

## The consumption of ultra-processed foods reduces overall quality of diet in pregnant women

Consumo de alimentos ultraprocessados reduz a qualidade global da dieta de gestantes

El consumo de alimentos ultraprocesados reduce la calidad global de la dieta de gestantes

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### Abstract

*This study analyzed the role of ultra-processed foods (UPFs) in the food and nutritional profile of pregnant women's diet. This was a cross-sectional study conducted in a representative sample of pregnant women attending primary healthcare units in Maceió, capital of the State of Alagoas, Brazil. Food consumption was assessed with the application of two 24-hour food recalls on nonconsecutive days, and the consumption items were grouped according to the NOVA classification. Overall estimates were expressed as absolute dietary consumption (mean calorie intake) and relative consumption (percentage of total energy intake according to food groups and consumption items). Analysis of variance was used to compare mean energy and nutrient intake according to food groups. The association between quintiles of the energy share from UPFs (exposure variable) and (1) consumption items and food groups, (2) percentage of total energy from macronutrients, and (3) micronutrient density was analyzed via adjusted linear regression models. Mean energy intake in pregnant women was 1,966.9Kcal/day, 22% of which from UPFs. A direct relationship was observed between the percentage of energy from UPFs and total energy consumption ( $\beta = 228.78\text{Kcal}$ ;  $SE = 21.26$ ). In addition, an increase in the share of UPFs was associated with a statistically significant reduction in the intake of protein, fiber, magnesium, iron, potassium, zinc, selenium, folate, and vitamins D and E, as well as in the consumption of traditional foods such as protein, beans, roots, and tubers. Our data thus indicate that the consumption of UPFs reduces the overall nutritional and food quality of diet in pregnant women.*

*Industrialized Foods; Food Quality; Food Consumption; Pregnant Women; Nutritional Epidemiology*

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## Introduction

Pregnancy is a period marked by important physiological and metabolic changes that contribute to the increase in vulnerability and inadequacies related to dietary intake and nutritional status <sup>1</sup>. The changes are expressed especially in the increase in demands for some micronutrients, such as iron, folic acid, and zinc, and in the increase in energy needs that vary as a function of pregestational nutritional status. Pregnancy is thus an essential period for the promotion and maintenance of adequate and healthy diet, since it directly impacts the health of the mother and infant <sup>2</sup>.

From an epidemiological perspective, changes in food and nutritional patterns in recent decades include a reduction in the consumption of fruits, vegetables, grains, and legumes and an increase in the intake of high energy-density foods, high in sugar, fat, and sodium <sup>3,4</sup>. This same pattern increases the risk of chronic noncommunicable diseases (NCDs) and is also a major threat during the gestational period and for health conditions in early childhood <sup>5</sup>.

Studies have shown that adequate nutrition during pregnancy is essential for the prevention of negative gestational outcomes <sup>6,7</sup>. Meanwhile, the consumption of ultra-processed foods is associated with maternal obesity <sup>8</sup>, increased gestational weight gain, and neonatal body fat <sup>9</sup>, increasing the risk of cesarean delivery, fetal macrosomia, and large-for-gestational-age newborns (LGA) <sup>10</sup>. Thus, monitoring the nutritional status and dietary pattern of pregnant women has been acknowledged as a priority strategy to promote and protect maternal and infant health <sup>11</sup>.

The NOVA classification has been applied successfully in food consumption studies to describe dietary patterns, assess changes in the consumption of ultra-processed foods (UPFs) over time, and analyze the association between the contribution of these foods and the nutritional profile of diets and health outcomes <sup>5</sup>. UPFs refer to industrial formulations whose manufacturing involves different processing stages and techniques, besides various ingredients which in many cases are only synthesized in laboratories for exclusively industrial use <sup>12,13</sup>.

In Brazil, although the association between the impact of UPFs on quality of diet and nutritional status have been reported in the general population <sup>3,5,14,15</sup>, the availability of information on pregnant women's food consumption is still limited, especially considering adherence to the recommendations from the *Dietary Guide for the Brazilian Population* <sup>12</sup> and the country's regional characteristics. The current study thus aimed to analyze the nutritional profile of the diet of pregnant women enrolled in primary healthcare services in Maceió, the capital of Alagoas State, Brazil, based on the theoretical framework of the NOVA classification.

## Methodology

This was a cross-sectional study conducted in Maceió, from September 2013 to February 2014. The identification of pregnant women treated at primary care units in the public system used two-stage stratified probabilistic sampling. Initially, 50% of the city's primary care units were sampled according to the units' proportional distribution in the eight health districts. Next, the proportional number of pregnant women was calculated to be enrolled in the study according to the number of pregnant women registered in each primary care unit selected in the previous stage.

Calculation of the sample for the finite population ( $n = 8,949$ ) used Epi Info 7 (<https://www.cdc.gov/epiinfo/index.html>), considering the anticipated frequency of the study's primary outcome, excess weight in pregnant women, estimated at 27.5% <sup>16</sup>, adopting a 95% confidence interval (95%CI), 5% margin of error, and additional 10% (for sample losses), resulting in a total of 322 pregnant women.

The study included pregnant women with singleton gestations, living in Maceió, and attending the municipal public healthcare system. Exclusion criteria were physical alterations that might distort the anthropometric evaluation and presence of neurological problems. For the analyses, we excluded pregnant women that lacked data from two 24-hour dietary recalls (24hR) or that had incomplete information on the size of servings, amounts and/or volumes consumed, and type of preparation. The final sample consisted of 295 pregnant women (8.4% losses).

