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Research Article

Associations of Vegetable and Fruit Consumption and Self-Rated Health Status among Brazilian Adults

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Abstract

Introduction: Although Brazil is an important producer of fruits and vegetables worldwide, the consumption of vegetables in the country is insufficient, with a scarce variety of products, and it is worse among individuals with higher consumption of ultra-processed foods. Consuming fruits and vegetables is a critical factor in maintaining a healthy lifestyle, decreasing the risk of developing diet-related chronic diseases, and positively affecting psychological well-being, mental health and overall health. The self-rated health (SRH) is a reliable indicator of overall health status. It is a useful independent predictor of healthy lifestyle behaviours, such as physical activity or healthy eating. This study analyses the association between fruit and vegetable consumption behaviours and self-rated health status in Brazilian adult populations.

Methods: Data came from the 2019 Brazilian National Health Survey data. SRH status was evaluated with the classical question: "In general, how would you rate your health status"? and responses were categorized into three ordinal categories from the worst to the best level. Vegetable and fruit consumption, were measured by the question: "How many days a week do you usually eat fruits and at least one type of vegetable. Then, three ordinal categories were built for each variable, from an optimal to a short consumption. The association between SRH status and fruit and vegetables consumption was examined using ordinal regression analysis, adjusted by relevant confounders and stratified by sex.

Results: A total of 63,444 adult participants were analysed. The mean age was 48.5 years (SD: 16.67), and 58% were women. Forty-four per cent and 37% say to have an optimal consumption (6-7 days/week) of vegetables and fruits, respectively. Conversely, 26% and 32% of the surveyed mentioned poor consumption (0-2 days/week) of vegetables and fruits, respectively. Additionally, 61%, 32% and 7% of the respondents reported a "good/very good", "fair", and "bad/very bad" SRH status, respectively. According to the model, men with optimal vegetable intake have a 64% probability of belonging to the SRH "good/very good" status, compared to 61% of women. Conversely, men with short vegetable intake have a 39% probability of belonging to "fair" or "bad/very bad" SRH status, compared to 43% of women. Differences were statistically significant. Similar to vegetable consumption, increased fruit consumption is associated with higher probabilities of a better SRH status in both sexes.

Conclusions: The study indicates that optimal and moderate fruit and vegetable consumption are significantly and positive associated with SRH status. This relationship is complex because both are directly affected by some relevant socio-demographic factors, and discriminating against this effect is difficult, becoming a methodological challenge. Furthermore, the SRH status differences associated to fruit and vegetable consumption across main socio-demographic factors represent well socioeconomic inequalities in health in Brazilian population.

Recommendations: These findings reinforce the importance of promoting healthy eating through public policies based on strategies and programmes focused on socially and economically vulnerable groups. Future research is needed to initiate longitudinal studies to address causality in the relationships among fruit and vegetable consumption and SRH status and monitor the effectiveness and efficiency of public policies oriented to improve healthy eating behaviours.

Keywords: Adult Peoples; Vegetable Consumption; Fruit Consumption; Self-Rated Health Status; Ordinal Logistic Regression; Brazil

Introduction

The proliferation of highly processed food, supported by aggressive marketing, rapid unplanned urbanization and changing lifestyles have contributed to more people eating unhealthy diets contributing to overweight and obesity and diet-related of non-communicable diseases (NCDs), including diabetes mellitus, cardiovascular disease, hypertension and stroke, and certain forms of cancer [1,2].

In response to the heavy and growing burden of NCDs and to address two of their primary risk factors, in 2004 World Health Organization (WHO) adopted the *Global Strategy on Diet, Physical Activity and Health* to reduce deaths and disease burden and to promote and protect health worldwide through healthy eating and physical activity [3].

Consuming fruits and vegetables is a critical factor in maintaining a healthy lifestyle. Studies have shown that individuals who eat a –mainly raw- diet rich in fruits and vegetables have a decreased risk of developing chronic diseases, such as heart disease [4-8], stroke [9-11], and diabetes [12-14], as well as improved overall health. In addition, a diet high in fruits and vegetables has been associated with improved psychological well-being [15,16] and positive effects on mental health [17,18].

According to Canella., *et al.* (2018) the consumption of vegetables in Brazil is insufficient with a scarce variety of products, and it is worse among individuals with higher consumption of ultra-processed foods. The inverse relationship between the consumption of vegetables and ultra-processed foods, beyond the negative nutritional effects of these products, also indirectly harms the diet given its ability to displace and interfere with the consumption of healthy foods [19]. Only 35% of the adolescents and 38% of the adults (residents of the state capitals and the Federal District) reported regular consumption (five or more days/week), while 20% and 8% reported not consuming them, respectively [20,21].

