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Obesity and its association with ultra-processed food consumption in older adults in Roraima, Brazil*

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Abstract

Objective: To estimate the prevalence of obesity and analyze its association with the consumption of ultra-processed foods (UPF) among older adults in primary health care.

Methods: This cross-sectional study involved 1322 older adults from Roraima, Brazil. Obesity was determined using the body mass index, calculated from weight and height measurements. UPF consumption was assessed using a dietary marker form, nationally employed in primary health care. Sociodemographic data were also collected.

Results: The prevalence of obesity was 14%, and seven out of ten older adults reported consuming at least one type of UPF the previous day. Older adults who consumed hamburgers and processed meats (aOR = 1.50; 95% CI = 1.08–2.08; p = 0.016) and those who consumed sweets and treats (aOR = 1.38; 95% CI = 1.02–1.80; p = 0.046) were more likely to be obese compared to those who did not consume UPFs.

Conclusion: Although obesity affects a significant portion of older adults, UPF consumption is frequent among them. UPF, especially hamburgers, processed meats, sweets, and treats, should be avoided as they increase the risk of obesity. Adopting a healthy diet and reducing UPF consumption is essential to promote longevity and quality of life in older adulthood.

-----**Keywords:** aging, adiposity, feeding behavior, health services, risk factors.

* This manuscript is linked to a master's thesis titled "Long COVID associated with SARS-CoV-2 infection and preexisting cardiovascular risk factors in older adults in the state of Roraima." The thesis was defended in 2023 and is partially published (without the presence of data or results) on the website of the Federal University of Rio Grande do Sul.

Obesidad y su asociación con el consumo de alimentos ultraprocesados en adultos mayores en Roraima, Brasil

Resumen

Objetivo: Estimar la prevalencia de la obesidad y analizar su asociación con el consumo de alimentos ultraprocesados (AUP) en adultos mayores en la atención primaria de salud. **Métodos:** En este estudio transversal participaron 1322 adultos mayores de Roraima, Brasil. La obesidad se determinó mediante el índice de masa corporal, calculado a partir de mediciones de peso y altura. El consumo de AUP se evaluó con un formulario de marcador dietético utilizado a nivel nacional en la atención primaria. También se recopilaron datos sociodemográficos. **Resultados:** La prevalencia de obesidad fue del 14%, y siete de cada diez adultos mayores reportaron haber consumido al menos un tipo de AUP el día anterior. Los adultos mayores que consumieron hamburguesas y carnes procesadas (aOR = 1,50; IC 95% = 1,08–2,08; p = 0,016) y aquellos que consumieron dulces y golosinas (aOR = 1,38; IC 95% = 1,02–1,80; p = 0,046) tuvieron mayor probabilidad de ser obesos en comparación con aquellos que no consumieron AUP. **Conclusión:** Aunque la obesidad afecta a una parte significativa de los adultos mayores, el consumo de AUP es frecuente entre ellos. Reducir el consumo de AUP, especialmente hamburguesas, carnes procesadas, dulces y golosinas, es esencial para promover la longevidad y la calidad de vida en la vejez.

-----*Palabras clave:* envejecimiento, adiposidad, comportamiento alimentario, servicios de salud, Factores de riesgo.

Obesidade e sua associação com o consumo de alimentos ultraprocessados em idosos em Roraima, Brasil

Resumo

Objetivo: Estimar a prevalência de obesidade e analisar sua associação com o consumo de alimentos ultraprocessados (AUP) entre idosos atendidos na atenção primária de saúde. **Métodos:** Este estudo transversal envolveu 1.322 idosos de Roraima, Brasil. A obesidade foi determinada pelo índice de massa corporal, calculado a partir das medidas de peso e altura. O consumo de AUP foi avaliado por meio de um formulário de marcador alimentar, empregado nacionalmente na atenção primária à saúde. Dados sociodemográficos também foram coletados. **Resultados:** A prevalência de obesidade foi de 14%, e sete em cada dez idosos relataram consumir pelo menos um tipo de AUP no dia anterior. Idosos que consumiram hambúrgueres e carnes processadas (aOR = 1,50; IC 95% = 1,08–2,08; p = 0,016) e aqueles que consumiram doces e guloseimas (aOR = 1,38; IC 95% = 1,02–1,80; p = 0,046) foram maior probabilidade de serem obesos em comparação com aqueles que não consumiram AUP. **Conclusão:** Embora a obesidade afete uma parcela significativa dos idosos, o consumo de AUP é frequente entre eles. Os AUP, especialmente hambúrgueres, carnes processadas, doces e guloseimas, devem ser evitados, pois aumentam o risco de obesidade. A adoção de uma alimentação saudável e a redução do consumo de AUP são essenciais para promover a longevidade e a qualidade de vida na idade adulta.