Collection of socioeconomic, clinical, demographic, and dietary data used semi-structured questionnaires applied by trained nutritionists. Anthropometry (weight and height) was performed with a

digital scale, Marte brand LC200 (Marte Científica, São Paulo, Brazil) and portable stadiometer, Wood brand (WCS Tecnologia, Curitiba, Brazil). Classification of the pregnant women's nutritional status, based on body mass index (BMI), was performed as proposed by Atalah et al.<sup>17</sup> and gestational weight gain was analyzed according to the recommendations of the United States Institute of Medicine<sup>18</sup>.

Food consumption data were collected by the application of two 24hR on non-consecutive days. Data included the types of food, modes of consumption, names of the preparations, and whenever possible the ingredients used and the way the food was prepared, as well as the amount consumed in household measurements. The first 24hR was performed during the prenatal interview and the second by telephone, with an interval of one month after the initial collection. For the analysis of food consumption, the amount of each food was transformed into grams or milliliters using household measurement tables for foods and preparations<sup>19,20</sup>.

The nutritional calculation of the 24hR was based on the nutritional composition table of foods consumed in Brazil, used in the *Brazilian Family Budget Survey* (POF) in 2008-2009. When some food or preparation was not found on the table, we opted to consider an equivalent standard food/preparation, consistent with the nutritional characteristics of the original food or preparation. When the amount of sugar added to fruit juices, coffee, tea, and milk was not informed, we standardized it as 10% of the volume consumed, according to the criterion adopted by the Brazilian Institute of Geography and Statistics (IBGE)<sup>21</sup>.

Consumption items were classified according to the four food groups in the NOVA classification: (1) natural or minimally processed foods; (2) cooking ingredients; (3) processed foods; and (4) UPFs<sup>13</sup>. The dishes that were not disaggregated according to their ingredients during application of the 24hR were included in the study as culinary preparations and classified according to the characteristics of their main ingredients. For example, "mozzarella pizza" was listed as belonging to Group 3 and "sausage rolls" as a preparation from Group 4 (Supplementary Material. Box S1. [http://cadernos.ensp.fiocruz.br/static//arquivo/suppl-e00030120-en\\_2855.pdf](http://cadernos.ensp.fiocruz.br/static//arquivo/suppl-e00030120-en_2855.pdf)).

The correction of intraindividual variability used calculation of the mean consumption in the two 24hR. Descriptive statistics were used to analyze absolute food consumption (mean calorie intake) and relative consumption (percentage of total energy intake according to food groups and consumption items) in pregnant women. Analysis of variances with Bonironni post hoc test was used to compare mean energy and nutrient intake according to food groups (Supplementary Material. Table S1. [http://cadernos.ensp.fiocruz.br/static//arquivo/suppl-e00030120-en\\_2855.pdf](http://cadernos.ensp.fiocruz.br/static//arquivo/suppl-e00030120-en_2855.pdf)).

Next, pregnant women were stratified in five groups, corresponding to quintiles of mean energy intake from ultra-processed foods, i.e., energy furnished by Group 4. This stratification was treated in all the models as an ordinal exposure variable.

The association among the quintiles of consumption from UPFs and the percent distribution of total energy intake by food groups and consumption items, as well as total energy and nutrient intake, were analyzed by multivariate linear regression models

Generalized linear models (binomial family and log link function) were used to estimate prevalence ratios (PR) of inadequate intake in relation to quintiles of energy intake from ultra-processed foods. Due to the absence of specific recommendations for pregnant women based on nutrient density, the nutritional guidelines of the World Health Organization (WHO) for the prevention of NCDs<sup>22,23</sup> were used to assess the prevalence of inadequate intake of free sugars, total, saturated, and trans fats, fiber, sodium, and potassium according to quintiles of the share of energy from UPFs. This decision was based on the risks associated with excessive gestational weight gain, gestational diabetes, preeclampsia, macrosomia, and fetal epigenetic alterations<sup>1,24</sup>.

All the analyses were adjusted for maternal age and schooling, whether the woman was receiving a government benefit, and work away from home, selected according to the theoretical framework on the influence on food consumption<sup>2,6,11,21</sup>. Since these factors are considered important in the literature for adjusting the estimates, the entry of these variables into the models was forced.

The nutrient density method was used to fit the total energy intake to the outcome variables. Regression coefficients were presented in their original scale with the respective standard errors (SE) and p-value, or as PR and 95%CI.

All the tests were performed with Stata/MP 13.0 (<https://www.stata.com>), with statistical significance set at p-value < 0.05.

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## Results

The analytical sample included 295 pregnant women from 14 to 43 years of age, with a mean age of 23.7 years ( $\pm 5.9$  SE). Three-fourths were married or in a stable union, 76.8% self-identified as black or brown, and 52.2% and 60.9% had, respectively, up to nine years of schooling and family income of one minimum wage or less. Concerning gestational age, 45.8% of the sample were in the second trimester of pregnancy. As for pregestational nutritional status, 67% began the pregnancy with normal weight, but only 40.5% presented adequate gestational weight gain (Table 1).

The analysis of the 24hR showed that mean energy consumption was 1,966.9Kcal/day, with 56.7% coming from natural or minimally processed foods, 9.7% from cooking ingredients, 11.4% from processed foods, and 22.2% from ultra-processed food products (Table 2).

The natural or minimally processed foods that contributed the most to total energy intake were beef, pork, and poultry (13.4%), fruits (8.8%), protein, pasta, and flours (6.8% each), and beans (6.4%). Importantly, the group of fruits also included juices (from the fruit or pulp), which may have increased the share of energy from this subgroup of foods. The group of pasta and flours also included cornmeal, an ingredient widely consumed in Northeast Brazil as cornmeal couscous. Other cereals, greens/legumes, and innards represented smaller shares of energy consumption (Table 2).

**Table 1**

Demographic, socioeconomic, and anthropometric characteristics of pregnant women attending primary healthcare units in Maceió, Alagoas State, Brazil, 2013-2014 (N = 295).

