Premature Deaths Attributable to the Consumption of Ultraprocessed Foods in Brazil

Eduardo A.F. Nilson, ScD, Gerson Ferrari, PhD, Maria Laura C. Louzada, PhD, Renata B. Levy, PhD, Carlos A. Monteiro, PhD, Leandro F.M. Rezende, ScD

Introduction: Ultraprocessed foods have been associated with an increased risk of noncommunicable diseases, such as diabetes, cardiovascular diseases, and cancer as well as all-cause mortality. The study aimed to estimate premature deaths attributable to the consumption of ultraprocessed food in Brazil.

Methods: A comparative risk assessment model was developed on the basis of RRs from a recent meta-analysis, national food consumption for 2017–2018, and demographic and mortality data for 2019. Population attributable fractions for all-cause mortality were then estimated within each sex and age stratum according to the distribution of the ultraprocessed food contribution to the total energy of the diet. Analysis was conducted in February 2022–April 2022.

Results: The contribution of ultraprocessed foods to the total energy intake of the diet across sex and age stratum of Brazilian adults ranged from 13% to 21% of the total energy intake. A total of 541,160 adults aged 30–69 years died in 2019. The consumption of ultraprocessed foods was responsible for approximately 57,000 premature deaths (95% uncertainty interval=33,493, 82,570) or 10.5% of all premature deaths in adults aged 30–69 years. Reducing the contribution of ultraprocessed foods to the total energy intake by 10%–50% could potentially prevent 5,900 deaths (95% uncertainty interval=2,910, 10,613) to 29,300 deaths (95% uncertainty interval=16,514, 44,226), respectively.

Conclusions: The consumption of ultraprocessed foods represents a significant cause of premature death in Brazil. Reducing ultraprocessed food intake would promote substantial health gains for the population and should be a food policy priority to reduce premature mortality.


INTRODUCTION

Ultraprocessed foods (UPFs) are industrial formulations of substances derived from foods (oils, fats, sugars, starch, protein isolates) that contain little or no whole food and are often added with flavors, colors, emulsifiers, and other additives for cosmetic purposes. The ingredients and processes used in the manufacture of UPFs aim to create low-cost production products that are extremely palatable and convenient and have the potential to replace unprocessed or minimally processed foods and culinary preparations made with these foods.1

Recent meta-analyses show significant dose–response associations between the dietary share of UPFs and increased risk of noncommunicable diseases (NCDs), such as diabetes, cardiovascular diseases, and cancer as

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well as all-cause mortality.2–4 Multiple mechanisms for these associations have been postulated, including typical attributes of UPFs such as low satiety potential, high glycemic loads,5 higher presence of additives,6 and contaminants newly formed during processing or released from synthetic packaging.7 In addition, UPF has been associated with the overall deterioration of nutritional dietary quality and increased risk of obesity.7

During the past decades, sales of UPFs have risen dramatically worldwide, particularly in middle-income countries.10 They now may make up to half or more of the total dietary energy consumed in some high-income countries such as the U.S., Canada, the United Kingdom, and Australia and between one fifth and one third of total dietary energy in middle-income countries. In Brazil, household food acquisition surveys have shown that the contribution of UPFs to total energy intake increased from 14.3% in 2002/2003 to 19.4% in 2017/2018.11

Several comparative risk assessment model studies have been conducted to estimate the potential impact of specific dietary risk factors, such as the inadequate consumption of macro and micronutrients and specific foods, on all-cause and cause-specific mortality and disability-adjusted life-years. For instance, the Global Burden of Diseases has estimated that approximately 8 million deaths and 188 million disability-adjusted life-year were because of inadequate dietary consumption.12 However, the evidence of the health impacts of dietary patterns dominated by UPF is lacking, despite the potential to inform public health policies and programs.

This study aimed to estimate the proportion and number of premature deaths attributable to the consumption of UPFs in Brazil. The evaluation was designed to account for the estimated impact of the consumption of UPFs deaths from all-causes.

METHODS

A comparative risk assessment macrosimulation model was developed to estimate the proportion and number of all-cause premature deaths that could be averted by reducing the contribution of UPF to total energy intake to (1) a theoretical minimum risk level, assumed as zero percent of the total energy intake, and (2) reducing the contribution of UPFs to different counterfactual consumption scenarios.

