidemiological profile of municipalities in the treatment and comparison groups.

Student's t-test was used to estimate the differences between the means regarding the hospitalizations of those exposed and not exposed to the HGP, and Fisher's exact test was used for proportions.

The analytical approach includes a pre-test of the estimation model, the evaluation of the impact of the HGP on the frequency of hospitalizations for stroke using DD and DDM estimators, and post-tests to validate the results.

Pre-tests of the model and empirical strategy

We constructed a graph with the means of the frequency of hospital admissions for stroke (dependent variable) in the pre-treatment period (2007 to 2010) to indirectly test the DD method assumption of a "parallel trend" for the period before the implementation of the HGP [24]. This procedure allows an indirect validation of the sample of counterfactuals selected for the DD model.

The Hausman test verified the hypothesis of endogeneity of the random term [25]. The presence of serial autocorrelation between the regression residuals was also tested using the Wooldridge and Wald tests [24,26].

Evaluation of the impact of the HGP

• Propensity score matching

The implementation of the HGP by municipalities was not random [9,10]. This lack of randomization in the treatment and comparison groups may result in potential sorting or selection biases [19,27,28]. To reduce the possibility of this statistical problem, the study used the PSM method, which compares the treatment and comparison groups concerning socioeconomic, demographic, and/or health characteristics, and estimates the probability of municipalities joining the HGP based on these profiles, thus creating a counterfactual scenario that enables comparisons between the groups [19,27,28].

The matching procedure uses a balanced score, computed from a logit regression model that used a binary dependent variable of 1 for the municipalities that implemented the HGP; otherwise, it was 0. The propensity score defines the probability of a municipality benefiting from the HGP, given its socioeconomic, demographic, and health-related characteristics [19,28]. The estimated propensity scores were used to compute the weights needed to balance the treatment and comparison groups so that, on average, they become similar to each other [19,27,28].

After defining the weights, the blocks of municipalities with similar characteristics were defined and the average treatment effect on the treated (ATT) was estimated using the "nearest neighbor" pairing algorithm (1:5) with replacement, which has the closest propensity score (measured by the absolute difference between the scores). Using this method, each municipality in the treatment group (municipality benefiting from the HGP) was paired with a municipality in the comparison group (municipality not benefiting from the HGP) with the closest propensity score value.

The Stata application "psmatch2" (https://www.stata.com) was used to estimate the propensity score and the ATT. As a robustness test of the PSM, a balancing test was conducted to verify statistical similarities between the matched variables before and after the implementation of the HGP. All statistical tests adopted a 5% significance level.

• Difference-in-differences method

The DD estimator is a method used in quasi-experimental approaches to evaluate interventions, using information about the participants (treatment group) and non-participants (comparison group), collected before an intervention/policy was applied and compared to the same information after its application. This procedure allows investigators to build counterfactual scenarios by estimating the difference in the differences in the results observed in a given period [29].

This study used the difference-in-differences method to assess the impact of the HGP, after estimating the propensity scores, since some unobservable characteristics may affect the outcome variable, even with PSM [19,21].

The DD model in this study considered many implementation periods from 2011 to 2019 since the implementation of the HGP in the municipalities occurred in different years since 2011. Moreover, fixed effects were added to the DD model by municipality and by year.

The impact evaluation (DD and DDM) used a dummy variable (presence of the HGP) that simultaneously shows if the municipality was in the treatment group and in which year the implementation took place. For the comparison group, this variable assumes a value of 0 for the entire study period. For the treatment group, "presence of the HGP" assumed the value 0 for the period before the implementation and value 1 for the year of implementation and subsequent years.

• Double difference matching

After performing PSM, the DD model was weighted by the weights derived from PSM. This combined approach yields estimates of the impact of the HGP on hospitalizations for stroke in municipalities matched by common support.

Therefore, the estimator for ATT was the mean difference estimated for the exposed municipalities minus the mean difference of the municipalities in the comparison group matched to the treatment ones.

The calculation of the impact of the HGP on the hospitalizations for stroke by gender and age group was conducted using specific models for each of these populational groups. These models considered the natural logarithms of the hospitalizations. Thus, a model with a different dependent variable for each population stratum was used.

