

# Timing of sugar introduction in diet and early childhood caries: a population-based study in preschoolers

Momento de introdução de açúcar na dieta e cárie na primeira infância: um estudo de base populacional em pré-escolares

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## Resumo

**Introdução:** A ingestão de açúcar é um importante fator relacionado à cárie dentária. O contato com alimentos açucarados em idade precoce pode representar risco para a saúde bucal de crianças em idade pré-escolar. **Objetivo:** Avaliar o momento de introdução do açúcar na dieta de pré-escolares e sua associação com a cárie na primeira infância. **Material e método:** Estudo transversal de base populacional com 888 pré-escolares de cinco anos de escolas públicas e privadas. Os pais responderam questionário sobre dados sociodemográficos, hábitos alimentares e saúde bucal. As variáveis tempo de introdução do açúcar (> 1 ano e ≤1 ano) e experiência de cárie dentária foram dicotomizadas e os dados foram analisados por meio de estatística descritiva e regressão de Poisson ( $p < 0,05$ ). **Resultado:** A introdução do açúcar na dieta ocorreu nos primeiros doze meses de vida para 73,8% dos pré-escolares. Não houve associação entre o momento de introdução do açúcar e a cárie na primeira infância ( $p > 0,05$ ). A interrupção do aleitamento materno exclusivo e a baixa renda familiar aumentaram a prevalência de pré-escolares com contato precoce com açúcar em 32% e 23%, respectivamente ( $p < 0,05$ ). A prevalência de cárie na primeira infância foi de 42,3% e esteve associada à menor escolaridade materna, baixa renda, maior frequência de ingestão de doces e uso de dentifrício não fluoretado ( $p < 0,05$ ). **Conclusão:** A introdução de açúcar na dieta ocorreu durante o primeiro ano de vida na maioria dos pré-escolares e não houve associação com cárie na primeira infância. **Descritores:** Açúcares; dieta; cárie dentária; criança.

## Abstract

**Introduction:** Sugar ingestion is the most important isolated factor related to dental caries. Contact with sugary foods at an early age may represent a risk to the oral health of preschool children. **Objective:** To evaluate the timing of the introduction of sugar in the diet of preschoolers and its association with early childhood caries. **Material and method:** Cross-sectional population-based study with 888 five-year-old preschoolers from public and private schools. Parents answered a questionnaire on sociodemographic data, eating habits and oral health. The variables timing of sugar introduction (>1 year and ≤1 year) and dental caries experience were dichotomized and data were analyzed using descriptive statistics and Poisson regression ( $p < 0.05$ ). **Result:** The introduction of sugar in the diet occurred during the first twelve months of life for 73.8% of preschoolers. There was no association between the timing of sugar introduction and early childhood caries ( $p > 0.05$ ). The interruption of exclusive breastfeeding and low family income increased the prevalence of preschoolers having early contact with sugar by 32% and 23%, respectively ( $p < 0.05$ ). The prevalence of early childhood caries was 42.3% and was associated with a lower level of maternal education, low income, increased frequency of ingestion of candy and the use of nonfluoridated



toothpaste ( $p < 0.05$ ). **Conclusion:** The introduction of sugar in the diet occurred during the first year of life in most preschoolers and there was no association with early childhood caries.

**Descriptors:** Sugars; diet; dental caries; child.

## INTRODUCTION

Adequate nutrition, especially in the first thousand days of life, the period between intrauterine life (270 days) and the first two years (730 days), is essential for the individual's long-term health<sup>1</sup>. Inadequate food choices in this period impact the child's metabolism, compromising the growth / development and learning / school performance processes<sup>2</sup>. Furthermore, they contribute to weight gain, increased risk of infections<sup>2</sup> and noncommunicable diseases, such as diabetes, cancer, heart disease and dental caries<sup>3,4</sup>.

