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Association between hypercholesterolemia and isolated and simultaneous consumption of ultra-processed foods in older adults

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Abstract

Background: Consumption of ultra-processed foods (UPFs) is a risk factor for several cardiovascular diseases and mortality, with potential physiological mechanisms including elevated serum cholesterol levels.

Objectives: To analyze the association between hypercholesterolemia and the isolated and simultaneous consumption of UPFs in older adults.

Methods: This is a cross-sectional epidemiological study conducted with 1322 Brazilian older adults (mean age of 70.4 years; 55.0% females) from the state of Roraima. The data was obtained from the Department of Epidemiological Surveillance of the State of Roraima. Hypercholesterolemia was diagnosed based on nosology criteria. Food consumption patterns were assessed using a nationally standardized instrument comprising four categories of UPFs. Binary logistic regression models were employed to explore potential associations.

Results: The prevalence of hypercholesterolemia was high (54.4%, 95% CI 51.7–56.6). While the simultaneous consumption of all UPFs types was lower (15.2%), over half of the older adults reported consuming at least one type of UPFs (71.8%). Isolated consumption of UPFs was associated with approximately twice the odds of hypercholesterolemia. Older adults who consumed two (OR 1.75, 95% CI 1.26–2.43), three (OR 2.28, 95% CI 1.58–3.29), or all four types of UPF (OR 6.65, 95% CI 4.35–9.44) had a higher likelihood of having hypercholesterolemia.

Conclusions: Isolated consumption of UPFs is a risk factor for hypercholesterolemia, which can increase up to sixfold when older adults consume multiple UPFs simultaneously. Prioritizing nutritional education and raising awareness regarding the reduction of UPFs consumption is crucial.

Keywords

Aging, cholesterol, cardiometabolic health, heart diseases, risk factors

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Background

Hypercholesterolemia—increased levels of serum cholesterol—is an important exposure factor for the development of atherosclerosis and several cardiovascular diseases.[1] A report involving data from different low- and middle-income countries indicated that the prevalence of hypercholesterolemia has been increasing in recent years.[2] Although there is a tendency for total cholesterol (TC) to decline in the last years of life,[3] serum cholesterol levels increase with age, and this suggests that the pathophysiological changes in cholesterol metabolism in aging need to be better understood.[4]

At the individual level, changes related to lifestyle (including unhealthy eating) can be the first step to preventing or controlling hypercholesterolemia.[5] In terms of food, specifically, several healthy foods can distinctly

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reduce cholesterol levels.[6] However, maintaining a balanced diet consisting of natural or minimally processed foods does not seem to be easy since half of the energy from the diet of the adult population in several countries comes from ultra processed foods (UPFs).[7] This is worrying, as medium and high consumption of UPFs can increase the risk of hypercholesterolemia by 12% and 30%, respectively.[8] In low- and middle-income countries, the prevalence of hypercholesterolemia varies considerably from 5% to 53%, depending on factors such as sex, age, presence or absence of chronic diseases, and lifestyle characteristics.[2] In Brazil, data from the most recent National Health Survey in 2019 estimated a prevalence of hypercholesterolemia at 14.6%, ranging from 7.8% in the state of Roraima, located in the Amazon region, to 21.1% in Sergipe, situated in northeastern Brazil.[9] Furthermore, due to the limited information on the consumption of UPFs in older adults,[10] it is unclear to what extent UPFs can increase the risk of hypercholesterolemia.

UPFs consist of industrial ingredients, whose manufacture involves several processing steps and are composed of substances (including dyes, emulsifiers, and flavorings) that mimic food, leaving the final product highly palatable.[11] Products such as sugars, salt, fats, and oils, often combined, are the basis for manufacturing UPFs, and additives that prolong their durability are widely used.[11] In adults, consumption of UPFs is associated with the development of high blood pressure,[9] a poor cardiometabolic profile, increased risk of cardiovascular disease, and all-cause mortality.[12]

The consumption of UPFs is lower in older adults compared to younger adults,[13] and the associations between the simultaneous consumption of UPFs and hypercholesterolemia in adults tend to be strong.[13,14] However, given the limited evidence available on the consumption of UPFs in older adults,[10,12] and the need to better understand the relationship between the consumption of UPFs and hypercholesterolemia in this population, further studies are necessary. Based on the existing literature and considering the composition of UPFs, it is hypothesized that the greater the consumption of these products, the greater the risk of hypercholesterolemia. Thus, the objective of the present study was to analyze the association between hypercholesterolemia and the isolated and simultaneous consumption of UPFs in older adults.