Both DD and DDM estimations were conducted from a cluster-robust variance-covariance matrix of municipalities to correct eventual problems of serial correlation of residuals and heteroscedasticity [30,31].

Post-test of the results

The impact of the HGP on the hospitalizations for stroke was estimated, as a robustness test, using a placebo-dependent variable that from a theoretical point of view is not directly influenced by the effects of the program. Thus, the frequency of hospitalizations for colon cancer was used as the placebo variable.

Results

This section begins with a descriptive summary of the study's municipality data and proceeds to the pre-tests results, followed by the estimates of the matching by PSM and their balancing test. Then, we present the results of the impact analyses of the HGP on hospitalization for stroke (after controlling for potential selection bias and an array of covariates) using the DD and DDM methods. Finally, we present the robustness of our findings, via the post-test (placebo regression).

In 2010, 540,045 hospitalizations for all causes were recorded in Pernambuco, with 2,771 for stroke (0.51% of all hospitalizations), whereas in 2019, 574,637 hospitalizations were recorded, with 11,542 for stroke (2%).

Table 1 describes that the municipalities in the treatment group had a lower proportion of overweight individuals per inhabitant in 2010 and a higher high school pass rate in 2019 than municipalities in the comparison group, and this difference was statistically significant at a 5% level.

Regarding hospitalizations for stroke, the treated municipalities in 2010 registered more occurrences in general (mean = 14.97; SD = 25.79) and by sex (mean = 7.75; SD = 3.45 among women).

Pre-tests of the model

The first pre-test verified the assumption of the parallel trend to the DD model. Figure 1 shows that the lines representing the mean frequency of hospitalizations for stroke for the treatment and control groups have the same curve and follow the same trajectory in the period before the implementation of the HGP (2007 to 2010).

The Hausman and Wald tests for heteroscedasticity presented statistically significant results at the 1% level (Prob > χ^2 < 0.01), showing that the functional form of the estimates (fixed effect models) was adequate for this impact evaluation and that the model is heteroscedastic. The Wooldridge pre-test showed no serial correlation of the regression residuals (Prob > F ≤ 0.01).

Estimates of the matching

The PSM model included the following variables: availability of hospital beds for 10,000 inhabitants, proportion of people with excess weight per inhabitants, number of physicians, number of hospitalizations for hypertension, general population by municipality, high school pass rate, annual total health expenditure, GDP per capita, proportion of federal social benefits for highly poor population per 10,000 inhabitants (Table 2). For this model, the observed ATT shows that the presence of HGP caused an overall reduction of 10.59% in hospitalizations for stroke (ATT = -0.1059; standard error = 0.059) and this result was statistically significant at the 10% level (t-stat = -1.79).

Table 1

Characteristics of the municipalities that implemented and did not implement the Health Gym Program in the state of Pernambuco, Brazil, 2010 and 2019.

