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The impact of physical activity on women`s health: evidences for Brazil

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Abstract

The benefits of practicing physical activity on health have been explored in some studies in Brazil. However, the causal nature of this relationship still lacks evidence. The present study aims to contribute by presenting an analysis of the impact of physical activity on the health of adult women in Brazil, using the body-mass index (BMI). In order to do so, microdata from the 2013 National Health Survey and the multivariate probit model are used. The identification strategy employed consists of a restriction of exclusion of the variable that indicates whether there is a public place for the practice of physical activity near the home. The results indicate that, when there is a public place near the residence, there is an increase in the probability of practicing physical activity. There is evidence of a positive impact of physical activity on women's health for the set of indicators used.

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THE IMPACT OF PHYSICAL ACTIVITY ON WOMEN'S HEALTH: EVIDENCES FOR BRAZIL

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Abstract

The benefits of practicing physical activity on health have been explored in some studies in Brazil. However, the causal nature of this relationship still lacks evidence. The present study aims to contribute by presenting an analysis of the impact of physical activity on the health of adult women in Brazil. In order to do so, the microdata of the National Health Survey of 2013, which allows the construction of self-assessed health indicators, of different chronic diseases and of weight indicators, are used. To address the endogeneity between physical activity and health practice, a multivariate Probit model is used. The identification strategy employed consists of a restriction of exclusion of the variable that indicates if there is a public place for the practice of physical activity near the home. The results indicate that it increases the probability of practicing physical activity when there is a public place near the residence. There is evidence of a positive impact of physical activity on women's health for the set of indicators used.

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1 Introduction

Physical inactivity is considered one of the main risk factors that cause Noncommunicable Chronic Diseases (NCDs), such as strokes, heart attacks, hypertension, type 2 diabetes, cancer, among other diseases[1] (Bauman et al., 2012). It is the fourth leading cause of death in the world, accounting for more than 3 million deaths per year (Hallal et al., 2008; Kohl 3rd et al., 2012; Pratt et al., 2012). Some studies suggest that regular and adequate physical activity may contribute to reducing the direct and indirect costs of a wide range of diseases[2] by improving muscular and cardiorespiratory fitness, and bone and functional health (Lee et al., 2012; Pratt et al., 2012; Ding et al., 2016; Arbel et al., 2018). For the United States, Carlson et al. (2015) estimated that annual per capita health expenditures for inactive adults compared to active adults were $1,313 and $576, respectively. The percentage of health care expenditures associated with inadequate levels of physical activity was 11.10% and the total cost of physical inactivity represented an additional $117 billion in health care costs. These numbers reinforce the incentive to practice regular physical activity as a way to reduce considerably the private and social costs associated with many chronic diseases.

In the specific case of women, practicing physical activity lead to health improvement and the prevention of many diseases, such as breast and cervical cancer, thereby reducing the depreciation rate of their health (Rezende et al., 2018b,a). According to the World Health Organization (2016), physical activity is also associated with improved psychological health by reducing levels of stress, anxiety and depression, contributing to the building of self-esteem and confidence, and providing a vector for social integration and equality for women in society.

For these reasons, the promotion of the practice of physical activity has become a priority for health agencies in many countries (Heath et al., 2012). In Brazil, the Ministry of Health launched in 2011 the "Strategic Action Plan for Coping with NCDs". The objective was to encourage the development of public policies for the prevention and control of NCDs and their risk factors Brasil (2011). In the same year, the Ministry of Health, through Ordinance No. 790 of April 7, 2011[3], instituted the "Health Academy Program", with the main objective being "[...] to contribute to the promotion of health and healthy lifestyles of the population by the creation of centers with adequate infrastructure and qualified professionals." However, only 26.20% of the Brazilian adult population practice leisure-time physical activity in standards considered adequate by the World Health Organization according to the 2013 National Health Survey (NHS).

The studies by Hallal et al. (2008), Ramires et al. (2014), Szwarcwald et al. (2014), Rezende et al. (2018b)[4] and Rezende et al. (2018a) sought to verify the effect of the practice of physical activity on health in Brazil[5]. However, because physical activity is a potentially endogenous variable, the observed correlations cannot be interpreted as a causal effect. Brechot et al. (2017) lists three reasons for suspecting the endogeneity of

[1] Rezende et al. (2015) using the microdata from the 2008 National Sample Household Survey showed that there is an association between physical inactivity and a set of noncommunicable diseases for Brazil.

[2] See, for example, the studies by Cecchini et al. (2010), by Rtveladze et al. (2013), by Canella et al. (2014) and Flores-Ortiz et al. (2019).

[3] Repealed by Ordinance No. 2681, of November 8, 2013.

[4] This study provides a comprehensive systematic review of the literature and provides evidence that physical activity is associated with a lower risk of various types of cancer.

[5] See also, for example, Mendonça and Anjos (2004).

physical activity.

The first is that physical activity most likely relates to other determinants of health that are not fully observed, such as healthy and unhealthy lifestyles, personal hygiene aspects, sleep-related behavior, and so on. Even though it is possible to control many of these factors, it is very likely that some will remain out of the analysis. The second reason is the problem of the reverse causality between health and physical activity. People in better health are more likely to exercise, so the health condition is what determines the practice of physical activity and not the other way around. Finally, the third reason is that self-reported information about the practice of physical activity tends to have measurement errors (Ferrari et al., 2007).

The causal effect of physical activity on health could be obtained through an experiment in which the practice of physical activity was randomized. In the absence of an experiment, the analysis of the causal effect of physical activity on health could be performed by a quasi-experiment. Therefore, it would be necessary to gather information at the individual's level regarding their health behavior and a variable that would allow exogenous variations to differentiate the endogeneity present in the relationship between physical activity and health. In a systematic review of the evolution of epidemiological research in physical activity in Brazil, Ramires et al. (2014) did not find evidence of an experimental study in this sense. However, experimental studies have been performed with small and generally representative samples of a very specific group, not allowing to generalize the results to the rest of the population.

Studies in the literature dealing with this theme recommend two approaches to this problem of endogeneity. The first one is the use of a single-equation model with instrumental variables (Rosenzweig and Schultz, 1983; Mullahy and Portney, 1990; Kenkel, 1995, 1991; Gilleskie and Harrison, 1998; Lindahl, 2005). The second is the use of a recursive multivariate probit model, in which a system of equations is specified for the health production function and for health behaviors (Contoyannis and Jones, 2004; Balia and Jones, 2008; Schneider and Schneider, 2009; Rasciute and Downward, 2010; Humphreys et al., 2014). However, according to Bhattacharya et al. (2006), the dichotomous nature of the variable related to the practice of physical activity in appropriate standards, and of the variables that represent health outcomes, represents a problem for the single-equation model with instrumental variables. This suggests that the multivariate probit model would then be the most appropiate econometric setting as to generate consistent estimates of the relationship between physical activity and health outcome, by assuming an error structure in which the two equations are allowed to be correlated.