On the other hand, self-rated health (SRH), or self-perceived health (SPH), is an indicator of overall health status and one of the most frequently used in health and social research. SRH is a subjective indicator of health status that integrates a person's biological, demographic, mental, social and functional aspects, including individual and cultural beliefs and health behaviours [22]. Then, people's culture, gender, economic conditions, health system organization, geographical units and economic differences must be considered when comparing SRH between populations [23-25].

SRH reflects respondents' holistic perception of general health status, which is obtained by answering a simple question such as – In general, how is your health status? on a four or five-point scale [26]. However, SRH measure has some limitations to keep in mind. Methodological difficulties related to data collection, i.e., the use of differently phrased or scale questionnaires, risking interpretations of questions and affecting the validity and reliability of the questionnaire. Also, difficulties interpreting this measure across varying age ranges and cultural groups must be considered [24].

Up to date, SRH has become a reliable measurement of overall health status, and as a significant independent predictor of morbidity, development of disability and mortality [27-29]. Despite seemingly non-specific nature of SRH, it has shown to be a useful predictor of healthcare services utilization [30,31], survival rate [32] functional health among older people [33], and healthy lifestyle behaviours, such as physical activity [34-36] or healthy eating [4-18,37,38].

In the last decade, more Brazilian researchers have explored the association of SRH with healthy eating behaviours. Overall the evidence suggests that regular (>5 days/week) of raw consumption of fruit, beans, and vegetables represents a positive health status perception and is influenced by modifiable lifestyle factors and sociodemographic factors [37,39-42].

On the other hand, according to the *Risk and Protective Factors Surveillance System for Chronic Non-Communicable Diseases Through Telephone Interview* (Vigitel), the prevalence of regular consumption of fruits and vegetables among inhabitants of Brazilian capitals showed a slight trend of increase from 19.5% (2010) to 22.9% (2019) [43]. Moreover, in 2019-PNS, the vegetable and fruit prevalence (consumption at least five days/week) was 55.2% and 45.1%, respectively [44].

The current study aims to analysed the association between fruit and vegetable consumption behaviours and self-rated health status in Brazilian adult populations.

Methods

Design, population and data collection

This study is an observational cross-sectional study based on the last Brazilian National Health Survey or *Pesquisa Nacional de Saude* (2019-PNS), conducted by the Brazilian Institute of Geography and Statistics (IBGE) in partnership with the Ministry of Health. The 2019-PNS project was approved by the National Research Ethics Committee, from the National Health Council, in August 2019 [45].

The 2019-PNS is a household based survey representative of the Brazilian noninstitutionalized population at the national, regional, state, and major metropolitan area levels. The selected sample originated from a IBGE master sample, stratified into three

cluster stages: census tracts selected with proportional probability, households selected by simple random and individual aged 15 or over randomly selected within each household. The interviews were carried out between August 2019 and March 2020 by trained teams using smartphone devices programmed with the survey questionnaire and the processes of criticizing the variables. A total of 90,846 households and 275,323 individuals were interviewed. The response rate for households was 93.6% [45].

The current analysis includes data from 63,444 surveys corresponding to people aged 18 or more who were considered able to answer the questionnaire, who answered by itself the module about the use of health services and those who answered the questions about self-rated health, the consumption of fruits and vegetables. Associations between the consumption of vegetables and fruits and self-rated health were assessed.

Main variables

Dependent variable

The outcome variable of this study was SRH status, obtained through the question: "In general, how would you rate your health status"? The response options are categorized according the World Health Organization (WHO) recommendation [46]; "very good", "good", "fair", "bad' or "very bad". For the current analyses, this variable was arranged into three ordinal categories from the worst to the best level. Those who answered "very bad" and "bad" were considered category 1; those who answered "fair" were considered category 2 and those who answered "very good", "good" category 3.

Independent variables

The interest variables were vegetable and fruit consumption. Vegetable consumption was measured by the question: "How many days a week do you usually eat at least one type of vegetable (not counting potatoes, cassava, taro or sweet potatoes) such as lettuce, tomato, cabbage, carrots, chayote, eggplant, zucchini? ". The respondents reported the number of days by a week, or never or less than once a week option. A similar question was asked about fruit consumption: "How many days a week do you usually eat fruits?". The same answer options for vegetable consumption were applied. Then, an arbitrary categorization of these discrete variables was carried out. Three categories were built for each one: optimal consumption (6-7 days/week), moderate (3-5 days/week) and short (0-2 days/week). Both vegetable and fruit consumption variables were included in the same model. An interaction term between these variables was included in the logistic model to explore a potential interaction effect on the outcome.