Dental caries is the most prevalent noncommunicable disease in the world<sup>5</sup> and, although there has been considerable progress in its control and treatment, the disease persists, causing pain, anxiety, functional limitations and social disadvantages due to the loss of teeth<sup>6</sup>. Frequent sugar consumption is the main etiological factor of the disease<sup>7</sup> and in preschoolers the intake of cariogenic foods is constant and prolonged<sup>8</sup>. In addition, the consumption of free sugars increases the overall caloric intake and reduces the consumption of nutritious foods and micronutrients, contributing to a harmful diet<sup>1</sup>.

In view of the relevance of nutritional aspects in the first thousand days of life and the impacts on health<sup>9-11</sup>, this study aimed to assess the timing of the introduction of sugar in the diet of preschoolers and its association with caries in early childhood. Two hypotheses were formulated:

1. The introduction of sugar in the diet occurs before the first thousand days of life for children;
2. Dental caries are associated with early introduction of sugar.

## MATERIAL AND METHOD

### Ethical Aspects and Study Design

This study was approved by the Research Ethics Committee (protocol 2.085.469) and followed the guidelines recommended by the Declaration of Helsinki. Parents / guardians signed a free and informed consent form. This is a cross-sectional, population-based study that followed the guidelines of STROBE (Strengthening the Reporting of Observational Studies in Epidemiology).

### Participants

This study was developed with preschoolers from public and private day-care centers in Teresina, Brazil, from September 2017 to May 2018. Teresina is the capital of the state of Piauí, located in the northeastern region of Brazil; it has an estimated population of 814,230 inhabitants, according to the Brazilian Institute of Geography and Statistics. In 2016, 10,213 five-year-old children were enrolled in preschools in Teresina.

Initially, a draw was carried out to select the day-care centers participating in this study in a proportional and random way, and their participation was requested by telephone contact. Five-year-old preschoolers with complete primary dentition were included. Children with special needs, cleft lip and palate, imperfect amelogenesis and fixed orthodontic appliances were not included.

### Sample Calculation

The sample calculation was performed using the Epi-info software, in the STATCALC module, version 7.0, using the formula:  $n = [EDFF * Np (1-p)] / [(d2/Z21-\alpha/2*(N-1)+p*(1-p)]$ , adjusted by

a correction factor (EDFF) for the study design of 2.0, where N is the population (10,213). A 95% confidence interval was considered ( $z_{21-\alpha/2} = 1.96$ ) and a confidence limit (d) of 4%, considering the proportion (p) of children with a timing of sugar introduction less than or equal to 12 months obtained in a pilot study of 76.3%; thus, a minimum sample of 832 preschoolers was obtained. To compensate for possible losses, the sample size was increased by 20%, obtaining a sample of 998 preschoolers. To ensure representativeness, the sample was stratified according to the region city and type of institution.

## Calibration

The calibration for the dental caries examination was carried out in two stages: 1. The theoretical approach of 4 hours to present the index for the diagnosis of dental caries (ceod) and projection of clinical cases with different severities; 2. Practical training for patients not participating in the study. In this last step, it was possible to calculate the *kappa* index of intra- and inter-examiner agreement for the two evaluators (*kappa* intra-examiner 1 – comparison standard = 0.88, *kappa* intra-examiner 2 – comparison standard = 0.90, *kappa* inter-examiner 1 – comparison standard = 0.89, inter-examiner *kappa* 2 – comparison standard = 0.91) of this study, obtaining a final value of 0.9 (inter-examiner *kappa* 1–2).

## Pilot Study

In order to evaluate the proposed methodology, a pilot study with 83 preschoolers (10% of the sample) was carried out in two preschools in Teresina chosen for convenience. Methodological changes were not necessary. Preschoolers recruited during the pilot study were not included in the final sample.