Based on these considerations, this study aims to present evidence of the causal effect of physical activity on the health of adult women in Brazil, using the body-mass index (BMI) as a proxy for women's health and a recursive multivariate probit model. The identification strategy is based on an exclusion restriction using a variable that expresses the fact that there is a public place close to their residence. To our knowledge, there are no studies dedicated to physical activity that seek to analyze the relationship in a causal perspective with a focus on women for Brazil. This topic gains relevance when observing the information from the NHS and verifying that Brazilian women have better health habits compared to men (lower proportion of smoking, better diet, lower consumption of soda, besides going more often to medical visits), but the physical activity among them is significantly lower.

The article is structured in 6 sections including this introduction. Section 2 presents an overview of the geographical and demographic aspects of Brazil. In section 3, the data used in the study are presented. Section 4 describes the method used and the empirical strategy employed. The results are presented and discussed in section 5. In section 6 the final considerations are presented.

2 Overview

Brazil is a continental-sized country, being the largest country in Latin America and the fifth largest in the world in territorial extension. In population terms, it is the fifth most populous country in the world, with a population estimated at about 210 million inhabitants in 2018 (IBGE, 2018). With a GDP of US$ 2.14 trillion in 2017, Brazil is the eighth largest economy in the world. In per capita terms, however, the country occupies the 62^{nd} position in the world ranking, with a per capita GDP of US$ 10,309 in 2017 (IFM, 2018).

Brazil is divided into five geographic regions: Midwest, Northeast, North, Southeast and South. The poorest regions are the North and Northeast, and the richest regions are the Southeast and Midwest Leivas and dos Santos (2018). As shown in Figure 1, in appendix, the Southeast region is the one with the highest concentration of people living in an urbanized area, while the North region has the lowest concentration.

Regarding the evolution of the urbanization rate in Brazil, only 36.16% of the population lived in urban areas in 1950, while this rate was 84,36% in 2010. Looking at the geographic regions, the least urbanized were, in 1950, the Midwest (24.38%) and the Northwest (26.4%), while the Southwest (47.55%) and the North (31.49%) were the most urbanized. This situation is different from that observed in 2010, where the Northeast region was the least urbanized (73.13% of the population living in urban areas), followed by the North (73.53%). Meanwhile, the Southeast region remained as the one with the highest proportion of people living in urban areas in 2010, with an urbanization rate of 92.95%. On the other hand, the Midwest region ceased to be the region with the lowest rate of urbanization in 1950 to reach the second largest rate in 2010, 88.8% IBGE (2011).

The increase in urbanization in Brazil is similar to the urbanization process that occurred in South America and the Caribbean (O'Sullivan, 2007). In a systematic review of the literature, Eckert and Kohler (2014) indicate that many health outcomes correlate with urbanization in developing countries. If, on the one hand, urbanization is associated with a low risk of malnutrition in children, on the other hand it is associated with a high risk of overweightness. In addition, the authors also showed that risk factors common to chronic diseases were more prevalent in urban areas.

The ethnic diversity is also relatively high in the country. In 2010, Brazil presented a fractionalization index (Taylor and Hudson, 1976) of 0.577 (Leivas and dos Santos, 2018), whose value is higher than the world average of 0.44 (Alesina et al., 2003). The socioeconomic inequalities among different ethnic groups, although they have improved in the last 30 years, are still a relevant issue in Brazil (Leivas and dos Santos, 2018). In 2010, the average black citizen's income was about 56% of the average white citizen's income. In terms of years of study, also in 2010, whites had 8.5 years of study, on average, while blacks had an average of 6.5 years of study (Leivas and dos Santos, 2018).

The proportion of people aged 60 years or more doubled between 1970 and 2000 (Paim et al., 2011) and the expectation is that in 2050 the number of older people will exceed that of children and adolescents in more than 38 million individuals Brasil (2010). This change in the age structure of the Brazilian population modified morbidity and mortality patterns in the country. In 2007, more than 70% of deaths in Brazil were related to Noncommunicable Chronic Diseases, while mortality from infectious and parasitic diseases was 10% (Schmidt et al., 2011). This situation contrasts with the data from 1930, when 45.6% of deaths in Brazilian capitals were attributed to infectious diseases (Brasil, 2009).

The significant increase in the number of overweight people, regardless of gender, age, income level or region has attracted the attention of public authorities in Brazil in recent years. Data from the 2013 National Health Survey show that the proportion of obese citizens in the period from 2002 to 2013 increased from 9.3% to 17.5% among men. For women, this increase was even higher, going from 14% to 25.2%. Because overweightness is one of the major risk factors for NCDs, this increase in the proportion of obese people represents a public health problem in the country.

3 Data

The database used was the NHS (National Health Survey) performed in 2013 by the Ministry of Health in partnership with the Brazilian Institute of Geographic and Statistics (IBGE). This research addresses several aspects of health and lifestyles of the population. The questionnaire used in the interviews was divided into three parts: the first and the second parts are related to the issues of households and their residents whereas the third part is an individual questionnaire from a sub-sample, in which a resident aged 18 years or older was selected to answer specific lifestyle and health questions, in addition to measures of weight, height, and blood pressure.

In this study, the data sample used in the regression analysis is formed by adult women aged between 18 and 59 years of age, who lived in the urban area and were not pregnant. Older women and rural women were excluded considering that these groups may have a health production function with very specific aspects.

To measure health outcomes we used objective measures based on weight and height measurements, and three dummy variables were formed based on the body mass index (BMI): BMI25 (1 = overweight or obese), BMI30 (1 = obesity type 1 or 2) e BMI35 (1 = type 2 obesity). The variables of age, color, bad habits of food and smoking, access to health care, basic sanitation, number of people at home, income, work, education, asset index, excessive time watching television, physical activity going to and at work, as well as area variables such as fixed effects for capital, metropolitan region and states will be used as control (see Table I, in appendix). These variables aim to control socioeconomic factors, health care, health habits and time allocation with activities, which can be correlated with physical activity and health. All estimations will be done by gender.

Lifestyle indicators follow the definition adopted by IBGE (2015), which is based on the recommendations of the World Health Organization. For example, physical activity (exercise or sport) at the recommended level occurs when the individual reports having practiced physical activity in the last three months, at least 75 minutes of intense activity, or 150 minutes of mild or moderate activity per week. It should be noted that the concept of the main variable of physical activity encompasses only the leisure practice, not counting physical activity at work.

Although this study focuses on women's health, we will present male descriptive statistics for comparison purposes. Table II, in appendix, presents the mean of the outcomes and controls used. As can be observed, 21,4% of women practices physical activity while for the men, this represents 31%. In general, those who practice physical activity have better eating habits, better socioeconomic conditions (education, income and asset index), health insurance, smoke less, go to medical appointments, watch less television.

4 Methodology

Two econometric approaches will be used to estimate the effect of physical activity on women's health indicators: a linear probability model (LPM) and a multivariate probit model. The specification of the linear probability model assumes that the physical activity variable is exogenous and can be described as:

$$H_i = \mathbf{x}_i\boldsymbol{\beta} + \alpha y_i + \mu_i, \tag{1}$$

where H_i is the health indicator (BMI25, BMI30 ou BMI35) of individual i. y_{pi} indicates whether individual i practices leisure physical activity in appropriate routines. $\mathbf{x}_i$ is a vector of exogenous explanatory variables and $\boldsymbol{\beta}$ and α are unknown parameters to be estimated. The μ_i is an error term.

