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# Effect of Excess Weight on Health Expenditure with Diabetic Patients in Primary Health Care

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**Keywords:** Diabetes; Propensity Score Matching; Primary Health Care; Impact Assessment; Econometrics

**ABSTRACT**

The objective of this study was to analyze the effect of excess weight on public health expenditures with diabetic patients in primary health care in the city of Caruaru, Brazil. This is a cross-sectional study, with a retroanalytical component, performed through propensity score matching. Expenses on consultations, exams, and medications related to the previous 12 months were collected from the electronic medical records of 65 diabetic individuals of both sexes, aged over 40 years, who were classified according to their body mass index as: "normal weight" and "excess weight" (overweight and obesity). The average treatment effects on the treated (ATET) were estimated using the radial algorithm and the robustness test of the econometric model was performed by comparing the means of the observable variables of individuals with normal weight and excess weight, before and after matching. The mean age of the sample was 60 years and there was a predominance of female individuals, who were not employed. The sample had an average BMI classification of 31.9 kg/m$^2$. Diabetic primary health care patients with excess weight spent in average US$ 45.55 more than diabetics with normal weight. The evidence generated from this article can serve as a basis for decision-making by public managers when planning strategies aimed at the implementation of health promotion, healthy lifestyle, and body weight maintenance programs aimed at diabetic patients.

**Abbreviations:** GDP: Gross Domestic Product; NCD: Non-Communicable Diseases; UHS: Unified Health System; PHCU: Primary Health Care Units; CAPS: Psychosocial Care Centers; IPCA: National Consumer Price Index

## Introduction

World health expenditures in 2017 were approximately 7.8 trillion dollars and represented 10% of the world's Gross Domestic Product (GDP) [1]. Developed countries invest an average of US $4,632.00 per capita on financing health actions and services, which represents approximately 16.8% of government expenditures in this sector [2], while countries with public and universal health systems spend approximately 8% of their GDP on health [3]. From this perspective, health expenditures in Brazil accounted for around 8% of GDP in the last 10 years [4]. Among the largest expenses, the expenditure on chronic non-communicable diseases (NCDs) stands out [5], requiring around BRL 2.4 billion (US$ 4,62 million) to pay for hospital admissions, and BRL 1.2 billion US$ 2,31 million) for outpatient treatments [6]. Among the main risk factors for NCDs, physical inactivity is highlighted [7], being responsible for between 20% and 30% of deaths from NCDs [5] and configured as one of the behaviors with the greatest burden on the public health system [8] In addition, the presence of obesity increases these risks even more, since, in addition to being an NCD, it is a risk factor for heart and chronic respiratory diseases, cancer, and diabetes [9]. Furthermore, when obesity is associated with the presence of type 2 diabetes mellitus, it causes an increase in private and public spending on this disease [10]. Evidence shows that the higher the body weight of patients with diabetes, the higher the average health care costs [11].

In addition, a study carried out with patients from the Brazilian public health system showed that when obesity is associated as a risk factor for hypertension and diabetes, it was associated with an increase in the total costs attributable to obesity of 1.39 billion reais (US$ 2,67 million) for the Unified Health System (UHS) in 2018 [12]. The Northeast Region of Brazil has a prevalence of NCDs of 75.3% and stands out as one of the most affected regions, including among those that spend the most on obesity and its associated diseases, including diabetes [13]. It is also worth noting that in the state of Pernambuco, 124,879 hospitalizations for diabetes were recorded in public hospitals in 2018, and that these hospitalizations were responsible for expenditure of BRL 92,679,325.10 (US$ 17,857,288.07) considering only the payment on Authorizations for Hospital Admission [8]. Although some evidence suggests that obesity is a risk factor for NCDs 9,12, while other studies indicate that diabetic individuals generate more expenses to the health system [14,15], these studies are restricted to hospital expenses. Thus, the current study aimed to analyze the effects of excess weight on health expenditures with diabetic patients enrolled in primary health care services in the municipality of Caruaru, in the state of Pernambuco, Brazil.

