ORIGINAL ARTICLE

Consumption of Cariogenic Ultra-processed Foods and Maternal Report of Dental Caries and Dental Pain among Preschool Children

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Academic Editor: Catarina Ribeiro Barros de Alencar

ABSTRACT

Objective: To assess the association between cariogenic ultra-processed foods (UPF) consumption and maternal reports of dental caries and dental pain among preschool children. **Material and Methods:** This cross-sectional study included 505 mothers of children aged 3 to 5 years enrolled in the Municipal Public School System in a large southern Brazilian city (Curitiba, Paraná). Socioeconomic data, maternal reports on dental caries and dental pain among children, and frequency of consumption of cariogenic UPFs among those children were collected. Univariate and multivariate Poisson regression analyses with robust variance were used for the data analysis (α=0.05) and presented in prevalence ratio (PR) and 95% confidence interval (95% CI). **Results:** The presence of dental caries and dental pain among children in the upper tercile of consumption of cariogenic UPFs was, respectively, 11.6% (95%CI:1.028-1.213) and 8% (95%CI:1.001-1.165) higher than that in the lower tercile. Dental caries and dental pain increased, respectively, by 12% (95%CI:1.074-1.169) and 10.3% (95%CI:1.060-1.149) for each year of the child. Moreover, a higher household income was a protective factor for dental caries (PR_a:0.978; 95%CI:0.959-0.997) and for dental pain as well (PR_a:0.977; 95%CI:0.958-0.997) among the children. **Conclusion:** A higher consumption of cariogenic ultra-processed foods (UPFs) was found to be associated with maternal reports of dental caries and dental pain among preschool children.

Keywords: Food, Processed; Dental Caries; Toothache; Observational Study; Child.

Introduction

While dental caries is a preventable disease, despite all efforts to control it, it is still one of the most widely spread health conditions worldwide [1]. Still, it is particularly troubling in low-income and middle-income countries [2]. Dental caries is the primary factor associated with dental pain in children [3], given its significant impact on their quality of life and their families [4]. Both conditions are conducive to a feeling of guilt among parents [5], change the children's sleep patterns [6], and may contribute to higher school absenteeism and poor school performance [7].

Concerning dental caries and its consequences [8], a sugar-rich diet is a common risk factor for several non-communicable diseases (NCDs) [9,10]. In childhood, sugar intake increases because of the higher consumption of ultra-processed foods (UPFs) [11]. The consumption of UPFs has aroused the interest of the scientific community and health agencies [12]. UPFs are formulations of ingredients, mostly of exclusive industrial use, typically created by a series of industrial techniques and processes; they are rich in free sugars, saturated and trans fats [13], and their consumption is associated with a wide range of health outcomes [14,15].

The NOVA classification, a system proposed by Monteiro et al. [16] and widely cited in the scientific literature, is one of the diverse classifications of foods based on processing levels [12]. In such a system, the foods are grouped into four categories based on the industrial processes they go through: unprocessed or minimally processed foods, processed food ingredients, processed foods, and ultra-processed foods [17].

Even though UPF consumption's impact on health at the individual and population levels has been extensively investigated [12], further research is still needed to shed additional light on the specific relationship between the intake of these foods and oral health. The association of dental caries with the higher intake of UPFs has been only described for the adult U.S. population [18]. Conversely, in Brazilian adolescents, the higher the consumption of UPFs, the higher the probability of dental caries [19]. A recent systematic review has demonstrated the higher consumption of UPFs was associated with the presence of dental caries among children and adolescents; however, the authors have pointed out that several studies do not take into account confounding factors, such as socioeconomic status/family and individual variables, for the association between higher consumption of UPFs and dental caries [20]. Furthermore, although many studies often generically consider ultra-processed foods, a specific analysis of those containing added sugars may help to clarify the relationship between their consumption and the prevalence of dental caries. This way, proposals for educational strategies to reduce their consumption could be better established.

The primary hypothesis of this study is that higher consumption of cariogenic ultra-processed foods (UPFs) is positively associated with maternal reports of dental caries and dental pain in preschoolers. To test this hypothesis, this study investigated the association between consumption of the five main cariogenic ultra-processed foods (UPFs) in Latin America and maternal reports of dental caries and dental pain in Brazilian preschoolers.

Material and Methods

Study Design and Sample Size Estimation

This cross-sectional study involved mothers of male and female preschool children aged 3 to 5 years, regularly enrolled in the Municipal Public School System of a prominent southern Brazilian city (Curitiba, state of Paraná). This study follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines to ensure a clear and transparent presentation of what was planned and conducted in this observational study [21].

