Maternal consumption of ultra-processed foods and newborn exposure to perfluoroalkyl substances (PFAS)

O consumo materno de alimentos ultraprocessados e exposição intrauterina a compostos perfluoroalquil (PFAS)

Consumo materno de comidas ultraprocesadas y exposición de recién nacidos a sustancias perfluoroalquílicas (PFAS)

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Abstract

Evolving evidence shows that ultra-processed food consumption may increase exposure to chemicals used in food packaging and production, such as per- and poly-fluoroalkyl substances, phthalates, and bisphenols. Studies suggested that these contaminants may be transferred from mother to child through placenta, increasing concerns for both maternal and child health. This study aimed to investigate the association of maternal consumption of ultra-processed foods with newborn exposure to perfluoroalkyl substances (PFAS) in the PIPA Project (The Rio Birth Cohort Study on Environmental Exposure and Childhood Development). The pilot cohort study conducted with 131 pregnant women-child pairs in a public maternity school in Rio de Janeiro, Brazil, was assessed. Maternal dietary intake in the third trimester of pregnancy was evaluated using a qualitative food frequency questionnaire. Food items were classified as non-ultra-processed food and ultra-processed food using the NOVA system and regular consumption of ultra-processed foods was estimated. Newborns of pregnant women who weekly consumed three or more subgroups of ultra-processed food presented the highest level of PFAS (2.47ng/mL; 95%CI: 1.22; 3.72), compared to non-consumption of ultra-processed food investigated (0 ultra-processed food = 1.86ng/mL; 95%CI: 1.38; 2.50). Additionally, cluster analysis grouped ultra-processed food, fish, and PFAS levels. In conclusion, we found increased levels of PFAS in newborns whose mothers were higher consumers of ultra-processed foods.

Food Processing; Pregnancy; Dietary Exposure; Endocrine Disruptors

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Introduction

Ultra-processed foods are becoming dominant in diets worldwide [1]. These are formulations manufactured from substances derived from foods (e.g. sugars, hydrogenated oil, high fructose corn syrup, protein isolates, and other chemically altered ingredients), with little or any whole food and they typically include flavors, colors, and other additives [2]. Evidence for the health implications of ultra-processing is rapidly increasing, and adverse health outcomes associated with their consumption include obesity, cardiovascular diseases, cancer, and mortality [3]. Some of these studies have hypothesized that ultra-processed foods may be linked to the exposure to endocrine-disrupting chemicals, which can lead to adverse health outcomes since ultra-processed foods are often packaged in synthetic materials containing chemicals, such as bisphenol-A and phthalates [4].

There is growing interest in how maternal diet and lifestyle factors during the fetal period are related to long-lasting fetal programming and how this factors affect the risk of non-communicable diseases in adulthood [5]. Particularly, dietary contaminants may be transferred from mother to child through the placenta, increasing concerns for maternal and child health [6].

Brazilian studies found high consumption of ultra-processed foods among pregnant women [7]. A previous study using data from The *Rio Birth Cohort on Environmental Exposure and Childhood Development* – PIPA Project [8] found that more than one-third of women reported weekly consumption of ultra-processed foods like sausages, fast foods, and packaged ready meals [7]. Higher maternal exposure to phthalates has been associated with higher fetal exposure to these compounds and child's metabolic dysfunction [9]. Nevertheless, how maternal diet is associated with child's exposure to contaminants commonly presented in ultra-processed foods is unknown. This study aimed to investigate the association of maternal consumption of ultra-processed foods with newborn exposure to perfluoroalkyl substances (PFAS) in the PIPA Project.

Methodology

Data from the PIPA Project conducted in a public maternity in Rio de Janeiro, Brazil, and composed of 131 pregnant women-child pairs were assessed. Briefly, women during the third trimester of pregnancy were enrolled in a birth cohort to investigate the effects of environmental pollutants on maternal-child health. Data on socio-demographics, diet, lifestyle, and other information were collected by trained interviewers using broader questionnaires. Additional information on the study population can be found elsewhere [8]. This study included 118 mothers aged over 16 years of age, who informed free consent, had data on diet assessed, and cord blood samples suitable for analysis.