Methods

Study design and participants

This cross-sectional observational study was conducted using data from the Department of Epidemiological Surveillance (DES) of the State Department of Health in Roraima, Brazil. The study focused on the older adult population who received healthcare services at the state's health centers in 2020. Roraima is a state located in the far North of Brazil and is the smallest state in terms of population and geography. It has an estimated total population of 652,713 inhabitants, with 68.9% residing in the capital. The older adult population (60 years or older) in Roraima is approximately 50,000 inhabitants. Additional information about the state of Roraima can be found on the Brazilian Institute of Geography and Statistics website.[15]

In 2020, information regarding the older adults who received healthcare services within the state's health system was registered in an internal monitoring and control system managed by the DES and recorded by healthcare professionals. The data, obtained without personal identifiers, were accessed in November 2022 with proper legal authorization. All procedures were approved by the Ethics Committee of the State University of Roraima (Opinion no. 5385012) in accordance with the guidelines of the Brazilian National Health Council. For this study, only data from older adults (60 years or older) who were registered and monitored by the DES and received care at basic health units in the state of Roraima were considered eligible.

According to the DES records, a total of 4194 records of the target population were available, sourced from 108 of the 115 basic health units across the state. The seven missing units did not have internet connectivity. However, many of these records had incomplete information due to various reasons, including disruptions caused by the COVID-19 pandemic, which affected routine appointments in 2020, as well as cases where specific health information or exams were not required, or the older adult individuals did not return for follow-up appointments. Considering these circumstances, the appropriate sample size was estimated based on recommended parameters,[16] including a 50% prevalence (for an unknown outcome), a 95% confidence level, a tolerable error of four percentage points, and a correction for the design effect (deff) equal to two. An additional 20% was added to account for potential losses. Therefore, a minimum of 1260 records with complete information on older adults was required. The data were analyzed anonymously.

Study variables

The study variables were obtained using a standardized form from the Department of Health, which was utilized by healthcare professionals and subsequently recorded in the internal control system of the DES. Hypercholesterolemia (dependent variable) was defined as a serum TC level of $\geq$200 mg/dL or low-density lipoproteins (LDL) level of $\geq$130 mg/dL,[17] and confirmed through nosological diagnosis. Venous blood samples were collected at the basic

health units themselves, with a recommended fasting period of at least 12 h, and analyzed at the Central Public Health Laboratory of the State or affiliated institutions.

The consumption of UPFs was assessed using the food consumption marker form of the Food and Nutritional Surveillance System, which is utilized in all basic health units across the country.[18] The protocol includes specific items to assess past-day UPFs consumption categorized into four food groups based on the *NOVA* classification.[11] For each food marker, a healthcare professional (typically from the nursing field) asked: "Did you consume this yesterday?" The markers included: (a) Hamburger and/or sausages (ham, mortadella, salami, sausage); (b) Sweetened drinks (soda, canned juice, powdered juice, canned coconut water, guava/blackcurrant syrups, fruit juice with added sugar); (c) Instant noodles, packaged snacks, or biscuits; (d) Filled biscuits, sweets, or treats (candies, lollipops, chewing gum, caramels, gelatin). The response options were "yes," "no," and "don't know." There were no responses reported as "I don't know."

The study covariates included all available information in the internal control system of the DES. The following data were recorded: gender (male/female), age in complete years, categorized by age group, ethnicity according to national classification (yellow/white/brown/black/indigenous),[19] and place of residence (capital/rural). The level of education, determined by the number of years of formal education, was categorized as no study, <8 years, and ≥ 8 years due to the multiple response options.

