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Impact of the Health Gym Program on mortality from Systemic Arterial Hypertension in Pernambuco state, Brazil

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Abstract *The aim of this paper was to analyze the impact of the Health Gym Program (HGP) on the Systemic Arterial Hypertension mortality rate in Pernambuco state, Brazil. This public policy impact analysis used a quasi-experimental approach which consisted of the application of Propensity Score Matching in the years 2010 and 2017. Socioeconomic, demographic, and epidemiological data of 89 municipalities that implemented HGP (treated) and 54 that did not (controls) were collected from the Brazilian Health Data Department, Brazilian Institute of Geography and Statistics, and other databases. The impact of HGP on hypertension mortality rate was estimated through a logit model using the Kernel algorithm. Treated municipalities presented a decrease of 12.8% in global hypertension mortality rate, 12.5% in brown-skinned people and 13.1% in those over 80 years of age. The balancing test attests to the robustness of the estimated model to explain the impact of the program on mortality due to hypertension. The implementation of the program proved to be effective in decreasing the mortality rate in the treated municipalities, indicating that it seems to contribute to controlling the progress of chronic non-communicable diseases.*

Key words *Hypertension, Mortality, Health Policy and Program Evaluation, Health Impact Assessment*

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Introduction

Evidence regarding the global burden of Hypertension indicates that 26.4% of the adult population worldwide was hypertensive in 2000 and that by 2025 this prevalence is predicted to increase by 60%, with more significant increases in developing countries[1].

Systemic Arterial Hypertension (SAH) has a multifactorial origin and is characterized by an increase in blood pressure levels to values equal to or greater than 140 mmHg for systolic pressure and 90 mmHg for diastolic pressure[2], representing a risk factor for cerebrovascular and cardiovascular diseases[3] and that can be aggravated by biological (dyslipidemia, abdominal obesity, glucose intolerance and diabetes)[2], behavioral (smoking, eating, and physical inactivity)[3], and socioeconomic factors (income, education, Human Development Index, Gross Domestic Product - GDP per capita - of the Municipalities, and access to health services)[4-6].

SAH is the disease with the greatest impact on morbidity and mortality in Brazil[7], with a prevalence of 32.6% among adults, and above 60% in older adults[8], with a mortality rate of 0.87 deaths for every 10,000 adults in Brazil[8]; 2.56 for the Northeast region (largest among the regions) and 2.13 in the state of Pernambuco (13th in the country). Among the main predictors of mortality from SAH in Brazil are increasing age, brown-skinned individuals[9], and the level of education of the population[10]. In addition, deaths from SAH are inversely associated with socioeconomic variables of the municipalities[6] and with the individual's level of physical activity[11-13].

Evidence from studies with different populations and with the Brazilian population indicate that the regular practice of physical activity reduces the risk of death from SAH and other non-communicable chronic diseases (NCDs)[11-13], which has led health authorities to invest in the implementation of policies and programs to encourage the adoption of more active and healthier lifestyles in the population[14,15].

In order to integrate the practice of physical activity into the country's health policy agenda, in 2011 the Ministry of Health instituted the Health Gym Program (HGP), with the objective of contributing to health promotion through federal and municipal co-financing for the construction and/or renovation of public spaces with infrastructure (called poles) and qualified professionals to carry out activities to promote health and care production in the field of Primary Health Care (PHC)[16,17].

The HGP is considered a strategic program for the execution of national health promotion policies and among its specific objectives is the proposal to increase the population's level of physical activity[17]. Furthermore, in addition to its goal to promote health, acting in the prevention and control of chronic diseases, influencing the conditioning and determinants of health, the HGP has an important role in improving the quality of life of the population, as it deals with both physiological and social aspects of the health-disease process[18].

The activities of the HGP comprise the scope of the National Health Promotion Policy (PNPS) and the National Primary Care Policy (PNAB), and the program is presented as one of the prevention and control actions that integrate the Strategic Action Plan for the Coping with Chronic Non-Communicable Diseases (NCDs)[16-19].

Records present in the National Register of Health Establishments (CNES) indicate that in 2017, the Northeast region of the country concentrated a total of 917 centers of the program, followed by the Southeast (527), South (390), Midwest (193), and North region with 189 HGP poles[20].

