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Research Article

Physical Activity Program Can Mitigate Public Health Expenses with Hospitalization for Osteoporotic Femur Fractures: An Econometric analysis of Health Gym Program - Brazil

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Abstract

Objective: This paper aimed to evaluate the impact of the Health Gym Program on public health expenses with hospital admissions for osteoporotic femur fractures in the state of Pernambuco, Brazil.

Method: This public policy impact evaluation had used econometric modeling which combined the Propensity Score Matching and Difference-in-difference with fixed effects. Data referring to the population over 50 years old were collected in official databases and contain demographic, socioeconomic, and health care information to the 185 municipalities in Pernambuco for the period from 2009 to 2019. Pre- and post-estimation tests were carried out in order to verify the fulfillment of the estimators' assumptions and the robustness of the models used.

Result: There were 37,334 hospitalizations for osteoporotic femur fracture in the state of Pernambuco in the period from 2009 to 2019 and the cost of these hospitalizations was US$ 2,102,565.12 (annual average = US$ 175,213.76). It represented 1.65% of expenses with all hospital admissions during the study period. The municipalities that implemented the Health Gym Program spent, on average, 16.54% less on hospitalizations for osteoporotic femur fractures than those that did not adhere to this intervention (ATET = - 0.1654; EP = 0.081) and this result was statistically significant at the 5% level.

Conclusion: The Health Gym Program impacted by reducing public spending on hospital admissions for osteoporotic femur fractures when comparing the municipalities that implemented this intervention with those that did not.

Keywords: Osteoporosis; Physical Activity; Health Evaluation; Economic Analysis; Chronic Disease; Health Economics

Introduction

Osteoporosis is an osteometabolic disorder caused by a decrease in bone mineral density. Evidence indicates that the prevalence of osteoporosis among people over 50 years old can vary from 2% to 8% among men, but the most affected population is the female, in which the prevalence is between 33% and 47% [1,2].

The loss of bone mass increases the fragility of this tissue and the risk of fractures [3], especially of the vertebrae, wrist, and femoral neck [4].

Studies indicate that osteoporotic fractures are frequent in individuals over 50 years of age in several countries worldwide. Studies point out that one in two women and one in five men in the UK will suffer osteoporotic fractures in their lifetime [5], and in the USA the estimate is 1.5 million fractures for fragility every year [6].

In Brazil, 413,564 osteoporotic fractures were recorded in individuals over 50 years in 2018 alone [7]. The annual incidence of these fractures ranged from 5.59 to 13 per 10,000 women. For men, the incidence ranged from 12.4 to 27.7 per 10,000 individuals. A study that evaluated 1,007 individuals in the largest city in the country (São Paulo) found a prevalence of 13.2% of osteoporotic fractures [8].

In addition to pain, discomfort, and decreased functional capacity [9-11], osteoporotic fractures increase the demand for hospitalization and rehabilitation services and, consequently, the costs for individuals and the health sector [12]. The economic costs of osteoporosis-related fractures exceed £4 billion in the UK [13]. For the United States, the estimate is that this expenditure will exceed 25 billion dollars in 2025 [14]. In Brazil, costs of diagnosis, hospitalizations, surgeries, drug prescriptions, and lost productivity due to fractures caused by osteoporosis reached 310 million dollars in 2018 alone [7].

Among osteoporotic fractures, the femur fracture is highlighted, which, although not the most prevalent, is an important public health problem, as it is responsible for high rates of both hospitalizations and deaths [15,16]. These fractures were responsible for an expense of more than 27 million dollars with hospitalization expenses in just one year in Brazil [17], and the average cost of these procedures was R$ 8,266.25 per hospital [18].

The practice of physical activities contributes to the maintenance and increase of bone density, strength, balance, and gait stability of individuals [19], which can reduce the risk of falls [20] and osteoporotic fractures [19]. In this sense, physical activity programs are considered effective strategies for preventing and controlling chronic diseases [21] and osteoporosis [19].

The Health Gym Program (HGP) was created by the Brazilian Ministry of Health in 2011. This program aims to expand the possibilities of promoting health and physical activity in the scope of primary health care and consists of financial investment of the federal government for the construction and for the funding of public spaces and professional teams aimed at encouraging more active and healthy behaviors in the Brazilian population [22].