Statistical analysis

Data were presented using descriptive statistics (mean, standard deviation, and frequency distribution) and 95% confidence intervals (95% CI). The general characteristics of the participants were compared between genders, using the independent *t*-test for continuous age, and the chi-square test for categorical variables. There were differences in the prevalence of hypercholesterolemia between categories of exposure factors when the 95% CI did not overlap. The prevalence of simultaneous consumption of UPFs was determined by creating a score, attributing 0 points to "no" and 1 point to "yes" in each of the groups of markers. After the summation, the score could vary from 0 to 4, with the attribution of 0 = non-consumption, 1 = one food, 2 = two foods, 3 = three foods, and 4 = four foods.[20] Crude binary logistic regression was used to verify the association of isolated and simultaneous consumption of UPFs with hypercholesterolemia. Adjusted models (for all covariates) were used to determine the risk of isolated and simultaneous consumption of UPFs with hypercholesterolemia, regardless of the *p*-value observed in the crude analyses. Odds ratio (OR) and 95% CI were presented. The reference group consisted of older adults who did not consume UPFs. Data analysis was conducted using IBM SPSS Statistics software package (Version 20.0; IBM Corp., Armonk, NY, USA). A significance level of $p < 0.05$ was considered statistically significant.

Results

A total of 1322 older adults were assessed, with 55.0% women and a mean age of 70.4 ± 7.87 years. The majority of participants were aged between 60 and 69 years, had brown Ethnicity, had no formal education, and resided in the capital. Associations were found between gender and all other sociodemographic variables investigated, except for place of residence ($p = 0.584$). Details regarding the frequency of older adults in each category of sociodemographic variables analyzed, in the total sample and stratified by gender, can be observed in Table 1.

Table 2 presents the prevalence of hypercholesterolemia for all the older adults investigated and for each category of sociodemographic factors and UPFs consumption. Overall, the proportion of older adults with hypercholesterolemia was significantly higher among the UPFs consumers compared to those without the outcome ($p < 0.001$). The prevalence of hypercholesterolemia was associated with most sociodemographic variables, except for educational level ($p = 0.106$). Among the older adults, 71.8% (95% CI 68.8–73.2) reported consuming at least one UPFs, and 15.2% (95% CI 13.2–16.8) reported consuming all UPFs on the previous day. Comparatively, UPFs consumers had a higher prevalence of hypercholesterolemia (from 63.0% to 71.6%) compared to non-consumers (44.2%–47.1%) ($p < 0.001$).

Table 3 displays the results of logistic regression analysis for the association between UPFs consumption and hypercholesterolemia in older adults. In the crude analysis, a strong association was found between isolated and simultaneous UPFs consumption and hypercholesterolemia. Regardless of covariates, UPFs consumption presented a statistically significant risk for hypercholesterolemia. A higher risk of hypercholesterolemia was observed in older adults who consumed instant noodles, packaged snacks, or crackers (OR 2.47, 95% CI 1.90–3.22), followed by those who consumed hamburgers and/or sausages (OR 2.44, 95% CI 1.89–3.14). In the adjusted analysis of simultaneous UPFs consumption, it was observed that consuming only one type of food did not increase the risk of hypercholesterolemia, regardless of confounding variables. Additionally, there was a dose-response gradient in the risk of hypercholesterolemia with the number of UPFs consumed simultaneously: two foods (OR 1.75, 95% CI 1.26–2.43); three foods (OR 2.28, 95% CI 1.58–3.29); four foods (OR 6.65, 95% CI 4.35–9.44).

Table 1. Sociodemographic characteristics of the 1322 older adult participants in the study. (Roraima—Brazil. 2020).

Variables	General	Gender		*p*-value
		Male	Female	
Age; mean (SD) years	70.4 (7.87)	70.9 (8.07)	69.9 (7.67)	0.021[a]
Age group, *n* (%)				0.003[b]
60–69	712 (53.9)	290 (40.7)	422 (59.3)	
70–79	416 (31.5)	206 (49.5)	210 (50.5)	
≥80	194 (14.7)	99 (51.0)	95 (49.0)	
Ethnicity, *n* (%)				<0.001[b]
Yellow	61 (4.6)	21 (34.4)	40 (65.6)	
White	302 (22.8)	107 (35.4)	195 (64.6)	
Brown	597 (45.2)	289 (48.4)	308 (51.6)	
Black	222 (16.8)	121 (54.5)	121 (54.5)	
Indigenous	140 (10.6)	57 (40.7)	101 (59.3)	
Educational level, *n* (%)				<0.001[b]
No study	624 (47.2)	323 (51.8)	301 (48.2)	
<8 years	395 (29.9)	154 (39.0)	241 (61.0)	
≥8 years	303 (22.9)	118 (38.9)	185 (61.1)	
Place of residence, *n* (%)				0.584[b]
Rural	475 (35.9)	209 (44.0)	266 (56.0)	
Capital	847 (64.1)	386 (45.6)	461 (54.4)	