Characteristics	2010				2019			
	Treatment [mean (SD)]	Control [mean (SD)]	p-value	95%CI *	Treatment [mean (SD)]	Control [mean (SD)]	p-value	95%CI *
Socioeconomic								
Total health expenditure (BRL)	15.1 mi (4.63 mi)	6.19 mi (4.43 mi)	0.173	-2.17mi; 3.94 mi	3.42 mi (1.10 mi)	1.45 mi (1.14 mi)	0.204	-5.02 mi; 1.08 mi
GDP per capita (BRL)	6,788.44 (6,508.69)	6,130.03 (3,054.43)	0.489	-2,532.73; 1,215.91	12,689.16 (51,176.56)	567,852.8 (14,538,68)	0.337	-213,888.4; 736,757.7
Social benefit/10,000 inhabitants	714.56 (942.44)	610.51 (571.86)	0.461	-382.33; 174.23	422.51 (565.63)	397.67 (411.33)	0.775	-196.23; 146.54
Demographic								
Population	57,185.99 (154,098.4)	26,234.33 (20,330.74)	0.155	-73,736.77; 11,833.46	60,641.73 (162,383.7)	28,060.37 (22,318.17)	0.155	-77,679.36; 12,516.64
High school pass rate	79.36 (8.77)	76.95 (10.26)	0.113	-5.401; 0.576	73.03 (8.53)	69.81 (9.78)	0.029	-6.103; -0.329
Health aspects								
Number of physicians	60 (338.92)	13.58 (22.49)	0.330	-140.28; 47.46	87.86 (484.12)	14.88 (23.34)	0.284	-207.01; 61.053
Hospitalizations for hypertension	14.33 (26.42)	8.15 (11.37)	0.108	-13.74; 1.38	6.06 (16.56)	3.21 (8.14)	0.241	-7.63; 1.93
Excess weight/inhabitants	0.028 (0.019)	0.034 (0.017)	0.049	-0.001; 0.012	0.067 (0.032)	0.062 (0.018)	0.294	-0.014; 0.004
Number of public hospital beds	117.52 (530.08)	42.60 (61.71)	0.316	-221.98; 72.15	108.12 (544.64)	28.52 (25.78)	0.299	-230.38; 71.20
Hospitalizations for stroke								
General	14.97 (25.79)	7.60 (8.55)	0.040	-14.65; -0.08	68.61 (206.84)	28.86 (29.13)	0.173	-97.21; 17.70
Men	7.22 (12.63)	4 (4.25)	0.076	-6.795; 0.347	35.19 (103.72)	15.47 (16.42)	0.179	-48.56; 9.11
Women	7.75 (3.45)	3.60 (4.50)	0.032	-7.945; -0.346	33.42 (103.37)	13.39 (13.26)	0.170	-48.72; 8.66

95%CI: 95% confidence interval; GDP: gross domestic product; SD: standard deviation.

Source: prepared by the authors, based on official statistics from the Brazilian Federal Government databases using the Stata software.

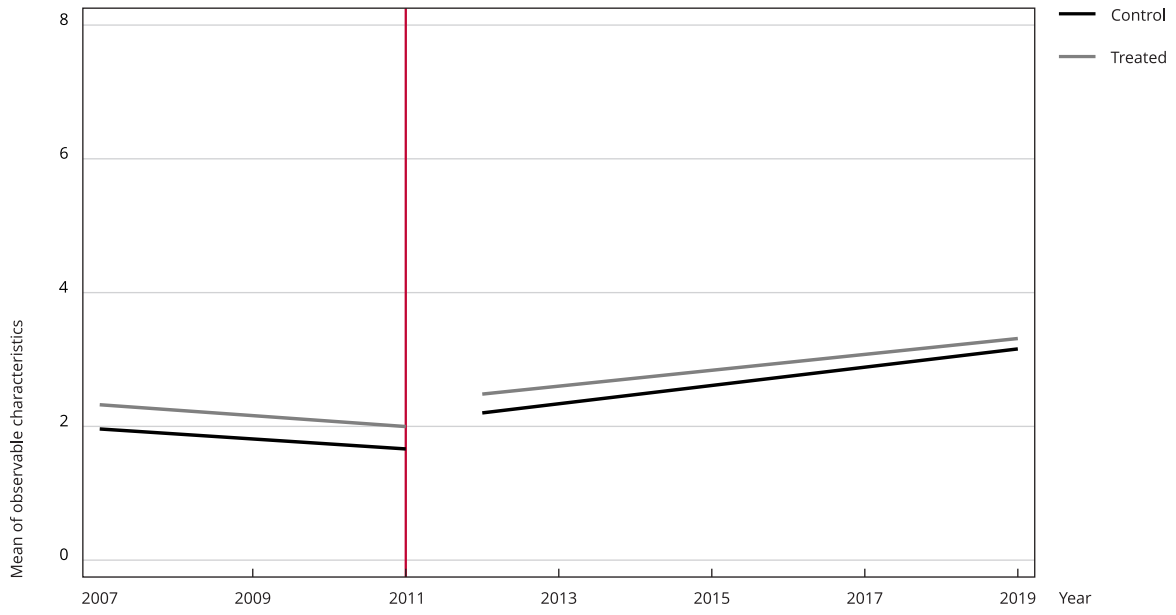
* t-test.

