British Journal of Nutrition, page 1 of 6 doi:10.1017/S0007114524001429

British Journal of Nutrition

Determinants of the consumption of ultra-processed foods in the Brazilian population

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(Submitted 20 February 2024 – Final revision received 25 June 2024 – Accepted 9 July 2024)

Abstract

This article aims to evaluate the sociodemographic determinants of ultra-processed foods (UPF) consumption in the Brazilian population ≥ 10 years of age. The study used data from the personal and resident food consumption module of the Family Budget Surveys, grouping foods according to the NOVA classification of food processing. The classification and regression tree (CART) was used to identify the factors determining the lowest to highest percentage participation of UPF in the Brazilian population. UPF accounted for 37·0 % of energy content in 2017–2018. In the end, eight nodes of UPF consumption were identified, with household situation, education in years, age in years and per capita family income being the determining factors identified in the CART. The lowest consumption of UPF occurred among individuals living in rural areas with less than 4 years of education (23·78 %), while the highest consumption occurred among individuals living in urban areas, < 30 years of age and with per capita income ≥ US$257 (46·27 %). The determining factors identified in CART expose the diverse pattern of UPF consumption in the Brazilian population, especially conditions directly associated with access to these products, such as penetration in urban/rural regions. Through the results of this study, it may be possible to identify focal points for action in policies and actions to mitigate UPF consumption.

Keywords: **Ultra-processed foods: Nutrition surveys: Sociodemographic factors: Brazil**

Ultra-processed foods (UPF) are industrialised food products originating from fresh or minimally processed foods with the addition of chemical additives such as flavourings, colourings, sweeteners and other compounds that enhance their sensorial properties and increase their shelf life[1–3]. These products have overt marketing, usually aimed at children and adolescents, and are often associated with practical consumption[4,5].

Studies show that the consumption of UPF is also associated with the emergence of non-communicable diseases and conditions such as obesity and cardiometabolic events[2,5–7]. Furthermore, due to water use and waste disposal, the impacts involved in the production and consumption of UPF on the environment are also highlighted[1,8].

Since 2008, Brazil has conducted a national survey on sociodemographic information and food consumption of the Brazilian population aged ≥ 10 years, the Family Budget Survey (POF)[9]. Based on estimates obtained by representative Brazilian surveys, it was observed that the consumption of UPF by the Brazilian population in 2023 was 17·7 %[10], 19·7 % in 2017–2018 and 18·68 % in 2008–2009[11]. However, studies that evaluate UPF consumption usually carry out cross-sectional investigations, which cannot indicate the existence of determinants of consumption, as well as interactions between different factors that may indicate different nuances in the consumption of these products. This allows us to identify the sociodemographic determinants of the consumption of UPF in the Brazilian population, a public health issue that negatively impacts the population's health, as well as the costs of the health sector.

Therefore, robust statistical methods, such as classification and regression trees (CART), appear as an analysis option because they consider the interaction of distinct sociodemographic factors on UPF consumption in the general population. Through this analysis, it is possible to identify consumption patterns across different population groups, making it possible to target guidelines and policies more specifically and understand the relationship between individuals and their diets.

Methods

Ethical aspects

The data in this study come from an open-access information system, therefore eliminating the obligation of prior requests to

Abbreviations: CART, classification and regression tree; INMP, *in natura* or minimally processed foods; UPF, ultra-processed foods.

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government bodies or institutions and approval by the Research Ethics Committee.

Design and sample

This is a cross-sectional study with data from the personal food consumption module of the National Food Survey (INA) of the POF, a nationally representative survey that took place between July 2017 and June 2018 in Brazil. It is considered the most complete survey to date in Brazil, and the POF is representative of the Brazilian population and investigated living conditions based on the analysis of their household budgets, food availability and food consumption[9].

The data collection used a complex sampling plan by conglomerates in two stages, with the drawing of census tracts in the first stage and households in the second. The census sectors come from the master sample of the Brazilian Institute of Geography and Statistics (IBGE), grouped into strata of households with high geographic homogeneity in the sector. Data collection occurred throughout the years of 2017 and 2018 divided into four quarters to consider dietary variability and foods from different seasons[9].

The POF involved 46 164 residents aged ≥ 10 years in Brazil. The sample of households was randomly selected, and all individuals within the target age range were invited to participate. With the expansion of the sampling plan, information was obtained from 52,906,759 Brazilian individuals aged ≥ 10 years[9].