SD: standard deviation; *n*: absolute frequency; %: relative frequency.
[a]Independent *t*-test.
[b]Chi-square test.

Discussion

This study stands out as one of the first to assess the risk of hypercholesterolemia in a group of older adults in Brazil, considering both isolated and simultaneous consumption of UPFs. The findings reveal a high prevalence of hypercholesterolemia among the study participants. It is noteworthy that approximately seven out of ten older adults reported consuming at least one type of UPFs, and 15.2% consumed all four types of food on the previous day. Moreover, the risk of hypercholesterolemia was found to be approximately two times or higher for isolated UPFs consumption and over six times for simultaneous consumption. From a practical standpoint, these results imply that older adults who consume UPFs are at risk of developing hypercholesterolemia, and the risk further increases with simultaneous UPFs consumption.

The prevalence of hypercholesterolemia among older adults was found to be high (54.4%), which is higher compared to previous studies involving older adults in Brazil[2,21] and other countries.[3,22,23] This finding, however, cannot be directly compared with other studies due to methodological differences and target population of interest. Furthermore, cutoffs such as CT ≥ 240 mg/dL or stricter CT ≥ 200 mg/dL, or use of statins and/or ezetimibe to characterize individuals with hypercholesterolemia may result in significantly different prevalence's, making timely comparison difficult. It is possible that there was an overestimation of the prevalence of hypercholesterolemia due to the specificity of the sample, where not all older adults utilize the Unified Health System. We hypothesize that older adults who do not use the SUS may have different health characteristics and behaviors compared to those who utilize public healthcare services, potentially influencing the observed results.

Several factors contribute to the elevated prevalence of hypercholesterolemia, including lifestyle habits such as unhealthy eating and physical inactivity,[24] and lack of body weight.[5] Other factors favorable to hypercholesterolemia may involve uncontrolled diabetes mellitus, irregular use of medication to control cholesterol,[25] and genetics (familial hypercholesterolemia).[26] In middle-income countries, such as Brazil, it is necessary to improve access to care for hypercholesterolemia especially by increasing the effectiveness of screening, diagnosis and treatment.[2] Such practices need to be in line with the clinical judgment that should not be replaced, especially in the conduct of prescribing lipid-lowering drugs such as, for example, statins.[4]

In this context, most older adults reported consuming some form of UPFs, which may partially explain the high prevalence of hypercholesterolemia. A recent systematic review revealed a lack of information on UPFs consumption in older adults due to the scarcity of studies.[10] However, studies involving older adults from Portugal,[13] Korea,[27] and the United States[14] reported comparatively more favorable results than those found in our study. It is important to note that the high UPFs consumption observed in our study may be related to the specific food items

Table 2. Prevalence of hypercholesterolemia and sociodemographic factors, and consumption of ultra-processed foods in older adults. (*N* = 1322; Roraima—Brazil. 2020).