Table 2 presents the results of the balancing test of the matching method, showing that the means of the variables for the treatment and control groups became statically equal after matching. Moreover, all variables presented more than 40% bias reduction, showing that the treatment and control groups are balanced (Rubin statistics R = 0.64, B = 14.8, respectively).

Regarding the quality of the matching method, Figure 2 shows that the distribution of the observable characteristics of the treatment and control groups before matching was different. The probability distribution in the control group was concentrated in the tail to the left. However, the distribution of these characteristics moved to the center after matching, showing that it reduced the differences in the estimated probability distribution and made the two groups more similar (and different only regarding the presence of the HGP).

Figure 1

Trend in the mean of hospitalizations for stroke in treated and control municipalities. State of Pernambuco, Brazil, 2007 to 2019.



Impact assessment of the HGP on hospitalizations for stroke

We tested the impact of the HGP on the frequency of hospitalization for stroke before and after treatment using two regression models: DD and DDM. Table 3 shows the results. Use of the DDM yielded an estimated average treatment effect (ATE) of -0.1837 fewer hospitalizations for stroke for the HGP. This reduction was even greater for men (ATE = -19.32). Regarding the age group, a 19.11% reduction in hospitalizations for stroke was reported for those aged between 71 and 80 years when compared with the same age group in the municipalities that did not implement the HGP.

Post-estimation test (robustness test of the findings)

We used the falsification test to verify if the treatment variable impacted the placebo outcome. Table 3 shows that the presence of HGP does not impact the reduction of hospitalizations for colon cancer (positive coefficient to the ATT, and no statistical significance at 5% level).

Discussion

Although a general downward trend in hospitalizations for stroke has been noted across Brazil, the opposite was reported in Pernambuco from 2010 to 2018 [33]. The frequency of hospitalizations for stroke as part of hospital admissions for all causes also increased, representing 1.3% of frequency on all hospitalizations in 2018 [33], whereas in our study stroke represented 2% of hospital admissions on all causes.

Table 2

Test of difference in means of treated and control groups before and after matching and balance test. Health Gym Program, state of Pernambuco, Brazil, 2007 to 2019.

Characteristics	Before matching			% bias reduction	After matching		
	Treatment	Control	p-value		Treatment	Control	p-value
Number of physicians	68.92	14.52	0.001	98.2	17.92	18.92	0.349
Hospitalizations for hypertension	11.31	6.04	< 0.000	97.8	7.367	7.48	0.826
Excess weight/inhabitants	11.318	6.0445	< 0.000	97.8	7.36	7.48	0.826
Number of hospital beds	118.63	39.86	0.001	96.5	49.92	47.18	0.246
Population	59,225	27,431	< 0.000	97.5	30,723	31,533	0.419
High school pass rate	82.35	82.23	0.764	-40.5	82.26	82.43	0.577
Total health expenditure (BRL)	> 210 million	> 89 million	< 0.000	97.2	> 100 million	> 100 million	0.279
GDP per capita (BRL)	8,672.9	7,987.5	0.104	61.2	7,712.8	7,978.8	0.228
Social benefit/10,000 inhabitants	1,120.1	1,192.6	0.416	92.3	1,203.3	1,197.8	0.937

GDP: gross domestic product.
Source: prepared by the authors.

In 2010, just before the implementation of the HGP in 2011, the treatment group municipalities had better health-related and demographic indicators, such as a lower proportion of overweight individuals per inhabitant and a higher high school pass rate than the comparison municipalities. Evidence suggests that these characteristics result in higher hospitalization rates for many chronic diseases, including cerebrovascular accidents [32,34,35].

Pazó et al. [34] showed that literacy was associated with hospital admissions for primary care sensitive conditions (including stroke) in the state of Espírito Santo, Brazil. Moreover, evidence suggests that the prevalence of stroke in the Brazilian population decreases among more educated people and increases in older and obese people [4,5,23].

Regarding the profile of hospital admissions by sex, this study found higher rates of hospitalization for stroke among women, thus corroborating the study by Gomez et al. [36].