Curitiba is the state capital, with an estimated population of 1,948,626 in 2020, situated on a territory of 434.863 km². The city has a high Human Development Index (HDI) of 0.823 and a per capita household income Gini Index of 0.5652, with a monthly per capita income of R$1,581.04 [22]. The municipal education network encompasses 230 Municipal Early Childhood Education Centers (CMEI) dispersed across 10 administrative regions. As of 2020, 33,531 children between the ages of 2 and 5 were enrolled in the Municipal Public School System of Curitiba, Brazil.

The sample size was estimated using the finite population proportion available at www.openepi.com to gather an adequate number of individuals for the investigation group. A 30% prevalence for the most frequent outcome variable in the pilot study (dental caries) was used for sample size calculation. A 95% confidence interval (1-α) and a 5% estimation precision were utilized. The sample size was multiplied by 1.5 to compensate for clustering effects, including at least 480 children. The total sample was distributed across the 10 local regions, keeping the proportion relative to the number of students enrolled in each area. The "random.org" website was used to select the schools randomly. Questionnaires were delivered to the residences of all preschool children enrolled in the 28 randomly selected schools.

Data Collection

Data were collected between October 2020 and February 2021. Although the educational units included had a full-time model, face-to-face instruction was suspended during the research period due to the social isolation measures adopted by the COVID-19 pandemic. Mothers answered a self-administered questionnaire developed by the authors about their socioeconomic and demographic backgrounds (household income, number of household members, marital status, maternal schooling, mother's work outside the home, and sex and age of the children), maternal perception of dental caries and dental pain, and assessment of the frequency of consumption of cariogenic UPFs. A pilot study, which included 71 children selected by convenience sampling, was conducted with the same population investigated in the present study. A few adjustments were made after the pilot study, and the only amendments were related to the graphical layout of the questionnaire. The data collected during the pilot study were not included in the final sample.

Maternal reports on the presence of dental caries and dental pain in children were assessed by the following questions, adapted from previous studies to which the answers were either "yes" or "no:" "Has your child ever had or has tooth decay? [23]" and "Has your child ever had or has a toothache? [24]".

The frequency of consumption of cariogenic UPFs was evaluated by collecting information from the past 3 months using a questionnaire containing a list of cariogenic UPFs and a scale for the frequency of consumption of each item. The list of food items was based on the report published by the Pan-American Health Organization (PAHO) on UPFs consumed in Latin America [9]. We included the five UPF items identified as the primary sources of free sugars, according to PAHO's report [9]: sodas or carbonated drinks; synthetic juices/powdered drink mixes/juice concentrates; sweets (candies, caramels, lollipops, ice-cream, chocolate); cakes (store-bought or made with mix); and cookies.

The frequency of consumption could be reported as never or rarely, once or twice weekly, 3 to 6 times weekly, once or twice daily, or three or more times daily. The reported frequencies for each food item were converted into a value that indicates the daily consumption. The following values were employed for the conversion of the frequencies expressed in the questionnaire: never or rarely = zero; once or twice weekly =

0.214 (1.5 times/7 days a week); 3 to 6 times weekly = 0.643 (4.5/7); once or twice daily = 1.5 (1.5/1); and three or more times daily = 3 (3/1) [25]. The daily consumption frequencies obtained for each food item were summed to indicate the daily equivalent frequency for the whole group of UPFs [25].

Statistical Analysis

To investigate the relationships between the consumption of cariogenic ultra-processed foods (UPFs) and oral health outcomes in children, we built a theoretical model using a Directed Acyclic Graph (DAG) [26]. The DAG was constructed based on previous literature [3,10,15,24,27-29]. This model included the following elements: Exposure: Consumption of cariogenic UPFs; Outcomes: Maternal report of dental caries and dental pain; Adjusted variables: Child demographics and maternal socioeconomic status.