Geographic and sociodemographic factors

Age, sex, ethnicity, marital status, region, urban residence, income deciles, education level, and number of chronic diseases were considered as potential confounders and included in the final models. We chose these covariates since they not only showed significant association with vegetables and fruits consumption but also could influence self-perceived health status [47,48].

Sex, marital status, and area of residence were included as dichotomous variables. Female, married and urban residents' conditions were considered categories of interest. Ethnicity and region of residence were included as categorical variables. In the 2019-PNS ethnicity options were: white, black, yellow, brown-skinned and indigenous. The yellow and indigenous ethnic groups -just for reasons of sample size- were considered the reference group. On the other hand, Brazil is divided into five regions: North, Northeast, Central West, Southeast and South. The South region was considered as a reference group. Age, the highest level of education attained, and the number of chronic diseases were included as discrete variables, according to recorded or derived values from the 2019-PNS.

Statistical analyses

The relationship between vegetable and fruit consumption by its three categories and the self-perceived health status was analysed. Descriptive statistics were performed to provide a profile of the general characteristics of the sample.

As dependent variable is measured on an ordinal scale, we use ordinal regression models also known as the proportional odds models. The key assumption in ordinal regression is the proportional odds/parallel lines, that is effects of any explanatory variables are consistent or proportional across the different thresholds or cut-off (the splits between each pair of categories of the *ordinal outcome variable).* In other words, that the explanatory variables have the same effect on the odds regardless of the threshold [49].

Model specification

Before the regression analysis, the multicollinearity of the variables was examined using correlation matrices and the variance inflation factor (VIF). VIF values exceeding ten are considered indicators of multicollinearity, but in weaker models, as is usually the case in logistic regression models, values greater than 2.5 may be of concern [50]. The multicollinearity diagnostic statistics were examined using linear regression analysis with household income as the dependent variable. Furthermore, the interaction term for vegetable and fruit consumption was explored.

Firstly, we fit a standard ordered logistic regression estimated via *ologit* command. However, Brant test and the approximate likelihood-ratio test fit with *omodel* command, shows that the proportional odds/parallel lines assumption was violated. Then, we tried a Partial Proportional Odds Model (PPOM) using a constrained

generalized ordered logit model (*gologit2* command with *autofit* option). In this model, the parallel lines assumption is then relaxed only for those explanatory variables that violate the assumption [51]. On the other hand, *autofit* option uses an iterative process to identify the partial proportional odds model that best fits the data [52]. Wald test of parallel lines assumption and Likelihood-ratio test for the final model where checked. Testing parallel lines assumption using the .05 level of significance in the model.

As the parameters for a PPO model can be hard to interpret, we use marginal effects at the means (MEMs), to calculate average adjusted probabilities (AAPs) to make results more understandable. The *dydx*() and *atmeans* options were used with *margins* command. The *dydx*() option tells margins which variables to compute marginal effects, and *atmeans* option tells *margins* command to fix some variable values, compute the mean values for the other variables, and then use the fixed and mean values to compute predicted probabilities [52]. Finally, we use *mtable* command from Spost13- a collection of post-estimation commands for regression models- to calculate average adjusted probabilities (AAPs) for the interest variables graphing their output stratified by sex [53,54].

The statistical analysis was performed using Stata version 14.0. The statistical significance was tested using Wald's chi-square statistic. We accepted a level of significance of 5% in the test. Expressed monetary values were, on average and expressed in nominal BRL$ 2019.

Results

A total of 63,444 adult individuals; 58.4% female, with an average age of 48.5 years (Std: 16.67), most of them living in Northeast (34,4%) and Southeast (22,0%), were studied. Fifty-one percent were self-referred as brown-skinned, 36% white, 12% black and 2% other ethnicities. Thirty-eight percent were married, 77% living urban areas and 41% unscholarly or incomplete elementary school. Individuals in the 1st and 10th deciles had an average monthly household income of BRL$484 and BRL$16,644, respectively. In general, 61.0% of the surveyed reported a "good/very good", 31.7% "fair' and 7.3% "bad/very bad" health status. The geographic and socio-demographic characteristics of the studied population, according to SRH status categories, are presented in table 1.