The state of Pernambuco was one of the pioneers in the implementation of the HGP, beginning these activities in 2011[21]. By 2017, the state had implemented 246 centers in its territory, which corresponds to 11.10% of the total units implemented in the country[20].

In this scenario, assessment of the impact of the HGP in Pernambuco could be considered a management tool that allows the identification of the program's strengths and weaknesses, in addition to contributing to the decision-making process of workers, managers, and funders of this intervention[22]. Thus, the aim of the current study is to analyze the impact of the Health Gym Program on mortality from Systemic Arterial Hypertension in the state of Pernambuco.

The choice to assess mortality from hypertension was due to the fact that a robust set of evidence points to the association between physical inactivity and the risk of illness and death from this disease[11-13], and that one of the specific objectives of the HGP is to increase the level of physical activity of the population[16], presenting itself as one of the strategies for the prevention and control of chronic diseases provided for in the national policies of Primary Care, Health Promotion and in the Strategic Action Plan for Coping with Non-Communicable Chronic Diseases in Brazil[16,23,24].

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Methods

Characterization of the study

This study is characterized as an evaluation of the impact of public policies, developed through a quasi-experimental approach that consists of applying the propensity score matching method (herein designated as PSM) to estimate the Average Treatment Effect on the Treated (ATT). In the current study, the ATT is characterized by the effect of the Health Gym Program on the mortality rate (per 10,000 inhabitants) from Systemic Arterial Hypertension in the state of Pernambuco.

Sampling and databases

Data on the presence of the HGP poles in the municipalities of Pernambuco were collected on the website of the National Register of Health Establishments (CNES), of the SUS Department of Informatics (DATASUS).

Epidemiological data refer to deaths and their respective extracts by sex, age group, and ethnicity/color (from the Mortality Information System -SIM), the rate of hospital beds per 1,000 inhabitants (taken from the CNES), and the Coverage of Primary Care (website of the Primary Care Information and Management System - e-Manager). For the demographic variables, the study took as reference the General population by municipality, proportion of female and male population, proportion of residents by age groups from 40 to 49 years old, 50 to 59 years old, 60 to 69 years old, 70 to 79 years old, and 80 years and more (collected on the website of the Brazilian Institute of Geography and Statistics - IBGE), the Human Development Index (HDI) (in the State Database - BDE), and the FIRJAN Municipal Development Index (IFDM), FIRJAN Index of health-related and education-related development. The socioeconomic variables used for this study were GDP per capita and the FIRJAN Index for employment and income, collected from the websites of the Federation of Industries of the State of Rio de Janeiro (FIRJAN).

Of the 185 municipalities across the state, the current study considered the 89 that implemented the Health Gym Program in 2011 as treated and the 52 municipalities that did not implement it as controls. Municipalities that implemented the program after 2011 and those that implemented it that year and canceled their activities in subsequent years were excluded from the sample. Data were collected using as a reference the years 2010 (year prior to implementation) and 2017 (six years after the beginning of the implementation of the HGP in the state of Pernambuco).

The result variable for this study is the natural logarithm of the mortality rate from hypertension per 10,000 inhabitants, by place of residence of the individual. These logarithms are used in the field of econometrics, especially when the relationships between dependent and independent variables are not linear[25].

Considering that some values of the SAH mortality rates were equal to zero, the artifice of adding one unit to the original rate value was used before converting to the natural logarithm, as recommended by Wooldridge[25].

Control covariates

The covariates in this study were selected based on scientific evidence about the confounding relationship they can exert on the relationship between exposure and the outcome of interest. In this case, the epidemiological model that guided the selection of explanatory variables took as reference the studies by Guimarães et al.[7] and Santos et al.[9], which point to factors associated with mortality from hypertension in the Brazilian population[7,9].

Propensity Score Matching and impact of the Health Gym Program on SAH mortality

Considering that the implementation of the HGP in the municipalities was due to adherence and that there was no randomness in the composition of the groups exposed and not exposed to this intervention, the sample that makes up this study could be subject to problems such as selection bias, and sensitive to multidimensionality of the factors that determine the probability of implementation of this policy. To minimize these problems, the current study used the propensity score matching (PSM) method, which compares the two groups in relation to some socioeconomic, demographic, and epidemiological characteristics and calculates the probability of municipalities joining the program based on these profiles, creating a counterfactual scenario that enables comparison of treated municipalities and controls[26].