Food consumption

The individuals' food consumption was assessed using two food records applied on two non-consecutive days using the Automated Multiple Steps Method[12]. In various stages, information was collected on all foods consumed the day before the application, their amounts in household measures, preparation method and, for some predetermined foods, information was requested on the addition of ingredients such as sugars, sweeteners and oils.

Foods with amounts considered unlikely or absent were imputed using the similarity matrix method[13] from variables correlated with the possible amount consumed. The foods were combined with the food codes present in the Brazilian Food Composition Table (TBCA)[14], while the preparations were disaggregated considering the TBCA standardised recipes. Finally, the reported/imputed amount of each food was converted into kJ using the TBCA information.

Subsequently, the foods were classified according to the NOVA classification criteria[3] in *in natura* or minimally processed foods (INMP), culinary ingredients, processed foods and UPF. The classification of the UPF followed the concept that they are industrial formulations obtained through the fractionation of foods from INMP foods[5]. Dyes, flavourings, emulsifiers, thickeners and other additives are often added, giving the formulations high palatability and extended shelf life[2].

For this work, the outcome was the percentage share in energy provided by UPF, which was obtained through the equation:

$$\%\text{UPF} = \frac{\text{kJ from UPF} \times 100}{\text{total dietetic kJ}}$$

Sociodemographic variables

Sociodemographic information was collected using standardised resident information questionnaires. The following variables were used: sex (male/female), age (in years), years of education (in years), home situation (urban/rural) and per capita family income (converted to US dollars at the 2018 exchange rate for comparative purposes). These variables were selected because they are the sociodemographic conditions assessed in the resident information module.

Data analysis

Initially, categorical data were described in absolute (n) and relative (%) frequencies. Continuous variables had their assumptions of normality tested through the asymptotic one-sample Kolmogorov–Smirnov test, which were rejected ($P < 0{\cdot}05$), therefore being described in medians and interquartile ranges (IQR). Due to this study using complex sampling, the sample weights were considered in all analyses.

The CART was used to evaluate the determinants of UPF consumption. The CART is a method that divides the data into segments that are as homogeneous as possible relative to the outcome variable (percentage of energy participation of UPF in the individual's diet)[15,16]. A homogeneous node is considered one in which all cases have the same value for the outcome, therefore being a terminal node[16].

The algorithms usually used to build trees work from top to bottom by grouping independent variables, which allows complex interactions to be established between variables and the outcome without prior specification. Also, the CART algorithm itself determines the ideal cut-off point for identifying risk or protection groups through interaction with one or more variables[16].

To analyse the adjustment of the CART, two metrics were used: root mean squared error, which measures the average prediction error committed by the model in predicting the result of observation, and the mean absolute error, an alternative to root mean squared error that is less sensitive to outliers and corresponds to the absolute average difference between observed and predicted results. These measurements were calculated on different subsets of data by the k-fold cross-validation method ($k = 10$). For each subset, the root mean squared error and mean absolute error were obtained. Namely, the mean mean absolute error was 15·09 with a SD of 0·15 and the mean root mean squared error was 18·61 with a SD of 0·16. These values reinforce a low variability in the ten repetitions performed, therefore confirming the reproducibility, reliability and generalisation of the results obtained.

Analyses were performed in the open-access statistical program R (R Core Team, 2023)[17]. The CART was created using the *rpart* package[18], and the sample weights were included in this method for sampling expansion. The *survey*[19] and *gtsummary*[20] packages were also used to describe the population.

https://doi.org/10.1017/S0007114524001429 Published online by Cambridge University Press https://doi.org/10.1017/S0007114524001429 Published online by Cambridge University Press

Table 1. Sociodemographic and food intake characteristics of the Brazilian population ≥ 10 years from the National Food Survey, 2017–2018

	N 52,906,759*	
Characteristic	Median or *n*	IQR or %
Sex		
Male	24 280 128	45·9 %
Female	28 626 631	54·1 %
Home situation		
Urban	44 950 344	85·0 %
Rural	7 956 415	15·0 %
Brazilian macroregion		
Midwest	4 152 505	7·8 %
Northeast	14 645 832	27·7 %
North	3 861 475	7·3 %
Southeast	22 878 689	43·2 %
South	7 368 257	13·9 %
Years of education	9·0	5·0–12·0
Age (in years)	39·0	24·0–55·0
Per capita family income (in US$)	246·7	127·2–440·7
Energy in kJ	6789·6	5202·3–8778·1
Energy in kcal	1616·4	1238·6–2090·6
Energy from UPF (in kJ)	2450·0	1418·8–3812·6
Energy from UPF (in kcal)	583·2	337.7–907.9
% participation of UPF in the diet	37·0	24·2–50·9

IQR, interquartile ranges; UPF, ultra-processed foods.
* Median (IQR); *n* (%).