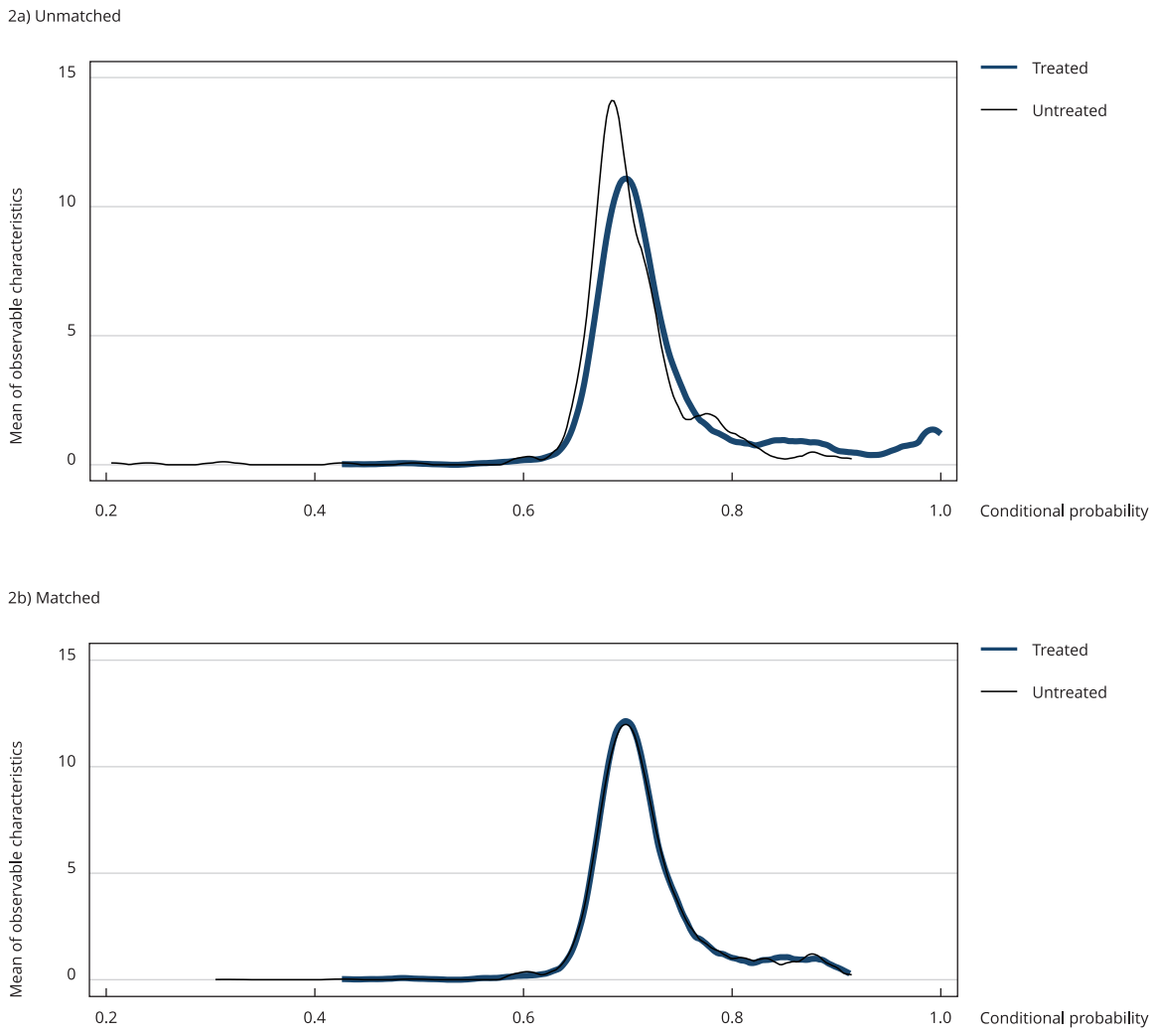
The first pre-test of the model verified the feasibility of using the DD estimator to assess the impact of the HGP on the frequency of hospitalizations for stroke. This test verified the assumption of the DD method, which requires that the trajectory of the dependent variable for the treatment and control groups must be parallel in the period before the implementation of a policy [37,38,39]. The result of this test allows us to infer that unobservable characteristics of the municipalities that implemented and did not implement the HGP had a similar impact in these two groups before the program's implementation. Thus, the difference in the number of hospitalizations for stroke between the exposed and the unexposed municipalities reflects only the average effect of the program after its implementation [38,39].