The main limitation of the LPM is in the decision to do physical activity, considered exogenous in equation (1). The presence of unobservable factors such as the preference in doing physical activity or the opportunity cost of the time spent practicing physical activity affects both the variables of physical activity and the health indicators. In this case the estimates of parameters β and α are not consistent.

One way to circumvent this problem is to assume that physical activity is an endogenous variable and use the instrumental variable (IV) estimator or a bivariate probit model to estimate the impact of physical activity on health indicators. In the health economic literature several studies have used the bivariate probit model to analyze the relationship between physical activity and health status[6]. This model with an endogenous variable is considered a system of equations whose dependent variables are binary, and the error terms are correlated. Equations (2) and (3) describe the system of equations of this model in the context of our problem:

$$H_{hi} = \mathbb{1}[\mathbf{x}_{hi}\boldsymbol{\beta}_h + \alpha y_{pi} + \mu_{hi} > 0], \tag{2}$$
$$y_{pi} = \mathbb{1}[\mathbf{x}_{pi}\boldsymbol{\beta}_p + \mu_{pi} > 0], \tag{3}$$

where H_{hi} is the health indicador (BMI25, BMI30 ou BMI35) of individual i, y_{pi} indicates whether individual i practices leisure physical activity in appropriate routines. $\mathbf{x}_{ji}, j = (h, p)$ is a vector of exogenous explanatory variables and $\boldsymbol{\beta}_j$ and α are unknown parameters to be estimated. Note that it is not necessary for $\mathbf{x}_h$ and $\mathbf{x}_p$ to contain the same variables. In order to analyze the impact of physical activity on health in a causal sense, our identification strategy consists of an exclusion constraint in the structural equation for health (2) that is included in the equation in reduced form for physical activity (3)[7]. The

[6] To Sarma et al. (2015), the bivariate probit model is superior to the IV procedure.

[7] Exclusion constraint is not a necessary condition to identify the parameters of the structural health equation (2) as emphasized by Heckman (1978). We adopt this strategy since we seek to establish causal relations. A similar procedure was used by Humphreys et al. (2014) and Sarma et al. (2015).

error terms (μ_h, μ_p) are independent of $\mathbf{x}_j$ and are distributed as normal multivariate, with zero mean, constant variance, and $corr(\mu_h, \mu_p) = \rho$.

A binary variable will be used as an exclusion restriction, indicating whether there is a public place to practice physical activity near the individual's home (reported variable, yes or no). It is expected that this variable is strongly associated with the practice of physical activity and that it allows to bring exogenous variations. A test of falsification will be used to give robustness to the results. Therefore, the variable hearing disability will be used as an outcome, assuming that the practice of physical activity has no effect on the ability of the person to hear or not. The coefficient is expected to be statistically non-significant on the outcome variables.

5 Results

Table III, in appendix, presents the marginal effects from the estimation of the bivariate probit model for BMI25 (overweight or obesity) by gender. Although the focus of this study is on women's health, we will present the results for men's health for comparison purposes. As can be seen, physical activity has a statistically significant impact for both genders. For example, the probability of being overweight or obese (BMI25) decreases by 28.70 percentage points (p.p.) for females and 21.38 for males. The estimated marginal effects indicate that physical activity at work and commuting to work (or other main activities) are statistically significant and have an impact on reducing overweight or obesity for males. For women, these same effects are not significant.

An interesting result was observed related to current daily smoking. It negatively affects the likelihood of practicing physical activity, however, women who formerly smoked are more likely to engage in this activity. This fact can be explained by the change in people's health habits. Thus, this control is important, since in the case of physical activity, we only have current information.

It was also verified that having a higher income, a greater asset index, higher education, practicing activities on the way to work, no partner, younger age, and good habits (food and not smoking) are factors positively associated to a greater probability of individuals (both gender) practicing physical activities in their leisure time. For example, among women in the last quintile of the Asset index, this probability increases by 9.4 p.p. compared to those in the first quintile.

For women, the variables excessive time watching TV and having children under 7 years of age are factors negatively associated with the practice of physical activity. These results suggest that socioeconomic factors and time spent in leisure activities (such as watching television) and at home (in cases of families with children) affect the availability of health-related activities as advocated in the Grossman (1972) model. In the case of men, one factor that draws attention is that being outside of the workforce increases the probability of practicing physical activity.

Table IV, in appendix, presents the marginal effects of the impact of physical activity on health for the different outcomes (BMI), as well as the coefficient of the exclusion restriction on the practice of physical activity. For comparison purposes, we also describe the coefficients estimated with robust errors for a linear probability model (LPM) considering physical activity as an exogenous variable. As can be observed, the estimated coefficients for the LPM exhibit a lower impact in absolute terms and some cases without statistical significance (BMI25 and BMI30 for women and BMI25 for men).

The results obtained by the bivariate probit model show that physical activity performed in leisure time has an impact on measures of overweight and obesity. Sarma et al. (2015) also finds a significant result of physical activity on BMI outcomes for adults in Canada, using the temperature variations in the estimation of the bivariate probit model as exclusion restrictions. However, physical activity did not prove significant for measures of chronic diseases. In addition, when controlling physical activity at work, the authors show that physical activity practiced in leisure time is only significant for individuals who are not sedentary at work. In contrast, Brechot et al. (2017) have shown that for Swiss adults, physical activity has only one non-causal relationship with health measures (among them, BMI-based outcomes) because, in the method of instrumental variables, when using the local density of sports facilities as an instrument, the impact of sport-based physical activity was not significant on all health measures.

Further, the studies that have been undertaken correlating genetic aspects to the occurrence of obesity and overweight have not been able to show the interference of these factors in more than a quarter of the obese, so that the process of excessive accumulation of body fat, in most cases, is still considered to be triggered by socio-environmental aspects (Bouchard, 1991; Stunkard, 2000). Thus, the obtained results corroborate the clinical studies which indicate that discretionary aspects, such as the practice of exercises, are fundamental to explain the incidence of obesity and overweightness.

Based on the results, it can be inferred that if the individual has a public space to practice physical activity near her home, the probability of the occurrence of such activity increases in magnitude between 5.9 p.p. and 6.4 p.p., depending on the outcome used. It should be noted that, given the socioeconomic controls, eating and smoking habits, coverage of health services, other types of physical activity and other indicators already highlighted, we expect that there will be no direct effect of this variable on health indicators. The natural physical environment or that built for the practice of physical activity plays an important role in facilitating this activity for large portions of the population, ensuring that walking, cycling and as well as other forms of exercise are accessible and safe for all. The physical environment also offers sports, recreation and leisure facilities and ensures adequate spaces for active living, both for children and adults. In this sense, having such place near her residence can be a prime factor for the individual to make the practice of physical activity a routine in her habits.

The results indicating the existence of a positive causality of the practice of physical activity on health outcomes support those obtained in the specialized medical literature (Mozaffarian et al., 2012). They are also in line with those observed by Szwarcwald et al. (2014), for Brazil, and by Kenkel (1995), Contoyannis and Jones (2004), Rasciute and Downward (2010) and Humphreys et al. (2014) for developed countries. The shift from physical inactivity to regular physical activity is associated with a greater decline in the incidence of chronic diseases and in better health conditions. In this sense, government interventions aimed at encouraging inactive people to become regular practitioners of physical activity should generate the greatest health benefits in terms of reducing the incidence of diseases (Kahn et al., 2002; Mozaffarian et al., 2012). According to the World Health Organization (2014) report, urban planning and active transportation policies can improve walking and cycling opportunities in the community they live in, resulting in long-term benefits.