Variables	n	%
Maternal age (years)		
$\leq 19$	75	25.4
20-34	200	67.8
$\geq 35$	20	6.8
Self-reported skin color		
White	67	23.2
Brown	176	60.9
Black	46	15.9
Marital status		
Single	63	21.6
Married/Stable union	229	78.4
Years of schooling		
$\leq 9$	154	52.2
10-12	127	43.1
$\geq 13$	14	4.7
Work away from home		
Yes	83	28.1
No	212	71.9
Family income (minimum wage)		
$\leq 1$	176	60.9
$> 1$	113	39.1

(continues)

**Table 1 (continued)**

Variables	n	%
Number of family members		
> 5	32	10.8
≤ 5	263	89.2
Poverty line		
Yes	10	3.5
No	279	96.5
Beneficiary of government program		
Yes	131	44.4
No	164	55.6
Access to running water		
Yes	291	98.6
No	4	1.4
Smoking		
Yes	28	9.5
No	267	90.5
First pregnancy		
Yes	120	4.7
No	175	59.3
Gestational age (weeks)		
1st trimester (3-13)	47	15.9
2nd trimester (14-26)	135	45.8
3rd trimester (27-42)	113	38.3
Pregestational BMI		
Underweight	26	9.3
Normal weight	87	67.0
Overweight	42	15.1
Obesity	24	8.6
Gestational weight gain		
Insufficient	98	35.1
Adequate	113	40.5
Excessive	68	24.4
Gestational BMI		
Underweight	50	16.9
Adequate	134	45.9
Overweight	79	26.8
Obesity	32	10.9

BMI: body mass index.

As for cooking ingredients, only three foods could be assessed based on the availability of data in the 24hR. Added sugar, normally used with beverages such as coffee, teas, and juices, contributed 8.8% of the total calorie intake. Bread made the largest share of energy from processed foods (8.7%).

Of the foods comprising the ultra-processed group, cookies, sweets, and salty snacks (e.g., chips) contributed 9.5% of the mean energy intake and were the second leading consumption item in percentage terms of the total energy intake in the pregnant women's diet (Table 2).

Table 3 presents the mean percentage of energy from the food groups and consumption items, according to quintiles of energy intake from UPFs. These analyses showed an inverse and statistically significant association with natural and minimally processed foods such as protein, beans, meat, eggs, roots and tubers, fruits, greens, and legumes. The consumption pattern of ultra-processed foods showed that the share of energy from the highest quintile was 8.2 times that of the lowest; in absolute

**Table 2**

Mean absolute and relative consumption of natural or minimally processed foods, cooking ingredients, processed foods, and ultra-processed foods in pregnant women attending primary healthcare units in Maceió, Alagoas State, Brazil, 2013-2014 (N = 295).

Food groups and consumption items	Kcal/day	% total energy intake
Natural or minimally processed foods	1,102.9	56.7
Beef, pork, and poultry	263.4	13.4
Fruits *	171.8	8.8
Rice	125.9	6.8
Pasta and flours **	142.8	6.8
Beans	122.5	6.4
Roots and tubers	76.3	3.8
Culinary preparations ***	49.6	2.7
Milk and natural yogurt	46.9	2.5
Eggs	32.7	1.7
Coffee and teas	29.1	1.5
Fish and seafood	24.1	1.3
Innards	12.5	0.7
Greens and legumes	4.0	0.2
Other cereals and grains #	1.3	0.1
Cooking ingredients	191.6	9.7
Added sugar and honey	174.5	8.8
Butter	17.1	0.9
Processed foods	221.8	11.4
Bread	166.7	8.7
Salted meats	36.9	1.8
Cheese	10.0	0.5
Culinary preparations based on processed foods	6.2	0.3
Canned goods	2.0	0.1
Ultra-processed foods	450.6	22.2
Cookies, sweets, crackers, and chip-type salty snacks	193.1	9.5
Sweets, cakes, and pies	49.4	2.4
Cold cuts	44.3	2.3
Sodas and sugary beverages	43.3	2.2
Culinary preparations based on ultra-processed foods	41.1	2.0
Sweetened dairy beverages	34.7	1.7
Margarine	23.4	1.0
Ready-to-eat or semi-ready-to-eat dishes ##	19.7	1.0
Sauces/Dressings	1.6	0.1
<b>Total</b>	<b>1,966.9</b>	<b>100.0</b>

\* Includes fruit and fruit pulp juices;

\*\* Manioc flour, cornmeal, tapioca, and macaroni;

\*\*\* Based on natural or minimally processed foods.;

# Oatmeal, linseed, granola, and Brazil nuts;

## Frozen French fries, hamburger, frozen lasagna, frozen chicken, and instant noodles.

terms, the mean difference in pregnant women's energy intake between the first and fifth quintiles was 882.4Kcal. Finally, the share of energy from natural or minimally processed foods compared to ultra-processed foods among women in the last quintile was practically 1:1.

Except for margarine and sauces/dressings, all the categories of UPFs increased significantly from the first to the fifth quintiles. An inverse trend was seen in the consumption of bread in the group of processed foods. For the other categories of foods, there was no significant variation between the quintiles of consumption of ultra-processed products (Table 3).

The dynamics in the share of energy from food groups and consumption items, according to quintiles of energy intake from UPFs (Table 3), is also reflected in the food consumption nutritional indicators (Supplementary Material. Table S1. [http://cadernos.ensp.fiocruz.br/static//arquivo/suppl-e00030120-en\\_2855.pdf](http://cadernos.ensp.fiocruz.br/static//arquivo/suppl-e00030120-en_2855.pdf)). As for distribution of macronutrients, the share of UPFs, when compared to the share of the diet from natural or minimally processed foods, had nearly double the amount of free sugar, more fats in general, including saturated fat, and eight times more trans fat. This same pattern was seen in the mean difference in micronutrient intake: potassium (1.131mg), iron (3mg), selenium (39.5mcg), magnesium (90.4mg), vitamin A (771.9mcg), vitamin C (1,070.2mg), and folate (141.2mcg) (Supplementary Material. Table S1. [http://cadernos.ensp.fiocruz.br/static//arquivo/suppl-e00030120-en\\_2855.pdf](http://cadernos.ensp.fiocruz.br/static//arquivo/suppl-e00030120-en_2855.pdf)).