In summary, the participants classified as "bad/very bad" are

Characteristics	Self-rated health status		
	Bad/very bad (n:4.633)	Fair (n:20.131)	Good/very good (n:38.680)
Age (avg., years) (std) **	57 (14.25)	53 (16.23)	45 (16.15)
Sex (% female) **	67%	62%	55%
Marital status (% married) n.s.	38%	39%	38%
Urban residence (%) **	70%	71%	80%
Education level			
Unscholarly **	21.5%	12.1%	5.4%
Incomplete ElemSch **	51.2%	44.0%	24.5%
Complete ElemSch *	6.4%	7.7%	7.5%
Incomplete HighSch **	3.8%	5.7%	6.2%
Complete HighSch **	12.4%	20.6%	29.4%
Incomplete GradSch **	1.0%	2.3%	5.4%
Graduated **	3.7%	7.6%	21.6%
Household income decils (monthly avg. R$)			
1st decile	16.1% (R$ 434)	13.3% (R$ 479)	9.6% (R$ 497)
2nd decile	26.3% (R$ 1,029)	19.6% (R$ 1,039)	12.6% (R$ 1,052)
3rd decile	10.4% (R$ 1,423)	10.4% (R$ 1,428)	9.0% (R$ 1,432)
4th decile	17.2% (R$ 1,937)	15.8% (R$ 1,933)	10.6% (R$ 1,908)
5th decile	8.7% (R$ 2,273)	9.6% (R$ 2,289)	8.8% (R$ 2,309)
6th decile	6.8% (R$ 2,846)	8.3% (R$ 2,840)	8.6% (R$ 2,850)
7th decile	5.6% (R$ 3,502)	7.8% (R$ 3,518)	9.1% (R$ 3,512)
8th decile	4.5% (R$ 4,569)	6.4% (R$ 4,570)	9.9% (R$ 4,571)
9th decile	2.8% (R$ 6,391)	5.2% (R$ 6,587)	10.2% (R$ 6,678)
10th decile	1.6% (R$ 14,013)	3.7% (R$ 14,732)	11.7% (R$ 17,000)
Number chronic diseases			
none **	10.0%	24.9%	54.1%
1-2 **	41.8%	48.7%	37.8%

3+ **	48.2%	26.4%	8.2%
Ethnicity			
White **	28.4%	30.5%	39.3%
Black **	13.7%	12.4%	11.0%
Yellow *	0.6%	0.7%	0.9%
Brown-skinned **	56.1%	55.5%	48.1%
Indigenous *	1.2%	0.9%	0.7%
Region			
North **	19.9%	20.4%	18.1%
Northeast **	45.4%	40.6%	29.8%
Central west **	8.7%	9.8%	12.8%
Southeast **	16.8%	18.7%	24.3%
South **	9.3%	10.4%	15.0%
Vegetable intake			
Optimal (6-7 days/week) **	35.6%	40.5%	46.0%
Moderate (3-5 days/week) **	27.3%	29.1%	31.0%
Short (0-2 days/week) **	37.1%	30.4%	23.0%
Fruit intake			
Optimal (6-7 days/week) **	31.9%	35.5%	38.5%
Moderate (3-5 days/week) *	29.7%	30.9%	31.8%
Short (0-2 days/week) **	38.4%	33.6%	29.7%

Table 1: Geographic and socio-demographic characteristics of the sample, according to SRH status categories. 2019-PNS.

*: pvalue < 0,05; **: p-value < 0,001; n.s.: Non Significant; ElemSch: Elementary School; HighSch: High School; GradSch: Graduate School

primarily women, older than other SRH categories, black or brown-skinned ethnicities, lower educational level, people located in the lowest deciles household income levels, most of them living in urban areas of the North or Northeast and with increased prevalence of chronic diseases. Concerning vegetable and fruit consumption, people in this category consume less.

Regarding the "good/very good" category, the participants are just equally distributed in both sexes, younger than other categories, primarily white ethnicity, higher educational level and located in the highest deciles household income levels, living mainly in urban areas of the Southeast and South regions and presenting lower chronic diseases prevalence. Concerning vegetable and fruit consumption, people in this category consume moderate or optimal intakes. Except for marital status, differences among all other variables were statistically significant in the SRH categories analysed in the current study.

Model goodness-of-fit statistics

The correlation between the dependent with the interest variables was weak (r < 0.25). As expected a moderate correlation (r = 0.35) between vegetable and fruit consumption was observed. The average VIF for all variables in the model was 1.6 and for the variables of interest was lower than 1.9, indicating the non-existence of multicollinearity.