## Data Collection and Studied Variables

Socioeconomic data were collected through questionnaires sent and answered by those responsible for the minors, containing information about gender, family income, maternal education (considering eight years of study as formal basic education in Brazil), dental caries experience and oral hygiene habits. The periods of exclusive breastfeeding and ablactation were dichotomized between less than six months and equal to or greater than six months. To obtain the timing of sugar introduction in the diet, a table with probable foods containing sugar was used to facilitate recall by parents. The frequency of ingestion of treats, such as candies, stuffed cookies, sweet cookies, sweet cake, chocolate and lollipops was quantified in: less than once; 1 to 2 times; and more than or equal to 3 times a week.

Prior to the clinical examination, oral hygiene of the preschoolers was performed with a toothbrush and fluoride toothpaste. Sterile gauze was used to remove excess saliva and the clinical dental examination was performed with the aid of a flat mouth mirror (Golgran®, São Paulo, Brazil), exploratory probe No. 5 (Golgran®, São Paulo, Brazil) and probe CPI (Golgran®, São Paulo, Brazil). Dental caries was evaluated using the ceod index (sum of the number of decayed teeth, extracted due to caries and filled<sup>12</sup>). Preschoolers were examined outdoors, with the aid of artificial lighting (Pelican® model – Startec with. 127V, São Paulo, Brazil), in a simplified position with the child's head positioned on the examiner's legs. After the dental examination, the preschoolers received guidance on ways to prevent dental caries and topical application of a neutral fluoride gel with the aid of a toothbrush.

## Statistical Analysis

Data processing and statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS® for Windows, version 20.0, Armonk, NY, USA). Initially, the description of

absolute and relative frequencies of the variables was performed. The variables timing of sugar introduction (> 1 year and ≤ 1 year) and dental caries experience (ceod = 0 and ceod ≠ 0) were dichotomized and an association with independent variables was verified through Poisson regression with robust variance. Variables with a value of  $p \leq 0.20$  in the bivariate analysis were included in the multivariate analysis. The results were expressed by prevalence ratio (PR), with a 95% confidence interval (95% CI), with variables with  $p < 0.05$  remaining in the final model.

## RESULT

A total of 998 preschoolers were invited to participate in this study; 38 did not accept the invitation, leaving 960 preschoolers with the consent of parents and/or guardians. Of these 960 preschoolers, 72 were excluded because they were absent at the time or did not cooperate with the clinical examination. Therefore, 888 preschoolers and their parents/guardians participated in this study (response rate of 89.9%).

Table 1 describes the demographic socioeconomic characteristics and health-related habits of preschoolers. The timing of sugar introduction in the diet occurred before 12 months of age in 73.8% of preschoolers.

**Table 1.** Demographic and socioeconomic characteristics and health-related habits of preschoolers

| Variables  | n          | %          |
|--|------------|------------|
| <b>Sex</b>   |            |            |
| Male   | 456        | 51.4       |
| Female   | 432        | 48.6       |
| <b>School type</b>                                       |            |            |
| Public   | 586        | 66         |
| Private  | 302        | 34         |
| <b>Maternal education (years of study) *</b>             |            |            |
| < 8  | 113        | 12.7       |
| 8 - 11   | 546        | 61.6       |
| > 11   | 228        | 25.7       |
| <b>Family income (minimum wage - 1MW = R\$937.00) *</b>  |            |            |
| < 1  | 190        | 21.4       |
| 1 - 3  | 466        | 52.5       |
| > 3  | 189        | 21.3       |
| <b>Exclusive breastfeeding (months)*</b>                 |            |            |
| ≤ 6  | 712        | 80.5       |
| > 6  | 172        | 19.5       |
| <b>Ablactation (months)*</b>                             |            |            |
| < 6  | 149        | 16.8       |
| ≥ 6  | 735        | 83.2       |
| <b>Time of sugar introduction (months)</b>               |            |            |
| ≤ 12   | 655        | 73.8       |
| > 12   | 233        | 26.2       |
| <b>Frequency of Ingestion of treats (times per week)</b> |            |            |
| < 1  | 251        | 28.3       |
| 01/fev   | 254        | 28.6       |
| ≥ 3  | 382        | 43.1       |
| <b>Use of toothpaste*</b>                                |            |            |
| Adult  | 329        | 37.1       |
| Infant fluoridated                                       | 466        | 52.5       |
| Infant not fluoridated                                   | 92         | 10.4       |
| <b>Total</b>   | <b>888</b> | <b>100</b> |

\*Variables with loss of information.