## Methodology

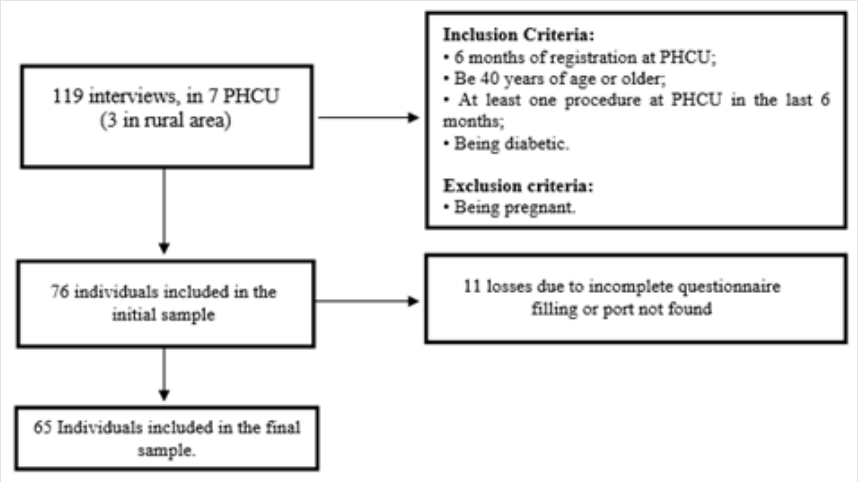


**Figure 1:** Sample selection flowchart and inclusion and exclusion criteria.

This is a cross-sectional study, with a retroanalytical component, performed using the propensity score matching (PSM) technique [16]. This study contributes to the specific objectives of a larger study entitled "Isolated and combined effect of physical inactivity and abdominal obesity on public health expenditure", approved by the Research Ethics Committee of the Federal University of Pernambuco – Academic Center of Vitória de Santo Antão, CAAE No. 21800819.3.0000.9430, with approval opinion no. 3,701,710. The research was carried out in the municipality of Caruaru, located 140 km from the capital of the state of Pernambuco, in the Northeast region of Brazil. Caruaru has the fourth largest population (360 thousand inhabitants) among the 185 municipalities in the state. Gross domestic product per capita is US$ 3,859.00 (12$^{th}$ in the state and 2396$^{th}$ in the country), the average income of formal workers

is 1.7 minimum wages (US$ 396,99), and the Human Development Index is considered average (0.677) [17]. The municipality has a semi-arid climate, with temperatures ranging between 17°C and 32°C, the annual average rainfall is considered low (540 mm), and the rains are concentrated in the months of June and July [18]. The health network is composed of 66 Primary Health Care Units (PHCU) that serve 69% of the population of the municipality, in addition to two Psychosocial Care Centers (CAPS), 12 teams from the Expanded Health Center of the Family and Primary Care, 27 specialized outpatient clinics, and seven hospitals [19]. The research subjects are primary health care patients of both sexes, aged 40 years or older, with a diagnosis of diabetes in their medical records, and who received medication in one of the seven PHCUs that met the inclusion criteria (having electronic patient medical records installed for at least 12 months). The sampling process, losses, and inclusion and exclusion criteria are shown in Figure 1.

Primary data (sociodemographic and economic characteristics, and anthropometric measurements) were collected by previously trained researchers from December 2019 to March 2020. Secondary data (quantity and type of medication received, as well as the number of consultations and number of tests performed at the unit in the previous 12 months) were taken from the citizen's electronic medical records, with the express consent of the municipal health department, and ensuring patient anonymity. In order to avoid sample losses, in cases where the electronic medical record was not found, a new visit to the health units was carried out to access the physical records. The dependent variable (total health expenditure) was calculated through the sum of the total expenditure on medicines, exams, and consultations carried out in the previous year at the PHCU of reference for the user. Expenditure on medicines was calculated based on the values contained in the national health price database [20] for the month of February 2020. For values of medicines not included in the BPS, consultations were carried out in the Price Panel of the Ministry of Economy, or, as a last resort, the market price was used, calculated from the average of the values of the three largest pharmacies in the region. Examination expenses were based on the values contained in the UHS Table of Procedures, Medicines, and OPM Management System [21].