In order to evaluate the robustness of the obtained results, a falsification test was performed in which the health outcome was the variable hearing disability, considering that people who presented this limitation would perform less physical activity. The estimated parameters did not present statistical significance as it can be observed in Table IV, in appendix. These results corroborate the identification strategy adopted in the present study. In general, the results are in agreement with the evidences of the international literature. As expected, socioeconomic factors and healthy habits are positively associated with better health. It is also perceived that the results suggest positive benefits of physical activity in leisure time, but not at work.

6 Final Considerations

This work aimed at evaluating the impact of the practice of physical activity on the health (measures of overweight and obesity) of adult women in Brazil, in order to contribute to the literature and to approach the subject from an economic perspective. Data from the 2013 NHS allowed the use of a multivariate probit with socioeconomic, demographic and lifestyle controls. The identification strategy consisted in the use of an exclusion variable.

The results indicate that the existence of a public place for the practice of physical activity near the residence of women increases the probability of them exercising. When addressing the endogeneity problem of the variable physical activity in the health equation, an important causal effect on the health of the person was evidenced.

The implications of causality observed in this study provide support for the formulation and implementation of public policies aimed at improving the health of the population with a focus on lifestyle change, encouraging them to be more active and adopting healthier habits.

References

Alesina, A., Devleeschauwer, A., Easterly, W., Kurlat, S., and Wacziarg, R. (2003). "Fractionalization". *Journal of Economic Growth*, 8(2):155–194.

Arbel, Y., Fialkoff, C., Kerner, A., et al. (2018). "What is the Optimal Housing Choice for a Minimal BMI?". *Economics Bulletin*, 38(3):1313–1337.

Balia, S. and Jones, A. M. (2008). "Mortality, Lifestyle and Socio-Economic Status". *Journal of Health Economics*, 27(1):1–26.

Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J., and Martin, B. W. (2012). "Correlates of Physical Activity: Why Are Some People Physically Active and Others Not?". *The Lancet*, 380(9838):258–271.

Bhattacharya, J., Goldman, D., and McCaffrey, D. (2006). "Estimating Probit Models with Self-Selected Treatments". *Statistics in Medicine*, 25(3):389–413.

Bouchard, C. (1991). "Current Understanding of the Etiology of Obesity: Genetic and Nongenetic Factors". *American Journal of Clinical Nutrition*, 53(6):1561S–1565S.

Brasil (2009). "Saúde Brasil 2008: 20 anos de Sistema Único de Saúde (SUS) no Brasil". Technical report, Ministério da Saúde, Brasília.

Brasil (2010). "Sistema de Planejamento do SUS: Uma Construção Coletiva: Plano Nacional de Saúde/PNS 2008/2009–2011". Technical report, Ministério da Saúde, Brasília.

Brasil (2011). "Plano de Ações Estratégicas para o Enfrentamento das Doenças Crônicas Não Transmissíveis (DCNT) no Brasil 2011-2022". Technical report, Ministério da Saúde. Secretaria de Vigilância em Saúde. Departamento de Análise de Situação de Saúde, Brasília.

Brechot, M., Nüesch, S., and Franck, E. (2017). "Does Sports Activity Improve Health? Representative Evidence using Local Density of Sports Facilities as an Instrument". *Applied Economics*, 49(48):4871–4884.

Canella, D. S., Levy, R. B., Martins, A. P. B., Claro, R. M., Moubarac, J.-C., Baraldi, L. G., Cannon, G., and Monteiro, C. A. (2014). "Ultra-Processed Food Products and Obesity in Brazilian Households (2008–2009)". *PloS One*, 9(3):e92752.

Carlson, S. A., Fulton, J. E., Pratt, M., Yang, Z., and Adams, E. K. (2015). "Inadequate Physical Activity and Health Care Expenditures in the United States". *Progress in Cardiovascular Diseases*, 57(4):315–323.

Cecchini, M., Sassi, F., Lauer, J. A., Lee, Y. Y., Guajardo-Barron, V., and Chisholm, D. (2010). "Tackling of Unhealthy Diets, Physical Inactivity, and Obesity: Health Effects and Ccost-Effectiveness". *The Lancet*, 376(9754):1775–1784.

Contoyannis, P. and Jones, A. M. (2004). "Socio-Economic Status, Health and Lifestyle". *Journal of Health Economics*, 23(5):965–995.

Ding, D., Lawson, K. D., Kolbe-Alexander, T. L., Finkelstein, E. A., Katzmarzyk, P. T., Van Mechelen, W., and Pratt, M. (2016). "The Economic Burden of Physical Inactivity: A Global Analysis of Major Non-Communicable Diseases". *The Lancet*, 388(10051):1311–1324.

Eckert, S. and Kohler, S. (2014). "Urbanization and Health in Developing Countries: A Systematic Review". *World Health Population*, 15(1):7–20.

Ferrari, P., Friedenreich, C., and Matthews, C. E. (2007). "The Role of Measurement Error in Estimating Levels of Physical Activity". *American Journal of Epidemiology*, 166(7):832–840.

Flores-Ortiz, R., Malta, D. C., and Velasquez-Melendez, G. (2019). "Adult Body Weight Trends in 27 Urban Populations of Brazil from 2006 to 2016: A Population-Based Study". *PloS One*, 14(3):1–18.

Gilleskie, D. B. and Harrison, A. L. (1998). "The Effect of Endogenous Health Inputs on the Relationship between Health and Education". *Economics of Education Review*, 17(3):279–295.

Grossman, M. (1972). *"The Demand for Health: A Theoretical and Empirical Investigation"*. National Bureau of Economic Research.

Hallal, P. C., Reichert, F. F., Siqueira, F. V., Dumith, S. C., Bastos, J. P., Silva, M. C. d., Domingues, M. R., Azevedo, M. R., and Ekelund, U. (2008). "Correlates of Leisure-Time Physical Activity Differ by Body-Mass-Index Status in Brazilian Adults". *Journal of Physical Activity and Health*, 5(4):571–578.

Heath, G. W., Parra, D. C., Sarmiento, O. L., Andersen, L. B., Owen, N., Goenka, S., Montes, F., and Brownson, R. C. (2012). “Evidence-Based Intervention in Physical Activity: Lessons from around the World”. *The Lancet*, 380(9838):272–281.

Heckman, J. J. (1978). “Dummy Endogenous Variables in a Simultaneous Equation System”. *Econometrica*, 46(4):931–959.

Humphreys, B. R., McLeod, L., and Ruseski, J. E. (2014). “Physical Activity and Health Outcomes: Evidence from Canada”. *Health Economics*, 23(1):33–54.

IBGE (2011). “Sinopse do Censo Demográfico: 2010”. Technical report, Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro.

IBGE (2015). “Pesquisa Nacional de Saúde 2013: Acesso e Utilização dos Serviços de Saúde, Acidentes e Violências: Brasil, Grandes Regiões e Unidades da Federação”. Technical report, Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro.

IBGE (2018). “Estimativas da População Residente para os Municípios e para as Unidades da Federação”. Technical report, Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro.