Some studies already showed the variables constituting the estimation models (PSM, DD, and DDM) as associated with hospital admissions for stroke [32,34,40] reinforcing the theoretical basis for the selection of the model's components [40,41] and corroborating the results that suggest the influence of the availability of hospital beds, excess weight, number of physicians, and number of hospitalizations for hypertension, schooling level, income, and poverty level in municipalities on hospitalizations for stroke [32,34,40].

Although PSM could show that the HGP was associated with a reduction in hospitalization rates for stroke, we only used this methodology to balance the treatment and comparison groups so that they would be comparable to minimize potential selection bias and the absence of common support [19,20,21]. Moreover, the use of PSM as one of the parameters of the DD model increases the robustness and reliability of our findings [42,43] and has been used in other studies evaluating the impact of public policies [21].

Figure 2

Distribution of treatment probability for treated and controls; before and after matching.



The presence of variables with non-significant coefficients in the PSM model (such as in DD and DDM models) does not suggest that they should be removed from the estimation models, as a variable can only be excluded from the model if theoretical evidence shows that it is not related to the outcome variable [44,45].

The impact of the HGP on the frequency of hospitalizations for stroke was statistically significant for the two regression models tested, showing that municipalities that implemented the program had 18.37% fewer hospitalizations when compared with municipalities that did not implement it. Although DD and DDM methods are consistent for evaluating the impact of public policies, the use of DDM with robust standard errors creates eventual problems of heteroscedasticity, avoiding overestimating the significance of the regression coefficients [42,43], making them more robust to assess the impact of HGP on stroke hospitalizations.

This result may be associated with the potential increase in physical activity level and greater participation of the population in health promotion activities offered by the HGP [9,17].

Table 3

Impact of the Health Gym Program (HGP) on hospital admissions for stroke, and placebo regression coefficients. State of Pernambuco, Brazil, 2007 to 2019.

Characteristics	DD Log frequency (stroke)	DDM Log frequency (stroke)	Placebo regression Log frequency (colon cancer)
Presence of HGP	-0.1725 *	-0.1837 *	0.298
PSM	-	1.814 **	6.550 ***
Number of physicians	-0.003 ***	-0.002 ***	< 0.001
Hospitalizations for hypertension	0.004 *	0.003	-0.023 ***
Excess weight/inhabitants	-2.036	-1.498	5.060
Number of hospital beds	-0.000	-0.0006 **	-0.001
Population	< 0.001	< 0.001	< 0.001
High school pass rate	< 0.001	< 0.001	-0.003
Total health expenditure (BRL)	< 0.001	< 0.001	< 0.001
GDP per capita (BRL)	< 0.001	< 0.001	< 0.001
Social benefit/10,000 inhabitants	< 0.001	< 0.001	< 0.001
Women #	-0.1291 **	-0.1433 **	-
Men #	-0.1798 ***	-0.1932 ***	-
< 60 years #	-0.0735	-0.0988	-
61 to 70 years #	0.2386	0.1473 *	-
71 to 80 years #	-0.1771 *	-0.1911 *	-
81 years and over #	-0.0837	-0.0975	
Year of exposure			
2008	-0.796 ***	-0.817 ***	1.075 ***
2009	-0.610 ***	-0.640 ***	0.648 *
2010	-0.562 ***	-0.610 ***	1.003 ***
2011	-0.447 ***	-0.499 ***	1.201 ***
2012	-0.367 ***	-0.435 ***	1.545 ***
2013	0.118	0.0227	1.855 ***
2014	0.428 ***	0.318 *	1.552 ***
2015	0.462 ***	0.356 *	1.808 ***
2016	0.483 ***	0.372 *	1.477 ***
2017	0.625 ***	0.506 ***	1.418 *
2018	0.659 ***	0.524 ***	1.344 *
Constant	1.676 ***	0.779	-4.466 **
Observation	2,152	2,152	2,152
R^2	0.413	0.416	0.097

DD: difference-in-differences; DDM: double difference matching; GDP: gross domestic product; log: natural logarithm; PSM: propensity score matching.