After fitting the standard ordered logit model, the Brant and Likelihood-Ratio tests on the parallel lines assumption reveals that it has been violated. By fitting the partial proportional odds model (gologit2 with *autofit* option), the global Wald test shows ten constraints have been imposed in the final model, corresponding to five variables (marital status, sex, region, vegetable consumption and ethnicity) being constrained to have their effects meet the parallel-lines assumption.

For the constrained partial proportional odds final model, statistically insignificant Wald test (Prob chi2 = 0.3581) and Likelihood-ratio test ((assumption gologit2 nested in ologit), Prob chi2 = 0.3632) of parallel lines assumption for the model indicates that this model does not violate the parallel-lines assumption.

The interaction (vegetable x fruit) coefficient was insignificant, meaning that the effect of fruit consumption on SRH is not affected by the effect of vegetable consumption, and vice versa.

Coefficients and odds ratios

Table 2 shown the partial proportional odds model results for two versions of the estimates, i.e., in coefficients and the odds ratio estimates. There are two result panels in table 2, i.e., SRH "bad/very bad" and SRH "regular". The first panel contrasts the "bad/very bad" SRH category with the "regular" and "good/very good"

categories. Similarly, the second panel contrasts the "bad/very bad" and "regular" SRH categories with the "good/very good" SRH category. Altogether, the model estimates 36 coefficients; however, the coefficients and odds ratios of the variables constrained for the parallel lines assumption are identical in both panels. In turn, the variables with different coefficients in both panels are the variables that were found to violate the parallel lines assumption in the standard ordered logistic regression model.

	Coefficient	S. E.	Odds ratio	S. E.
SRH: bad/very bad				
Age **	-0.0107	0.0013	0.9893	0.0012
Sex **	-0.1817	0.0191	0.8339	0.0159
Marital status **	-0.1737	0.0190	0.8405	0.0160
Urban residence (n.s.)	-0.051	0.0381	0.9499	0.0362
Education level **	0.2601	0.0127	1.2971	0.0165
Household income decils **	0.1315	0.0078	1.1405	0.0089
Number chronic diseases **	-0.5424	0.0098	0.5814	0.0057
Ethnicity				
White *	0.1513	0.0729	1.1634	0.0849
Black (n.s.)	-0.0953	0.0754	0.9091	0.0685
Brown-skinned (n.s.)	0.0509	0.0775	1.0523	0.0815
Region				
North **	-0.5756	.03596	0.5693	0.0205
Northeast **	-0.5565	.03287	0.5732	0.0188
Central west **	-0.1835	.03947	0.8323	0.0328
Southeast (n.s.)	-0.0223	0.0342	0.9779	0.0334
Vegetable intake				
Optimal **	0.1975	0.0238	1.2184	0.0289
Moderate **	0.1536	0.0239	1.1660	0.0279
Fruit intake				
Optimal **	0.3473	0.0424	1.4152	0.0600
Moderate **	0.2102	0.0413	1.2339	0.0510
SRH: fair				
Age **	-0.0156	0.0007	0.9846	0.0007
Sex **	-0.1817	0.0191	0.8339	0.0159
Marital status **	-0.1737	0.0190	0.8405	0.0160
Urban residence **	0.0767	0.0231	1.0797	0.0249
Education level **	0.1075	0.0042	1.1135	0.0046
Household income decils **	0.1940	0.0062	1.2141	0.0075
Number chronic diseases **	-0.5720	0.0078	0.5644	0.0044
Ethnicity				
White *	0.1513	0.0729	1.1634	0.0849
Black (n.s.)	-0.0953	0.0754	0.9091	0.0685
Brown-skinned (n.s.)	-0.0676	0.0722	0.9346	0.0675
Region				
North **	-0.5756	.03596	0.5693	0.0205
Northeast **	-0.5565	.03287	0.5732	0.0188
Central west **	-0.1835	.03947	0.8323	0.0328
Southeast (n.s.)	-0.0223	0.0342	0.9779	0.0334
Vegetable intake				
Optimal **	0.1975	0.0238	1.2184	0.0289
Moderate **	0.1536	0.0239	1.1660	0.0279
Fruit intake				
Optimal **	0.2187	0.0251	1.2445	0.3124
Moderate **	0.1207	0.0240	1.1283	0.2710

Table 2: Coefficients and the odds ratio estimates of the constrained PPOM. SRH bad/verybad = (Y = 1); SRH regular = (Y=2). s. e. = standard errors. Significant: * at < 5%, **< 1%, (n. s.): no significant.