The PSM is characterized as a quasi-experimental method that allows the formation of groups (of individuals or other aggregated units) with similar characteristics, but that differ from each other in terms of exposure (or not) to a given intervention[27,28].

The method was developed to solve the problem of multidimensionality of matching and consists of identifying untreated units that are similar to treated units and comparing the means in the result, seeking to identify, through the selection of observable characteristics between these two groups, the impact of treatment (HGP). The *propensity score matching* configures itself as an important pairing resource used for the evaluation of public policies[26,27].

The matching procedures use a balanced score, computed from a regression model (*logit* or *probit*) that uses a *dummy* dependent variable that takes the value *one* if the individual (or unit) was exposed to the policy under analysis, or *zero*, if not.

The choice between the *logit* and *probit* models was performed using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC), considering the lowest values found in both criteria as a reference for the best fit of the model[29].

The PSM is defined as the probability of the individual (municipality) being a beneficiary of the program, given its characteristics (socioeconomic, demographic, and epidemiological).

Through the estimate of the PSM, subgroups are identified within the control group, with similar probabilities to the municipalities in the intervention group. Then, the variables are balanced, which allows testing of each block of the *propensity score*, as to whether the mean of each variable used in the model differed between beneficiary and non-beneficiary municipalities of the HGP.

After this step, a final number of blocks was defined and we proceeded with the calculation of the Average Treatment Effect on the Treated (ATT) by testing the matching algorithms. These tests aim to build a counterfactual scenario from the weighted average of the number of control units with each treatment unit[28]. Using this method, each unit of the treated group was paired with the unit of the control group with the closest *propensity score*. The ATT was determined to assess the impact of the Health Gym Program on mortality from Hypertension for each of the groups of municipalities (treated and controls).

Data analysis

Descriptive statistical procedures (frequencies, means, and standard deviations) were adopted to characterize the socioeconomic, demographic, and epidemiological profile of the treated and control municipalities before matching. To compare the means and standard deviations of the variables related to those exposed and not exposed to the policy under analysis (Health Gym Program) and the respective calculation of the effect size, Cohen's *D* measure was used.

To estimate the PSM, regression models for binary data were tested using the link functions *logit* and *probit*[30], to determine the probability of participation of municipalities in the HGP, given the socioeconomic, demographic, and epidemiological characteristics of the municipalities that made up the sample, using a vector of characteristics from the period prior to exposure to the program ($X_{i,-1}$)[31], which is given by:

$$P(PAS_i^0 = 1) = \emptyset(\beta X_{i,-1}) \quad (1)$$

Where HGPi is a dummy variable that takes the value 1 (treated) if the i-th municipality was exposed to HGP and the value 0 (control) if it was not exposed. $\emptyset$ is an accumulated distribution function of type *logit* or *probit*, $X_{i,-1}$ is a vector of k explanatory variables weighted by the inverse of the treatment probability, and β is a vector of parameters associated with these variables.

The probability of the municipality being treated, given the set of characteristics *X*, is called the propensity score, which is defined by:

$$\hat{P}(X) = P(PAS_i^0 = 1 \mid X_{i,-1}) \quad (2)$$

To calculate this score, we used a set of socioeconomic, demographic, and epidemiological variables that could potentially influence a municipality's willingness to adhere to the HGP.

In the next step, the estimated propensity scores were used to compute the weights needed to balance the municipalities in the control group, so that, on average, these become similar to the treated group. For this, the nearest neighbor methods (1:5), with and without replacement, Kernel matching, and radial matching were tested, in order to identify the best way to perform the matching[28].

To test the robustness of the model, the balancing test (*pstest*) was performed, which sought to verify statistical similarities between the matching variables and the reduction in standardized bias before and after, both at the 5% level[26,27].

All analyses were performed using Stata software, version 15.0, considering the complex design of the sample. The Stata application "psmatch2" was used to calculate the *propensity score* and ATT, adopting a significance level of 5% for all statistical tests.