Note: Natural logarithm of the frequency of hospital admissions for stroke. Standard errors clustered at the municipality level. The exposure time starts in 2011.

* $p < 0.05$;

** $p < 0.1$;

*** $p < 0.01$;

The average treatment effect on the treated (ATT) was calculated based on the natural logarithm of the frequency of hospital admissions for stroke as a dependent variable in the DD and DDM models. Categories are not compared to each other.

The impacts of the HGP on hospitalization for stroke occurred among both men and women, and in older people, which is consistent with studies that showed that these population strata were frequent participants in the HGP in Pernambuco [17]. Notably, the program reduced the frequency of hospitalizations for the age group from 71 to 80 years, thus showing the potential for this program to reduce hospitalizations for individuals with stroke prevalence [46].

The HGP does not impact the frequency of hospitalizations for colon cancer in the placebo regression, showing that the treatment group is directing the results [47], which reinforces the robustness of the results and allows us to infer that the estimators used in this study were adequate to evaluate the impact of the HGP on hospitalizations for stroke.

Although our study contributes to the literature in using robust methodologies to evaluate the effect of the HGP on hospitalization for stroke, it also has many limitations. First, results derived from one state in Brazil may lack generalizability, not just to Brazil but to other jurisdictions. However, although caution is important when making inferences from this study, our results have good internal validity regarding the measurement of the impact of the HGP in this state. Second, our study used municipal-level data to evaluate the impact of the HGP rather than individual-level data, as they were not available. However, the use of aggregated data did not diminish the robustness of assessments derived when compared to other studies that adopt similar methods and used individual-level data [27,28,42,43].

Conclusion

This study showed that the HGP in the state of Pernambuco reduced the frequency of hospitalizations for stroke in general and especially among men and those over 71 years of age, therefore showing that the program was effective particularly among the groups in which the prevalence of stroke is highest.

The HGP directly reduced hospitalizations for stroke, lowered the demand for hospital beds (and other health and social care resources), and has the potential to reduce human suffering due to cerebrovascular accidents. Also, the HGP may indirectly reduce social security expenses (temporary leave, retirement, and pensions) regarding the consequences of stroke for the patient and unpaid caregivers that need to take time away from other productive activities. The study findings highlight the effectiveness of the HGP and encourages strategic investments in similar health and social care programs.

Contributors

F. R. B. Guarda contributed to the study conception, data design, analysis and interpretation, writing, and review; and approved the final version. B. L. S. Rodrigues contributed to the study conception, data design, analysis and interpretation, writing, and review; and approved the final version. R. N. Silva contributed to the study conception, data design, analysis and interpretation, writing, and review; and approved the final version. S. J. M. Farias contributed to the data design, analysis and interpretation, writing, and review; and approved the final version. P. B. C. Silva contributed to the data collection, analysis and interpretation, and review; and approved the final version. R. E. Silva Júnior contributed to the data collection, analysis and interpretation, and review; and approved the final version. D. K. S. Feitosa contributed to the data collection, analysis and interpretation, and review; and approved the final version. N. K. Anokye contributed to the data analysis and interpretation, and review; and approved the final version. P. C. Coyte contributed to the data design, analysis and interpretation, writing, and review; and approved the final version.

Additional information

ORCID: Flávio Renato Barros da Guarda (0000-0002-9214-7784); Bárbara Letícia Silvestre Rodrigues (0000-0001-7754-4282); Rafaela Niels da Silva (0000-0001-8065-0780); Shirlley Jackllanny Martins de Faria (0000-0002-2782-5462); Paloma Beatriz Costa Silva (0000-0001-8785-0259); Redmilson Elias da Silva Júnior (0000-0003-2638-6549); Daíze Kelly da Silva Feitosa (0000-0001-9308-0430); Nana Kwame Anokye (0000-0003-3615-344X); Peter C. Coyte (0000-0002-2993-3491).