Study Sample

The modeling approach involved 3 stages: (1) estimating baseline intakes of UPFs using a nationally representative dietary survey from Brazil (POF—National Household Budget Survey 2017–2018) by sex and age groups, (2) estimating the reduction in UPF intake for each age and sex group in each counterfactual scenario, and (3) estimating the impacts of reduced UPF intake on all-cause mortality through comparative risk assessment analysis.

<table>
<thead>
<tr>
<th>Age groups, years</th>
<th>Men, % (95% CI)</th>
<th>Women, % (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30–34</td>
<td>18.4 (17.2, 19.6)</td>
<td>21.0 (19.3, 22.7)</td>
</tr>
<tr>
<td>35–39</td>
<td>18.6 (16.7, 20.4)</td>
<td>19.0 (17.9, 20.1)</td>
</tr>
<tr>
<td>40–44</td>
<td>15.5 (14.4, 16.6)</td>
<td>18.3 (17.3, 19.7)</td>
</tr>
<tr>
<td>45–49</td>
<td>18.1 (16.4, 19.6)</td>
<td>18.4 (17.0, 19.8)</td>
</tr>
<tr>
<td>50–54</td>
<td>15.4 (14.3, 16.6)</td>
<td>17.4 (15.9, 18.8)</td>
</tr>
<tr>
<td>55–59</td>
<td>14.6 (13.6, 15.7)</td>
<td>16.2 (15.2, 17.3)</td>
</tr>
<tr>
<td>60–64</td>
<td>13.0 (11.9, 14.1)</td>
<td>16.3 (15.2, 17.4)</td>
</tr>
<tr>
<td>65–69</td>
<td>14.2 (13.0, 15.5)</td>
<td>16.0 (14.5, 17.5)</td>
</tr>
</tbody>
</table>

Measures

The consumption of foods and beverages in Brazilian adults by sex and age groups (30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, and 65–59 years) were obtained through a 2 nonconsecutive 24-hour food recall from the Personal Food Intake module of the POF 2017–2018.13 Foods and beverages were classified into 4 major groups (unprocessed or minimally processed foods, processed culinary ingredients, processed foods, and UPFs) on the basis of the NOVA classification1 (Appendix Table 1, available online). The contribution of UPF to total energy intake was computed as the ratio of the mean energy from UPF group over the mean total energy intake (Appendix Table 2, available online).

Counterfactual scenarios were built to estimate the potential impact of reducing UPF intake by 10%, 20%, and 50% according to sex and age groups. The potential reduction of the contribution of UPF to less than the fourth quartile of baseline consumption of UPF was also estimated, as summarized in Figure 1 (and detailed in Appendix Table 3, available online).

Statistical Analysis

RRs for all-cause mortality were estimated within each sex and age stratum considering discrete intervals of 0.1% of the contribution of UPF to total energy intake of 0.0% (RR=1.00) to 35.7% (RR=1.25) on the basis of the summary RR from a recent meta-analysis3 and extrapolated the RR for contributions up to 100%. The estimated RR from the meta-analysis was based on a random-effects model for pooled analysis of the association of UPF consumption with increased risk of all-cause mortality on the basis of 5 prospective cohort studies,14–18 including 111,056 participants and 4,687 deaths (RR=1.25, 95% CI=1.14, 1.37; p<0.00001).3

Baseline model inputs included demographics, mortality, and food consumption data from the Brazilian adult population and RR for all-cause mortality (Appendix Table 4, available online). Key assumptions and restrictions of the model are summarized in Appendix Table 5 (available online).

The distribution of UPF consumption was modeled using a log-linear function for the mean contribution of UPF to total energy intake and its SD by sex and age stratum. On the basis of these intermediate outputs, population attributable fractions (PAFs) were calculated for mortality outcome (o) in each age group (a) and sex (s) stratum for each counterfactual scenario.
through the following formula:

\[
P_{\text{PAF}} = \frac{\int_{x=0}^{m} RR_{ao}(x) P_{ao}(x) \, dx - \int_{x=0}^{m} RR_{ao}(x) P_{ao}(x) \, dx}{\int_{x=0}^{m} RR_{ao}(x) P_{ao}(x) \, dx}
\]

where \( P_{ao}(x) \) and \( P_{ao}'(x) \) are the UPF intake distributions at the baseline and in the counterfactual scenarios, respectively. \( RR_{ao}(x) \) is the RR for all-cause mortality \( o \) as a function of the contribution of UPF to the total energy intake.