-----*Palavras-chave:* envelhecimento, adiposidade, comportamento alimentar, serviços de saúde, fatores de risco.

Introduction

Obesity is recognized as one of the most urgent challenges of contemporary public health, affecting over 1 billion people, including approximately 880 million adults and older individuals worldwide [1]. It is a clinical condition characterized by excess body fat, resulting from imbalances in energy intake and expenditure, and influenced by metabolic and hormonal factors, as well as the consumption of ultra-processed foods (UPFs) [2]. In recent decades, there has been a steady increase in obesity rates in several countries, including the United States [3], the United Kingdom [4], and Brazil [5], placing a considerable burden on healthcare systems globally [6].

Several risk factors for developing obesity have been previously identified, including poor diet, physical inactivity, depression, and socioeconomic stress [7,8]. Another critical factor contributing to obesity is diet, particularly the high intake of UPFs, which has been increasingly recognized for its negative impact on health. The NOVA classification, introduced by Monteiro et al. in 2017 in the Brazilian Dietary Guidelines, offers a framework for understanding the extent and purpose of industrial food processing [9]. This classification categorizes foods into four groups: unprocessed or minimally processed foods, culinary ingredients, processed foods, and UPFs [9]. UPFs, in particular, are industrially manufactured products often high in saturated fats, simple sugars, salt, and various additives, with low nutritional value [9]. Examples include sodas, sweetened beverages, stuffed cookies, sausages, and processed meats [9].

Studies conducted in Brazil have shown that excessive consumption of UPFs is strongly correlated with a higher risk of obesity, both in its development and progression, across various populations [10,11]. The prevalence of obesity in Brazil, currently estimated at 20.6%, is projected to reach 29.6% by 2030, with capitals in the North region exhibiting some of the highest obesity rates in the country [12]. Interestingly, the consumption of UPFs has increased over the past decade, particularly in the North (+2.95 percentage points) and Northeast (+3.11 percentage points), where the highest growth rates were observed among the regions [13]. These trends are alarming, as both obesity and the consumption of UPFs increase the likelihood of developing type 2 diabetes, cardiovascular diseases, hypertension, and hypercholesterolemia, which have become more prevalent among older adults [14-17]. Given the growing burden of these health issues in older adults, it is crucial to further investigate these outcomes within this population.

In this context, it is noteworthy that the recent pandemic has brought to light concerns related to dietary habits, unfortunately highlighting an increase in UPF consumption [18]. The intake of sweets (such as choco-

late, candy, cookies, pies, and cakes), fatty snacks, baked goods, instant soups, canned foods, fast food, and sugary drinks, in general, has risen considerably [18]. Moreover, previous studies have revealed that, during the pandemic, sources of carbohydrates increased significantly, especially those with a high glycemic index (such as homemade pizza, bread, cake, and sweets), leading to weight gain [19]. While information on the diet of older adults is not widely available, the known effects of UPFs on human health across much of the population are well documented [19]. It is therefore presumed that UPF consumption is also linked to obesity in older adults.

Given this scenario, it becomes crucial to investigate the relationship between UPF consumption and obesity, as this is of significant public health interest. Research in this area can assist health policymakers and guide nutritional interventions aimed at mitigating the negative impacts of UPF consumption on the health of older adults. Hence, this study aims to estimate the prevalence of obesity and analyze its association with UPF consumption in older adults.

Methodology

Study Design and Location

This cross-sectional epidemiological study focuses on older adults (aged 60 years or older) who attended Primary Health Care (PHC) services in the state of Roraima, Brazil, in 2020. The data—sourced from the internal control system of the Roraima State Health Department—, were provided by the Department of Epidemiological Surveillance (DES) under confidentiality agreements. Roraima is the northernmost state of Brazil, bordering Venezuela and Guyana. The state has a population of 636,303, with 14 municipalities in the interior and the capital, Boa Vista, which alone comprises 65% of the state's population. The state's Human Development Index (HDI) is 0.707, and the estimated life expectancy is 71.8 years. Additional information about the state of Roraima can be found elsewhere [20].