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In order to avoid comparisons between municipalities that started HGP activities at different periods, and which in these cases would be subject to the potential effects of the program at different points in time, cities that started HGP activities less than six years previously were excluded from the analysis. In order to avoid comparisons between municipalities that started HGP activities at different periods, and which in these cases would be subject to the potential effects of the program at different points in time, municipalities that started HGP activities less than six years ago were excluded from the analysis.

Results

The results are presented in four parts. The first presents a descriptive analysis of the socioeconomic, demographic, and epidemiological characteristics of the municipalities that make up the groups of treated and controls, before carrying out the matching. The second part describes the mortality profile of the sample, stratified between treated and controls before the implementation of the HGP. The third part presents the results of the estimation of the model for evaluating the impact of the HGP on mortality from SAH and the fourth part presents the results regarding the impact of the HGP on the mortality rate from Hypertension in the state of Pernambuco.

Socioeconomic, demographic, and epidemiological characteristics of the municipalities

In the state of Pernambuco, a total of 35,493 deaths from all causes were registered, 783 (2.20%) due to SAH in 2010, while in 2017, 42,134 deaths were registered, of which 728 (1.72%) were due to SAH. The mortality rate due to SAH was 1.59 and 1.60 deaths for each group of 10,000 inhabitants for the years 2010 and 2017, respectively.

The descriptive analysis of the epidemiological and care profile of the treated and control municipalities before the implementation of the HGP (2010) showed that the municipalities that would implement the program in 2011 already had higher rates of general mortality and deaths in people over 50 years of age and a higher hospital bed rate, in addition to a lower mortality rate due to SAH and lower coverage of Primary Care than the municipalities considered as controls (Table 1).

With regard to socioeconomic characteristics, as described in Table 1, the municipalities that implemented the HGP in 2011 already presented in 2010 better indicators of GDP, Gini Index, General IFDM, education IFDM, unemployment rate, and HDI.

Mortality profile due to Hypertension in the municipalities

Regarding the SAH mortality rate in 2010, it was observed that the municipalities evaluated had a higher SAH mortality rate in the female population compared to the male population. With regard to the variable ethnicity/color, the highest rates were among brown-skinned individuals, and with regard to age group, it was observed that the mortality rate due to SAH, both in the treated municipalities and in the controls, was higher in older individuals, with more expressive values in the population over 60 years old (Table 2).

Estimation of the HGP impact assessment model on SAH mortality

To perform the Propensity Score Matching, *logit* and *probit* models were estimated, considering the socioeconomic, demographic, and health care network variables of the municipalities that make up the sample. The *logit* model was selected for presenting lower AIC and BIC values than the *probit* model and the Kernel algorithm showed the best statistical significance and was chosen to assess the impact of HGP on mortality from SAH. The results of the *logit* model are presented in Table 3, together with the matching algorithms.

The Propensity Score Matching was estimated using the *logit* model, considering socioeconomic and health variables of the municipalities that make up the sample. Table 4 describes the model used to perform the propensity score matching.

The analysis shows that the variables that best explain the probability of a municipality adhering to the HGP were the Gross Domestic Product, the coverage of primary care in the municipality, the rate of hospital beds per 1,000 inhabitants, the unemployment rate, and the FIRJAN index for education, with the last two being statistically significant at the 5% level. In this sense, it was observed that the chance of a municipality joining/implementing the HGP is directly proportional to the increase in the education indicator and inversely proportional to the unemployment rate.

Table 1. Socioeconomic, demographic, and epidemiological characteristics of treated and control municipalities. Pernambuco, 2010.