Extensive information on the diet of this population can be found elsewhere [7]. Particularly interesting, maternal regular consumption of ultra-processed food was estimated by the consumption of sausage and other reconstituted meat products ($\geq$ 3 times/week), fast food meals ($\geq$ 1 time/week), and packaged ready meals ($\geq$ 1 time/week) (other ultra-processed food subgroups were not assessed in the cohort). Regular consumption of non- ultra-processed foods ($\geq$ 5 times/week for fruits, vegetables, rice, and beans; and $\geq$ 3 times/week for meats, eggs, and fish) was also estimated.

Perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) were determined in the 118 umbilical cord blood samples. Serum samples were stored at -40°C in polypropylene bottles and the triple quadrupole mass spectrometer with an API 3200 electrospray source (Applied Biosystems, Foster City, United States) was used to detect the analytes. At these conditions, the retention times were 6.9 minutes for PFOA, and 7.5 for PFOS. Due to the low detection rate of PFOA found in this population (16.1%) that leads to a small sample size within the ultra-processed food consumption strata, we will present PFAS, which comprises the sum concentration of PFOA and PFOS.

Adjusted means and 95% confidence intervals (95%CI) of PFAS levels (in ng/mL) in umbilical cord blood were estimated according to maternal ultra-processed food consumption (0, 1, 2, or 3 subgroups consumed regularly) by predictive margins regression, including age, skin color, family income, education level, and parity. K-means clustering method was applied to identify how food subgroups (n = 11) consumed during pregnancy were grouped with cord PFAS levels (R software – http://www.r-project.org).

Results

Among the 131 pregnant women involved in the birth cohort, over 25% of them reported regular consumption of at least two ultra-processed foods subgroups [7]. Among the PFAS investigated, PFOS had the highest detection rate (67.8%) in this population. Table 1 shows pregnant women who consumed regularly three or more subgroups of ultra-processed food presented the highest level of PFAS (2.47ng/mL; 95%CI: 1.22; 3.72), compared to non-consumption of ultra-processed food investigated (0 ultra-processed food = 1.86ng/mL; 95%CI: 1.38; 2.50).

Also, two different clusters were derived from the cluster analysis: one grouping all ultra-processed food subgroups and fish consumed during pregnancy and PFAS in umbilical cord blood; and another grouping all other non-ultra-processed food subgroups (Figure 1a). Similar grouping was found when including PFOA and PFOS separately (Figures 1b and 1c).

Discussion

In this birth cohort study of pregnant women-child pairs assisted by public health care in Brazil, we evaluated the association between maternal consumption of ultra-processed foods and PFAS in umbilical cord blood levels. We found increased PFAS concentration in umbilical cord blood of newborns whose mothers were high consumers of ultra-processed foods during the third trimester of pregnancy. PFOS was the most abundant PFAS in these samples. Also, cluster analysis grouped ultra-processed foods and fish with PFAS. To the best of our knowledge, this is the first study to quantify relationships between ultra-processed food consumption and PFAS exposures in a cohort of mother-child.

Chemicals used in food packaging and production, such as PFAS, phthalates, and bisphenols, and ultra-processed foods, have been previously associated with several adverse outcomes, including cardiometabolic outcomes [3,10,11,12,13]. Two recent cross-sectional studies using nationally representative sample data of the US population found associations between ultra-processed food consumption and urinary concentrations of phthalates and bisphenol [4,14]. Findings suggest the possibility of contact materials in ultra-processed foods as a link between ultra-processed food and these health outcomes. Besides, the U.S. Environmental Protection Agency reports that living organisms, including fish, in addition to food packing, are a potential source for PFAS exposure due to to the potential of these chemicals to bioaccumulate and biomagnify in the food chain [15].

