



Consumption of ultra-processed foods and obesity in Brazilian adolescents and adults



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ABSTRACT

Objectives. The aim of this study was to evaluate the relationship between the consumption of ultra-processed foods and obesity indicators among Brazilian adults and adolescents.

Methods. We used cross-sectional data on 30,243 individuals aged ≥ 10 years from the 2008–2009 Brazilian Dietary Survey. Food consumption data were collected through 24-h food records. We classified food items according to characteristics of food processing. Ultra-processed foods were defined as formulations made by the food industry mostly from substances extracted from foods or obtained with the further processing of constituents of foods or through chemical synthesis, with little if any whole food. Examples included candies, cookies, sugar-sweetened beverages, and ready-to-eat dishes. Regression models were fitted to evaluate the association of the consumption of ultra-processed foods (% of energy intake) with body-mass-index, excess weight, and obesity status, controlling for socio-demographic characteristics, smoking, and physical activity.

Results. Ultra-processed foods represented 30% of the total energy intake. Those in the highest quintile of consumption of ultra-processed foods had significantly higher body-mass-index (0.94 kg/m²; 95% CI: 0.42,1.47) and higher odds of being obese (OR = 1.98; 95% CI: 1.26,3.12) and excess weight (OR = 1.26; 95% CI: 0.95,1.69) compared with those in the lowest quintile of consumption.

Conclusion. Our findings support the role of ultra-processed foods in the obesity epidemic in Brazil.

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Introduction

Ultra-processed foods are formulations made by the food industry mostly from substances extracted from foods or obtained from the further processing of constituents of foods or through chemical synthesis, with little if any whole foods (Monteiro et al., 2012; Moodie et al., 2013). Compared to the rest of the diet, these formulations have less fiber and protein, more added sugar, and, when solid, higher energy density (Monteiro et al., 2011; Moubarac et al., 2013). They are also extremely palatable and habit-forming, convenient, sold in large portion sizes, and aggressively advertised and marketed (Monteiro et al., 2012; Moodie et al., 2013; Ludwig, 2011). Sales of ultra-processed foods have increased in parallel with the rates of obesity worldwide, particularly in middle-income countries (Monteiro et al., 2013).

One analysis in Brazil showed that household purchase of ultra-processed foods was associated with greater prevalence of obesity (Canella et al., 2014). However, this study had only used purchase

data rather than individual-level consumption data. To our knowledge, no evidence in a developing country is available for how much people consume ultra-processed foods across different demographic groups and how it is related to obesity.

The objective of the present study was to evaluate the association of the intake of ultra-processed foods with obesity indicators in a national-representative sample of Brazilian adolescents and adults.

Methods

Design and population

We performed a cross-sectional analysis based on individual-level dietary data from 34,003 individuals aged ≥ 10 years in Brazil, collected as part of the 2008–2009 National Household Budget Survey (Instituto Brasileiro de Geografia e Estatística, Ibge, 2011a). These individuals represented a randomly selected subsample of 25% of the 55,970 total households randomly selected for the budget survey. The survey employed a complex clustered sampling procedure, first selecting census tracts and then selecting households within those tracts. The selection of census tracts was preceded by an examination of the tracts of the Master Sample of Household Surveys or Common Sample (containing the pool of the 12,800 tracts of the country) to obtain strata of households with high geographic and socioeconomic homogeneity. The geographic locations of tracts (region, state, capital city or other, urban or rural) and the years of schooling of the heads of households in the sector were considered, and 550 strata of households that were geographically and socioeconomically homogeneous were selected. For this study, we excluded pregnant women and individuals with diabetes, hypertension or cancer, each defined by self-reported medication ($n = 3760$).

The project was approved by the Ethics Committee of the University of São Paulo.

Food consumption

Individuals completed two non-consecutive 24-h food records days spanning 1 week (Instituto Brasileiro de Geografia e Estatística, Ibge, 2011a). Nutrient intakes were estimated based on a Brazilian food composition table (Instituto Brasileiro de Geografia e Estatística, Ibge, 2011b).

Food items were divided into three main groups (Supplementary Fig. 1). The first was composed of *unprocessed, minimally, or moderately processed foods*. Unprocessed foods were defined as having not undergone any kind of industrial processing, minimally processed foods as processed in ways that did not add substances or subtract edible parts, and moderately processed foods as those that had an edible part subtracted, but no substance added. This category also included handmade dishes made from these foods and culinary ingredients such as oils, salt, and sugar. The second category was *processed foods*, and the third, *ultra-processed foods*. Processed and ultra-processed foods were defined as products made by the food industry with at least two ingredients. We characterized processed foods as those manufactured by adding salt, sugar, or oil to unprocessed, minimally processed or moderately processed foods; and ultra-processed foods as those formulations mostly made from substances extracted from foods or obtained with the further processing of constituents of foods or through chemical synthesis, such as oils, hydrogenated fats, starches, sugars, protein isolates, amino acids, and additives like flavors and colors (Monteiro et al., 2012; Moodie et al., 2013; Ludwig, 2011; Monteiro and Cannon, 2012). Examples of ultra-processed foods include: ice-creams, soft drinks, industrialized baked products, and sausages.