Variables	Control		Treated		Difference in means	Cohen-d	CI95%*
	Mean	SD	Mean	SD			
Proportion of men in the population	0.508	0.008	0.505	0.008	0.003	0.408	0.062 – 0.753
Proportion of women in the population	0.512	0.007	0.515	0.008	-0.003	-0.371	-0.715 – -0.026
Proportion of people 40 to 49 years old	0.118	0.071	0.111	0.013	0.007	0.159	-0.182 – 0.502
Proportion of people 50 to 59 years old	0.083	0.055	0.078	0.010	0.005	0.142	-0.200 – 0.484
Proportion of people 60 to 69 years old	0.061	0.044	0.059	0.010	0.002	0.061	-0.281 – 0.403
Proportion of people 70 to 79 years old	0.036	0.025	0.035	0.008	0.001	0.047	-0.294 – 0.390
Proportion of people >80 years old	0.018	0.014	0.018	0.005	0	-0.040	-0.382 – 0.302
Death rate >50 years/1,000 inhab	4.28	1.23	4.54	1.11	-0.26	-0.222	-0.565 – 0.120
General death rate (per 1,000 inhab)	5.98	1.312	6.22	1.24	-0.24	-0.190	-0.532 – 0.152
Death rate of SAH/10,000 inhab	1.85	1.68	1.44	1.34	0.41	0.274	-0.069 – 0.617
Hospital bed rate/1,000 inhab	1.407	0.954	1.600	1.130	-0.193	-0.180	-0.522 – 0.162
Primary Care Coverage (%)	91.4	15.0	85.8	19.4	5.6	0.311	-0.032 – 0.655
Gini Index	0.514	0.043	0.521	0.045	-0.007	-0.159	-0.501 – 0.183
General IFDM	0.576	0.066	0.580	0.078	-0.004	-0.052	-0.394 – 0.289
Gross domestic product (per capita)	5,872.50	2,796.10	6,463.50	4,156.10	-591.00	-0.159	-0.501 – 0.183
Human development Index	0.586	0.044	0.602	0.048	-0.016	-0.344	-0.688 – 0.000
Unemployment rate	10.69	5.43	8.24	3.71	2.45	0.554	0.204 – 0.901
Education IFDM	0.569	0.074	0.609	0.633	-0.04	-0.593	-0.941 – -0.242

*CI95%I: 95% Confidence Interval of Cohen's *D* measure.

Source: Elaborated by the authors based on data from SIM, DATASUS, BDE, and IBGE, using STATA.

The model's robustness test showed that the matching met the balancing property, as no statistical similarities were observed between the matching variables (all with p>0.05). In addition, regarding the reduction in the standardized bias before/after, it was found that all variables presented a reduction in the percentage of *bias* of at least 5%.

Impact of HGP on Hypertension Mortality Rate

The propensity score matching was used in this study with the aim of making the treated and control groups similar, considering their observable characteristics described in Table 5.

In the analysis of the PSM presented in Table 5, it is observed that the presence of HGP caused a reduction of 12.8% in the mortality rate due to arterial hypertension and that this reduction was greater and statistically significant in brown-skinned people and in adults over 80 years.

Discussion

In the current study, it was observed that SAH was responsible for approximately two percent of deaths from all causes in the state in 2010 and 2017, with a mortality rate per thousand inhabitants practically equal for the two years evaluated, corroborating the results of studies which

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Table 2. SAH mortality rate for every 10,000 inhabitants in treated and control municipalities. Pernambuco, 2010.

Extracts	Treated		Controls		Cohen-d	CI95%*
	Total	SD	Total	SD		
Female	0.72	0.74	0.84	0.81	0.156	-0.184 – 0.495
Male	0.66	0.79	0.99	1.14	0.342	-0.000 – 0.683
White	0.48	0.68	0.54	0.77	0.086	-0.256 – 0.428
Black	0.09	0.21	0.16	0.32	0.272	-0.071 – 0.615
Brown-skinned	0.75	0.84	1.06	1.24	0.314	-0.029 – 0.658
Other ethnicity/color	0.03	0.13	0.02	0.12	-0.134	-0.476 – 0.208
40 to 49 years	0.06	0.19	0.06	0.18	-0.044	-0.386 – 0.297
50 to 59 years	0.09	0.22	0.15	0.33	0.211	-0.132 – 0.553
60 to 69 years	0.18	0.33	0.25	0.43	0.181	-0.161 – 0.523
70 to 79 years	0.36	0.52	0.45	0.53	0.172	-0.170 – 0.515
80 years and over	0.67	0.77	0.91	1.03	0.272	-0.071 – 0.615

*CI95%I: 95% Confidence Interval of Cohen's *D* measure.