After calculating all expenses in Reais (BRL), the values were adjusted for inflation based on the National Consumer Price Index (IPCA) accumulated between February 2020 and August 2021, followed by conversion to the US Dollar, using the quotation on August 30, 2021 (US$ 1.00 = R$ 5.19). Body weight was measured using a portable electronic scale, with a capacity of 150 kilograms (kg) and graduation of 100 grams (g), calculated and classified using the body mass index (BMI), dividing the patient's weight by their height squared (BMI = Weight/Height$^2$). Regarding the classification of BMI, patients were classified into two groups: Normal Weight (BMI = 18.5 to 24.9) and Excess Weight (BMI > 24.9). Descriptive statistics of numerical variables are presented through the mean, standard deviation, and confidence interval at the 95% level (95%CI), and stratified between the "Normal Weight" and "Excess Weight" groups. Categorical variables are presented in absolute and relative frequencies. The analyses were performed according to the following steps: i) estimation of the effect of excess weight on health expenditures, by means of propensity score matching; ii) testing the robustness of the PSM model by calculating the difference in means between individuals with normal weight and excess weight before and after propensity score matching.

### Estimation of the Effect of Excess weight on Health Expenditures through Propensity Score Matching

The selection of study participants was based on their adherence and, therefore, there was no randomization in their selection. In this sense, the choice of some individuals to participate in the study could be associated with intrinsic factors (non-observable variables), and this could imply a self-selection bias [16,22]. In order to avoid the potential problem of selection bias, we decided to use a strategy that allows comparison between individuals with normal weight and excess weight, through propensity score matching (PSM). This method makes it possible to find, in the control group ("Normal Weight"), individuals with observable characteristics similar to those of the exposed group ("Excess Weight") by calculating the conditional probability of an individual being exposed [16]. The PSM produces a good estimate of the average treatment effect on the treated (ATET), provided that the assumptions of conditional independence or ignorability, as well as the hypothesis of overlap or common support, are met [16]. In the current study, propensity score matching was calculated using the "nearest neighbor" (1:1 and 1:5, both with replacement), Radial and Kernel Matching algorithms [22]. In addition, the PSM standard error was estimated with 50 bootstrap replications.

### Robustness Test of the Matching Model

The verification of compliance with the common support assumption was carried out by comparing the averages of the observable variables of "Normal Weight" and "Excess Weight" before and after matching [23], with results presented through a graph and a table.

## Results

The mean age of the sample was 60.21 years (sd ± 10.50), and there was a predominance of female individuals, who were not employed (unemployed, without income, or retired), who had not completed elementary school, in addition to individuals of white and mixed ethnicity/color, and with an income of up to 3 minimum

wages. As for the classification of BMI, it was observed that the sample presented an average of 31.9 kg/m$^2$ (sd ± 8.24). Among the normal weight and excess weight groups, females over 50 years of age predominated. Table 1 presents, in detail, the frequency of individuals with normal weight and excess weight in each of the categorical variables analyzed. The total expenditure on health actions in diabetic individuals was US$ 3,068.37 (mean: 47.20; sd + 59.06). The total expenditure with individuals classified as normal weight was US$ 221.84 (mean: 27.73; sd + 17.84), representing 7.23% of the total spent. Spending on individuals classified as excess weight was US$ 2,846.52 (mean: 49.93; sd + 62.33), representing 92.77% of the total spent. No statistically significant differences were observed between total health expenditures among men (mean: 35.23; sd + 22.24) and women (mean: 49.91; sd 64.41; p=0.7794). For expenses related to ethnicity/color, it was observed that white individuals spent on average US$ 56.66 (sd + 82.55), compared to US$ 39.58 (sd + 28.17) for non-white individuals. Table 2 presents the variables used in the estimated models and the coefficients for propensity score matching using the Radial method algorithm, which demonstrated the greatest effect of excess weight on total expenditures with diabetic individuals using PHC. In the analysis using propensity score matching, the models showed that diabetic patients with excess weight spend US$ 45.55 more when compared to the normal weight group. The results are reported in Table 3. Table 3 presents the ATET, that is, the difference in expenditure between individuals with excess weight and normal weight, through propensity score matching.