The total number of deaths in Brazil in 2019 was from the Mortality Information System.\(^1\) The averted deaths in each counterfactual scenario were computed by multiplying an age- and sex-specific PAF by the total number of deaths for the same stratum. The results are represented for Brazilian adults aged 30–69 years because these are considered premature deaths by the WHO (i.e., deaths before age <30 years are unlikely related to UPF intake and NCDs, and deaths ≥70 years excess life expectation in several countries increase the proportion of ill-defined causes of deaths).\(^2\)

The Appendix details the estimated RR (Appendix Table 6, available online), the distribution of the contribution of UPF to total energy intake at baseline and in the counterfactual scenarios (Appendix Table 7, available online), the PAF calculation

Table 2. Deaths From All Causes, PAF, and Estimated Deaths Attributable to the Consumption of Ultraprocessed Foods in Brazilian Adults Aged 30–69 Years, 2019

<table>
<thead>
<tr>
<th>Age groups, years</th>
<th>PAF Men, %</th>
<th>PAF Women, %</th>
<th>Deaths attributable to the consumption of ultraprocessed foods and the 95% uncertainty intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>30–34</td>
<td>12.3 (7.3, 17.9)</td>
<td>14.2 (8.4, 20.2)</td>
<td>Men 2,400 (1,468, 3,734) Women 1,000 (619, 1,520) Total 3,500 (2,047, 4,993)</td>
</tr>
<tr>
<td>35–39</td>
<td>12.4 (7.1, 18.7)</td>
<td>12.8 (7.6, 18.1)</td>
<td>Men 2,800 (1,608, 4,225) Women 1,300 (787, 1,877) Total 4,100 (2,395, 6,101)</td>
</tr>
<tr>
<td>40–44</td>
<td>10.3 (6.0, 15.1)</td>
<td>12.4 (7.4, 17.6)</td>
<td>Men 2,700 (1,560, 3,920) Women 1,700 (1,018, 2,426) Total 4,400 (2,578, 6,346)</td>
</tr>
<tr>
<td>45–49</td>
<td>12.1 (6.8, 17.6)</td>
<td>12.3 (7.3, 17.5)</td>
<td>Men 3,800 (2,132, 5,529) Women 2,200 (1,313, 3,127) Total 6,000 (3,446, 8,656)</td>
</tr>
<tr>
<td>50–54</td>
<td>10.2 (5.9, 15.0)</td>
<td>11.6 (6.9, 16.4)</td>
<td>Men 4,300 (2,514, 6,384) Women 2,900 (1,711, 4,059) Total 7,200 (4,225, 10,443)</td>
</tr>
<tr>
<td>55–59</td>
<td>9.7 (5.7, 14.4)</td>
<td>10.8 (6.4, 15.2)</td>
<td>Men 5,300 (3,338, 8,399) Women 3,600 (2,159, 5,102) Total 8,900 (5,239, 12,925)</td>
</tr>
<tr>
<td>60–64</td>
<td>8.5 (5.0, 12.6)</td>
<td>10.6 (6.5, 15.3)</td>
<td>Men 5,700 (3,338, 8,399) Women 4,700 (2,810, 6,646) Total 10,400 (6,148, 15,045)</td>
</tr>
<tr>
<td>65–69</td>
<td>9.4 (5.5, 13.7)</td>
<td>10.6 (6.4, 15.0)</td>
<td>Men 7,000 (4,057, 10,128) Women 5,600 (3,357, 7,932) Total 12,600 (7,414, 18,060)</td>
</tr>
<tr>
<td>Total</td>
<td>10.6 (6.2, 15.6)</td>
<td>12.0 (7.1, 16.9)</td>
<td>Men 33,900 (19,729, 49,938) Women 23,100 (13,764, 32,632) Total 57,000 (34,493, 82,632)</td>
</tr>
</tbody>
</table>

PAF, population attributable fraction.

Figure 1. Distribution of the contribution of UPFs to total energy intake in the diet of Brazilian adults aged 30–69 years in the baseline and counterfactual scenarios for changes in UPF consumption (2019). Q4, fourth quartile; UPF, ultraprocessed food.
All preventable NCD deaths in adults aged 30–69 years (Table 2).

Most of the attributable deaths (60%) were among men. Regarding age groups, most attributable deaths were among men (66%) and women (73%) aged 50–69 years. However, the PAF was 30% greater in younger age groups for both men and women. In both men and women, the PAF was higher in the younger age groups than in the oldest (Table 2).