In interpreting the results of each panel in table 2, positive coefficients or odds ratios greater than one, indicate that higher values on the explanatory variable make it more likely that the individual will be in a higher category of Y than the current one. In contrast, negative coefficients or odds ratios less than one, indicate that higher values on the explanatory variable increase the likelihood of being in the current or a lower category [55]. Then, the positive coefficient of 0.1975 for the variable 'optimal vegetable intake' in the first panel indicates that an individual consuming vegetables 6/7 days by week would be more likely to express a "fair" or "good/very good" SRH status than a "bad/very bad" SRH status. This variable presents an identical coefficient and odds ratio in both panels because it was constrained in the model.

On the other hand, the positive coefficient of 0.3473 for the variable 'optimal fruit intake' in the first panel indicates that an individual consuming fruits 6/7 days by week would be more likely to express a "fair" or "good/very good" SRH status than a "bad/very bad" SRH status. Moreover, the positive coefficient of 0.2187 for the variable 'optimal fruit intake' in the second panel indicates that an individual consuming fruits 6/7 days by week would be more likely to express a "good or very good" SRH status than a "fair" or "bad/very bad" SRH status.

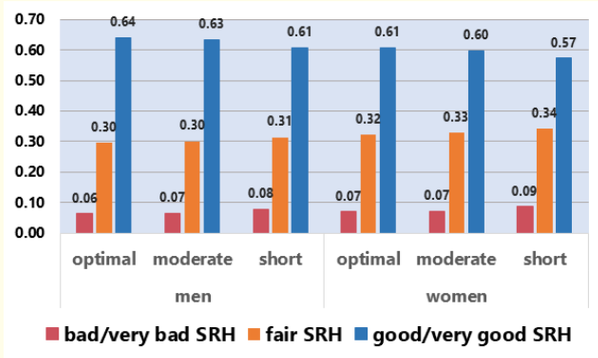
In terms of odds ratio, optimal (OR = 1.2184) and moderate level (OR = 1.1660) of vegetable consumption was positively associated with the odds of being above a particular better SRH level as opposed to being at "bad/very bad". Because the effect of fruit consumption changed across the outcome categories, different interpretations were required. In synthesis, optimal and moderate fruit consumption was significantly associated with the likelihood of a better SRH status level. The effect became much more robust when the SRH status level moved from worse to better.

Marginal effects

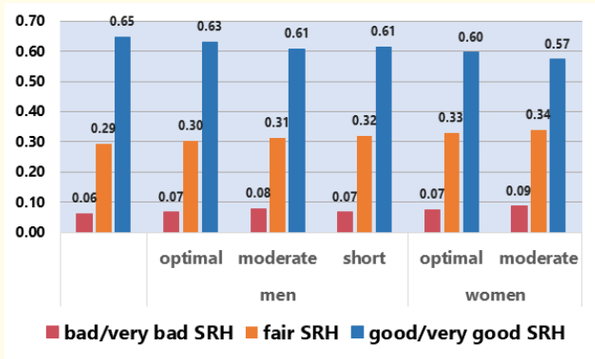
The following graphs present the marginal effects of vegetable and fruit consumption in terms of average adjusted probabilities (AAPs) on SRH categories, computed with MEMs using the *mtable* command, by sex.

According to the model, on an all-other-things-being-equal basis, graph 1 shows that increased vegetable consumption is associated with higher probabilities of a better SRH status in both sexes. In particular, men with optimal vegetable intake have a 64% probability of belonging to the SRH "good/very good" status, compared to 61% of women. Conversely, men with short vegetable intake have a 39% probability of belonging to "fair" or "bad/very bad" SRH status, compared to 43% of women. Differences were statistically significant.

Graph 2 shows that, in general -and similar to vegetable consumption-, increased fruit consumption is associated with higher probabilities of a better SRH status in both sexes. Remarkably 65% of men with optimal fruit intake say their SRH status is "good/very good", compared to 61% of women. Conversely, 39% of men with short fruit intake say their SRH status is "fair" or "bad/very bad", compared to 42% of women. Differences were statistically significant.



Graph 1: Average Adjusted Probabilities for vegetable consumption level and SRH status by sex. 2019-PNS.



Graph 2: Average Adjusted Probabilities for fruit consumption level and SRH status by sex. 2019-PNS.

We also calculate the AAPs of some representative cases of Brazilian society. A poor 30-year-old black woman, household income belongs to 2nd decile, living in the Northeast and with a short vegetable consumption has a probability of 11.3% and 50.5% belonging to "bad/very bad" and "good/very good" SRH status, respectively. In contrast, a same-age white woman with a high household income (9th decile) living in the South and with short vegetable consumption has 2.7% and 78.6% probabilities of presenting a bad/very bad" and "good/very good" SRH status, respectively. Regarding the men with the same socio-economic conditions as women, their SRH status is better in both SPH status; however, the gap between poor and wealthy men's related to "bad/very bad" SRH status is higher than women and lower in the "good/very good" SRH status.