Table 1

Adjusted mean levels of perfluoroalkyl substances in umbilical cord blood according to maternal ultra-processed foods consumption. PIPA Project, 2017-2018, Rio de Janeiro, Brazil.

Regular consumption of ultra-processed foods (subgroups)	n	PFAS adjusted mean * (95%CI)	n	PFOA adjusted mean * (95%CI)	n	PFOS adjusted mean * (95%CI)
0	29	1.86 (1.38; 2.50)	7	0.98 (0.46; 1.50)	28	1.72 (1.29; 2.15)
1	29	1.79 (1.32; 2.25)	4	0.32 (-0.51; 1.16);	29	1.78 (1.38; 2.18)
2	19	2.22 (1.66; 2.78)	7	0.69 (0.10; 1.28);	19	2.09 (1.60; 2.57)
3	6	2.47 (1.22; 3.72)	1	2.50 (1.04; 3.96)	4	1.76 (0.69; 2.83)
p-value for trend **	-	0.242	-	0.767	-	0.380

95%CI: 95% confidence interval; PFAS: perfluoroalkyl substances; PFOA: perfluorooctanoate; PFOS: perfluorooctane sulfonate.

Note: PFAS limits of detection: PFOA: 0.07ng/mL; PFOS: 0.24ng/mL.

* Adjusted to maternal age, skin color, family income, education level, and parity;

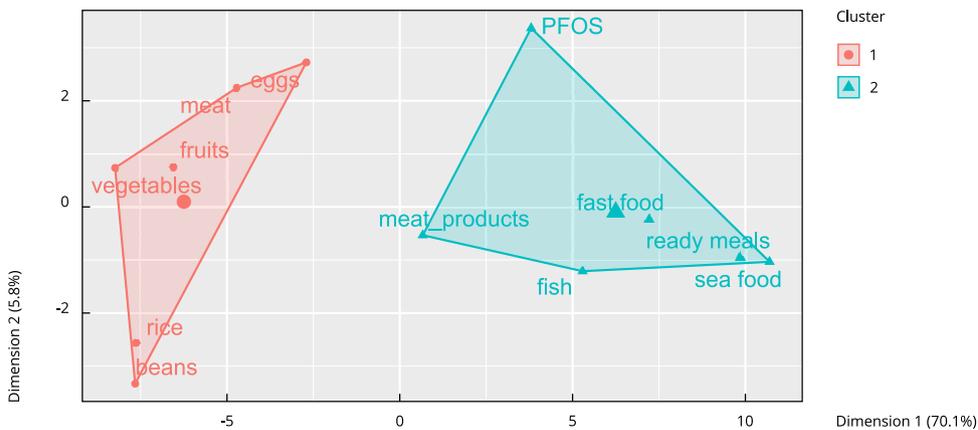** Predictive margins regression.