For each category, we computed the relative contribution of foods in that category to each person's total energy intake. We evaluated intake as the percentage to total energy intake in order to reduce variation due to body size, physical activity, and metabolic efficiency (each major determinants of total energy intake).

Obesity indicators

Weight and height were measured by researchers with standard techniques and recorded in specific questionnaires (Instituto Brasileiro de Geografia e Estatística, Ibge, 2010). In individuals aged ≥ 20 years old, excess weight and obesity were defined as BMI ≥ 25 kg/m² and 30 kg/m², respectively (World Health Organization, 1995). Excess weight and obesity of 10 to 19 year-old individuals were defined as BMI-for-age z-scores from the World Health

Organization references $\geq +1$ and $+2$, respectively (de Onis et al., 2007). Excess weight includes excess weight and obesity.

Covariates

Information on age, sex, race, education, and income were obtained via standardized interviews. Annual household income per person was calculated using a purchasing power parity basis (PPP 2009: US\$ 1.00 = R\$ 1.63) (World Bank, 2015). Geographic region and urban status of the household were also used as covariates.

Smoking was assessed based on data from each individual's purchases, with current smokers defined as those having purchased any type of cigarettes during the previous 7 days. Because physical activity was not assessed in the household survey, we predicted physical activity levels by evaluating data from the VIGITEL Survey (Ministério da Saúde, 2010) for adults and from the PENSE Survey (Ministério da Saúde, 2009) for adolescents. Using these datasets, we modeled a regression equation predicting the likely leisure-time and transportation physical activity (minutes/week) by age, sex, race, years of education, and smoking status used as the predictors. Using two regression equations, we obtained predicted leisure-time and transportation physical activity duration for individuals in the dataset of the current study.

Statistical analyses

Analyses were performed with Stata 13.0 (Texas, US) with two-tailed $\alpha = 0.05$. Analyses accounted for sample weights and the design effect of the survey.

Linear regression models were used to assess differences in BMI across quintiles of consumption of ultra-processed foods (% of total energy).

Logistic regression models were fitted in order to evaluate the odds ratio (OR) for being excess weight or obese according to quintiles of consumption of ultra-processed foods (% of total energy).

Multivariate models were fitted to adjust for age, sex, race, region, urban status, education, income, smoking status, and physical activity levels. We further adjusted for each person's consumption of fruits, vegetables, and beans to evaluate if the association was independent of these other components of the diet. Total energy intake was not included as a covariate because it may plausibly mediate (i.e., be in the causal pathway of) the effects of ultra-processed foods on BMI and obesity. We performed sensitivity analyses using the energy intake of ultra-processed foods (and not the percentage of total energy intake of the diet) as the explanatory variable.

We explored potential effect modification by sex, age, household income and food consumption outside home. For any significant interactions, subgroup analyses were conducted.

Lastly, we examined whether the association remained significant after adjustment, one at a time, for dietary intakes of saturated fatty acids (g/day), trans fatty acids (g/day), added sugars (% of total energy), fiber (g/1000 kcal), and total energy (kcal/day). We calculated the percent change in the regression coefficient for a linear relationship of the association between the consumption of ultra-processed foods and BMI before and after adjustment for each of the selected factors, by using an ordinal variable for quintile categories of consumption of ultra-processed foods (% of total energy).

Results

A total of 30,243 Brazilian adults were evaluated (Table 1). Consistent with the national population, the great majority resided in urban areas, 51% were women and 52% African-descent. Forty-one percent of the participants were excess weight and 12% obese.

Mean reported energy intake was 1908 kcal. Nationally, more than two thirds (68.6%) of these calories came from unprocessed, minimally, or moderately processed foods, while 29.6% came from ultra-processed foods.

On average, rice and beans represented about 25% of the energy consumed throughout the day (Supplementary Table 1). Other major foods in the Brazilian diet were red meat (9.3% of total energy), fruits (6.9%) and cereals other than rice (5.9%). Among ultra-processed foods, the categories with the highest energy contribution were industrialized breads (9.2% of total energy intake), pizzas, hamburgers and sandwiches (4.7%), and cakes and cookies (3.0%).

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