Concerning elderly people, the SRH status for a poor 65-year-old black woman living in the Northeast and with a short vegetable consumption compared with same-age women white, wealthy living in the South and the same vegetable intake their probability to belong at "bad/very bad" SRH status is four times higher (14.9% vs 3.7%). Regarding belonging at the "good/very good" SRH status, older wealthy white women living in the South are almost twice

as likely as poor black women living in the Northeast (70.1% vs 39.1%). On the other hand, poor older men living in the Northeast with a short vegetable consumption have a probability of 13.0% to belong at "bad/very bad" SRH status, compared just with 3.2% of the wealthy older men living in the South. In turn, poor older men of the Northeast had a probability of 42.9% presenting a "good/very good" SRH status compared with a 73.2% of wealthy southern older men.

In the representative cases, the relation between fruit and vegetable consumption and SRH status, independent of age, ethnicity, region, and household income, individuals with optimal fruits intake have a higher probability of belonging to the "good/very good" and a lower probability of belonging to "bad/very bad" SRH status, than those with optimal vegetable consumption level. In contrast, individuals with short fruit intake independent of these sociodemographic and geographic factors have a marginally higher probability of belonging to the "good/very good" and "bad/very bad" SRH status than those with short vegetable consumption levels.

Discussion

In this cross-sectional study, including data from a representative sample of the adult populations in Brazil, we assessed the relationship between fruit and vegetable consumption behaviours and self-rated health status.

Descriptive results show that 43.5% and 37.0% say to have an optimal consumption (6-7 days/week) of vegetables and fruits, respectively. Conversely, 26.3% and 31.6% of the surveyed mentioned poor consumption (0-2 days/week) of vegetables and fruits, respectively. Additionally, 61.0%, 31.7% and 7.3% of the respondents reported a "good/very good", "fair", and "bad/very bad" SRH status, respectively.

Dietary behaviour reflects and relates strongly with socioeconomic background, particularly educational level and income. Less educated people and low-income households are more likely to engage in poorer dietary behaviour than their more educated and wealthier counterparts [56]. In our study, 46% and 26% of those surveyed on the 1st decile reported a short and optimal vegetable intake, respectively. Conversely, 10% and 63% surveyed on the 10th decile say to have a short and optimal vegetable intake, respectively. Regarding the fruit intake, these differences are more significant in the 1st decile and lesser in the 10th decile. These differences could be explained by the more challenging fruit purchase of the poor compared with wealthy people.

Controlling for potentially confounding factors, the results of the PPO model suggest a significant positive association between fruit and vegetable consumption and SRH status in men and women. Individuals describing their fruit and vegetable consumption as optimal or moderate are likelier to report "good/very good" self-rated health status. Conversely, individuals with short fruit and vegetable intake are likelier to report "bad/very bad" self-rated health status. Furthermore, even with no great differences, a positive gradient scale was observed through fruit and vegetable consumption categories in all three SHH levels in both sexes, i.e., a better fruit or vegetable intake, SRH status is better.

The positive relationship between SRH status and a healthy diet, consuming fruits and vegetables, could be explained by an increasing global population awareness that a healthy diet is crucial to maintaining a healthy lifestyle and preventing cardiovascular diseases, obesity or cancer. It must also be noticed that, after 2014, the Brazilian Minister of Health implemented the recommendations of the Dietary Guidelines for the Brazilian Population [57], encouraging the consumption of a healthy diet. However, the current socioeconomic inequalities negatively affect the access, habits and eating patterns to reach a healthier dietary behaviour.

These findings must be considered cautiously because the biological, socio-demographic and geographic confounders significantly affect self-rated health status. Even more, the relationship between fruit and vegetable consumption and SRH becomes more complex, since some socio-demographic factors are also associated with the healthy dietary behaviour [56].

In our model, age, education level, household income, ethnicity and chronic diseases were strong confounders. Overall, through all categories of vegetable intake, individuals, women, black ethnic, with a lower level of education, lower-income households, married, with chronic diseases and urban residents living in the North or Northeast regions have higher probabilities of belonging to "bad/very bad" SRH. Similar associations were observed in all fruit consumption categories.