**Table 3**

Distribution (%) of total energy intake according to food groups and consumption items in strata of pregnant women attending primary healthcare services in Maceió, Alagoas State, Brazil, corresponding to quintiles (Q1, Q2, Q3, Q4, Q5) of consumption of ultra-processed foods, 2013-2014 (N = 295).

Food groups and consumption items	Quintiles of energy intake from ultra-processed foods					$\beta$ (SE)	p-value *
	(% of total energy)						
	Q1 **	Q2 **	Q3 **	Q4 **	Q5 **		
Natural or minimally processed foods	74.4	62.7	53.4	51.2	41.7	-7.71 (0.50)	< 0.001
Rice	9.8	7.3	6.8	5.9	4.3	-1.19 (0.23)	< 0.001
Beans	7.3	7.4	6.1	6.0	5.1	-0.53 (0.19)	0.006
Beef, pork, and poultry	20.0	14.2	12.1	12.3	8.3	-2.62 (0.38)	< 0.001
Innards	1.0	0.8	0.6	0.5	0.5	-0.13 (0.09)	0.178
Eggs	2.7	1.9	1.4	1.5	1.2	-0.33 (0.11)	0.005
Fish and seafood	1.5	1.2	1.1	1.5	1.0	-0.03 (0.15)	0.824
Roots and tubers	6.2	4.1	3.0	3.1	2.4	-0.85 (0.26)	0.002
Pastas and flours ***	6.2	8.4	6.0	6.9	6.7	-0.13 (0.30)	0.666
Milk and natural yogurt	3.3	2.0	2.7	1.9	2.6	-0.15 (0.17)	0.388
Coffee and teas	1.2	2.0	2.0	1.2	1.0	-0.11 (0.07)	0.123
Fruits #	10.8	10.1	8.8	7.9	6.4	-1.09 (0.26)	< 0.001
Greens and legumes	0.4	0.3	0.2	0.2	0.1	-0.07 (0.02)	0.002
Other cereals and grains ##	0.0	0.2	0.1	0.0	0.0	-0.01 (0.02)	0.592
Culinary preparations ###	4.0	2.8	2.5	2.3	2.1	-0.41 (0.20)	0.040
Cooking ingredients	9.1	10.9	10.7	9.5	8.1	-0.40 (0.21)	0.059
Added sugar and honey	8.6	9.5	9.7	8.6	7.5	-0.33 (0.20)	0.098
Butter	0.5	1.4	1.0	0.9	0.6	-0.06 (0.07)	0.359
Processed foods	11.6	11.5	14.3	9.7	10.1	-0.48 (0.39)	0.221
Salted meats	1.3	1.4	2.7	1.2	2.2	0.23 (0.21)	0.276
Preserves	0.3	0.1	0.0	0.1	0.0	-0.04 (0.02)	0.117
Cheese	0.5	0.6	0.7	0.3	0.5	-0.01 (0.06)	0.796
Bread	9.3	9.3	10.3	7.9	7.0	-0.70 (0.32)	0.030
Culinary preparations §	0.2	0.1	0.6	0.2	0.4	0.04 (0.07)	0.493

(continues)

Table 3 (continued)

Food groups and consumption items	Quintiles of energy intake from ultra-processed foods (% of total energy)					$\beta$ (SE)	p-value *
	Q1 **	Q2 **	Q3 **	Q4 **	Q5 **		
Ultra-processed foods	4.9	14.9	21.6	29.6	40.1	8.60 (0.32)	< 0.001
Sodas	0.5	1.3	2.7	2.4	4.1	0.84 (0.13)	< 0.001
Cold cuts	1.1	2.0	2.3	2.0	3.8	0.52 (0.16)	0.001
Margarine	0.4	0.6	2.0	1.0	1.3	0.21 (0.12)	0.086
Sweetened dairy beverages	0.3	1.2	0.9	3.6	2.8	0.74 (0.15)	< 0.001
Ready-to-eat or semi-ready-to-eat dishes <sup>§§</sup>	0.1	0.8	1.0	2.2	1.0	0.34 (0.13)	0.010
Sauces/Dressings	0.0	0.0	0.0	0.3	0.1	0.05 (0.03)	0.072
Sweets, cakes, and pies	0.5	1.3	2.4	3.0	4.7	1.06 (0.19)	< 0.001
Cookies <sup>§§§</sup>	1.7	6.3	8.4	12.9	18.1	3.94 (0.33)	< 0.001
Culinary preparations <sup>†</sup>	0.3	1.4	1.9	2.2	4.2	0.86 (0.16)	< 0.001
<b>Total</b>	100.0	100.0	100.0	100.0	100.0	-	-

SE: standard error.

\* Obtained by multivariate linear regression model adjusted for age, government benefit, schooling, and work away from home;

\*\* Means and 95% confidence intervals for quintiles of energy intake from ultra-processed foods: Q1 = 72.4Kcal (59.7-85.1); Q2 = 245.1Kcal (231.8-258.5); Q3 = 398.9Kcal (389.2-408.6); Q4 = 583.4Kcal (565.3-601.5); Q5 = 954.8Kcal (894.9-1.010.7);

\*\*\* Manioc flour, cornmeal, tapioca, and macaroni;

# Includes fruit and fruit pulp juices;

## Oatmeal, linseed, granola, and Brazil nuts;

### Based on natural or minimally processed foods;

§ Based on processed foods;

§§ Frozen French fries, hamburger, frozen lasagna, frozen chicken, and instant noodles;

§§§ Cookies, sweets, crackers, and chip-type salty snacks;

† Based on ultra-processed foods.