Source: Elaborated by the authors based on data from SIM, DATASUS, BDE, and IBGE, using STATA.

Table 3. Testing the HGP matching algorithms on mortality from Hypertension, using the propensity score matching method.

Difference in the means				
Mortality from SAH[a]	Treated	Control	Difference	t-Value
No algorithm	0.820	0.948	-0.127	-1.43**
Radial	0.820	0.862	-0.041	-1.03
Nearest neighbor	0.820	0.956	-0.136	-1.79*
Kernel	0.820	0.948	-0.128	-1.73*

t-Value: * Significant at the 5% level; **Significant at the 10% level. [a] Natural logarithm of the mortality rate per 10,000 inhabitants.

Source: Elaborated by the authors based on data from SIM, DATASUS, BDE, and IBGE, using STATA.

Table 4. *Logit* model for participation in the Health Gym Program and model balancing test. Pernambuco, 2010 and 2017.

Logit kernel Model				
Variables	Coef	Standard error	p-Value	CI95%
PIB	0.000	0.000	0.504	-0.000 – 0.000
PC Coverage	-1.653	0.893	0.064	-3.403 – 0.096
Hospital bed rate	0.080	0.137	0.556	-0.188 – 0.349
Unemployment rate	-0.122	0.030	<0.001	-0.181 – -0.062
IFDM Education	1.788	1.816	0.001	2.420 – 9.542
Constant	-0.872	1.264	0.490	-3.351 – 1.606

Model balancing				
Variables	Mean		% Bias	p-Value
	Treated	Control		
PIB	8534.1	8253.2	5.2	0.610
PC Coverage	0.899	0.910	-7.2	0.517
Hospital bed rate	1.527	1.436	9.1	0.374
Unemployment rate	8.246	7.659	12.7	0.164
Education	0.655	0.646	11.3	0.284

CI95%: 95% Confidence Interval.

Source: Elaborated by the authors based on data from SIM, DATASUS, BDE, and IBGE, using STATA.

Table 5. Impact of the Health Gym Program on the SAH mortality rate. Pernambuco, 2010 and 2017.

	SAH Mortality rate		
Extracts	ATT	Standard error	t-Value
Overall impact of the program	-0.128	0.074	-1.73*
Men	-0.090	0.061	-1.49**
Women	-0.091	0.057	-1.60**
White	-0.047	0.054	-0.86
Black	-0.003	0.024	-1.14
Brown-skinned	-0.125	0.064	-1.95*
Other ethnicity/color	-0.005	0.030	-0.17
40 to 49 years	-0.004	0.017	-0.27
50 to 59 years	0.004	0.025	0.18
60 to 69 years	-0.019	0.034	-0.58
70 to 79 years	-0.043	0.046	-0.94
80 years or more	-0.131	0.064	-2.05*

ATT = Average Effect of Treatment on the Treated. t-value: *Significant at the 5% level; **Significant at the 10% level.

Source: Elaborated by the authors based on data from SIM, DATASUS, BDE, and IBGE, using STATA.

point to stability in mortality from this cause over the last decade[9].

The descriptive analysis of the socioeconomic, epidemiological, and care profile of the treated and control municipalities before the implementation of the HGP reiterates the results of the health information systems and epidemiological studies, which indicate that the rate of hospital beds per thousand inhabitants in Pernambuco is slightly lower that the national average (1.67)[32] and that the coverage of primary care found in this study was higher than the average for Brazil (51.8%)[33]. It is noteworthy, however, that the differences observed in the profile of municipalities before the PSM were eliminated through the selection of pairs of treated and control municipalities that presented similar characteristics and probabilities of implementation of HGP[26].

The findings related to the profile of mortality by sex in this study are in contrast to the results of research that indicate that mortality from SAH is more prevalent in men. In a study that evaluated the variations and differentials of mortality from cardiovascular disease in Brazil, Brant et al. (2017) point out that mortality from hypertensive diseases was higher in males between 1990 and 2015[34].

Regarding the ethnicity-color variable, our study showed a higher mortality rate in the black and brown-skinned population, corroborating the results of other studies on mortality from hypertensive diseases, which indicate greater risks in non-white individuals than in white individuals[35]. From this perspective, the high mortality rates from hypertension in black individuals (both in Pernambuco and in Brazil) can be justified by socioeconomic conditions, which are intrinsically linked to inequalities in social opportunities throughout life in these subgroups[36].