Population and Sample

All available records from the 2020 system were provided by DES, totaling 4,194 older adults who attended 108 of the 115 primary healthcare units across the state of Roraima. Seven primary healthcare units located in the state's interior (small municipalities) did not provide data to the control system due to a lack of internet connectivity. Many of the records obtained were incomplete. Among the reasons for this was the cancellation of routine consultations caused by the COVID-19 pande-

mic and, more importantly, the inadequate completion of patient data in the health control system by healthcare professionals. Therefore, the minimum sample size was estimated considering: i) a 95% confidence level; ii) an estimated prevalence of 50% for unknown information;

iii) a four-percentage-point error margin; iv) a design effect (deff) of two; and v) an additional 20% to compensate for losses. Thus, the minimum estimated amount was 1,260 complete records. Despite the incomplete data entry in the DES system, the final sample remained robust, totaling 1,322 older adults (Figure 1).

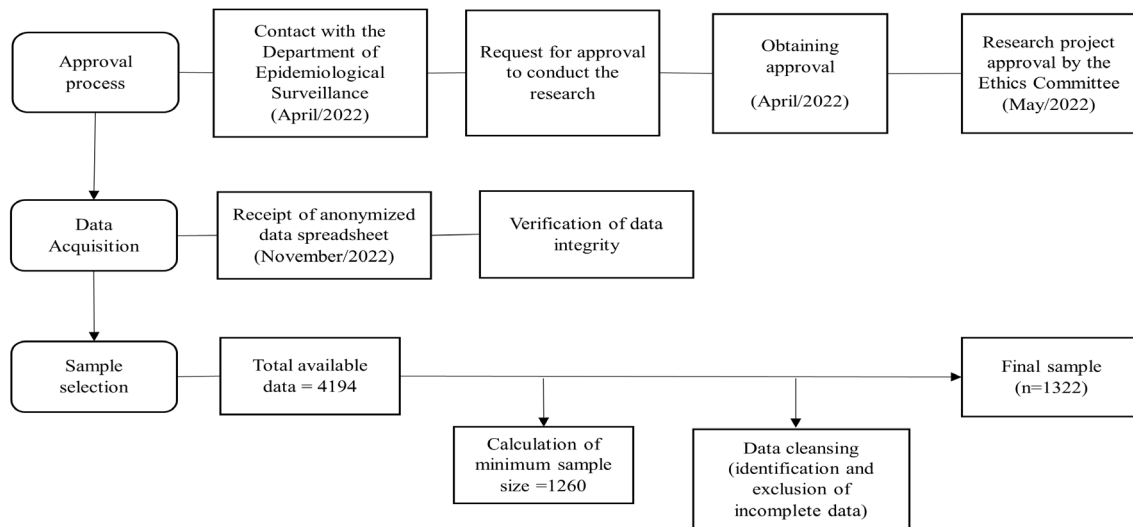


Figure 1. Flowchart of the process of obtaining the final sample.

Data Collection Procedures

All information was obtained using a standardized health form, utilized across all primary healthcare units in Brazil. Healthcare professionals recorded sociodemographic and health information collected during medical consultations. This data was entered into DES's internal control system in a binary format (yes or no). The state health authorities provided the data in a spreadsheet generated from the control system in November 2022.

All older adults residing in Roraima who attended PHC services were considered eligible, regardless of the reason for seeking public health services (e.g., routine check-ups, follow-up care, treatment of chronic diseases, or acute illness care). Records of patients lacking information on obesity, UPF consumption, or essential sociodemographic details (such as gender or age) were excluded.

Study Variables

The dependent variable was obesity, determined by Body Mass Index (BMI). The body mass and height of the older adults were measured using scales and stadiometers from the respective primary healthcare units. BMI was calculated by dividing body mass (in kilo-

grams) by height squared (in meters). BMI values were only collected for body weight classification purposes (e.g.: yes for obesity; no for obesity). Obesity was defined as a BMI of 30 kg/m² or higher, according to World Health Organization criteria [21]. The other classifications such as "eutrophic" or "overweight" are included in the health system as "not obese", and are unavailable for analysis.