The analyses of indicators of the diet's nutritional profile according to quintiles of energy from UPFs (Table 4) identified a positive and statistically significant exposure-response relationship between total energy intake and percentage of energy from UPFs (228.78Kcal; SE = 21.26); there was a mean difference of 962.2Kcal (163%) between the first and fifth quintiles. Besides energy intake, this same relationship was reproduced in the consumption of free sugar (1.6%; SE = 0.33), total fat (0.77%; SE = 0.24), saturated fat (0.29%; SE = 0.10), and trans fat (0.33%; SE = 0.04).

An inverse exposure-response relationship was identified for protein (-1.15%; SE = 0.16), fiber (-0.55g; SE = 0.11), magnesium (-5.40mg; SE = 1.00), iron (-0.15mg; SE = 0.06), sodium (-51.22mg; SE = 14.66), potassium (-83.72mg; SE = 11.15), zinc (-0.35mg; SE = 0.06), selenium (-3.23mcg; SE = 0.84), folate (-6.71mcg; SE = 2.11), vitamin D (-0.08mcg; SE = 0.03), and vitamin E (-0.14mg; SE = 0.02). For carbohydrates, calcium, copper, and vitamins A and C, there was no statistically significant variation in the quintiles of consumption of ultra-processed foods, but vitamin A intake in the first quintile was almost double the intake in the last quintile.

Table 5 shows the prevalence of inadequate nutrient intake according to quintiles of energy intake from ultra-processed foods. Independently of the fraction of ultra-processed food consumption, the prevalence of inadequate critical nutrient intake according to WHO recommendations was very high. In the case of trans fats, the increase in the prevalence of inadequate nutrient intake was positively associated with higher energy intake from ultra-processed foods (RP = 1.54; 95%CI: 1.37-1.72); the relative difference between the first and fifth quintiles was 240%.

**Table 4**

Mean indicators of dietary consumption in pregnant women attending primary healthcare units in Maceió, Alagoas State, Brazil, corresponding to quintiles (Q1, Q2, Q3, Q4, Q5) of consumption of ultra-processed foods, 2013-2014 (N = 295).

Indicator	Quintile of consumption of ultra-processed foods (% total energy)					$\beta$ (SE)	p-value *
	Q1	Q2	Q3	Q4	Q5		
<b>Total energy (Kcal/day)</b>	1,532.5	1,733.9	1,932.3	2,141.4	2,494.7	228.78 (21.26)	< 0.001
Percentage of total energy from							
Protein	19.1	16.7	15.4	15.2	13.9	-1.15 (0.16)	< 0.001
Carbohydrates	56.6	59.1	57.7	57.6	58.8	0.26 (0.34)	0.440
Free sugars	20.9	23.7	25.2	25.7	28.0	1.60 (0.33)	< 0.001
Total fats	24.9	24.8	27.1	27.0	27.6	0.77 (0.24)	0.002
Saturated fat	8.4	8.6	9.6	9.2	9.6	0.29 (0.10)	0.005
Trans fat	0.9	1.1	1.8	1.8	2.3	0.33 (0.04)	< 0.001
Nutrient density							
Fiber (g/1,000Kcal)	10.1	9.7	8.6	8.5	7.8	-0.55 (0.11)	< 0.001
Calcium (mg/1,000Kcal)	248.1	239.2	244.8	242.5	244.2	-0.13 (4.74)	0.977
Magnesium (mg/1,000Kcal)	132.8	127.7	113.3	116.0	110.1	-5.40 (1.00)	< 0.001
Iron (mg/1,000Kcal)	5.6	5.5	5.0	4.9	5.0	-0.15 (0.06)	0.011
Sodium (mg/1,000Kcal)	1,676.8	1,599.5	1,586.6	1,472.2	1,472.8	-51.22 (14.66)	0.001
Potassium (mg/1,000Kcal)	1,365.4	1,180.8	1,086.0	1,068.3	988.7	-83.72 (11.15)	< 0.001
Copper (mg/1,000Kcal)	1.2	1.0	0.9	0.8	0.8	-0.10 (0.06)	0.140
Zinc (mg/1,000Kcal)	5.9	5.3	5.1	4.7	4.5	-0.35 (0.06)	< 0.001
Selenium (mcg/1,000Kcal)	48.5	47.2	37.9	40.8	35.2	-3.23 (0.84)	< 0.001
Vitamin A (mcg/1,000Kcal)	849.8	569.7	555.5	449.7	469.4	-84.86 (46.82)	0.071
Folate (mcg/1,000Kcal)	126.3	132.8	111.2	107.2	104.0	-6.71 (2.11)	0.002
Vitamin D (mcg/1,000Kcal)	1.7	1.4	1.4	1.4	1.3	-0.08 (0.03)	0.031
Vitamin E (mg/1,000Kcal)	2.2	1.8	1.7	1.7	1.5	-0.14 (0.02)	< 0.001
Vitamin C (mg/1,000Kcal)	546.6	553.2	466.1	465.3	499.5	-14.30 (36.49)	0.695

SE: standard error.

\* Obtained by multivariate linear regression model adjusted for age, government benefit, schooling, and work away from home.

## Discussion

This study analyzed the nutritional profile of diet in pregnant women attending primary healthcare services in Maceió, with the NOVA classification as the theoretical reference, based on extensive scientific evidence and which has consistently demonstrated the association between diet and health events, besides adhering to public policies on food and nutrition in Brazil<sup>5</sup>. As far as we know, this was the first study to employ this approach to assess pregnant women's diet in a state capital in Northeast Brazil.