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Resumo

O estudo teve como objetivo avaliar o impacto do Programa Academia da Saúde (PAS) nas internações hospitalares por acidente vascular cerebral (AVC) no Estado de Pernambuco, Brasil. Esta avaliação de impacto das políticas utilizou uma abordagem quase-experimental que consiste em um estimador de diferença-em-diferenças, ponderado pelo pareamento por escore de propensão para lidar com possíveis fatores de confusão. O estudo foi composto por dados socioeconômicos, demográficos e epidemiológicos de bases de dados oficiais brasileiras entre os anos de 2010 e 2019. O grupo de tratamento foi composto pelos 134 municípios que implantaram o PAS a partir de 2011, e os 51 municípios que não implantaram foram alocados no grupo de comparação. O algoritmo do vizinho mais próximo (N5) foi utilizado para emparelhar os municípios tratados e comparar aos municípios do grupo controle, criando os pesos que foram utilizados para avaliar o efeito médio do tratamento sobre o tratado (ATT) no estimador de diferença-em-diferenças. Houve 2.771 internações por AVC em 2010 (0,51% de todas as internações) e 11.542 (2%) em 2019. Os municípios que implementaram o PAS tiveram 18,37% menos internações em comparação com seus homólogos no grupo de comparação. O impacto do programa na redução das taxas de internação foi maior entre os homens (ATT: -0,1932) e naqueles com idade entre 71 e 80 anos (ATT: -0,1911). Todos os resultados foram estatisticamente significativos em um nível de 5%. O PAS reduziu a hospitalização por AVC em vários grupos populacionais, mas principalmente naqueles em que a prevalência subjacente de AVC é mais alta, reforçando a importância dos investimentos públicos em políticas de promoção da saúde destinadas a estimular mudanças nos estilos de vida.

Avaliação de Programas e Projetos de Saúde; Doença Crônica; Promoção da Saúde; Pontuação de Propensão; Acidente Vascular Cerebral

Resumen

El objetivo de este trabajo es evaluar el impacto del Programa Academia de la Salud (PAS) en los ingresos hospitalarios por accidente cerebrovascular (ACV) en el estado de Pernambuco, Brasil. Esta evaluación del impacto de la política utilizó un enfoque cuasi-experimental que consiste en un estimador de diferencias en diferencias, ponderado por el emparejamiento de puntuación de propensión para hacer frente a posibles factores de confusión. El estudio incluyó datos socioeconómicos, demográficos y epidemiológicos de bases de datos oficiales brasileñas de 2010 a 2019. El grupo de tratamiento se compuso de los 134 municipios que implementaron el PAS a partir de 2011 y los 51 municipios que no lo hicieron se asignaron al grupo de comparación. Se utilizó el algoritmo del vecino más próximo (N5) para emparejar los municipios tratados y los del grupo de comparación y crear las ponderaciones que se emplearon para evaluar el efecto medio del tratamiento sobre los tratados (ATT) en el estimador de diferencias en diferencias. Hubo 2.771 hospitalizaciones por ACV en 2010 (0,51% de todas las hospitalizaciones) y 11.542 (2%) en 2019. Los municipios que aplicaron el PAS tuvieron un 18,37% menos de hospitalizaciones en comparación con sus homólogos del grupo de comparación. El impacto del programa en la reducción de las tasas de hospitalización fue gradualmente mayor entre los hombres (ATT: -0,1932) y entre las personas de 71 a 80 años (ATT: -0,1911). Todos los resultados fueron estadísticamente significativos al nivel del 5%. El PAS redujo la hospitalización por ACV en varios grupos de población, pero principalmente en aquellos en los que la prevalencia subyacente de ACV es mayor, lo que refuerza la importancia de las inversiones públicas en políticas de promoción de la salud diseñadas para impulsar cambios en los estilos de vida.

Evaluación de Programas y Proyectos de Salud; Enfermedad Crónica; Promoción de la Salud; Puntaje de Propensión; Accidente Cerebrovascular

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