Results

We present the sociodemographic and food intake characteristics of the 52,906,759 Brazilian individuals interviewed in Table 1. Most individuals were female (54·1 %) and lived in urban areas (85·0 %) in the southeast region of Brazil (43·2 %). The median energy intake was 6789·6 kJ (1616·4 kcal), and the median contribution from UPF was 37 %.

The results of the CART are presented in Fig. 1. The home situation, years of education, age (in years) and per capita family income (in US dollars) were selected by the CART to group the mean percentage participation of UPF in the individual's diet. For the continuous variables, the best cut-off points were determined by the CART algorithm.

The CART algorithm identified eight terminal nodes. The home situation, age and per capita family income were considered the most important predictors, since the people who lived in urban areas were < 30 years and had per capita income ≥ 257 US$ had the highest UPF participation in the diet. The lowest UPF participation was determined by living in rural Brazil and having less education (< 4 years).

The nodes obtained show a growth behaviour in energy values from UPF and their percentage contributions as observed in CART. However, although the values of total energy ingested according to the nodes also show a similar growth behaviour, we can observe that node 3 (lowest proportional UPF consumption) presented a higher and similar total energy consumption when compared with nodes 8 and 9. Furthermore, node 4 (third lowest proportional consumption of UPF) presented energy consumption similar to that observed by individuals from nodes 12 and 14, who had a significantly higher consumption of UPF (Table 2).

Discussion

Through the results of this work, we can admit that the percentage participation of UPF in the diet of the Brazilian population is more dependent on the individuals' residence conditions, since the root node that divided the sample was the household situation. It is important to emphasise that Brazilian individuals residing in rural areas still show a large variation in their UPF consumption since years of study ≥ 4 years (node 4) were responsible for an increase of 7·29 p.p.

We suggest that individuals with less education, and consequently lower socio-economic status, may be more dependent on their agricultural production, therefore with lower UPF consumption[21]. At the same time, individuals residing in rural areas with more education may experience greater economic growth and prosperity; however, alone, these conditions are not markers of improvements in eating habits and may even reduce the consumption of healthy foods to the detriment of an increase in unhealthy foods, as occurs in low-income countries, especially in Latin America[22]. Furthermore, it is important to highlight that Brazil has a vast use of land for agroecological production, which may be associated with greater consumption of INMP in regions adjacent to agricultural centres[22,23].

On the other hand, residing in an urban environment was the ramification that showed the greatest participation of UPF in the diet of the Brazilian population. Possibly, this is due to easier access in large centres and penetration of these products in markets and snack bars[11,24]. However, age was the knot that later divided the population into different categories of consumption, since age is positively associated with nutritional knowledge and better dietary choices, as well as scientific evidence reinforces the inverse association between UPF consumption and the advancement of age as a global standard[25,26].

In the urban environment, even the node with the lowest dietary contribution of UPF (node 8) was 6·28 p.p higher than the lowest contribution observed in the tree (node 3). Also, the participation observed in node 8 was slightly lower than in node 4 (–1·01 p.p). We showed that, even if the individuals lived in an urban area, the population of node 8 was divided according to their age (≥ 30 years) and years of schooling (< 4), factors that have a strong influence on the eating habits of populations[21]. Individuals in this age group usually have better nutritional knowledge and greater resistance to UPF consumption due to the prudence of their age and greater concern about their health status, as well as having less education, therefore lower socio-economic status, and consuming more INMP foods[2,26].

We hypothesise that a portion of the population at node 8 may represent individuals from the rural area who emigrated to large centres in search of better living conditions, but who may be suffering from food deprivation. We support this hypothesis through the differences in energy consumption between individuals from nodes 3 and 8, the latter of which generally consume less food.