**Table 1:** Characteristics of patients of basic health units in the city of Caruaru, Pernambuco, 2020 (n = 65).

| Variables (N - 65) | Normal Weight | | Excess Weight | | Total | |
|---|---|---|---|---|---|---|
| | N | % | N | % | N | % |
| BMI | 8 | 12.31 | 57 | 87.69 | 65 | 100 |
| **Sex** | | | | | | |
| Male | 1 | 12.50 | 11 | 19.3 | 12 | 18.46 |
| Female | 7 | 87.5 | 46 | 80.7 | 53 | 81.54 |
| **Age** | | | | | | |
| <50 years | 1 | 12.5 | 9 | 15.79 | 10 | 15.38 |
| <60 years | 2 | 25 | 19 | 33.33 | 21 | 32.31 |
| <70 years | 3 | 37.5 | 16 | 28.07 | 19 | 29.23 |
| 70 years or more | 2 | 25 | 13 | 22.81 | 15 | 23.08 |
| **Occupation** | | | | | | |
| Does not work / no income | 4 | 50 | 16 | 28.07 | 20 | 30.77 |
| Retired / pensioner | 4 | 50 | 27 | 47.37 | 31 | 47.69 |
| Formal employment | 0 | 0 | 3 | 5.26 | 3 | 4.62 |
| informal/temporary employment | 0 | 0 | 7 | 12.28 | 7 | 10.77 |
| Retailer | 0 | 0 | 2 | 3.51 | 2 | 3.08 |
| Others | 0 | 0 | 2 | 3.51 | 2 | 3.08 |
| **Ethnicity/Color** | | | | | | |
| White | 3 | 37.5 | 26 | 45.61 | 29 | 44.62 |
| Back | 0 | 0 | 3 | 5.26 | 3 | 4.62 |
| Pardo | 4 | 50 | 18 | 31.58 | 22 | 33.85 |
| Other | 1 | 12.5 | 10 | 17.54 | 11 | 16.92 |
| **Schooling** | | | | | | |
| Illiterate / PS incomplete | 4 | 50 | 36 | 63.16 | 40 | 61.54 |
| PS complete/ SS incomplete | 2 | 25 | 16 | 28.07 | 18 | 27.69 |
| SS complete/ HS incomplete | 1 | 12.5 | 2 | 3.51 | 3 | 4.62 |
| HS complete/ HE incomplete | 1 | 12.50 | 3 | 5.26 | 4 | 6.15 |
| **Income** | | | | | | |
| <1 Minimum wage | 5 | 62.5 | 30 | 52.63 | 35 | 53.85 |
| 1 to 3 Minimum wages | 3 | 37.5 | 27 | 47.37 | 30 | 46.15 |

Note: Source: produced by the authors.

Legend: ES: elementary school; SS: secondary school, HS: high school, HE: higher education, BMI: body mass index.

**Table 2:** Variables and Coefficients of the propensity score matching model to assess the effect of excess weight on total health expenditures in PHC, Caruaru, 2020.

| Total Expenditure | | | | | |
|---|---|---|---|---|---|
| **Variable** | **Coefficient** | **Standard Error** | **P>\|z** | **95% CI** | |
| Sex | -0.3677702 | -1.179 | 0.755 | -2.679 | 1.943 |
| Age | -0.014807 | -0.043 | 0.733 | -0.099 | 0.07 |
| Occupation | 1.034557 | -0.651 | 0.113 | -0.243 | 2.312 |
| Ethnicity/color | -0.0236862 | -0.189 | 0.901 | -0.395 | 0.348 |
| Income | -0.3460686 | -936 | 0.712 | -2.182 | 1.49 |
| Schooling | -0.550105 | -0.371 | 0.138 | -1.277 | 0.177 |
| Constant | 3.28232 | -3.648 | 0.368 | -3.868 | 10.433 |