The consumption of UPFs (independent variable) was assessed using the Food Consumption Markers Form from the Food and Nutrition Surveillance System (SISVAN) [22]. This form, widely used in primary health care (PHC), serves as a tool to evaluate food intake and accurately reflects the quality of the Brazilian diet [23]. Although initially developed to monitor general dietary patterns, the inclusion of specific UPF markers in the instrument allows for the exploration of relevant associations in epidemiological studies, as demonstrated in prior research [8,17,23]. Moreover, the instrument has psychometric validity evidence, with exploratory and confirmatory factor analyses revealing a consistent bidimensional structure [24]. The reported fit indices (RMSEA < 0.08; TLI and CFI > 0.95) further confirm the instrument's suitability for population-based studies and for monitoring dietary indicators [24].

Since 2015, SISVAN has annually collected data on the previous day's food consumption of patients who attended PHC units across Brazil. The form, administered in an interview format by healthcare professionals, contains four exclusive UPF consumption markers. For each food marker, the healthcare professional asked: "Did you consume this yesterday?" The response options were 'yes,' 'no,' and 'don't know.' No responses with the 'don't know' option were reported. The markers are:

1. Hamburgers and/or processed meats (ham, mortadella, salami, sausages);
2. Sweetened beverages (soda, boxed juice, powdered artificial juice, canned coconut water, guaraná/syrup, fruit juice with added sugar);
3. Instant noodles, packaged snacks, or crackers;
4. Stuffed cookies, sweets, or treats (candies, lollipops, chewing gum, caramels, gelatin).

The study's recorded covariates included gender (male or female) and age (in full years), which were also grouped into age brackets. Skin color/race was determined according to the national classification system, where participants self-identified as yellow, white, black, brown, or indigenous. Data on the place of residence (capital or interior) and the educational level of the older adults were collected, with responses categorized into three groups due to variability: "no education," "less than 8 years," or "8 years or more."

Statistical Analysis

The data were analyzed using descriptive statistics (mean, standard deviation, and frequency distribution). The normality of the age variable was tested using the Kolmogorov-Smirnov test ($p = 0.215$). The mean age between genders was compared using the independent t-test. Each UPF was considered an independent variable and analyzed individually, and their possible interactions with obesity were tested using the chi-square test. Using both crude and adjusted logistic regression, the hypothesis of an association between UPF consumption and obesity prevalence was tested. All covariates were included in the adjusted model, estimating the Odds Ratio (OR) and their respective 95% confidence intervals. The data were analyzed using IBM® SPSS® software (version 20), with a significance level of 5%.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and approved by the Human Research Ethics Committee of the State University of Roraima (protocol no. 5385012, approval date: May 3, 2022). All individuals involved in the research signed a consent

form in compliance with Resolution n°. 466/2012 of the National Health Council.

Results

The study sample comprised 1322 older adults (727 women). Table 1 presents the general characteristics of the sample, where differences between sexes in mean age ($p = 0.021$), age group ($p = 0.003$), skin color/race ($p < 0.001$), and education level ($p < 0.001$) can be observed. Regarding age, men were older. Women showed a higher proportion a) in the age group of 60 to 69 years, b) for yellow, white, and indigenous skin color/race, and c) for education level less than 8 years and 8 years or more.

The prevalence of obesity in the studied sample was 14.0% (Table 2). For the consumption of UPFs among older adults with and without obesity, differences in proportions were observed only for the consumption of hamburgers and/or sausages. Although the proportion of older adults with obesity is higher among those who consumed the other UPFs, this difference was not statistically significant ($p > 0.05$).

Figure 2 presents the associations (crude and adjusted) between UPF consumption and obesity. In the crude analysis, it was observed that older adults who consume hamburgers and/or sausages have a higher chance of being obese. When adjusting the analyses for sociodemographic variables, it was observed that in addition to the consumption of hamburgers and/or sausages (aOR = 1.50; 95% CI = 1.08–2.08; $p = 0.016$), the consumption of biscuits, sweets, and treats (aOR = 1.38; 95% CI: 1.02–1.80; $p = 0.046$) also showed an association, indicating that older adults who consume biscuits, sweets and treats are more likely to be obese.

Discussion

The findings of this study provide crucial insights into the relationship between obesity and UPF intake among older adults attending PHC services. The estimated obesity prevalence of 14% underscores the significance of this public health issue within this specific population. Furthermore, the analyses revealed a notable association between the consumption of hamburgers and/or sausages and the intake of cookies, sweets, and treats with obesity, suggesting a potentially harmful link between these foods and the outcome. These findings can inform more effective practices in PHC, enabling targeted approaches to prevent and treat obesity in older adults. Health professionals may implement nutritional guidance programs and interventions, while targeted health policies can be adopted to reduce obesity and improve the health of older adult patients.