Figure 1

K means cluster analysis of regularly consumed food groups during pregnancy and PFAS levels in umbilical cord blood. PIPA Project, Rio de Janeiro, Brazil, 2017-2018.
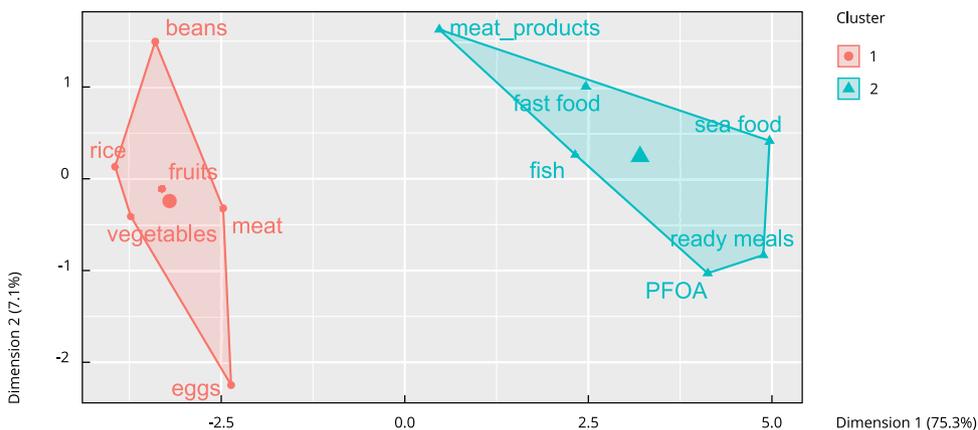
1a) PFAS levels in umbilical cord blood
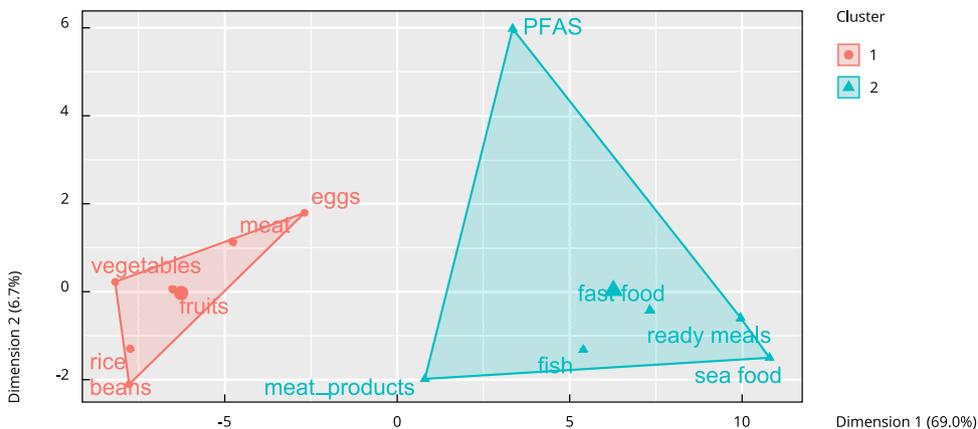
1b) PFOA levels in umbilical cord blood

1c) PFOS levels in umbilical cord blood

Fast food: fast food dishes; meat products: sausage and other reconstituted meat products; PFAS: perfluoroalkyl substances; PFOA: perfluorooctanoate; PFOS: perfluorooctane sulfonate; ready meals: packaged ready meals.

Maternal exposure to contaminants during pregnancy is concerning due to its potential negative effect on both maternal and child health [16]. Newborns are particularly vulnerable to such threats because their metabolic system is still developing, and key organ maturation is susceptible to permanent and lifelong disruption [17].

Potential limitations of our study should be considered. The population size of the survey did not ensure high statistical power and some potential differences could not reach statistical significance. The diet module, designed to collect data on the prevalence of environmental pollutant exposure, is not a complete dietary assessment and this potentially led to an underestimation of ultra-processed food consumption [8]. Nevertheless, this study deserves appreciation for being innovative in assessing the role of ultra-processed food consumption in maternal-child transfer of contaminants. Future studies could confirm our findings, explore mechanisms of action and help determine how the observed associations manifest in childhood.

In conclusion, we found increased levels of PFAS in newborns whose mothers were higher consumers of ultra-processed foods, and cluster analysis grouped ultra-processed foods and fish with PFAS cord levels. Considering all the harms associated with ultra-processed food consumption, including increased exposure to endocrine-disruptor chemicals, as shown in our study, the consumption of ultra-processed foods should be discouraged.

Contributors

N. F. Naspolini contributed to the conceptualization, methodology, and writing (review and editing the text). P. P. Machado contributed to the conceptualization and writing of the original draft. J. C. Moreira contributed in the writing (review and editing the text). C. I. R. F. Asmus contributed to the fundamental participation in the revised version of this manuscript. All authors approved the final version of the manuscript. A. Meyer contributed to the methodology, supervision, and writing (review and editing the text).