**Note:** Source: Own elaboration using STATA software.

**Table 3:** Mean effect of excess weight on total health expenditures in patients of basic health units in the city of Caruaru, Pernambuco, 2020 (n = 65).

| Total Expenditure | | | | |
|---|---|---|---|---|
| **Model** | **ATET** | **t-statistic** | **Standard error** | **Standard error of bootstrap** |
| Kernel | 25.92 | 2.07 | 12.55 | 18.23 |
| nearest neighbor n(1) | 29.51 | 2.27 | 13.01 | 11.44 |
| nearest neighbor n(5) | 24.11 | 2.14 | 11.27 | 12.20 |
| Radius | 45.55 | 1.99 | 22.83 | 27.56 |

**Note:** Source: produced by the authors.

NN(1) with replacement; NN(5) with replacement; Radius with 0.01% caliper and common support; Kernel with window value of 0.06 and common support. PSM: standard errors generated by bootstraps (50 reps). The models used all covariates from Table 2. Common support satisfied. Estimated PSM standard error with 50 bootstrap replications.

The verification of the robustness of the results was based on the hypotheses of common support, tested through graphical analysis and the analysis of the quality of the matching, which was verified from the distribution of covariates between the groups of individuals of normal weight and excess weight before and after matching. Figure 2 shows that the distribution of values for the vector of observable characteristics of excess weight and normal weight individuals was different before matching, with normal weight concentrated in the left tail of the distribution. After matching (Radius – 0.1% Caliper with replacement), the common support area between the excess weight and normal weight groups (in the center of the distribution) was enlarged, indicating the good quality of matching. Table 4 presents the means of the variables for the excess weight and normal weight groups before and after matching, aiming to check the balance conditions in the treatment distribution (body weight). The result of the comparison of means test allows us to state that after matching the groups became statistically equal (and different only in relation to the exposure - body weight).

**Table 4:** Difference in means of normal weight and excess weight groups, before and after matching.

| **Observable variables** | **Before Matching** | | | **After Matching** | | |
|---|---|---|---|---|---|---|
| | **Normal Weight (N = 8)** | **Excess Weight (N = 56)** | **p-value** | **Normal Weight** | **Excess Weight** | **p-value** |
| Sex | 1.875 | 1.803 | 0.635 | 1.916 | 1.85 | 0.524 |
| Age | 61.125 | 60.089 | 0.797 | 65.992 | 65.8 | 0.941 |
| Occupation | 0.5 | 1.2679 | 0.106 | 0.91667 | 0.9 | 0.86 |
| Income | 0.375 | 0.46429 | 0.641 | 0.85833 | 0.65 | 0.133 |
| Ethnicity/color | 2.25 | 2.0357 | 0.802 | 0.825 | 2.1 | 0.046 |
| Schooling | 1 | 0.57143 | 0.282 | 0.05833 | 0.15 | 0.355 |

Note: Source: produced by the authors.