IFM (2018). “World Economic Outlook, October 2018: Challenges to Steady Growth”. Technical report, International Monetary Fund, Washington DC.

Kahn, E. B., Ramsey, L. T., Brownson, R. C., Heath, G. W., Howze, E. H., Powell, K. E., Stone, E. J., Rajab, M. W., and Corso, P. (2002). “The Effectiveness of Interventions to Increase Physical Activity: A Systematic Review”. *American Journal of Preventive Medicine*, 22(4):73–107.

Kenkel, D. S. (1991). “Health Behavior, Health Knowledge, and Schooling”. *Journal of Political Economy*, 99(2):287–305.

Kenkel, D. S. (1995). “Should You Eat Breakfast? Estimates from Health Production Functions”. *Health Economics*, 4(1):15–29.

Kohl 3rd, H. W., Craig, C. L., Lambert, E. V., Inoue, S., Alkandari, J. R., Leetongin, G., and Kahlmeier, S. (2012). “The Pandemic of Physical Inactivity: Global Action for Public Health”. *The Lancet*, 380(9838):294–305.

Lee, I.-M., Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., and Katzmarzyk, P. T. (2012). “Effect of Physical Inactivity on Major Non-Communicable Diseases Worldwide: An Analysis of Burden of Disease and Life Eexpectancy”. *The Lancet*, 380(9838):219–229.

Leivas, P. H. S. and dos Santos, A. M. A. (2018). “Horizontal Inequality and Ethnic Diversity in Brazil: Patterns, Trends, and their Impacts on Institutions”. *Oxford Development Studies*, 46(3):348–362.

Lindahl, M. (2005). “Estimating the Effect of Income on Health and Mortality using Lottery Prizes as an Exogenous Source of Variation in Income”. *Journal of Human Resources*, 40(1):144–168.

Mendonça, C. P. and Anjos, L. A. d. (2004). "Dietary and Physical Activity Factors as Determinants of the Increase in oOverweight/Obesity in Brazil". *Cadernos de Saude Publica*, 20(3):698–709.

Mozaffarian, D., Afshin, A., Benowitz, N. L., Bittner, V., Daniels, S. R., Franch, H. A., Jacobs, D. R., Kraus, W. E., Kris-Etherton, P. M., Krummel, D. A., Popkin, B. M., Whitsel, L. P., and Zakai, N. A. (2012). "Population Approaches to Improve Diet, Physical Activity, and Smoking Habits: A Scientific Statement from the American Heart Association". *Circulation*, 137(24):1–214.

Mullahy, J. and Portney, P. R. (1990). "Air Pollution, Cigarette Smoking, and the Production of Respiratory Health". *Journal of Health Economics*, 9(2):193–205.

O'Sullivan, A. (2007). *"Urban Economics"*. McGraw-Hill/Irwin.

Paim, J., Travassos, C., Almeida, C., Bahia, L., and Macinko, J. (2011). "The Brazilian Health System: History, Advances, and Challenges". *The Lancet*, 377(9779):1778–1797.

Pratt, M., Sarmiento, O. L., Montes, F., Ogilvie, D., Marcus, B. H., Perez, L. G., Brownson, R. C., Group, L. P. A. S. W., et al. (2012). "The Implications of Megatrends in Information and Communication Technology and Transportation for Changes in Global Physical Activity". *The Lancet*, 380(9838):282–293.

Ramires, V., Becker, L., Sadovsky, A., Zago, A., Bielemann, R., and Guerra, P. (2014). "Evolução da Pesquisa Epidemiológica em Atividade Física e Comportamento Sedentário no Brasil: Atualização de uma Revisão Sistemática". *Revista Brasileira de Atividade Física & Saúde*, 19(5):529.

Rasciute, S. and Downward, P. (2010). "Health or Happiness? What is the Impact of Physical Activity on the Individual?". *Kyklos*, 63(2):256–270.

Rezende, L. F. M., de Sá, T. H., Markozannes, G., Rey-López, J. P., Lee, I.-M., Tsilidis, K. K., Ioannidis, J. P., and Eluf-Neto, J. (2018a). "Physical Activity and Cancer: An Umbrella Review of the Literature including 22 Major Anatomical Sites and 770 000 Cancer Cases". *British Journal of Sports Medicine*, 52(13):826–833.

Rezende, L. F. M., Garcia, L. M. T., Mielke, G. I., Lee, D. H., Wu, K., Giovannucci, E., and Eluf-Neto, J. (2018b). "Preventable Fractions of Colon and Breast Cancers by Increasing Physical Activity in Brazil: Perspectives from Plausible Counterfactual Scenarios". *Cancer Epidemiology*, 56:38–45.

Rezende, L. F. M., Rabacow, F. M., Viscondi, J. Y. K., Luiz, O. d. C., Matsudo, V. K. R., and Lee, I.-M. (2015). "Effect of Physical Inactivity on Major Noncommunicable Diseases and Life Expectancy in Brazil". *Journal of Physical Activity and Health*, 12(3):299–306.

Rosenzweig, M. R. and Schultz, T. P. (1983). "Estimating a Household Production Function: Heterogeneity, the Demand for Health Inputs, and their Effects on Birth Weight". *Journal of Political Economy*, 91(5):723–746.

Rtveladze, K., Marsh, T., Webber, L., Kilpi, F., Levy, D., Conde, W., McPherson, K., and Brown, M. (2013). "Health and Economic Burden of Obesity in Brazil". *PloS One*, 8(7):e68785.

Sarma, S., Devlin, R. A., Gilliland, J., Campbell, M. K., and Zaric, G. S. (2015). "The Effect of Leisure-Time Physical Activity on Obesity, Diabetes, High BP and Heart Disease Among Canadians: Evidence from 2000/2001 to 2005/2006". *Health Economics*, 24(12):1531–1547.

Schmidt, M. I., Duncan, B. B., e Silva, G. A., Menezes, A. M., Monteiro, C. A., Barreto, S. M., Chor, D., and Menezes, P. R. (2011). "Chronic Non-Communicable Diseases in Brazil: Burden and Current Challenges". *The Lancet*, 377(9781):1949–1961.

Schneider, B. S. and Schneider, U. (2009). "Determinants and Consequences of Health Behaviour: New Evidence from German Micro Data". SOEPpapers on Multidisciplinary Panel Data Research 253, Deutsches Institut für Wirtschaftsforschung (DIW), Berlin.

Stunkard, A. (2000). "Factores Determinantes de la Obesidad: Opinión Actual". In Pena, M. and Bacallao, J., editors, *La Obesidad en la Pobreza: Un Nuevo Reto para la Salud Pública*, chapter 3, pages 27–32. Pan American Health Organization, Washington D.C.

Szwarcwald, C. L., Malta, D. C., Pereira, C. A., Vieira, M. L. F. P., Conde, W. L., Souza Júnior, P. R. B. d., Damacena, G. N., Azevedo, L. O., Azevedo e Silva, G., Theme Filha, M. M., et al. (2014). "National Health Survey in Brazil: Design and Methodology of Application". *Ciência & Saúde Coletiva*, 19(2):333–342.

Taylor, C. L. and Hudson, M. C. (1976). *"World Handbook of Political and Social Indicators II"*, volume 1. Inter-University Consortium for Political Research.