The study's results showed that UPFs represented a large share of total energy intake in the pregnant women's diet (22.2%), and that as this share increased in the diet, there was a reduction in nutritional quality. Comparing the extremes of UPF consumption (first and fifth quintiles), there was a difference of nearly 1,000Kcal/day.

Another finding in the study was the lower consumption of traditional Brazilian foods by pregnant women, such as protein, beans, roots, and tubers, since energy intake from ultra-processed food products increased, evidencing the potential negative effect of the consumption of UPFs on regional food culture, further adding to the evidence demonstrating that UPFs represent a nutritional profile that contributes to NCDs<sup>3,15</sup>.

**Table 5**

Prevalence of inadequate nutrient intake in strata in pregnant women attending primary healthcare units in Maceió, Alagoas, Brazil, corresponding to quintiles (Q1, Q2, Q3, Q4, Q5) of consumption of ultra-processed foods, 2013-2014 (N = 295).

Indicator	Recommended values for indicators	Total	Prevalence of inadequate intake according to quintile of consumption of ultra-processed foods (%)					PR	95%CI
			Q1	Q2	Q3	Q4	Q5		
Percentage of total energy from									
Total sugars	≥ 10 *	97.3	89.8	96.6	100	100	100	**	**
Total fats	15-30 *	26.8	23.7	28.8	28.8	28.8	23.7	1.0	1.05-0.95
Saturated fat	≥ 10 *	34.2	30.5	28.8	38.9	35.6	37.3	1.04	1.09-0.97
Trans fat	< 1 *	63.4	25.4	55.9	72.9	76.3	86.4	1.54 ***	1.37-1.72
Nutrient density									
Fiber (g/1,000Kcal)	< 10 *,#	92.5	89.8	81.4	94.9	96.6	100	**	**
Sodium (mg/1,000Kcal)	≥ 1,000 ##	96.5	98.3	98.3	96.6	96.6	94.9	**	**
Potassium (mg/1,000Kcal)	< 1.755 ##	96.5	86.4	98.3	100.0	100.0	100.0	**	**

95%CI: 95% confidence interval; PR: prevalence ratio.

\* Values based on World Health Organization <sup>22</sup>;

\*\* The PR could not be calculated due to the high prevalence of inadequate intake, which thus prevented regression due to the presence of places with few observations;

\*\*\* p-value < 0.001 for linear trend between quintiles of consumption of ultra-processed foods;

# The value for the recommendation is based on a diet of 2,000Kcal;

## Values based on World Health Organization <sup>23</sup>.

The Brazilian population's diet has changed in recent years. The percentage of energy from UPFs has increased while that of natural or minimally processed foods has decreased, mirroring the global food and nutritional transition related to demographic, technological, economic, and environmental changes <sup>5,25,26</sup>. Different studies pointed to deteriorating quality of diet as the result of higher consumption of ultra-processed foods, expressed by the increase in the amount of free sugar, sodium, and total, saturated, and trans fats and the reduction in the share of fiber, protein, and micronutrients, proportional to the energy share of UPFs in total calorie content in different populations <sup>3,5,14,15</sup>.

These changes in dietary patterns are worrisome, because inadequate dietary intake during pregnancy can alter the intrauterine environment and adversely affect placental development, in addition to fetal development and growth <sup>1</sup>, besides increasing the risk of gestational diabetes, hypertensive syndromes, nutritional deficiencies, and excessive gestational weight gain, compromising the health of the mother/infant dyad and favoring long-term emergence of NCDs <sup>24</sup>.

Concerning the share of ultra-processed foods in the diet, the current study's data are consistent with those of Louzada et al. <sup>15</sup>, who assessed the nutritional profile of the Brazilian population's diet and showed that mean daily energy intake was 1,896Kcal, of which 58.1% came from unprocessed/minimally processed foods, 10.9% from cooking ingredients, 10.6% from processed foods, and 20.4% from ultra-processed foods.

Despite the studies' similarity, the consumption of ultra-processed foods varies widely according to the country's economic level. Such consumption tends to be greater in high-income countries compared to low and middle-income countries <sup>5,8</sup>. Studies in different countries show wide variability in the percent consumption of ultra-processed foods: United States, 56.1% <sup>27</sup>; United Kingdom, 56.8% <sup>28</sup>; Canada, 48% <sup>29</sup>; and France, 35.9% <sup>30</sup>.

Studies with this approach in pregnant women are still scarce, but data from a longitudinal study in the United States showed that 54.4% of pregnant women's energy intake came from UPFs, and that this percentage was associated with the increase in gestational weight gain and the newborn infant's body fat, thus making such consumption an efficient predictor of maternal and neonatal health

outcomes<sup>9</sup>. In Brazil, Gomes et al.<sup>31</sup> identified 24.6% of energy consumption from ultra-processed foods in the diet of pregnant women attending primary care units in São Paulo, while other studies in South and Southeast Brazil found a higher energy share from ultra-processed foods: 38% in Rio Grande do Sul<sup>32</sup>; 32% in São Paulo<sup>8</sup>; and 41.3% in Rio de Janeiro<sup>25</sup>.

As in the comparison between countries, the level of economic development in Brazil's states appears to influence the proportions of consumption of ultra-processed foods. The differences may be associated with socioeconomic and cultural issues and food choices, especially in studies conducted in other countries besides Brazil<sup>5,33</sup>. Our results thus corroborate this tendency.

Meanwhile, the NOVA classification is a recent approach, and the methodological procedures for its application to epidemiological studies are still being consolidated, which can also influence the discrepancies between the studies' results<sup>8</sup>.