Table 1. Sociodemographic characteristics of older adult patients who attended Primary Health Care. (N = 1322; Roraima, BR, 2020).

Variables	Total	Sex		p-value
		Men	Women	
Age; mean (sd). years	70.4 (7.87)	70.9 (8.07)	69.9 (7.67)	0.021†
Age group, n (%)				
60–69 years	712 (53.85)	290 (40.73)	422 (59.27)	0.003*
70–79 years	416 (31.46)	206 (49.52)	210 (50.48)	
≥ 80 years	194 (14.69)	99 (51.03)	95 (48.97)	
Skin color/race, n (%)				
Yellow	61 (4.64)	21 (34.42)	40 (65.58)	<0.001*
White	302 (22.84)	107 (35.43)	195 (64.57)	
Brown	597 (45.15)	289 (48.40)	308 (51.60)	
Black	222 (16.79)	101 (45.49)	121 (54.51)	
Indigenous	140 (10.58)	57 (40.71)	101 (59.29)	
Education level, n (%)				
No study	624 (47.20)	323 (51.76)	301 (48.24)	<0.001*
< 8 years	395 (29.87)	154 (38.98)	241 (61.02)	
≥ 8 years	303 (22.93)	118 (38.94)	185 (61.06)	
Place of residence, n (%)				
Interior	475 (35.93)	209 (44.0)	266 (56.0)	0.584*
Capital	847 (64.07)	386 (45.57)	461 (54.43)	

Note: SD: standard deviation; n: absolute frequency; %: relative frequency. [†]Independent t-test; *Pearson's chi-square test.

Table 2. Prevalence of obesity and association with the consumption of ultra-processed foods in older adult patients. (Roraima, BR, 2020).

Variables	Total	Obesity		p-value
		No	Yes	
Total	1322	1137 (86.0)	185 (14.0)	<0.001*
Hamburgers and/or sausages, n (%)				
Yes	475 (35.93)	396 (83.36)	79 (16.64)	0,038**
No	847 (64.07)	741 (87.48)	106 (12.52)	
Sweetened drinks, n (%)				
Yes	718 (54.31)	613 (85.37)	105 (14.63)	0,472**
No	604 (45.69)	524 (86.75)	80 (13.25)	
Instant noodles, packaged snacks or crackers, n (%)				
Yes	412 (31.16)	351 (85.19)	61 (14.81)	0,567**
No	910 (68.84)	786 (86.37)	124 (13.63)	

Variables	Total	Obesity		p-value
		No	Yes	
Biscuits, sweets and treats, n (%)				
Yes	634 (48.95)	534 (84.22)	100 (15.78)	0,073**
No	688 (51.05)	603 (87.64)	85 (12.36)	

Note: n: absolute frequency; %: relative frequency. *Chi-square test for differences between proportions; **Pearson's chi-square test.