Additional informations

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Resumo

Evidências crescentes demonstram que o consumo de alimentos ultraprocessados pode aumentar a exposição a substâncias químicas utilizadas na produção e embalagem desses alimentos, como os compostos per- e polifluoroalquil, ftalatos e bisfenóis. Os estudos sugerem que esses contaminantes podem ser transferidos da mãe para o feto pela via transplacentária, o que aumenta as preocupações em relação à saúde tanto materna quanto infantil. O estudo buscou investigar a associação entre o consumo materno de alimentos ultraprocessados e a exposição intrauterina aos compostos perfluoroalquil (PFAS) no Projeto PIPA Rio – Projeto Infância e Poluentes Ambientais. Foi avaliada a coorte-piloto com 131 pares gestante-feto em uma maternidade-escola pública no Rio de Janeiro. A ingestão materna no terceiro trimestre da gestação foi avaliada com um questionário qualitativo de frequência alimentar. Os itens alimentares foram classificados entre não ultraprocessados e ultraprocessados, usando o sistema NOVA, e foi estimado o consumo regular de ultraprocessados. Os PFAS foram medidos no sangue do cordão umbilical. Os recém-nascidos de mães que haviam consumido três ou mais subgrupos de ultraprocessados por semana apresentaram os níveis séricos mais elevados de PFAS (2,47ng/mL; IC95%: 1,22; 3,72), comparado com nenhum consumo dos subgrupos de alimentos ultraprocessados (0 alimento ultraprocessado = 1,86ng/mL; IC95%: 1,38; 2,50). Além disso, a análise de clusters agrupou ultraprocessados, peixe e níveis de PFAS. Em conclusão, o estudo mostrou níveis elevados de PFAS em neonatos de gestantes com maior consumo de alimentos ultraprocessados.

Processamento de Alimentos; Gravidez; Exposição Alimentar; Disruptores Endócrinos

Resumen

Evidencias recientes han mostrado que el consumo de comida ultraprocesada puede incrementar la exposición a sustancias químicas usadas en el empaquetado de comida y producción, tales como las sustancias per- y poli- fluoroalquílicas, ftalatos, y bisfenoles. Los estudios han sugerido que estos contaminantes pueden transmitirse de la madre al niño, a través de la placenta, incrementando los problemas de salud de la madre y el niño. El objetivo de este estudio fue investigar la asociación del consumo materno de comidas ultraprocesadas con la exposición de los recién nacidos a las sustancias perfluoroalquílicas (PFAS) en el Proyecto PIPA (Estudio de Cohorte de Nacimiento en Río sobre la Exposición Ambiental y Desarrollo en la Infancia). El estudio de la cohorte piloto evaluó a parejas constituidas por 131 mujeres embarazadas y sus hijo/as en una escuela de maternidad pública en Río de Janeiro, Brasil. Se evaluó la ingesta alimentaria materna en el tercer trimestre de embarazo, usando un cuestionario de calidad de frecuencia de la comida. Los ítems alimentarios fueron clasificados como no-comida ultraprocesada y comida ultraprocesada usando el sistema NOVA y se estimó el consumo regular de comidas ultraprocesadas. Las PFAS se determinaron en la sangre del cordón umbilical. Los recién nacidos de mujeres embarazadas que consumieron tres o más subgrupos de comidas ultraprocesada semanalmente presentaron el nivel más alto de PFAS (2,47ng/mL; IC95%: 1,22; 3,72), comparado con ninguno consumo de comida ultraprocesada (0 comida ultraprocesada = 1,86ng/mL; IC95%: 1,38; 2,50). Asimismo, el análisis de conglomerados agrupó comida ultraprocesada, pescado y niveles de PFAS. En conclusión, se encontraron niveles elevados de PFAS en recién nacidos, cuyas madres eran grandes consumidoras de comidas ultraprocesadas.

Procesamiento de Alimentos; Embarazo; Exposición Dietética; Disruptores Endocrinos