Our results are consistent with several worldwide studies showing that appropriate fruit and vegetable consumption, as part of a healthy diet behaviour, is associated with positive SRH status and vice versa [38,58-63]. Also, similar results have been verified by other studies conducted on the Brazilian population. Kretschmer and Loch (2022) studied the relationship between eating behaviours and self-rated health in young, middle-aged, and older adults urban Brazilian population, findings that regular intake of fruits and vegetables is associated with better SRH status, particularly in young adults.

Meireles., *et al*. (2015) investigates the association between prevalence of poor self-rated health with individual and environmental characteristics in an adult population with and without reported morbidity, in two districts of Belo Horizonte, Minas Gerais State, Brazil. In the stratum without reported morbidity a low consumption of fruits/greens/vegetables was associated with poor self-rated health.

Câmara., *et al.* (2018), when studying aspects of the dimensions of quality of life as predictors of self-rated health among school adolescents (12 to 19 years-old) in southern Brazil, indicate that approximately 70% of adolescent's report being very or fairly healthy. The results show that higher consumption of healthy foods presented a significant association with self-rated health. This pos-

itive relationship has also been pointed out by Loch and Possamai (2007) also with adolescents from southern Brazil, and the authors identified a positive relationship between the consumption of fruits and vegetables and a perception of better health only among girls [64].

Ferrari., *et al*. (2021), in a sample of adults' population from five representative capitals of the five regions of Brazil, determined the factors associated with negative self-rated health. Regarding the perception of consumption of healthy foods, individuals who reported not practicing healthy eating ((never, rarely eating healthy food) were 64% more likely to report negative perceptions of health (fair, poor and very poor) compared to those who did.

Trindade and Sarti (2022) analysed the evolution and determinants of regular consumption (≥5 days/week) of beans, fruits and vegetables and soft drinks and their association with self-rated health among Brazilian adults during the period 2006-2019. During the period, consumption of beans and fruits increased whilst consumption of vegetables decreased. They concluded that regular consumption of *raw* beans, vegetables and fruits represented protective factors for poor SRH.

Additionally, although less evidence is available about the relation between the "fair" SRH category and the prevalence of diseases, clinical and laboratory parameters, and health-related factors, it is consistently associated with an intermediate or transitional "actual", "objective", or "subjective" health status. Individuals choosing this option are considered "relatively healthy" [65]. In our study, an increasing positive gradient of "fair" SRH probabilities from optimal to short vegetable and fruit intakes was reported in both sexes, and higher probabilities were observed in women. Then, when SRH is analysed, it seems recommendable not to aggregate the "fair" SRH category to the better or worse SRH categories because of the risk of overestimating or underestimating the effect of the interest variable analysed.

The strengths of this study are as follows: (1) it includes a representative sample of the total adult Brazilian population. (2) the association between fruit and vegetable consumption behaviours and SRH status using a PPO model, which allows us to go beyond a binary analysis that can overestimate or underestimate fruit and vegetable consumption effect on SRH status depending on the category - "good/very good" or "bad very/bad" - that the "fair" SHR category is assigned, (3) identifying and including relevant confounding variables in the statistical analysis allows us to build a robust and parsimonious model, (4) using *margin* and *mtable* commands to estimate APPs simplifies the interpretation of the results, and (5) using ordinal logistic regression, we will gain meaningful information, increase the statistical power, and decrease the sample size to detect the relation between healthy eating behaviour and SRH status.

The study also had some limitations. No causal inference can be drawn when interpreting these results since the study relies on cross-sectional data, and fruit and vegetable consumption behaviours were assessed based on self-reports. Second, the assessment based on the number of days by a week of fruit and vegetable consumption to date is far off the use of detailed food diaries or 24-hour recall methods [66,67], including multiple measurements (e.g., assessing intake on at least three days during a week, representing two weekdays and one weekend day). Finally, the model may be over-adjustment since some socio-demographic factors significantly affect both self-rated health status and fruit and vegetable consumption behaviours.

Conclusion

In conclusion, the study indicates that optimal and moderate fruit and vegetable consumption are significantly and positive associated with SRH status. This relationship is complex because both are directly affected by some relevant socio-demographic factors, and discriminating against this effect is difficult, becoming a methodological challenge. Furthermore, the study suggest SRH status is a consistent health inequality measurement. The SRH status differences associated to fruit and vegetable consumption across main socio-demographic factors represent well socioeconomic inequalities in health in Brazilian population.

These findings reinforce the importance of promoting healthy eating through public policies based on strategies and programmes focused on socially and economically vulnerable groups. Future research is needed to initiate longitudinal studies to address causality in the relationships among fruit and vegetable consumption and SRH status and monitor the effectiveness and efficiency of public policies oriented to improve healthy eating behaviours.

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