World Health Organization (2014). *"Global Status Report on Noncommunicable Diseases 2014"*. Geneva: World Health Organization.

World Health Organization (2016). *"Global Recommendations on Physical Activity for Health"*. Geneva: World Health Organization.

7 Appendix

Figure 1 – Brazil and its Geographical Regions

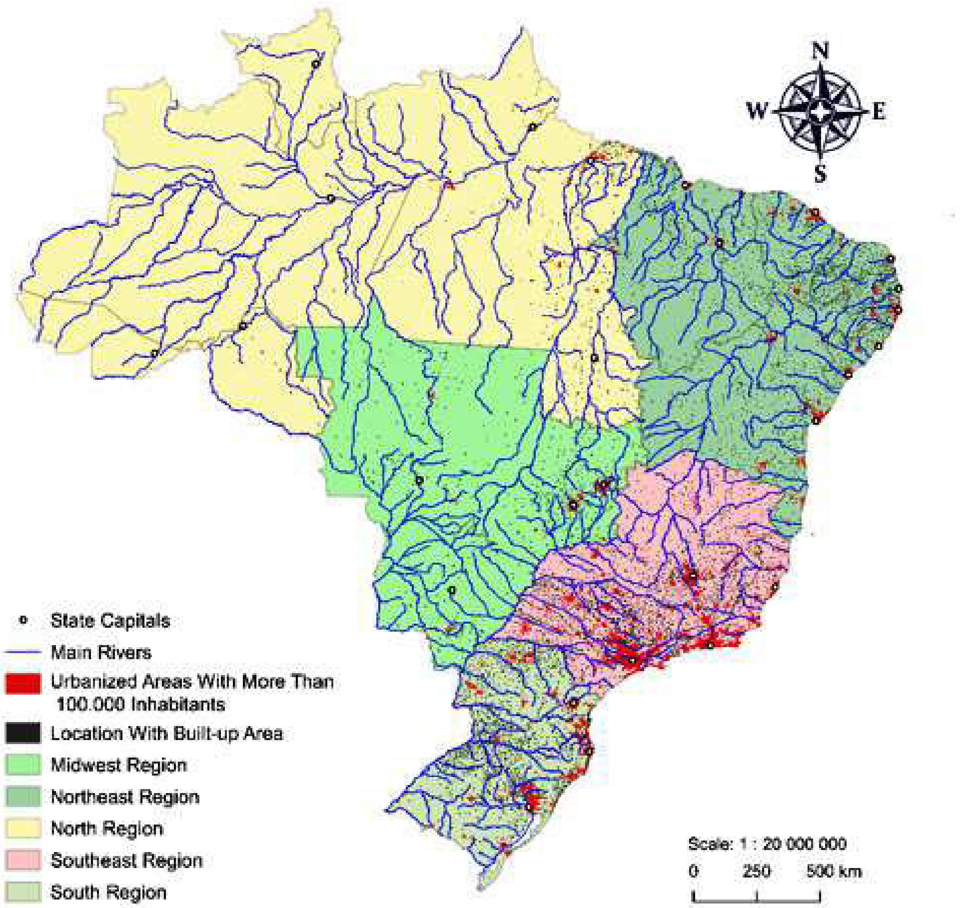

Table I – Variable Description

Variables or groups	Definition
Health Variables	
BMI25	Dummy variable that is equal to 1 when the individual has a Body Mass Index greater than or equal to 25 (classified as having overweight or obesity), considering height and weight as established by NHS.
BMI30	Dummy variable that is equal to 1 when the individual has a Body Mass Index greater than or equal to 30 (classified as having type 1 or 2 obesity), considering height and weight as established by NHS.
BMI35	Dummy variable that is equal to 1 when the individual has a Body Mass Index greater than or equal to 35 (classified as having type 2 obesity), considering height and weight as established by NHS.
Physical Activity	
Adequate Physical Activity	Binary: 1 if the person has practiced physical exercise or sport in the last three months (at least 70 minutes in intense activities or 150 minutes in mild or moderate activities per week); 0, otherwise.
Proximity	Binary: 1 if there is a public space for practicing physical activity and / or sport close to home; 0, otherwise.
Individual Characteristics	
Color	Binary: 1 if white; 0, otherwise.
Age	Age in years.
Marriage	Binary: 1 if married; 0, otherwise.
Unhealthy Habits	
Fruits and Vegetables	Binary: 1 if the person eats vegetables and fruits (or drinks fruit juice) less than 5 days a week; 0, otherwise.
Meat with Fat	Binary: 1 if the person usually eats meat with fat or chicken with skin; 0, otherwise.
Alcoholic Beverages	Binary: 1 if the person consumes alcoholic beverages at least once a week; 0, otherwise.
Salt	Binary: 1 if the person considers their salt consumption very high or high; 0, otherwise.
Milk	Binary: 1 if the person usually doesn't drink whole milk; 0, otherwise.
Beans	Binary: 1 if the person doesn't eat beans 5 of more days of the week; 0, otherwise.
Fish	Binary: 1 if the person doesn't eat fish at least once a week; 0, otherwise.
Soda	Binary: 1 if the person consumes soda at least 5 times a week; 0, otherwise.
Sweets	Binary: 1 if the person consumes sweets at least 5 times a week; 0, otherwise.
Smokes	Binary: 1 if the person smokes daily; 0, otherwise.
Has Smoked	Binary: 1 if the person has previously smoked daily; 0, otherwise.
Access to Medical Care	
Endemic Agents	Binary: 1 if the person has received in their home a guest with an endemic disease at least once a year 0, otherwise.
Medical Appointments	Binary: 1 if the person has gone to the doctor at least once in the last 12 months; 0, otherwise.
Health Insurance	Binary: 1 if the person has a health care plan; 0, otherwise.
Recommendation of Activities	Binary: 1 if the person has received a medical recommendation to practice a physical activity; 0, otherwise.
Sanitation	
Sewage	Binary: 1 if the person has a bathroom with a drain connected to the general or rainwater system or septic tank; 0, otherwise.
Water	Binary: 1 if the person has piped water connected to the general distribution network; 0, otherwise.
Waste	Binary: 1 if the person has direct or indirect garbage collection; 0, otherwise.
Number of People in the Household	
# of children $\leq$ 6 years	Number of children in the household with ages equal to or less than 6 years old.
# of children $\geq$ 7 and $\leq$ 14 years	Number of children with ages higher than or equal to 7 years, and less than or equal to 14 years.
# of people $\geq$ 15 years	Number of people in the household with ages equal to or higher than 15 years.
Income, Work and Education	
Schooling	Categorical: 1 = uneducated; 2 = unfinished elementary/middle school; 3 = finished elementary/middle school; 4 = unfinished high school; 5 = finished high school; 6 = unfinished higher education; 7 = finished higher education.

continues

continued

Variables or groups	Definition
ln income	Natural logarithm of household income per capita.
Work	Categorical: 1 = occupied; 2 = unoccupied; 3 = not inserted in the workforce.
Asset index (in quintiles, created based on the local NHS sample)	Indicator (based on PCA) of the following variables: TV; DVD; refrigerator; washing machine; microwave; cell phone; computer; internet; motorcycle; car.
TV	Binary: 1 if the person watches television for 3 hours or more per day; 0, otherwise.
Other Physical Activities	
Domestic Physical Activities	Binary: 1 if the person practices domestic physical activities (150 minutes or more per week); 0, otherwise.
Physical Activities at Work	Binary: 1 if the person practices physical activities at work (30 minutes or more per day); 0, otherwise.
Physical Activities to Work	Binary: 1 if the person practices physical activities on the way to work or other usual activity such as going to school (30 minutes or more per day); 0, otherwise.
Area	
Area	Categorical: 1 = capital; 2 = metropolitan region; 3 = others.
State Fixed Effects	Binary: 1 if the person lives in the federation unit j, $j = 1, 2, \ldots, J$; 0, otherwise.