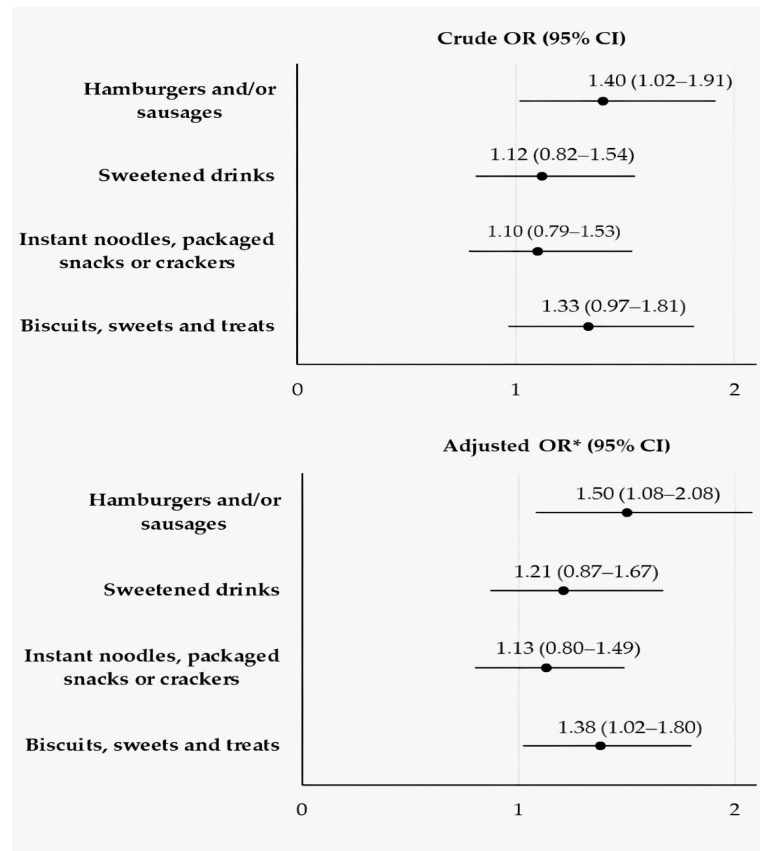


Figure 2. Crude and adjusted ORs for the association between obesity and consumption of ultra-processed foods in older adults. (Roraima, BR, 2020).

*Adjusted for covariates.

The prevalence of obesity ($\geq 30 \text{ kg/m}^2$) among older adults in this study was 14%, which, although lower than that found in similar studies [25,26], still highlights the relevance of this public health issue in this age group. Comparatively, results from the Brazilian telephone survey Vigitel revealed a high prevalence of obesity among older adults, with rates of 20.96% for individuals aged 65 and older, using the same classification criteria adopted in the National Health Survey [25]. These data emphasize the need for specific public health policy in-

terventions aimed at preventing and treating obesity in urban populations, considering regional variations and socioeconomic factors that may influence the prevalence of this condition [25]. Additionally, data from the 2019 National Health Survey showed that obesity rates among older adults vary significantly by sex and age group. For example, among individuals aged 60 and older, obesity rates were 21.24% among men and 27.52% among women [26]. Although widely used, the BMI has significant limitations, such as its inability to distinguish

between lean and fat mass, leading to underestimating obesity in muscular individuals and overestimating it in older adults with lean mass loss [1]. This limitation can affect the accuracy of obesity prevalence estimates, especially by failing to reflect body fat distribution and differences among diverse populations adequately. These findings highlight the importance of implementing interventions to prevent and manage obesity in older adults, particularly in light of observed trends in body weight changes with advancing age.

The observed association between the consumption of hamburgers and sausages and obesity among older adults in this study underscores the importance of diet quality in obesity prevention. Similar results were found by Khodayari et al. [27], who observed that higher intakes of processed meat were associated with an increased risk of central and general obesity. Among older adults, a higher consumption of UPFs, including canned meats and fish, was specifically associated with an increased incidence of abdominal obesity over a six-year period [28]. The Longitudinal Study of Adult Health (ELSA-Brasil) also indicated that high consumption of processed meats increases the risk of insulin resistance and the development of diabetes by 40.65% in men [29]. Furthermore, most prospective studies support the hypothesis that red and processed meat consumption predicts long-term weight gain due to its high energy density, cholesterol, saturated fatty acids, sodium, and additives like nitrates [27,28,30].

The results of this study reinforce the association between the consumption of sweets and treats and the increased odds of obesity among older adults, corroborating previous findings on the negative health effects of these foods [14,16,17,31]. In Brazil, the Household Budget Survey indicated that the prevalence of regular consumption of sweets and soft drinks among Brazilian older adults increased from 5.10% of daily energy intake in 2008-2009 to 8.80% in 2017-2018, suggesting a concerning trend in the consumption of these sugary foods [32]. On the other hand, the rate of consumption of sweets and treats observed here is higher than that found in the ANIBES study conducted in Spain among older adults aged 65 to 75 years (5.11%), which investigated sugar intake (both added and intrinsic) in diets, considering sex and age group [33]. These findings are significant because free sugar intake is among the most consistently associated nutritional risk factors with the development of obesity and non-communicable chronic diseases [34].

The definition of free sugars includes monosaccharides and disaccharides added during the processing of foods and beverages, as well as those naturally occurring in honey, syrups, and fruit juice concentrates [35]. A recent meta-analysis from several countries, including Brazil, found that increased consumption of UPFs is

linked to higher intake of free sugars, which reduces the nutritional quality of diets [36]. These findings highlight the importance of policies and interventions aimed at reducing UPF consumption and promoting healthier eating habits. It is believed that older adults, in addition to facing an increased risk of developing chronic diseases due to the natural aging process, may also experience a decline in their ability to perceive the taste of food. This can negatively impact their nutritional status, as they may feel the need to add more sugar to foods to enhance the flavor and make them more palatable. This practice can lead to excessive sugar consumption, contributing to diet-related health problems [37].