The HGP is considered the main health and physical activity promotion program in the Brazilian public health system and the main strategy for increasing the population's levels of physical activity [22]. Among the main activities developed in the program are health education actions aimed at healthy eating and supervised physical activities, such as gym, dance, walking, and running classes [23].

Since 2011 more than 4,000 HGP centers were implemented in more than 1,500 Brazilian cities. The state of Pernambuco, located in the Northeast region of Brazil, has 267 centers of the Health Gym Program in 135 municipalities and was the first Brazilian state to implement this intervention [24].

Evidence indicates that health promotion programs can mitigate the occurrence of falls in the elderly and the fractures resulting from these events [19,20]. Furthermore, other studies pointed out that the HGP increased the population's level of physical activity [25] and in reduced expenses with hospitalizations for cerebrovascular diseases [26]. However, the relationship between the HGP implementation and public spending on health is still unclear. In this sense, this paper aims to evaluate the impact of the Health Gym Program on public hospital admission expenses due to osteoporotic fracture of the femur in the state of Pernambuco from 2009 to 2019.

Method

This study is an impact assessment of public policies, which used a quasi-experimental approach to assess the impact of HGP on hospital admissions for osteoporotic fracture of the femur in municipalities that implemented this intervention, compared to those that not deployed it.

The implementation of the HGP took place through voluntary adherence. Therefore there was no randomization of the municipalities that adhered to this policy. In this way, this study could present selection bias because of the different characteristics of the municipalities that could be associated with their decisions to implement (or not) the program [27-29].

The combination of PSM and DID estimators is called Double Difference Matching (DDM). It is considered a robust strategy for public policy impact assessment [30], as PSM minimizes biases related to the absence of common support and reduces biases arising from the distribution of observable characteristics, while the DID method reduces potential selection biases by characteristics of the treated and controls [31,32].

Data refer to the population of both sexes and over 50 years of age in the 185 municipalities in Pernambuco. The 134 municipalities that implemented the HGP from 2011 onwards were designated as treated, and the 51 that did not implement the program formed the comparison group (controls), totaling 1,850 observations.

The econometric models of this study used a set of variables described in the scientific literature as associated with osteoporotic fractures. It includes gender, social and economic characteristics, income, and supply of health services [33-36].

The study uses a panel of demographic, socioeconomic and health care network data in Pernambuco municipalities from 2009 (two years before the implementation) to 2019 (eight years after the implementation of the HGP). The demographic variables that make up the econometric analysis models were the female population of the municipalities and the proportion of individuals over 50 years of age in the population, both collected on the website of the Brazilian Institute of Geography and Statistics.

Socioeconomic variables were the total health expenditure in each municipality (collected on the website of the Public Budget Information System), the Gross Domestic Product *per capita* of each municipality (collected on the website of the Brazilian Institute of Geography and Statistics), the pass and fail rates in elementary education, and dropout rates (elementary and high school) in each municipality, all collected on the website of the National Institute of Educational Studies and Research Anísio Teixeira.

Data related to the care network were the percentage of the population served by public primary health care services (collected from the information system of primary health care management), the proportion of doctors per inhabitant, and the number of beds in public hospitals in each municipality (both collected from the National Registry of Health Establishments).

The dependent variable for this study is the natural logarithm of public spending on hospitalizations for osteoporotic femoral fractures. Considering that the expense had a value of zero for some observations, we adopted the strategy of adding one unit to the original value of the expense before converting to the natural logarithm, as recommended by Wooldridge [37].

Some municipalities present values much above the average of the other municipalities for most variables and were considered *outliers*. We included a *dummy* variable in the econometric models indicating whether or not a municipality was an *outlier* in order to minimize possible distortions that these extreme values could cause in the estimators based on means.

Data analysis

We performed descriptive statistics procedures for the independent variables and for the expenses with hospital admissions due to osteoporotic femur fracture. The propensity score matching model used the same variables as the DID and DDM models for matching and used the Kernel algorithm with 50 bootstrap repetitions to perform the matching [38,39]. The DID and DDM models were estimated for Fixed Effect panel data [40,41].