Table II – The Average of the Variables by Physical Activity

	Women			Men		
	Practices Activities Yes	Practices Activities No	Difference	Practices Activities Yes	Practices Activities No	Difference
BMI25	0.545	0.570	-0.025	0.548	0.580	-0.032
BMI30	0.206	0.249	-0.043	0.143	0.192	-0.049
BMI35	0.050	0.087	-0.037	0.036	0.049	-0.013
Color (white)	0.532	0.469	0.063	0.485	0.472	0.013
Age	36.530	37.740	-1.210	32.480	38.530	-6.050
Partner	0.554	0.614	-0.060	0.495	0.666	-0.171
Capital	0.308	0.283	0.025	0.322	0.256	0.066
Metropolitan region	0.156	0.196	-0.040	0.161	0.203	-0.042
Other areas	0.536	0.521	0.015	0.517	0.541	-0.024
Fruits and vegetables$^{\mp}$	0.489	0.632	-0.143	0.590	0.680	-0.090
Meat with fat$^{\mp}$	0.204	0.318	-0.114	0.420	0.499	-0.079
Alcohol$^{\mp}$	0.234	0.141	0.093	0.427	0.384	0.043
Salt$^{\mp}$	0.141	0.144	-0.003	0.172	0.190	-0.018
Milk$^{\mp}$	0.490	0.378	0.112	0.379	0.376	0.003
Beans$^{\mp}$	0.399	0.323	0.076	0.264	0.215	0.049
Fish$^{\mp}$	0.381	0.486	-0.105	0.420	0.470	-0.050
Soda$^{\mp}$	0.192	0.256	-0.064	0.294	0.327	-0.033
Sweets$^{\mp}$	0.236	0.248	-0.012	0.240	0.205	0.035
Never smoked daily	0.837	0.800	0.037	0.808	0.679	0.129
Has smoked daily	0.103	0.085	0.018	0.096	0.136	-0.040
Smokes daily	0.060	0.115	-0.055	0.096	0.185	-0.089
Endemic agents	0.731	0.750	-0.019	0.728	0.743	-0.015
Medical appointments	0.859	0.792	0.067	0.656	0.639	0.017
Health insurance	0.380	0.236	0.144	0.320	0.232	0.088
Recommendation of activities	0.231	0.204	0.027	0.124	0.173	-0.049
Sewage	0.875	0.823	0.052	0.858	0.822	0.036
Water	0.936	0.925	0.011	0.934	0.916	0.018
Waste	0.992	0.981	0.011	0.985	0.978	0.007
# of hildren $\leq$ 6 years	0.252	0.384	-0.132	0.257	0.323	-0.066
# of children $\geq$ 7 and $\leq$ 14 years	0.384	0.472	-0.088	0.324	0.419	-0.095
# of people $\geq$ 15 years	2.897	2.881	0.016	2.977	2.843	0.134
Uneducated	0.040	0.087	-0.047	0.039	0.099	-0.061
Unfinished elementary/middle school	0.108	0.211	-0.103	0.118	0.250	-0.132
Finished elementary/middle school	0.070	0.103	-0.033	0.101	0.119	-0.018
Unfinished high school	0.059	0.068	-0.009	0.076	0.065	0.011
Finished high school	0.362	0.341	0.021	0.390	0.309	0.081
Unfinished higher education	0.078	0.055	0.023	0.092	0.050	0.042
Finished higher education	0.282	0.136	0.146	0.184	0.109	0.075
Domestic income per capita	1682.000	1003.000	679.000	1704.000	1122.000	582.000
Occupied	0.656	0.596	0.060	0.829	0.852	-0.023
Unoccupied	0.051	0.049	0.002	0.052	0.027	0.025
Outside of workforce	0.294	0.355	-0.061	0.119	0.121	-0.002
Asset index (1st quintile)	0.075	0.153	-0.078	0.097	0.158	-0.061
Asset index (2nd quintile)	0.113	0.188	-0.075	0.145	0.191	-0.046
Asset index (3rd quintile)	0.190	0.226	-0.036	0.211	0.216	-0.005
Asset index (4th quintile)	0.542	0.382	0.160	0.469	0.377	0.092
Asset index (5th quintile)	0.080	0.051	0.029	0.078	0.058	0.020
Time spent watching television	0.243	0.329	-0.086	0.262	0.270	-0.008
Domestic physical activities	0.205	0.196	0.009	0.052	0.051	0.001
Physical activities at work	0.058	0.088	-0.030	0.187	0.249	-0.062
Physical activities to work	0.365	0.353	0.012	0.325	0.302	0.023
Proximity	0.612	0.449	0.163	0.583	0.448	0.135
Physical activity		0.214			0.310	
N(observations)	4537	17636		4537	11544	

Source: Author's elaboration based on the data of the 2013 NHS.
Notes: $^{\mp}$ indicators of bad health habits.

Table III – Marginal effects of the BMI25 indicator using the multivariate probit models