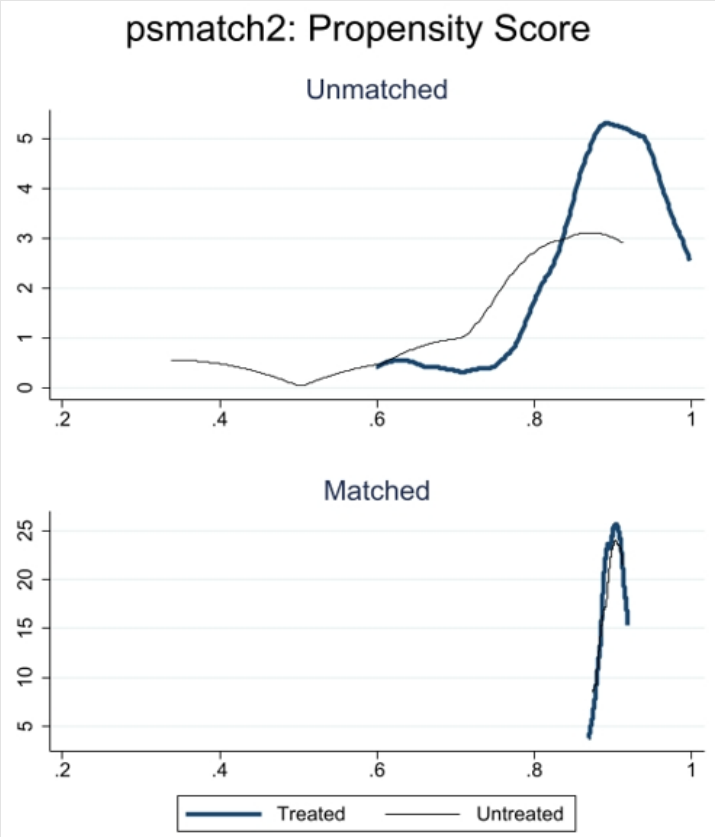


**Figure 2:** Distribution of treatment probability before and after matching.

## Discussion

The current study, carried out with diabetic patients treated by the PHCUs in the city of Caruaru, observed low levels of education and income, with a high prevalence of female individuals, and a mean age of 60 years. These characteristics are similar to those found in the study by Barreto and colleagues. [24], who analyzed 823 diabetic individuals throughout the state of Pernambuco. One justification for the majority of the sample being female is because women are more concerned about their health and attend health facilities more often [25]. Considering BMI, 87% of the participants were classified as excess weight, with an average BMI of 31.9 kg/m$^2$, corroborating the mean BMI found by Arcânjo and colleagues, and Silveira and Colleagues [26,27]. The mean expenditure on health actions and services with diabetic individuals was US$ 47.20 per pacient for one year, which is lower than that found by Aquino, et al. [28], who showed that diabetic patients of primary care presented average expenditure of US$ 289.60 on health actions and services. Regarding health expenditure between the sexes, it was found that expenditure on men was, on average US$ 35.23 and on women was, on average US$ 49.91, corroborating the findings of Codogno, et al. [29], who observed that expenditure on women was, on average US$ 24.66 and men US$ 20.80 considering consultations, exams, and medicines in Primary Health Care. In this sense, one of the reasons for women generating higher expenses than men is justified by the well-consolidated presence of the Comprehensive Attention to Women's Health program [30]. In addition, even with the presence of awareness-raising policies for the male public, men have a reduced share of PHC spending [29]. With regard to expenses related to BMI, it was found that expenditure on diabetic individuals with excess weight was US$ 45.55 more when compared to diabetics with normal body weight. Johnston, et al. [31] demonstrate that the higher the BMI of diabetic individuals, the greater the total health costs, with a variation of US$ 16.10 for individuals with overweight and US$ 20.43 for individuals with obesity. It is also noteworthy that when obesity is associated with the presence of DM2, it causes an increase in private and public spending on this disease [10].

## Conclusion

The results of this study show the importance of public investment in health promotion, maintenance, and control of body weight, both for improving the health and quality of life of the population, and to mitigate the potential consequences of obesity and diabetes, which can evolve into more serious conditions,

generating suffering, hospitalizations, and greater public spending, not only in the health sector, but also with sick leave, retirement, and pensions for disability or death. The limitation of this research is the impossibility of investigating the patients of all Primary Care Units in the city, given that only seven of them met the inclusion criteria. However, it is noteworthy that the method used, in addition to being robust, presents characteristics that minimize problems with possible selection bias problems. In addition, the use of bootstrap replication minimizes sample size issues and produces more reliable standard error estimates. Finally, the evidence generated from this article can serve as a basis for decision-making by public managers when planning strategies aimed at the implementation of health promotion, healthy lifestyle, and body weight maintenance programs aimed at diabetic primary health care patients.

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## Conflict of Interest

There is no Conflict of Interest.

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