Variables	Hypercholesterolemia		*p*-value
	No	Yes	
General	45.6 (42.9–47.9)	54.4 (51.7–56.6)	<0.001[a]
Gender			<0.001[b]
Male	54.8 (50.8–58.2)	45.2 (41.4–48.6)	
Female	38.1 (34.5–41.1)	61.9 (58.3–64.8)	
Age group, *n* (%)			<0.001[b]
60–69	52.5 (48.9–55.6)	47.5(44.0–50.6)	
70–79	38.0 (33.7–42.1)	62.0 (57.5–65.9)	
≥80	36.6 (29.9–42.3)	63.4 (56.7–69.1)	
Ethnicity, *n* (%)			0.001[b]
Yellow	29.5 (18.0–39.4)	70.5 (59.0–78.7)	
White	43.0 (37.4–47.7)	57.0 (51.3–61.6)	
Brown	51.3 (47.2–54.6)	48.7 (44.7–51.9)	
Black	43.2 (36.5–48.7)	56.8 (50.5–62.2)	
Indigenous	37.9 (30.0–44.3)	62.1 (53.6–68.6)	
Educational level, *n* (%)			0.106[b]
No study	43.1 (39.0–46.2)	56.9 (52.9–59.9)	
<8 years	49.9 (45.1–53.9)	50.1 (45.3–54.2)	
≥8 years	45.2 (39.6–49.8)	54.8 (49.2–59.4)	
Place of residence, *n* (%)			<0.001[b]
Interior	38.7 (34.5–42.3)	61.3 (56.9–65.1)	
Capital	49.5 (46.2–52.2)	50.5 (47.1–53.3)	
Hamburger and/or sausages			<0.001[b]
No	52.9 (49.6–55.6)	47.1 (43.8–50.0)	
Yes	32.6 (28.4–36.0)	67.4 (63.2–70.7)	
Sweetened drinks			<0.001[b]
No	55.8 (51.8–29.3)	44.2 (40.2–47.5)	
Yes	37.0 (33.4–40.0)	63.0 (59.5–65.9)	
Instant noodles, package, snacks, or biscuits			<0.001[b]
No	53.4 (50.1–56.1)	46.6 (43.4–49.2)	
Yes	28.4 (24.0–32.0)	71.6 (67.2–75.0)	
Stuffed biscuits, sweets, or treats			<0.001[b]
No	55.2 (51.5–58.1)	44.8 (41.0–48.0)	
Yes	35.2 (31.6–38.2)	64.8 (61.1–68.0)	

[a]Chi-square test for proportions.
[b]Pearson's chi–square test.

assessed. In recent years, the NOVA food classification system, which categorizes food consumption into four groups based on the purpose, extent, and level of food processing, has been frequently used.[11,13,14,27] Another hypothesis suggested is that individuals of different skin colors and educational backgrounds may face socio-economic, cultural, and educational inequalities that influence their dietary choices. For instance, minority groups may be more exposed to environments where ultra-processed foods are more accessible or culturally more acceptable.

In Brazil, there is limited information on food consumption based on the NOVA system, particularly among older adults, making it challenging to draw comparisons.[28] However, it is presumed that the high UPFs consumption found in our study reflects an increasing trend in the consumption of these foods in Brazil in recent years, a trend that has already been observed in other age groups.[29–31] The high consumption of UPFs in our study is also influenced by the period in which the data were collected. For instance, in 2020, the COVID-19 pandemic negatively impacted the dietary patterns of Brazilians, leading to increased consumption of UPFs, instant and fast food, and reduced intake of vegetables and fruits.[32,33]

The consumption of UPFs was associated with hypercholesterolemia, with a predicted risk exceeding six-fold for simultaneous consumption of these foods, revealing an apparent dose-response relationship. Although consistent with previous studies, the situation is unfavorable.[8,34] The

Table 3. Crude and adjusted ORs and 95% CI for the development of hypercholesterolemia and isolated and simultaneous consumption of ultra-processed foods. (*N* = 1322; Roraima—Brazil. 2020).

Variables	Prevalence	Crude		Adjusted[a]	
		p-value	OR (95% CI)	OR (95% CI)	*p*-value
Isolated consumption					
Hamburger and/or sausages			<0.001		<0.001
No	47.1	1		1	
Yes	67.4	2.32 (1.83–2.93)		2.44 (1.89–3.14)	
Sweetened drinks			<0.001		<0.001
No	44.2	1		1	
Yes	63.0	2.15 (1.72–2.67)		1.95 (1.54–2.46)	
Instant noodles, package, snacks, or biscuits			<0.001		<0.001
No	46.6	1		1	
Yes	71.6	2.89 (2.25–3.71)		2.47 (1.90–3.22)	
Stuffed biscuits, sweets, or treats			<0.001		<0.001
No	44.8	1		1	
Yes	64.8	2.27 (1.82–2.84)		2.03 (1.61–2.56)	
Simultaneous consumption			<0.001		<0.001
Does not consume	40.8	1		1	
One food	44.7	1.17 (0.86–1.62)		1.17 (0.84–1.63)	
Two foods	55.2	1.79 (1.31–2.46)		1.75 (1.26–2.43)	
Three foods	62.0	2.36 (1.67–3.36)		2.28 (1.58–3.29)	
Four foods	83.6	7.40 (4.83–9.89)		6.65 (4.35–9.44)	