	Women		Men	
	Physical Activity	BMI25	Physical Activity	BMI25
Physical activity		-0.2870***		-0.2138**
		(0.0626)		(0.1045)
Color (whites)	-0.0066	-0.0134	-0.0168	0.0127
	(0.0102)	(0.0116)	(0.0127)	(0.0137)
Age	-0.0030***	0.0068***	-0.0078***	0.0040***
	(0.0005)	(0.0007)	(0.0006)	(0.0013)
Partner	-0.0406***	0.0470***	-0.0323**	0.0963***
	(0.0098)	(0.0124)	(0.0143)	(0.0183)
Metropolitan region	0.0062	0.0084	-0.0321**	0.0094
	(0.0105)	(0.0130)	(0.0136)	(0.0152)
Other areas	0.0477***	0.0054	0.0214*	0.0204
	(0.0098)	(0.0117)	(0.0129)	(0.0134)
Fruits and vegetables∓	-0.0620***	-0.0176	-0.0709***	-0.0246*
	(0.0100)	(0.0118)	(0.0125)	(0.0147)
Meat with fat∓	-0.0582***	0.0265**	-0.0225*	-0.0003
	(0.0102)	(0.0129)	(0.0120)	(0.0130)
Alcohol∓	0.0732***	0.0137	0.0296**	0.0408***
	(0.0138)	(0.0153)	(0.0123)	(0.0128)
Salt∓	-0.0147	-0.0029	-0.0406***	0.0217
	(0.0126)	(0.0145)	(0.0146)	(0.0163)
Milk∓	0.0389***	0.0140	0.0131	0.0056
	(0.0096)	(0.0112)	(0.0121)	(0.0128)
Beans∓	0.0109	0.0468***	0.0132	0.0262*
	(0.0098)	(0.0113)	(0.0139)	(0.0146)
Fish∓	-0.0416***	-0.0235**	-0.0270**	-0.0123
	(0.0098)	(0.0114)	(0.0119)	(0.0129)
Soda∓	-0.0314***	-0.0323**	-0.0350***	-0.0011
	(0.0114)	(0.0127)	(0.0127)	(0.0143)
Sweets∓	-0.0217**	-0.0623***	0.0076	-0.0352**
	(0.0110)	(0.0127)	(0.0139)	(0.0151)
Smoked daily	0.0537***	0.0216	-0.0045	-0.0015
	(0.0175)	(0.0194)	(0.0195)	(0.0190)
Smokes daily	-0.0477***	-0.0898***	-0.0918***	-0.1531***
	(0.0146)	(0.0179)	(0.0170)	(0.0181)
Endemic agents	-0.0005	0.0104	0.0038	0.0010
	(0.0104)	(0.0128)	(0.0135)	(0.0136)
Medical appointments	0.0387***	0.0348***	0.0023	-0.0150
	(0.0114)	(0.0132)	(0.0124)	(0.0130)
Health insurance	0.0169	-0.0009	0.0340**	-0.0109
	(0.0118)	(0.0134)	(0.0144)	(0.0161)
Recommendation of activities	0.0407***	0.1518***	-0.0184	0.1256***
	(0.0122)	(0.0138)	(0.0165)	(0.0191)
Sewage	0.0041	0.0030	0.0040	0.0083
	(0.0124)	(0.0144)	(0.0153)	(0.0159)
Water	-0.0268	0.0133	0.0300	0.0022
	(0.0164)	(0.0176)	(0.0204)	(0.0220)
Waste	0.0370	-0.0185	-0.0269	0.0050
	(0.0311)	(0.0352)	(0.0387)	(0.0424)
# of children $\leq$ 6 years	-0.0346***	0.0019	-0.0152	0.0154
	(0.0084)	(0.0090)	(0.0109)	(0.0118)
# de children $\geq$ 7 and $\leq$ 14 years	0.0027	0.0122*	-0.0069	-0.0011
	(0.0062)	(0.0073)	(0.0085)	(0.0092)
# of people $\geq$ 15 years	0.0001	0.0056	0.0116**	-0.0128**
	(0.0045)	(0.0051)	(0.0050)	(0.0059)
Unfinished elementary/middle school	0.0039	0.0124	0.0245	-0.0128
	(0.0193)	(0.0227)	(0.0228)	(0.0243)
Finished elementary/middle school	0.0285	0.0225	0.0907***	-0.0066
	(0.0225)	(0.0253)	(0.0256)	(0.0299)
Unfinished high school	0.0356	-0.0380	0.0898***	-0.0057
	(0.0246)	(0.0294)	(0.0282)	(0.0324)
Finished high school	0.0475**	-0.0203	0.1206***	0.0310
	(0.0191)	(0.0229)	(0.0225)	(0.0263)
Unfinished higher education	0.0338	-0.0333	0.1093***	0.0484
	(0.0247)	(0.0297)	(0.0306)	(0.0346)
Finished higher education	0.0811***	-0.0571**	0.1584***	0.0349
	(0.0230)	(0.0277)	(0.0283)	(0.0329)
Ln income	0.0404***	-0.0149*	0.0419***	0.0483***

continues

continued

	Women		Men	
	Physical Activity	BMI25	Physical Activity	BMI25
	(0.0073)	(0.0089)	(0.0095)	(0.0098)
Unoccupied	0.0192	-0.0205	0.1196***	-0.0356
	(0.0273)	(0.0261)	(0.0369)	(0.0398)
Outside of workforce	0.0154	-0.0153	0.0314	-0.0391*
	(0.0112)	(0.0127)	(0.0197)	(0.0206)
Asset index (2nd quintile)	0.0044	0.0327*	0.0150	0.0175
	(0.0158)	(0.0169)	(0.0189)	(0.0210)
Asset index (3rd quintile)	0.0337**	0.0712***	0.0436**	0.0597***
	(0.0167)	(0.0177)	(0.0192)	(0.0219)
Asset index (4th quintile)	0.0692***	0.0652***	0.0582***	0.0602**
	(0.0176)	(0.0189)	(0.0203)	(0.0239)
Asset index (5th quintile)	0.0770***	0.0417	0.0660**	0.0946***
	(0.0286)	(0.0306)	(0.0304)	(0.0342)
Time spent watching television	-0.0352***	0.0292**	0.0018	0.0072
	(0.0100)	(0.0120)	(0.0130)	(0.0136)
Domestic physical activity	0.0236*	0.0041	0.0220	0.0099
	(0.0121)	(0.0135)	(0.0294)	(0.0271)
Physical activity at work	-0.0379**	0.0006	-0.0077	-0.0484***
	(0.0156)	(0.0190)	(0.0155)	(0.0164)
Physical activity to work	0.0248**	0.0070	0.0493***	-0.0347**
	(0.0101)	(0.0113)	(0.0129)	(0.0152)
Proximity	0.0626***		0.0644***	
	(0.0091)		(0.0116)	
Fixed State Effects	Yes	Yes	Yes	Yes
N (observations)	22173	22173	22173	22173

[a] *Source*: Author's elaboration based on the data of the 2013 NHS.
[b] *Notes*: $^{\mp}$ indicates poor health habits. The outcomes are binary variables with 1 indicating better health (e.g., not having arthritis). Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table IV – Marginal Effects of Health Outcomes and Physical Activity for the Multivariate and linear Probability Models

	Biprobit			LPM	N
	ρ	Physical Activity	BMI	BMI	
Women					
BMI25	0.4924***	0.0626***	-0.2870***	0.0147	22,173
	(0.1013)	(0.0091)	(0.0626)	(0.0142)	
BMI30	0.4474***	0.0590***	-0.1989***	-0.0145	22,173
	(0.1206)	(0.0093)	(0.0437)	(0.0125)	
BMI35	0.3401***	0.0586***	-0.0834***	-0.0261***	22,173
	(0.1108)	(0.0095)	(0.0176)	(0.0067)	
Hearing disability	-0.3285	0.0598***	0.0896	0.0014	22,173
	(0.2090)	(0.0094)	(0.0835)	(0.0071)	
VIF				3.1000	
Men					
BMI25	0.3584*	0.0644***	-0.2138***	-0.0003	16,850
	(0.1745)	(0.0116)	(0.1045)	(0.0144)	
BMI30	0.5143	0.0597***	-0.2152***	-0.0383***	16,850
	(0.3194)	(0.0136)	(0.1063)	(0.0106)	
BMI35	0.1280	0.0624***	-0.0288	-0.0121**	16,850
	(0.3443)	(0.0120)	(0.0425)	(0.0061)	
Hearing disability	-0.0055	0.0626***	-0.0098	-0.0109	16,850
	(0.2653)	(0.0120)	(0.0493)	(0.0068)	
VIF				3.0300	

Source: Author's elaboration based on the data of the 2013 NHS.
Notes: Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The Variance Inflating Factor (VIF) measures the level of collinearity, where VIF above 0 indicates high degree of collinearity.