Although pregnancy is an important period in the woman's life and diet plays a crucial role in maternal and fetal health, pregnant women's dietary pattern was similar to that of the general population, demonstrating that these women are vulnerable to the changes in food systems that have promoted the food and nutritional transition in the Brazilian population<sup>26</sup>. Importantly, gestation is a favorable period for changes in the dietary pattern<sup>32</sup> due to the mother's concern for her child's health and closer contact with health services during prenatal care, since coverage of this service is practically universal in all regions of Brazil, considering the different demographic, social, and reproductive characteristics<sup>34</sup>.

Based on the above, the problem is probably not related to the coverage of prenatal care per se, but to the quality of the care provided. Studies have shown that the quality of access (initiation of prenatal care, number of visits, and performance of basic procedures) is still inadequate in various regions of Brazil, especially for economically and socially underprivileged groups<sup>34,35</sup>. A study in Rio de Janeiro identified the deficiency of prenatal services in relation to the promotion of healthy diet, since fewer than 40% of pregnant women received specific orientation on diet and adequate weight gain in pregnancy<sup>36</sup>.

It is known that food choices are not defined exclusively by physiological and/or nutritional needs. Rather, they also receive the direct influence of various environmental, cultural, and socioeconomic factors, such as accessibility, availability, quality, advertising, and food prices<sup>37</sup>. One can also cite convenience and attractiveness: when accompanied by aggressive marketing, the latter favor an increase in the sales of ultra-processed foods in middle-income countries like Brazil<sup>5</sup>.

There is thus systematic and wide-reaching stimulus for changes in food consumption patterns towards the consumption of ultra-processed food products/meals, which have the effect of replacing natural or minimally processed foods and homecooked meals (associated with a healthier dietary pattern)<sup>5</sup>. This became evident in the current study, showing lower consumption of culturally important foods from the natural or minimally processed group by women in the upper quintile of energy intake from ultra-processed foods.

These changes in dietary patterns help explain the new epidemiological scenario in regions historically affected by malnutrition, since UPFs have characteristics that contribute to the development of obesity and other NCDs<sup>3,5,8</sup>. The phenomenon of "high-calorie malnutrition", caused by higher consumption of foods with high calorie density and low nutritional quality, tends to increase the risk of vitamin and mineral deficiencies<sup>38</sup>, especially in more vulnerable groups like pregnant women and children, creating one of the most serious nutritional problems in low and middle-income countries<sup>14</sup>. In addition, pregnant women present greater nutritional requirements to favor the pregnancy's outcome and foster optimal fetal growth and development<sup>1</sup>.

Considering pregnant women's socioeconomic conditions, the risk of dietary and nutritional deficiencies is even more worrisome, since low socioeconomic status can affect pregnancy outcomes, both directly (via increased responses to stress, inflammation, and/or susceptibility to infection) and indirectly (via a decrease in timely access to healthcare)<sup>33</sup>. A study in Recife, Pernambuco State, found that low maternal schooling was closely associated with excessive gestational weight gain and that pregnant women with lower purchasing power prioritized the consumption of more caloric foods such as ultra-processed products<sup>39</sup>.

Concerning the impact of this kind of dietary behavior on pregnancy, a review (that included human and animal studies) showed that excessive intake of saturated fatty acids appears to trig-

ger alterations in liver function and adipose tissue associated with insulin resistance and diabetes, and that trans fatty acids can have harmful health effects through the increased lifetime risk of developing metabolic disorders<sup>40</sup>. As for the consumption of trans fat during pregnancy, a study of 6,695 pregnant women and their newborns found that higher plasma concentration of trans fatty acids during pregnancy was associated with lower birthweight, lower placental weight, and higher risk of preeclampsia<sup>41</sup>.

Excessive consumption of added sugar not only contributes to increased calorie intake and thus reduced consumption of foods with better nutritional composition, but has also been associated with increased risk of weight gain and obesity in the general population<sup>42,43</sup> and in pregnant women with increased adipose tissue in the offspring, gestational weight gain, and greater risk of gestational diabetes<sup>44,45</sup>. The WHO recommends daily intake of added sugars less than 10% of total calories, and there is no specific recommendation on consumption of added sugar during pregnancy<sup>43</sup>.

As for consumption of fiber and micronutrients, the study's results reflect an unhealthier diet. Pregnant women are normally more vulnerable to nutritional inadequacies and are unable to meet dietary and nutrient intake recommendations for the gestational period, thus compromising maternal and fetal nutrition<sup>25</sup>. This became even more evident due to the high prevalence of inadequate intake of the target nutrients, particularly relevant with the higher consumption of ultra-processed foods. Therefore, future studies in pregnant women should complement the analyses of dietary data with the use of vitamin and mineral supplements. More studies are also necessary that assess specific nutritional guidelines for pregnant women.

A review provided evidence on the impact of dietary and supplementary intake of zinc, folate, calcium, and vitamin D during pregnancy, as well as dietary patterns, on infant birthweight. The study found that dietary intake below the guidelines is frequent not only in developing countries like Brazil but also in developed countries, independently of maternal BMI. The most promising results were from the analyses of dietary patterns and not those of nutrient supplementation, emphasizing the importance of consuming whole foods, including fruits, vegetables, whole grains, low-fat dairy products, and lean meat, with a positive effect on birthweight<sup>46</sup>.

This analysis on the positive effect of healthier dietary patterns corroborates the *Dietary Guidelines for the Brazilian Population*<sup>12</sup>, which recommend avoiding consumption of ultra-processed products and prioritizing a diet high in natural or minimally processed foods, as well as meals cooked with these foods. The guidelines can promote health and guarantee more adequate nutrition for pregnant women, facilitating the process of dietary and nutritional education in the family context.