[a]Adjusted for gender, continued age, ethnicity, educational level, and place of residence.

consumption of these products is associated with cardiovascular diseases and contributes to approximately 22% of premature deaths resulting from these diseases in Brazil.[35] Furthermore, while several risk factors are more prevalent in the adult population, their co-occurrence is more common among older adults.[36] This may explain the higher risk of hypercholesterolemia among older adults who consume multiple types of UPFs simultaneously. Additionally, the general characteristics of our older adults may partially explain the associations found. For example, having no formal education, being predominantly of brown ethnicity, and residing mainly in a large city can limit access to healthy food options and increase reliance on more accessible and culturally accepted UPFs. We believe that the increased consumption of UPFs, which are rich in sugars, salts, oils, and hydrogenated fats, contributes to higher cholesterol levels and a greater risk of hypercholesterolemia.

UPFs are largely composed of sugars, salt, oils, and hydrogenated fats, which contribute to increased blood sugar levels, energy density, and fat content,[11] promoting lipogenesis.[37] Additionally, these products, being rich in saturated fatty acids, have a linear relationship with serum TC concentrations,[38] and enhance the activity of key enzymes involved in cholesterol synthesis.[39] Therefore, it is presumed that higher UPFs consumption is associated with an increased risk of developing hypercholesterolemia. Given the association between UPFs consumption and hypercholesterolemia, it is imperative to reduce their consumption and exercise caution when including them in the regular diet. This is crucial as hypercholesterolemia increases the risk of atherosclerosis and serves as a risk factor for peripheral vascular disease, stroke, and arterial disease.[1]

The current study has several limitations that should be acknowledged. Firstly, the study design employed does not allow for establishing causality between the outcomes. Secondly, the information on UPFs consumption was not collected on the same day as the tests were conducted, which introduces the possibility of spurious associations. Thirdly, the data are specific to the older adult population residing in the northern region of Brazil, a country with vast geographical dimensions and distinct regional behaviors and health profiles.[21,30] Fourthly, residual confounding factors may still exist in the final analyses, despite their inclusion in the adjusted analyses. Lastly, since the data were obtained from the health control system of the state of Roraima, older adults who did not attend consultations or undergo tests in the public health system in 2020 may not have been represented in our analysis, potentially leading to underreporting.

Among the strengths of this study, the representativeness of the sample of older adults from a relatively unexplored region is notable, as well as the significance of the knowledge generated regarding UPFs consumption and hypercholesterolemia in the Brazilian older adult population. Another positive aspect is the utilization of a standardized protocol for assessing UPFs consumption that is widely employed in the Brazilian Unified Health System.

Lastly, the use of an objective measure to evaluate the outcome, which was subsequently confirmed by nosological diagnoses, adds to the robustness of the findings.

Conclusion

In conclusion, UPFs play a significant role in the diets of older adults in the northernmost region of Brazil, being consumed by the majority of this population. More than half of the older adults had hypercholesterolemia, and all individual UPF groups increased the risk of developing this condition. Simultaneous consumption of UPFs showed a gradual increase in the risk of hypercholesterolemia, indicating a dose-response effect. These findings may encourage the implementation of effective public policies that involve the regulation of UPFs, explicit labeling of their risks for older adults with little or no education (characteristic of primary care). It is imperative to implement actions focused on targeted nutritional education for the most exposed groups to reduce access and exposure to these products. Disseminating these findings can support evidence-based recommendations and inform future research on nutritional interventions aimed at improving the cardiovascular health of older adults.

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Author contributions

GJSR, EHM and AAP conceptualized the study. AAP conducted the formal analysis, visualizations, interpreted the results, and undertook the writing of the original draft. GJSR, EHM, and AAP provided ideas and thoughts for discussion. EHM and GJSR revised the manuscript for important intellectual content and supported AAP in writing—reviewing and editing.

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