Other procedures performed were the pre-tests to validate the estimation model and the empirical strategy and post-estimation tests to validate the results. The first pre-test was the Hausman test, which verified the hypothesis of endogeneity of the random term, allowing the choice of the best functional form between the fixed-effect and random-effect models [37,42]. Then the presence of serial autocorrelation in the regression residuals was verified using the Wooldridge test [38,39,41]. The third pre-test was heteroscedasticity for panel data, using the Wald test [43,44].

We calculated the standard errors of the estimates through a robust variance-covariance matrix per cluster of municipalities in order to reduce problems related to heteroscedasticity and serial autocorrelation of the regression residuals [40,45]. Still aiming to improve the quality of the model's fit, the results of the estimations were reweighted by the residual variance of the units (treated and control municipalities).

The first post-estimation test was the *leads* and *lags* test, which aimed to verify the correlation between the investigated variables and the treatment [46,47]. The *leads* (anticipations) were inserted in the DID model to check if the behavior of the dependent variable (expenses with hospital admissions for osteoporotic femur fracture) after adherence to the HGP already existed before its implementation in the municipalities. *Lags* (delays) were inserted in the model to assess whether the effect of the HGP diminished after its implementation. Two *leads* and two *lags* were included in the model [46,47].

We also performed a "placebo regression" as a post-estimation test [41]. Therefore, the DDM model was estimated keeping the same exposure variable (presence of HGP in the municipalities) and the same independent variables of the DDM model, but with a dependent variable with no theoretical relationship with the expected effect for the study (decrease in expenses with hospitalizations for osteoporotic femur fracture). The placebo variable chosen was the proportion of men for every 10,000 inhabitants in the state of Pernambuco.

All analyzes were performed in Stata 16.0 software and the monetary values of the results were converted to US dollars, using the exchange rate on December 31, 2019, as a reference.

Results

The results are presented in four sections. The first contains descriptive statistics of demographic, socioeconomic and health services variables of the treated and control municipalities. The second presents the model estimation pre-tests. The following section presents the estimation of the PSM, DID, and DDM models used to measure the impact of HGP on expenses with hospitalizations for osteoporosis. The fourth section presents the results of post-estimation and model robustness tests.

Demographic, socioeconomic, and health service characteristics of the municipalities

In the state of Pernambuco, US$ 2,398,937.12 were spent on hospitalizations (average = US$ 1,199,468.56; SD + US$ 56,774.94) for all causes in the period prior to the implementation of the HGP (2009 to 2010), being US$ 1,778,517.26 (mean = US$ 444,629.31; SD + US$ 266,027.57) per osteoporotic femur fracture. In the period after the implementation of the HGP (2011 to 2019) the expenditure was US$ 19,625,317.95 (average = US$ 2,180,590.88; SD + US$ 248,290.45) with hospitalizations for all causes, being US$ 324,047.86 (mean = US$ 36,005.32; SD + US$ 11,441.53) with hospitalizations for osteoporotic femur fracture.

Table 1 presents the descriptive statistics of the demographic, socioeconomic, and health service variables of the treated and control municipalities.

Variable	Obs	Mean	Std. Dev.	Min	Max
% coverage PHC teams	1,850	.919	.145	.141	1
Population (log)	1,850	10.157	.916	7.898	14.314
Female Population	1,850	26,058.43	72,744.073	1,368	890936
age 50 years or older /inhabitant	1,850	.117	.022	850,044.6	.180
Physician / inhabitant	1,850	.000	.000	0	.003
Hospital bed/municipality	1,850	92.371	468.274	0	6,594
Total Health Care spends	1,850	16.078	1.565	0	20.913
pass rate in elementary school	1,850	86.424	5.315	67.8	98.9
dropout rate	1,527	2.212	5.478	0	87
failure rate in elementary school	1,850	10.550	3.903	.9	26.9
high school pass rate	1,850	89.398	6.482	54.6	100
per capita GDP	1,665	754,057.8	895,976.3	5,793.6	18,000,000.0
Spending on hospitalizations for osteoporosis	1,850	23,900.77	81,292.7	0	1,508,925.0

Table 1: Descriptive statistics of demographic, and health service variables of the treated and control municipalities. Pernambuco, 2009 to 2019.