In the current study, we observed that the mortality rate due to SAH is directly proportional to the increase in age, corroborating a study that indicates that the progressive increase in age increases the chances of the occurrence of deaths due to SAH[9].

Regarding the estimation of the model for evaluating the impact of the HGP on the mortality rate from hypertension, *probit* and *logit* models were tested, with the latter being the one chosen to measure the probability of a municipality implementing the HGP. The *logit* model is the most widely used regression model in research in the field of public policy impact assessment[37]. In addition, it was more appropriate to the data and presented lower values for the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC)[29].

The test results of the matching algorithms showed that the nearest neighbor method presented slightly better results than the Kernel matching, both for the impact of HGP on mortality, and for the statistical significance of the treatment effect on the treated (ATT). However, as the values were close, we chose to use the Ker-

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nel algorithm as it is more efficient and produces lower variances when compared to other matching strategies[38].

The pairing through the Kernel algorithm made the conditional probability of deploying HGP poles more similar between the treated and control groups, minimizing the selection bias and indicating that the PSM was successful[39,40].

The variables that made up the model for evaluating the impact of the HGP on mortality from SAH (GDP, coverage of primary care, the rate of hospital beds, unemployment rate, and the FIRJAN index for education) corroborate findings in the literature that report the influence of income, structure of the health care network, and education on the mortality rate from SAH[41,42]. In addition, the proposed model met the balancing properties, which indicate that the PSM manages to balance the observable characteristics of the treated and control groups[39,40].

The balancing test also showed that the mean of each variable used in the model did not differ between treated and controls, indicating that the participation of municipalities in the HGP does not depend on the results found, that is, mortality is not a determinant of participation (or not) in the program, but only determined by it[26,43].

Before the implementation of the HGP in 2010, there was already a discrepancy in the profile of mortality from SAH between the evaluated municipalities, however, after the implementation of the program, it was found that beneficiary municipalities (treated) had a 12.8% lower rate of deaths from SAH, compared to municipalities that are not beneficiaries of the program (controls).

The impact of the program on black and brown-skinned people, as well as older people, reiterates the results of studies that point to the effects of a program similar to the HGP in increasing levels of physical activity in non-white people and older individuals[44,45].

The relationship between the presence of the HGP and mortality from hypertension may be related to the adoption of more active and healthier lifestyles by the population of the beneficiary municipalities, which allows us to infer that the specific objective of the HGP to increase the quality of care and the level of physical activity of the population[17,45] and its guideline to configure itself as a strategy for health promotion, care production, and chronic disease prevention[18] is being achieved in the cities treated. On the other hand, evidence points to the lack of clearly defined goals[16] and action protocols[24], which could excessively expand the possibilities of intervention and eventually compromise the effect of the program.

As a limitation of this study, which had an ecological design, it is highlighted that the mortality rates used in the analysis model may have been underestimated due to the registration of deaths with the cause classified as ill-defined and incompleteness in filling out some death certificates that feed the Mortality Information System (MIS)[46].

On the other hand, this study is innovative, as it employed a method widely used to assess the impact of social policies, but which is still little explored in the field of health. In addition, the evidence generated from this study can serve as a reference to assess the impact of other health promotion and physical activity programs and support the decision-making of public managers in planning strategies aimed at implementing or expanding the Health Gym Program in their municipalities.

Collaborations

FRB Guarda was responsible for the project and the study design, writing the manuscript, interpretation, and data analysis until the final revision of the manuscript. DKS Feitosa participated in the writing of the manuscript, data collection, interpretation, and analysis, until the final review of the manuscript. RN Silva participated in the writing, critical analysis, and final review of the manuscript. BLS Rodrigues participated in the writing of the manuscript, obtaining, interpreting, and analyzing data, until the final review of the manuscript. PBC Silva contributed to the writing of the manuscript, obtaining the databases, until the final revision of the manuscript. RG Arruda contributed to the interpretation and analysis of data, and critical analysis of the manuscript.

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