As in the study by Louzada et al.<sup>3</sup>, the high sodium content in the three main food groups and the significant inverse association between higher consumption of ultra-processed foods and lower sodium intake show that excessive consumption of this mineral in Brazil is caused not only by the consumption of industrialized products, but also by excessive addition of salt to meals. Note that it was not possible to measure the amount of salt added to the culinary preparations, and that these data were taken from the food composition table used in the study. Given the difficulty in obtaining accurate information, the measurement of sodium intake is a common limitation in food consumption studies. As an alternative, some studies have adopted 24-hour urinary sodium excretion (gold standard method) to improve the accuracy of this electrolyte's assessment, but its operationalization and costs limit its adoption in population-based studies<sup>47</sup>.

Another common limitation to studies on food consumption is the difficulty in establishing the amounts and ingredients in the recipes, which prevented breaking down the recipes into their constituent ingredients, potentially impacting the accuracy of the dietary assessment. Furthermore, since at the time the data collection was planned, the NOVA classification had still not been consolidated, the data collection instrument was not designed to assess foods according to the degree of industrial processing, which may have led to incorrect classification of some food items.

To minimize these biases, rigorous quality control procedures were applied to the collected data, and inconsistent records were not included in the sample. The above-mentioned limitation notwithstanding, the data were collected by trained nutritionists, and the use of two 24hR contributed to the reduction in the intraindividual variability of consumption and improvement in the estimates' accuracy and precision. Besides, the choice of the IBGE nutritional composition table allowed comparison of our estimates to those of other studies and was aligned with Brazil's culinary habits.

This study provided evidence that the proportion of consumption of ultra-processed foods determines the overall nutritional quality of diet for pregnant women attending primary care services and underscores the urgent need for remodeling food systems and the adoption of better strategies for food and nutritional education for the population, especially in countries like Brazil with high rates of obesity, diabetes, and other NCDs, jointly with contexts of micronutrient deficiencies, especially among pregnant women.

### Contributors

N. G. Graciliano contributed to the study's conception and design, data analysis and interpretation, writing of the article, and approval of the final version for publication. J. A. C. Silveira and A. C. M. Oliveira contributed to the study's conception and design, data analysis and interpretation, critical revision, and approval of the final version for publication.

### Additional informations

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## Resumo

*Este trabalho analisou a contribuição dos alimentos ultraprocessados (AUP) no perfil alimentar e nutricional da dieta de gestantes. Trata-se de um estudo transversal conduzido com uma amostra representativa de gestantes usuárias de unidades básicas de saúde de Maceió, Alagoas, Brasil. O consumo alimentar foi avaliado pela aplicação de dois recordatórios de 24 horas em dias não consecutivos e os itens de consumo agrupados segundo a classificação NOVA. As estimativas gerais foram expressas no consumo alimentar absoluto (média de ingestão calórica) e relativo (percentual da ingestão energética total segundo grupos de alimentos e itens de consumo). Análises de variâncias foram utilizadas para comparar as médias do consumo energético e de nutrientes, segundo grupos alimentares. A associação entre os quintis de contribuição energética dos AUP (variável de exposição) e (1) itens de consumo e grupos alimentares, (2) contribuição percentual para o total de energia de macronutrientes e (3) densidade de micronutrientes foi analisada por meio de modelos ajustados de regressão linear. O consumo médio de energia das gestantes foi de 1.966,9Kcal/dia, sendo 22% proveniente dos AUP. Observou-se relação direta entre a contribuição energética dos AUP na dieta e o consumo energético total ( $\beta = 228,78\text{Kcal}$ ;  $EP = 21,26$ ). Ainda, o aumento da participação de AUP implicou a redução estatisticamente significativa da ingestão de proteínas, fibras, magnésio, ferro, potássio, zinco, selênio, folato e vitaminas D e E, assim como o consumo de alimentos tradicionais, como arroz, feijão, raízes e tubérculos. Portanto, nossos dados apontam que o consumo de AUP reduz a qualidade global (nutricional e alimentar) da dieta de gestantes.*

*Alimentos Industrializados; Qualidade dos Alimentos; Consumo de Alimentos; Gestantes; Epidemiologia Nutricional*

## Resumen

*Este estudio analizó la contribución de los alimentos ultraprocessados (AUP) al perfil alimentario y nutricional de la dieta de gestantes. Se trata de un estudio transversal, realizado con una muestra representativa de gestantes usuarias de unidades básicas de salud de Maceió, Alagoas, Brasil. El consumo alimentario se evaluó mediante la aplicación de dos recordatorios de 24 horas en días no consecutivos y los ítems de consumo agrupados según la clasificación NOVA. Las estimaciones generales fueron expresadas en el consumo alimentario absoluto (media de ingestión calórica) y relativo (porcentaje de la ingestión energética total según grupos de alimentos e ítems de consumo). Se utilizaron análisis de variancias para comparar las medias del consumo energético y de nutrientes, según grupos alimentarios. La asociación entre los quintiles de contribución energética de los AUP (variable de exposición) y (1) ítems de consumo y grupos alimentarios, (2) porcentaje de contribución para el total de energía de macronutrientes y (3) se analizó la densidad de micronutrientes mediante modelos ajustados de regresión lineal. El consumo medio de energía de las gestantes fue 1.966,9Kcal/día, siendo un 22% proveniente de los AUP. Se observó una relación directa entre la contribución energética de los AUP en la dieta y el consumo energético total ( $\beta = 228,78\text{Kcal}$ ;  $EP = 21,26$ ). Asimismo, el aumento de la participación de AUP implicó la reducción estadísticamente significativa de la ingestión de proteínas, fibras, magnesium, hierro, potasio, zinc, selenio, folato y vitaminas D y E, así como en el consumo de alimentos tradicionales como: arroz, frijoles, raíces y tubérculos. Por tanto, nuestros datos apuntan que el consumo de AUP reduce la calidad global (nutricional y alimentaria) de la dieta de gestantes.*

*Alimentos Industrializados; Calidad de los Alimentos; Consumo de Alimentos; Gestantes; Epidemiologia Nutricional*

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