Different counterfactual scenarios based on reductions of 10%, 20%, and 50% in the contribution of UPF to the total energy intake would prevent or postpone approximately 5.9, 12.0, and 29.3 thousand premature deaths per year, respectively. If all adults consumed UPF comprising less than the fourth quartile of the baseline contribution of UPF to total energy intake, 19,900 deaths could be prevented or postponed. Approximately, 60% of the averted deaths would be among men (Table 3).

Considering the 6 different sensitivity analysis scenarios (detailed in Appendix Table 9, available online, and Appendix Figure 1, available online), premature deaths attributable to the consumption of UPF varied from −13.2% (theoretical minimum and maximum risk exposure levels of 2% and 98%, respectively) to +8.9% (10% higher UPF intake) compared with the primary model. All other sensitivity analysis scenarios, including assuming different RR values and different maximum theoretical risks, had a relatively minor impact on the modeled estimates compared with the primary model.

RESULTS

The contribution of UPF to total energy intake of Brazilian adults tended to decrease with age for both men and women. In all age groups, the average contribution of UPF was larger than 13% of the total energy intake (Table 1).

In Brazil, a total of 541,160 adults aged 30–69 years died prematurely in 2019, of which 261,061 of these deaths were from preventable NCDs, and 62% of all-cause deaths were among men (Appendix Table 2, available online). The consumption of UPF was responsible for approximately 57,000 deaths in 2019, which corresponded to 10.5% of all premature deaths and 21.8% of

<table>
<thead>
<tr>
<th>Sex</th>
<th>10% reduction</th>
<th>20% reduction</th>
<th>50% reduction</th>
<th>&lt;4th quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(4,189, 7,097)</td>
<td>(3,661, 11,800)</td>
<td>(9,771, 27,132)</td>
<td>(6,515, 19,306)</td>
</tr>
<tr>
<td>Women</td>
<td>2,400</td>
<td>4,800</td>
<td>111,900</td>
<td>8,000</td>
</tr>
<tr>
<td></td>
<td>(1,420, 5,157)</td>
<td>(2,877, 6,974)</td>
<td>(6,743, 17,094)</td>
<td>(4,701, 11,642)</td>
</tr>
<tr>
<td>Total</td>
<td>5,900</td>
<td>12,600</td>
<td>29,300</td>
<td>19,900</td>
</tr>
<tr>
<td></td>
<td>(2,910, 10,613)</td>
<td>(6,537, 18,774)</td>
<td>(16,514, 44,226)</td>
<td>(11,215, 30,948)</td>
</tr>
</tbody>
</table>

DISCUSSION

This is the first study the authors are aware of that estimates the premature deaths attributable to the consumption of UPFs in a countrywide modeling study. It was estimated that approximately 57,000 premature deaths were attributable to the consumption of UPFs in Brazil in 2019. Most attributable deaths occurred among men, although PAFs were slightly higher among women, likely because most premature deaths are among men in Brazil, including deaths from NCDs.
These premature deaths attributable to UPF intake were equivalent to 10.5% of all-cause premature deaths and to 21.8% of the premature deaths from preventable NCDs in Brazil. Progressive reductions in the consumption of UPFs in 10%–50% could potentially prevent approximately 5,900–29,300 deaths per year, respectively.

Previous modeling studies have only estimated the health and economic burden of critical nutrients and specific foods/drinks, such as sodium, sugars and fats, and sugar-sweetened beverages, on cardiovascular diseases, diabetes, and obesity. Some modeling studies have shown that the consumption of sugar-sweetened beverages in different countries may lead to a reduction in obesity and the attributable deaths and incident cases of other diet-related NCDs. Nevertheless, to the best of the authors’ knowledge, no study to date has estimated the potential impact of UPF on premature deaths. The findings highlight the importance of dietary patterns on health over a nutrient approach.

Estimating the synergies of nutrients and different foods and their impacts on population health is challenging. Therefore, this study opted to estimate the association between the dietary pattern of UPFs and all-cause mortality. Several lines of observation support this methodologic decision. First, the detrimental health impact of UPF has been extensively described in the literature. For instance, the consumption of UPF has been associated with diabetes, cancer, and cardiovascular disease. Poor nutritional dietary quality; food additives; and other xenobiotics, physical structure, and other attributes of UPF as well as increased risk of obesity and other cardiometabolic risk factors are the major candidates for mediating these health effects.