The resulting DAG (Figure 1) was structured to highlight the postulated causal relationships among the variables. Exposure to cariogenic UPFs was the leading risk factor, with arrows pointing to maternally reported dental caries and dental pain outcomes. The adjustment variables were included in the model to isolate the effect of exposure on the outcomes.
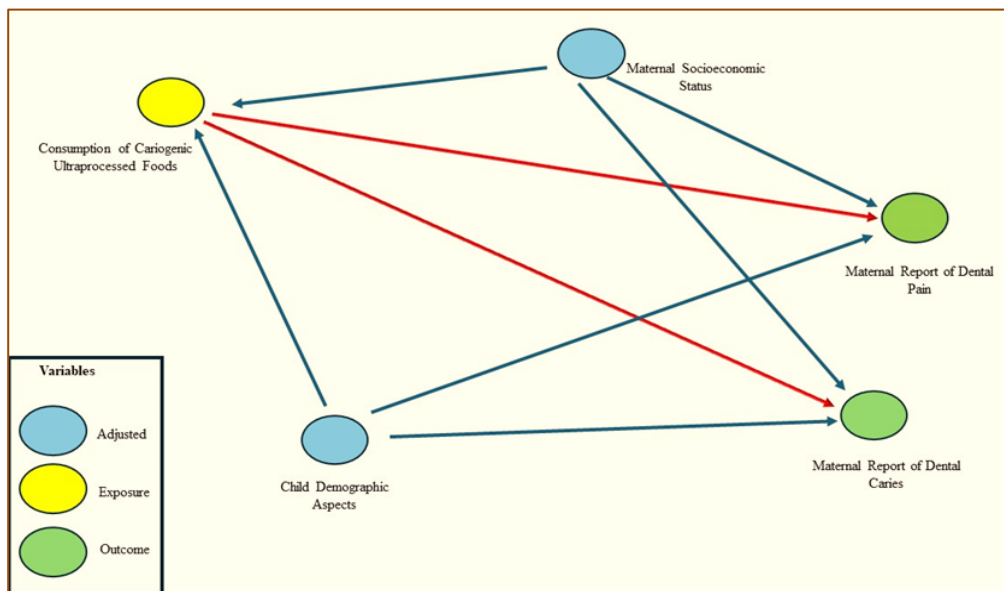

Figure 1. Directed Acyclic Graph (DAG) representing the postulated causal hypotheses between consumption of cariogenic ultra-processed foods (UPFs), maternal reported dental caries and dental pain outcomes, and the adjustment variables (child demographics and maternal socioeconomics).

Univariate and multiple Poisson regression analyses with robust variance, using SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA), were performed to check the association between the maternal report of dental caries and dental pain and the other covariables. Maternal responses to questions about the presence of caries and toothache were dichotomized as "yes" or "no." The frequency of consumption of cariogenic UPFs was calculated by summing the daily frequency for each of the five food items and then categorizing it into terciles (upper, median, and lower). The other independent variables were classified as follows: maternal schooling ("college education," "high school education," or "elementary education"), mother's marital status – either married or in common-law marriage ("yes" or "no"), mother's work outside the home ("yes" or "no"), child's sex ("female" or "male"), household income per capita (in Brazilian minimum wages), and child's age in years.

Variables with p < 0.20 in the univariate analyses were selected to construct the multivariate Poisson regression model with robust variance for the response variable (maternal report of dental caries or dental pain). Those variables with the best model fit that remained significant (p<0.05) in the set of variables were kept in the model.

Ethical Clearance

This study followed the Declaration of Helsinki and was approved by the Research Ethics Committee of the Division of Health Sciences of *Universidade Federal do Paraná* (Opinion No. 4.449.974) of the Local Health Department and Local Education Department of Curitiba (Opinion No. 4.463.990), following their requirements and requests.

■ Results

A total of 672 caregivers answered the questionnaire. In this study, only questionnaires answered by mothers were included (n=597). In addition, ninety-two children were excluded because they were outside the age range. Therefore, the present study finally included 505 mothers and their children aged 3 to 5 years [mean of 4.04 years], and 52.7% of the children were male. Most mothers were married or in a common-law marriage (58.1%), had finished high school (47.7%), worked outside the home (61.1%), and had an average household income on the order of 2.3 Brazilian minimum wages. Dental pain and dental caries were reported by the mothers to have occurred in 16.8% and 26.8% of the children, respectively (Table 1).

Table 1. Socioeconomic and demographic factors and children's consumption of cariogenic UPFs.

Variables	N	%
Child's sex		
Male	266	52.7
Female	239	47.3
Maternal schooling		
College Education	197	39.2
High school	240	47.7
Elementary school	66	13.1
Mother's work outside the home		
Yes	305	61.1
No	194	38.9
Married or in common-law marriage		
Yes	291	58.1
No	210	41.9
Children's consumption of cariogenic ultra-processed foods		
1st tercile	197	31.3
2nd tercile	211	33.5
3rd tercile	222	35.2
Maternal report of dental caries in children		
Yes	140	28.6
No	350	71.4
Maternal report of dental pain in children		
Yes	84	16.9
No	412	83.1
Household income (Brazilian minimum wage) [Mean and SD]	2.30	1.45
Child's age (in years) [Mean and SD]	4.04	0.79

The maternal reports on the presence of dental caries and dental pain were independently correlated with children's consumption of cariogenic UPFs. Those children in the upper tercile of cariogenic UPF consumption had an 11.6% higher prevalence of dental caries than those in the lower tercile (95%CI:1.028-1.213) and an 8% higher prevalence of dental pain than those in the lower tercile (95%CI:1.001-1.165). The prevalence rates of dental caries (PR=1.120; 95%CI:1.074-1.169) and dental pain (PR=1.103; 95%CI:1.060-1.149) were associated with the child's age. Higher household income was a protective factor for both dental caries (PR=0.978; 95%CI:0.959-0.997) and dental pain in children (PR=0.977; 95%CI:0.958-0.997) (Tables 2 and 3).