Source: Prepared by the authors with secondary data in the public domain.

Model estimation pre-tests

The Hausman pre-test was carried out, considering the same explanatory and control variables for each of the three models for estimating the impact of HGP on expenditures. The result was statistically significant at the 5% level (Prob > chi2 < 0.05), indicating that the fixed effects model is more adequate for the data than the random effects model.

The Wald test pre-test also showed statistically significant results, which allowed us to reject the null hypothesis that the model is not homoscedastic. Finally, we performed Wooldridge's test for serial autocorrelation of errors, which allowed us to accept the null hypothesis that there is no serial autocorrelation of the regression residuals (Prob > chi2 F = 0.2979).

Estimation of PSM, DID, and DDM models

The variables that made up the PSM, DID and DDM models and that best explain the impact of HGP on hospital admissions for osteoporotic femur fractures in the state of Pernambuco were: the percentage of the population served by primary health care teams, the female population of the municipalities, the proportion of people over 50 years old per inhabitant, the number of doctors per inhabitant, the number of public hospital beds in the municipalities, the natural logarithm of the total expenditure on health actions in each municipality, the approval and failure in elementary school, approval in high school, the dropout rate and the GDP per capita of the municipalities.

The PSM model was estimated only to perform the matching of treated and control municipalities, and to later be used to weight the estimation by the DID method. However, the results of the PSM (Average Treatment Effect on the Treated – ATET) already indicate that the presence of HGP reduces the expenses of hospitalizations for osteoporotic femur fracture (ATET = -0.5012; T-stat = -2.58). The coefficients are presented in table 2.

HGP	Coef.	Std. Err.	z	P > z	[95% Conf.	Interval]
% coverage PHC teams	-1.122	.531	-2.11	0.035	-2.163	-.082
Population (log)	-.831	.279	-2.98	0.003	-1.378	-.2846
Female Population	.000	.000	2.11	0.035	-0,000	.000
age 50 years or older/inhabitant	25.472	3.420	7.45	0.000	18.769	32.176
Physician/inhabitant	693.981	258.139	2.69	0.007	188.037	1199.925
Hospital bed/municipality	.001	.001	0.97	0.330	-.001	.004
Total Health Care spends (log)	.651	.248	2.63	0.009	.166	1.137
pass rate in elementary school	-.021	.034	-0.64	0.521	-.089	.045
dropout rate	-.014	.0108	-1.34	0.181	-.036	.007
failure rate in elementary school	-.065	.043	-1.52	0.129	-.149	.019
tx_aprovacao_medio	-.006	.012	-0.50	0.615	-.029	.017
per capita GDP	-0,000	-0,000	-0.30	0.766	--0,000	-0,000
outlier	.537	.238	2.26	0.024	.071	1.003
_cons	-.614	3.936	-0.16	0.876	-8.328	7.100

Table 2: Coefficients of the Propensity Score Matching model. Pernambuco, 2009 to 2019.

Source: Own elaboration, using STATA software.

Note: matching performed by Kernel algorithm with 50 bootstrap repetitions.

Municipalities that implemented the HGP spent 16.54% less on hospitalizations for osteoporotic femur fractures than municipalities that did not implement the program, and this result was statistically significant (ATET = -0.1654; p = 0.044). Table 3 presents the estimations performed using the difference-in-differences (DID) estimator weighted by the Propensity Score Matching (DDM method).