Also, we can observe the influence of schooling in the following nodes, since even being in the same age group

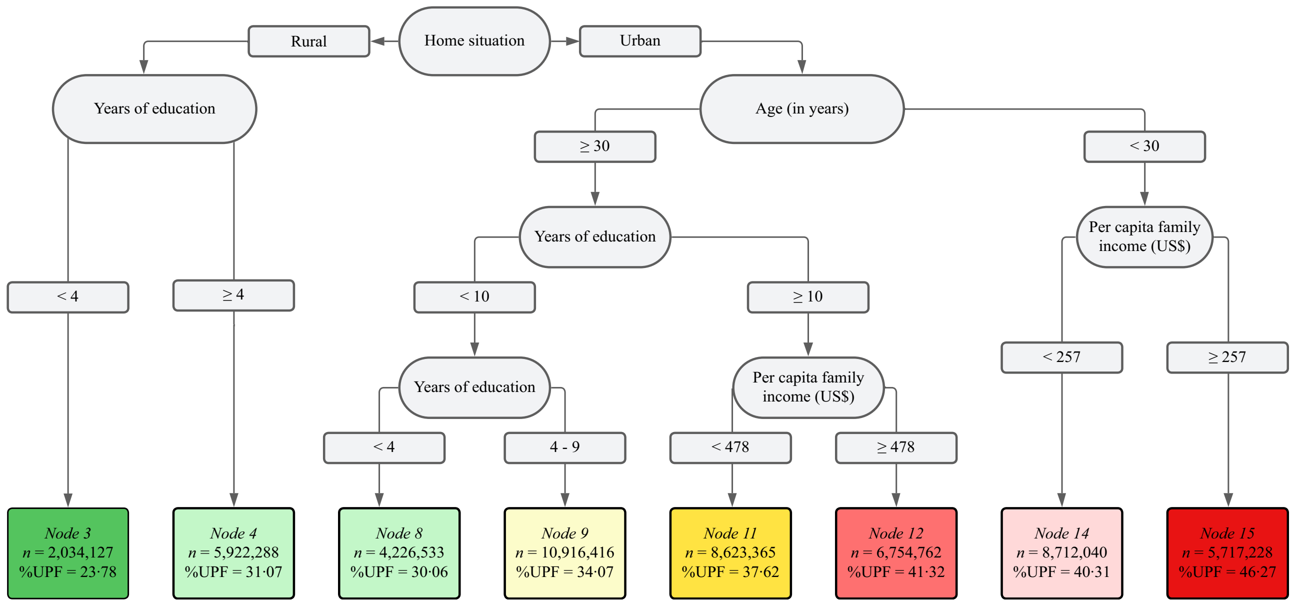

Fig. 1. Classification and regression tree of the determinants of ultra-processed food consumption in the Brazilian population ≥ 10 years. From left to right, the colour gradient represents a progressive increase in the percentage contribution of ultra-processed foods. Green tones correspond to lower values, yellow tones indicate intermediate values and red tones signify higher values. UPF, UPF, ultra-processed foods.

Table 2. Total and from UPF energy intake

	Energy in kJ		Energy in kcal		Energy from UPF (in kJ)		Energy from UPF (in kcal)		% of energy from UPF	
Nodes	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR
3	6381·7	4763·1–8326·3	1518·9	1133·9–1984·6	1397·4	655·7–2449·3	332·5	156·5–583·1	22·5	10·8–35·3
4	7085·5	5390·2–9167·4	1688·5	1282·5–2183·1	2025·1	1098·9–3307·7	482·4	262·5–788·3	30·0	17·8–43·0
8	5836·3	4511·2–7612·5	1388·8	1076·0–1813·9	1663·9	956·5–2577·6	395·5	227·3–612·3	29·7	18·1–42·2
9	6413·1	4940·8–8264·1	1526·9	1176·6–1968·9	2150·7	1259·7–3306·2	512·3	299·6–786·6	34·3	22·4–46·7
11	6776·9	5214·3–8720·2	1614·5	1240·8–2077·4	2526·4	1497·9–3814·9	601·6	356·7–907·2	38·2	26·0–51·3
12	6903·6	5380·9–8844·4	1642·6	1280·6–2106·6	2846·9	1865·1–4210·7	678·3	444·2–1001·5	42·8	30·4–55·4
14	7049·2	5486·4–9076·1	1677·1	1306·1–2160·8	2815·2	1708·3–4297·1	670·1	406·5–1023·0	40·7	27·7–55·0
15	7537·9	5856·2–9649·0	1796·5	1392·9–2300·5	3445·7	2261·3–5059·6	819·8	537·8–1206·4	47·9	33·3–61·7

UPF, ultra-processed foods; IQR, interquartile ranges.

(≥ 30 years), having only more years of study, but still, low schooling increased the participation of UPF in the diet by 4·01 p.p. of the population (node 9). We suggest that this may be due to the greater possibility of access to jobs and, consequently, a slight increase in income. However, we hypothesise that the jobs available for this level of education are usually made up of strenuous workloads and long hours, in addition to the time spent commuting between home and the workplace[27]. Thus, there is an inclination towards the choice of UPF, since they are more practical to acquire and prepare[1,3].