Table 2. Univariate and multivariate Poisson regression analysis with robust variance for maternal report of dental caries in children.

Variables	Dental Caries		p-value	Crude PR (95%CI)	p-value	Adjusted PR (95%CI)
	No N (%)	Yes N (%)				
Child's sex						
Male	247 (73.5)	89 (26.5)	0.819	1.007 (0.946-1.072)		
Female	227 (73.7)	81 (26.3)		1		
Maternal schooling						
College Education	68 (26.3)	191 (73.7)	0.372	0.955 (0.864-1.056)		
High school	68 (23.1)	227 (76.9)	0.069	0.913 (0.828-1.007)		
Elementary school	33 (37.5)	55 (62.5)		1		
Mother's work outside the home						
Yes	114 (28.5)	286 (71.5)	0.045	1.067 (1.001-1.137)		
No	54 (23.1)	180 (76.9)		1		
Married or in common-law marriage						
Yes	92 (23.7)	297 (76.3)		1		
No	76 (30.4)	174 (69.6)	0.186	1.044 (0.980-1.112)		
Children's consumption of cariogenic UPFs						
1st tercile	33 (17.3)	158 (82.7)		1		1
2nd tercile	56 (27.7)	146 (72.3)	0.055	1.079 (0.998-1.166)	0.330	1.043 (0.958-1.135)
3rd tercile	69 (32.2)	145 (67.8)	0.002	1.133 (1.049-1.225)	0.009	1.116 (1.028-1.213)
Household income (Brazilian minimum wage) [Mean and SD]	2.12 (1.13)	2.39 (1.60)	0.035	0.979 (0.959-0.998)	0.023	0.978 (0.959-0.997)
Child's age (in years) [Mean and SD]	4.34 (0.72)	3.91 (0.79)	<0.001	1.116 (1.076-1.158)	<0.001	1.120 (1.074-1.169)

PR= Prevalence Ratio.

Table 3. Univariate and multivariate Poisson regression analysis with robust variance for maternal report of dental pain in children.

Variables	Dental Pain		p-value	Crude PR (95%CI)	p-value	Adjusted PR (95%CI)
	No N (%)	Yes N (%)				
Child's sex						
Male	46 (13.7)	290 (86.3)	0.443	0.978 (0.924–1.035)		
Female	55 (17.1)	266 (82.9)		1		
Maternal schooling						
College Education	34 (12.9)	229 (87.1)	0.116	0.927 (0.843–1.019)		
High school	47 (15.6)	254 (84.4)	0.292	0.951 (0.866–1.044)		
Elementary school	20 (22.2)	70 (77.8)		1		
Mother's work outside the home						
Yes	71 (17.2)	341 (82.8)	0.095	1.050 (0.992–1.111)		
No	30 (12.9)	203 (87.1)		1		
Married or in common-law marriage						
Yes	55 (13.9)	341 (86.1)		1		
No	45 (17.6)	210 (82.4)	0.245	1.035 (0.977–1.097)		
Children's consumption of cariogenic UPFs						
1st tercile	19 (9.8)	174 (90.2)		1		1
2nd tercile	32 (15.5)	174 (84.5)	0.159	1.050 (0.981–1.124)	0.526	1.025 (0.951–1.104)
3rd tercile	41 (19)	175 (81)	0.020	1.087 (1.013–1.166)	0.046	1.080 (1.001–1.165)
Household income (Brazilian minimum wage) [Mean and SD]	2.08 (1.25)	2.37 (1.5)	0.075	0.982 (0.962–1.002)	0.028	0.977 (0.958–0.997)
Child's age (in years) [Mean and SD]	4.39 (0.73)	3.98 (0.78)	<0.001	1.084 (1.047–1.112)	<0.001	1.103 (1.060–1.149)

PR= Prevalence Ratio.