ln_fratura osteoporótica de fêmur	Coef.	Std. Err.	P > t	[95% Conf.	Interval]
HGP	-.1654	.081	0.044	-.326	-.004
Time (before/after HGP)	.798	.198	0.000	.407	1.189
PSM	1.146	1.150	0.320	-1.123	3.417
% coverage PHC teams	.393	.300	0.192	-.198	.985
Population (log)	-2.076	1.330	0.121	-4.696	.555
Female Population	.000	.000	0.469	-.000	.000
age 50 years or older/inhabitant	11.395	11.823	0.336	-11.930	34.722
Physician/inhabitant	-14.650	176.831	0.934	-363.528	334.226
Hospital bed/municipality	-.001	.001	0.018	-.002	-.000
Total Health Care spends (log)	-.073	.0474	0.125	-.166	.020
pass rate in elementary school	-.022	.019	0.250	-.061	.016
dropout rate	.006	.005	0.194	-.003	.015
failure rate in elementary school	-.027	.024	0.264	-.075	.020
tx_aprovacao_medio	.003	.006	0.617	-.009	.015
per capita GDP	.000	.000	0.844	-.000	-.000
outlier	-8.171	.140	0.000	-8.449	-7.894
Year					
2011	-.450	.166	0.003	-.827	-.171
2012	-.599	.153	0.000	-.901	-.297
2013	-.554	.138	0.000	-.826	-.281
2014	-.214	.124	0.086	-.458	.030
2015	-.288	.119	0.016	-.522	-.053
2016	.049	.101	0.626	-.150	.249
2017	.162	.010	0.106	-.034	.358
2018	0	(omitted)			
_cons	30.304	14.094	0.033	2.497	58.111
sigma_u	2.343				
sigma_e	.721				
rho	.913	(fraction	of variance due	to	u_i)

Table 3: Impact of the Health Gym Program on hospital admission expenses for osteoporotic femur fractures in the state of Pernambuco - Brazil. 2009 to 2019.

Source: Own elaboration, using STATA software.

The result of the post-estimation test for *leads* and *lags* was not statistically significant, indicating that the HGP impact estimation model does not present anticipations, nor delays and is adequate to establish the causal inference about the impact of the program on public spending on hospitalizations for osteoporotic femoral fractures. Table 4 presents the coefficients of the *leads* and *lags* test used as a post-estimation test of the HGP impact assessment model on expenses with osteoporotic femoral fractures.

The last post-estimation test used a placebo regression with the same variables of the DDM model but with another dependent variable to verify the robustness of the main model of this study.

nl_osteo-porotic fracture of femur	Coef.	Std. Err.	P > z	[95% Conf. Interval]	
lag2	.679	.411	0.099	-.127	1.485
lag1	-.360	.266	0.176	-.881	.161
treat	.320	.266	0.229	-.201	.841
lead1	.116	.269	0.667	-.411	.643
lead2	-.104	.274	0.703	-.642	.433
_cons	7.767	.162	0.000	7.450	8.085
sigma_u	1.833				
sigma_e	3.019				
rho	.269 (fraction		of variance due		to u_i)

Table 4: Leads and Lags Model Coefficients.

The results show that the variable tested (proportion of men for every 10,000 inhabitants in the population) was not statistically significant and presented results with a sign different from that found in the model for osteoporotic femoral fractures. This result indicates that only the expenditure on hospitalizations for osteoporotic femur fractures is influenced by the presence of HGP and that the DDM model estimated for this study is sufficiently robust to assess the impact of this program. Table 5 presents the coefficients of the falsification test performed through placebo regression.

Discussion

Spending on hospitalizations for osteoporotic femur fracture represented 1.65% of spending on all hospitalizations in the state of Pernambuco between 2011 and 2019. This result was slightly lower than that found in other studies, which indicate that spending on attention to Femur fractures accounted for 2% of medical expenses from the same causes [48]. However, this study consid-

Men/10.000 inhabitant	Coef. Std.	Err. t	P > t	[95% Conf. Interval]	
HGP	2.475	1.859	0.185	-1.194	6.145
Time (before/after HGP)	16.733	5.682	0.004	5.523	27.944
PSM	-29.103	30.762	0.345	-89.797	31.589
% coverage PHC teams	-8.671	7.493	0.249	-23.455	6.112
Population (log)	82.417	52.364	0.117	-20.894	185.730
Female Population	-.000	.000	0.172	-.001	.000
age 50 years or older/inhabitant	-1160.639	342.188	0.001	-1835.756	-485.521
Physician/ inhabitant	6183.704	4815.863	0.201	-3317.708	15685.110
Hospital bed/municipality	-.024	.0474	0.607	-.118	.069
Total Health Care spends (log)	1.199	1.255	0.341	-1.278	3.676
pass rate in elementary school	.170	.4257	0.690	-.669	1.010
dropout rate	-.148	.116	0.204	-.377	.081
failure rate in elementary school	.411	.605	0.498	-.783	1.605
tx_aprovacao_medio	-.179	.116	0.125	-.409	.050
per capita GDP	.000	.000	0.787	-.000	.000
outlier	.070	3.346	0.983	-6.533	6.673
Year					
2011	-17.031	5.104	0.001	-27.101	-6.961
2012	-15.492	4.370	.000	-24.115	-6.870
2013	-14.039	3.669	0.000	-21.279	-6.798
2014	-11.969	3.005	0.000	-17.898	-6.039
2015	-9.524	2.394	0.000	-14.248	-4.799
2016	-7.217	1.982	0.000	-11.129	-3.305