When the age group ≥ 30 years is maintained, but the level of education increases to ≥ 10 years, we can observe the emergence of the effect of per capita family income on UPF consumption. Since this level of education can cover high school, as well as higher education and postgraduate courses, it was possible to distinguish that those with higher per capita income (node 12) had higher UPF consumption daily. We suggest that higher per capita income may represent a sign of economic prosperity and greater susceptibility to ostensive UPF marketing, as well as increased consumption due to practicality[22,23,28].

Differently from the population ≥ 30 years old, individuals under the age of 30 years did not show consumption variation according to their level of education, but only with per capita family income. Younger age is globally associated with higher UPF consumption[1,11], with a progressive decrease as age advances, thus justifying the higher dietary UPF contributions at this extreme of the CART. Also, in addition to younger age, per capita income affected UPF consumption since those with higher income had the highest national consumption of these products[22,28–30].

In high-income countries, UPF prices are lower and, therefore, more accessible to the general population, but this trend is not followed by middle- and low-income countries[23,28]. This behaviour was observed by Claro *et al.*[30], in which the average value of UPF was higher than that of other foods; therefore, there was no economic advantage for most of the population. In some countries, a process of reversal of eating habits and nutritional status of their populations has already started, but Brazil and other middle- and low-income countries do not follow this trend[29].

We emphasise that the two nodes with the highest income (nodes 12 and 15) had the highest UPF shares, corroborating the greater access to these products granted by income[31]. Furthermore, we highlight that individuals from nodes 11, 12, and 14 have median energy consumption lower than those from node 4, but their average UPF consumption is much higher, indicating that the diet of these individuals is mostly constituted of UPF.

This study has limitations arising from inherent biases of the dietary survey methods used, such as underestimation/overestimation of foods and/or groups of foods and preparations. However, to minimise these potential biases, the instruments used were validated and procedures were carried out to certify the quality and validity of the information obtained. Furthermore, scientific evidence indicates that the consumption of UPF can be mediated by different mechanisms and sociodemographic conditions; however, to our knowledge, the effects of interactions of different sociodemographic conditions grouped on the consumption of these products in the Brazilian population have not yet been evaluated, reinforcing the uniqueness of this work, especially in the largest Brazilian food survey. It is important to highlight that existing research[1,2,21,22,24,27,31] on the consumption of UPF and their correlated factors is supported by cross-sectional associations with methods that consider only the consumption outcome, such as regressions. The unique feature of this study allows for a homogenisation of the Brazilian population according to different sociodemographic conditions, thus allowing a classification of individuals according to their higher or lower consumption. It was possible to observe that lower levels of consumption were primarily correlated with fewer factors (education and housing situation), while higher levels led to a gradual increase in the conditions necessary for their consumption. This reinforces the multi-motivated behaviour pattern of human eating, as well as filling specific gaps regarding which population groups are more and less subject to the deleterious effects of UPF.

We concluded that the findings of this study indicate that the Brazilian population aged ≥ 10 years has a different pattern of consumption of UPF. We observed consumption averages ranging from 23 to 46 % that were influenced by residence conditions, demographics and income. The biggest divisor of food consumption was the region of residence, with the urban area responsible for accommodating the highest consumption of UPF.

Unlike high-income countries that show a downward trend in UPF consumption, Brazil follows the nutritional transition pattern of middle- and low-income countries, especially its neighbours in Latin America that have high UPF consumption rates and a reduction of dietary participation of INMP foods. We emphasise that Brazil is the protagonist of food and nutrition education campaigns, as well as the production of educational materials such as the Dietary Guide for the Brazilian Population, but the recommendations are general and aimed at the average population. Through the results of this work, it may be possible to determine focal points for the action of education and intervention policies that minimise or circumvent the rise in the consumption of these products and mitigate the appearance of health problems in the medium and long term.

Acknowledgements

This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

Substantial contributions to conception and design, data acquisition, analysis and/or interpretation: V. N. C. S., A. M. S. and A. K. T. C. F.; drafting the article or revising it critically for important intellectual content: V. N. C. S., A. M. S. and A. K. T. C. F.; and final approval of the version to be published: A. M. S. and A. K. T. C. F. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved: V. N. C. S., A. M. S. and A. K. T. C. F.

The authors declare none.

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