Given the complexity and plethora of diseases and health outcomes potentially associated with UPF through these mechanisms, it is plausible to assume that a disease-specific approach (e.g., selecting specific diseases that have been associated with UPF consumption) would likely underestimate the total burden of UPF. This is particularly true for a risk factor (or pattern of dietary consumption) that has been proposed in the early 2000s, and therefore only a few cohorts have investigated specific diseases associated with UPFs. Estimating the total burden of a given risk factor in these circumstances is challenging. In contrast, the UPF–all-cause mortality association has been consistently reported in several cohort studies. It is also plausible to assume that a given risk factor associated with all-cause mortality is likely related to several diseases and causes of death, such as smoking and obesity. Of note, all-cause mortality may be a useful marker of the total burden of a given risk factor (the average total net effect). For instance, excess all-cause mortality has been used as a marker of the total burden of the coronavirus disease 2019 (COVID-19) pandemic on population health because during 2020–2022 (versus previous years), an increased COVID-19 and NCDs mortality but lower car accidents and other external causes of death may have occurred. It is worth noting that even though all-cause mortality was used as a surrogate outcome of the total burden of UPF, only premature deaths (age 30–69 years) was used to estimate the absolute number of attributable deaths. In 2019, approximately 72% of premature deaths occurring in Brazil are owing to NCDs, and life expectancy at birth was 76.6 years.

Over the last 2 decades, the contribution of UPF to the total energy intake of the Brazilian population has continuously increased by replacing fresh foods and culinary preparations on the basis of fresh and unprocessed foods. In addition, there is an equity concern in these changes, considering that the consumption of UPF has increased more rapidly among low-income households. The consumption of traditional whole foods and meals, such as rice and beans in Brazil, has gradually decreased, giving place to ready-to-eat UPFs.

Reducing the consumption of UPFs may require multiple interventions and public health measures, such as changing food environments; strengthening the implementation of food-based dietary guidelines; and improving consumer knowledge, attitudes, and behavior. Promoting healthy food environments is key to reducing the intake of UPF by both stimulating the consumption of fresh and minimally processed foods and discouraging UPF, especially through bold fiscal and regulatory policies. Measures may include the regulation of food marketing and sales of foods in school and work environments, the implementation of front-of-package nutritional labeling, subsidies for the production and sales of fresh local foods, and through the taxation of UPF.

The Dietary Guidelines for the Brazilian Population play an important role in the promotion of a healthy diet through intersectoral policies, considering individual-focused and collective interventions by recommending natural or minimally processed foods as the basis of diets and avoiding the consumption of UPFs. These food-based dietary recommendations have been implemented in other national guidelines and supported by international institutions.

Comparative risk assessment models have been extensively validated and replicated in different countries for dietary risk factors and food policies. This is the first simulation model developed to assess the impact of
dietary patterns on the basis of the extent and purpose of food processing. Prevalence of UPF intake was based on the most recent representative national dietary surveys, and mortality and demographic data were obtained from robust national official statistical records. RRs were obtained from a recent meta-analysis on the basis of robust cohort studies in various countries.

Limitations

This study has also some limitations. First, by considering all-cause mortality, it is not possible to disentangle the causes of death attributable to the consumption of UPFs. The model also did not include potential mediators for the possible impacts on all-cause mortality (e.g., reduction in the prevalence of obesity) and assumes the portability of the pooled RR to estimate PAF for Brazil.47 Reverse causation and residual confounding in these RR estimates cannot be excluded. However, the uncertainty of these estimates was incorporated into the model through the Monte Carlo simulations, together with the uncertainties in other inputs to the model.22,48 Compared with more complex modeling approaches, the comparative risk assessment models do not include a time dimension, so the time lag between changes in risk exposure and disease outcomes was not considered. In addition, the model did not account for recurring events or incorporate the influence of interactions between individuals, populations, or their environments and the potential impact on health equality.

Despite these limitations, this model allows a comparable and consistent estimation of premature deaths attributable to the consumption of UPFs. In addition, the model incorporated the population health impact of changing the consumption of UPFs that can be applied to different contexts. Consequently, they can be helpful tools for policymakers to understand the impact of dietary patterns on mortality and to develop context-specific strategies to reduce premature mortality.

CONCLUSIONS

Approximately 57,000 premature deaths were estimated as attributable to the consumption of UPFs in Brazil in 2019. These findings may be useful to assess the overall impact of industrial food processing on preventable deaths. The results also reinforce the recommendations of the Dietary Guidelines for the Brazilian Population, particularly avoiding the consumption of UPFs. Reducing the consumption of UPFs should be a food policy priority to achieve population health gains and reduce premature death in Brazil.