2017	-5.618	1.718	0.001	-9.009	-2.227
2018	0	(omitted)			
_cons	4234.87	555.317	0.000	3139.263	5330.478
sigma_u	143.557				
sigma_e	11.046				
rho	.994				

Table 5: Coefficients of the falsification test performed through placebo regression. Pernambuco. 2009 to 2019.

Source: Own elaboration, using STATA software.

ered not only hospitalization expenses, but also costs with prostheses and orthotics.

The pre-estimation tests used in this study allowed us to choose the most appropriate functional form (fixed-effects model) to assess the impact of HGP on expenses with hospitalizations for osteoporotic femoral fractures, given the characteristics of the program and the data used [37,42]. These tests also made it possible to test the main assumptions of the methods used, increasing the robustness of the results found [38,43,44,49].

The variables used in the econometric models of this study reinforce the relationship between gender, age of patients, socioeconomic characteristics (e.g.: education and income), and the availability of health services as factors that interfere in the frequency and, consequently, in the expenses with hospital admissions for osteoporotic femur fracture [33-36].

According to the models estimated in this study, the treated municipalities (those that implemented the HGP from 2011 onwards) spent, on average, 16.54% less on hospital admissions for osteoporotic femur fracture than the control municipalities. The presence of the HGP in the municipalities can therefore generate an average savings of US$ R$ 7,599.74 per year, only with expenses related to hospitalizations.

The hospital care represents only 15.29% of the financial resources used to treating femur fractures [50].

So, the impact of HGP in reducing public spending on health may be even greater if we consider the potential savings with drugs, prostheses, orthotics, and with social security expenses loss of productivity [7].

Productivity loss represents 36% of all osteoporosis expenditures in Brazil, accounting for an annual cost of US$188,144,113 [7]. In this sense, the impact of the HGP in reducing expenses with hospitalizations may indirectly contribute to the reduction of social security expenses related to temporary leaves and early retirements.

The impact of the HGP on the reduction of expenses with hospitalizations for osteoporotic femur fractures may be associated with the fact that the program has already proven to be effective in increasing the level of physical activity in the population, especially females over 50 years of age [25]. Considering that physical activity is an important strategy to prevent osteoporosis and falls, especially in the elderly, the program is effective for the population strata that have a higher prevalence of osteoporotic femur fractures in Brazil [51,52].

This study has as a limitation the impossibility of verifying the impact of HGP on populations with different characteristics, such as race/color, tobacco consumption, and calcium intake, which may be related to osteoporotic fractures. On the other hand, the study used a combination of robust impact assessment methods and a set of strategies that increase the efficiency of the estimates.

Conclusions

The Health Gym Program impacted by reducing 16.54% of the public spending on hospital admissions for osteoporotic femur fractures by comparing the municipalities that implemented this intervention with those that did not. It is noteworthy that the estimate of savings in financial resources in this study represents only a small fraction of the expenditure on care for patients who are victims of these fractures since it does not consider expenses for medicines, prostheses, and orthoses.

It is also noteworthy that although this is not the objective of this study, it is possible to infer that the presence of HGP can also impact the reduction of indirect costs with loss of productivity and social security expenses with temporary leaves and early retirements.

The findings of this study can support decision-making processes on expanding the scope of the program in the municipalities, as well as justifying public investment in its implementation or expansion.

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Conflict of Interest

We declare there is no conflict of interest.

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