Among the limitations that should be considered when interpreting the results of this study, the cross-sectional design stands out, as it prevents the inference of causality between the exposure and the outcomes investigated. Although this study focused on the specific association between UPF consumption and obesity rather than dietary quality or eating patterns, the instrument used has important limitations: i) it was not specifically designed for UPF assessment, potentially limiting its ability to capture detailed consumption patterns and their health impacts; ii) it lacks additional validation metrics, such as construct validity and reliability, which could affect the robustness of the findings; iii) it does not cover all UPFs listed in the NOVA system, though it reasonably reflects dietary quality among Brazilian adults [23]; iv) it evaluates only four UPF groups consumed on the previous day, which may not reflect participants' habitual dietary patterns; and v) reliance on a single-day reference could introduce bias, as the assessed day may not represent typical dietary variability, leading to over- or underestimation of habitual UPF consumption.

On the other hand, food frequency questionnaires (FFQ) and 24-hour dietary recalls (R24h) are often more appropriate for capturing detailed dietary patterns. However, these methods have limitations. They frequently lead to overreporting of intake and impose a high burden on respondents, especially when estimating portion sizes [38]. Additionally, their implementation is more complex and resource-intensive. In contrast, the instrument used in PHC stands out for its simplicity and practical feasibility. It offers lower costs, reduced memory bias, and better alignment with surveillance systems. These features enable the rapid and efficient collection of relevant population data, which is often challenging with methods like R24h and FFQ.

Additionally, since this study relied on data from follow-up in PHC, applying the same methodological rigor found in nutritional surveys for measuring anthropometric data was not possible. Critical covariates such as diet, physical activity, and previous health status were not considered, likely due to the complexity of their monitoring in a PHC context. Moreover, other anthropometric

measures, such as calf and waist circumference, could have strengthened the assessment of nutritional status but were unavailable. Moreover, BMI data for values < 30 kg/m², therefore including overweight people, were not assessed in primary care, with only data for obesity (BMI > 30 kg/m²) being considered. It is recognized that being overweight is also an important condition for older adults, but in the PHC system, normal weight or overweight statuses are entered as “no” for obesity.

Regarding the robustness of this study, it is worth noting that the information was collected through a standardized instrument, using national data from PHC in Brazil. Finally, the findings of this study contribute to the literature on the importance of good eating habits for maintaining health, especially among older adults.

In conclusion this study highlights the significant association between the consumption of UPFs and obesity among older adults attending PHC, confirming the initial hypothesis that increased UPF consumption is associated with obesity in this age group. The prevalence of obesity was 14%, and foods such as hamburgers, processed meats, sweets, and treats were particularly associated with increased obesity. To reduce the impact of UPF consumption in older adults, public policies should focus on food and nutrition education programs that raise awareness of UPF risks and promote fresh or minimally processed foods. Regulatory measures should limit UPF advertising aimed at older adults and require clear health warnings on packaging. Expanding access to healthy foods through fiscal incentives for fresh food producers and local farmers' markets is also important. Additionally, training primary healthcare professionals to assess UPF consumption and provide effective nutrition counseling can enhance individual interventions.

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Declaration of conflict of interest

The authors declare that there is no conflict of interest.

Author's disclaimer

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Author's contribution statement

Gabriela Rocha dos Santos: She is the lead author, responsible for writing all sections of the manuscript and carefully reviewing subsequent versions of the article

Guilherme José Silva Ribeiro: He contributed significantly to data analysis, interpretation of results, and writing the first version of the manuscript, in addition to participating in subsequent revisions.

Mateus Augusto Bim: He contributed significantly to the analysis of data, interpretation of results and writing of the first version of the manuscript, in addition to participating in subsequent revisions.

Clair Costa Miranda: Ayudó en la concepción general del estudio y revisó cuidadosamente las versiones preliminares del manuscrito.

Andreia Pelegrini: He participated in the conception of the manuscript, elaborated the figures and tables in detail, and contributed to the overall writing of the document.

André de Araújo Pinto: He collaborated in the conception and design of the study, data acquisition, analysis and interpretation, and discussion. He was also responsible for the preparation and approval of the final version of the article.

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