■ Discussion

The main finding of this study confirms the hypothesis that children who consume cariogenic UPFs more frequently tend to have a higher prevalence of maternal reports of dental caries and dental pain. These findings suggest prevention strategies targeted at dental caries and dental pain should underscore the importance of restricting the consumption of UPFs. The results of recent research conducted with Brazilian adolescents also indicate the need to limit the consumption of UPFs to prevent dental caries [19]. UPFs are prepackaged, have a long shelf life, are hyperpalatable, have an affordable cost, are highly profitable to the manufacturers, and are highly advertised [9,12], which eventually contributes towards their widespread consumption, especially among children [13] and adolescents [19].

This scenario represents a major cause for concern, given the high consumption of UPFs despite the global efforts to reduce the intake of foods rich in free sugars [30]. Many young children do not eat fruits and vegetables as part of their daily lives but consume sugary drinks [31]. The high consumption of UPFs is closely related to excessive sugar intake and to a higher risk for the development of several non-communicable diseases throughout life [32].

It is widely acknowledged that high sugar intake is one of the main determinants of the onset and progression of dental caries [8,10]. It is known that the frequency of sugar consumption and the development of dental caries show a dose-response pattern: the higher the consumption of free sugars, the greater the risk of developing caries lesions [33]. Ultra-processed foods are high in sucrose [34], which is readily fermentable and contributes to forming a more adherent and porous dental biofilm [35]. The findings of this study support the evidence of the impact of high consumption of cariogenic UPFs on the development of dental caries [15] and also establish a significant association with the presence of dental pain among children.

Dental caries and dental pain impact the quality of life of children and their families [36]. They also interfere with masticatory ability [37] and are associated with poor school performance [38] and school absenteeism [39]. In addition to the impact on quality of life, dental caries and dental pain incur economic and human costs [40] and burden the healthcare system [41].

It is estimated that approximately 20% of children aged less than 5 years have experienced dental pain and that this condition increases with age [42]. Dental caries tend to progress and worsen, causing pain [43]. In line with the previous literature, the present study indicated that older children had a higher prevalence of dental caries and pain.

Socioeconomic background has been associated with dental caries [29] and dental pain [44]. In the present study, a higher household income was a protective factor for dental caries and pain. A cohort study of southeastern Brazilian children demonstrated that those children living in poverty during their early childhood had a higher prevalence of dental pain in subsequent years [28]. Lima et al. [45], in a study of Brazilian preschool children, found that the prevalence of dental caries was significantly higher among children from lower-income families who consumed more sugar. However, this pattern was not observed in children from higher-income families [45]. Children from lower socioeconomic backgrounds have less access to health services and visit the dentist less frequently [27]. In addition, vulnerabilities such as food insecurity are also associated with higher sugar consumption among children from very low-income families [46].

Some limitations of the present study should be considered when analyzing the data. Eating habits are inherently regional and are influenced by economic, social, cultural, and geographic factors. Therefore, their investigation demands some caution with the selection of foods. The present study included food items widely consumed in Latin America, which could hinder the generalization of the findings to other regions. Furthermore, although the sample size calculation considered the design effect, the lack of correction for the sample design effect may limit the generalizability of the results. Moreover, data collection relied on maternal reports, which could introduce a memory bias. It should be remarked, however, that parental perception is often considered a valuable indicator of clinical outcomes associated with dental caries [47]. The use of maternal reports of oral health problems in children has been considered a valid tool in epidemiology [48], and an association has been observed between maternal reports and dental caries in Brazilian preschool children [23]. However, other studies have warned that, despite the reasonable specificity, the sensitivity of maternal reports of dental caries in children may be low [49]. Then, data collected through maternal reports of dental caries in children should be analyzed with caution.

Strategies targeted at promoting nutrient adequacy in childhood are needed, with a clear recommendation for restricting the consumption of cariogenic UPFs. Educational policies should be formulated to prevent and reduce the consumption of cariogenic UPFs. These policies could indirectly improve the prevention of dental caries and dental pain in children and reduce expenditures on clinical procedures. An excellent initiative was the recent nutrition labeling regulations in Brazil, implemented by the National Health Surveillance Agency (ANVISA), which include front-of-package warnings on products that contain high levels of added sugars, saturated fat, and sodium. These changes aim to make it easier to identify ultra-processed foods, which are recognized as potential contributors to the development of chronic diseases such as tooth decay. Implementing these measures is particularly relevant in the context of the consumption of ultra-processed foods, as exposure to these products has been associated with a higher prevalence of dental caries, especially in vulnerable populations such as children and adolescents [50].

■ Conclusion

Maternal reports of dental caries and dental pain among preschool children were independently associated with the consumption of cariogenic UPFs by the children.

■ Authors' Contributions

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All authors declare that they contributed to a critical review of intellectual content and approval of the final version to be published.

■ Financial Support

■ Conflict of Interest

The authors declare no conflicts of interest.

■ Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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