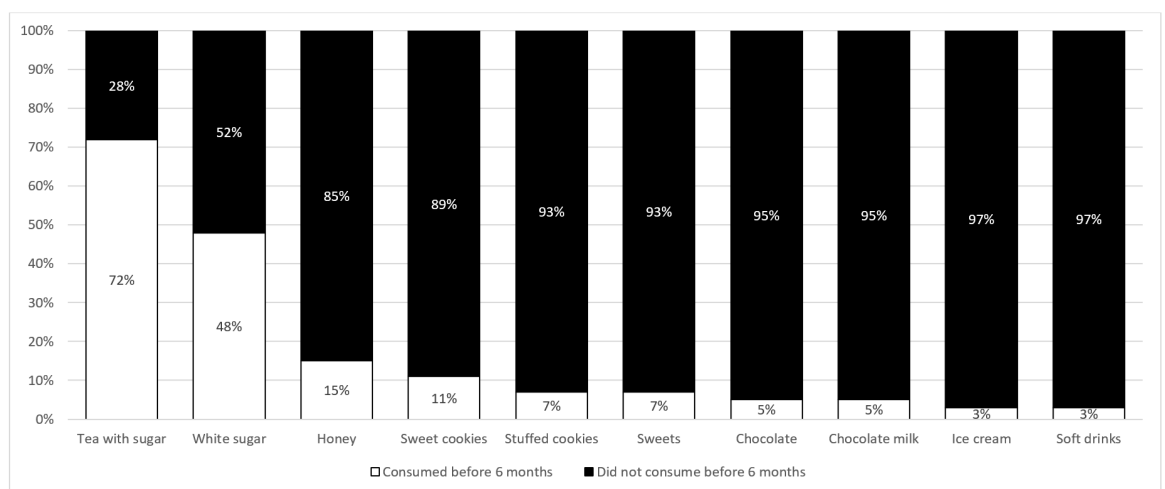
The factors associated with the timing of sugar introduction are described in Table 2. In the final model, it was observed that parents/guardians of preschoolers with a family income below one minimum wage had a 23% higher prevalence (PR = 1.23; 95% CI = 1.08–1.40) of introducing early sugar in the diet of preschoolers than families that had purchasing power greater than three minimum wages. The interruption of exclusive breastfeeding before six months increased the prevalence (PR = 1.32; 95% CI = 1.16–1.51) of preschoolers having early contact with sugar by 32% (Table 2).

**Table 2.** Association between time of sugar introduction and sociodemographic characteristics and breastfeeding (n = 888 preschoolers)

| Variables   | Time of sugar introduction |                       | Unadjusted PR<br>(CI95%) | p**   | adjusted PR<br>(CI95%)    | p**          |
|---|----------------------------|-----------------------|--------------------------|-------|---------------------------|--------------|
|   | Before 1 year<br>n (%)     | After 1 year<br>n (%) |                          |       |                           |              |
| <b>Sex</b>  |                            |                       |                          |       |                           |              |
| Male  | 346 (75.9)                 | 110 (24.1)            | 1.06 (0.97 – 1.15)       | 0.157 | -                         | -            |
| Female  | 309 (71.5)                 | 123 (28.5)            | 1                        | -     | -                         | -            |
| <b>Maternal education (years of formal study) *</b>             |                            |                       |                          |       |                           |              |
| < 8   | 84 (74.3)                  | 29 (25.7)             | 1.09 (0.95 – 1.26)       | 0.187 | -                         | -            |
| 8 – 11  | 412 (75.5)                 | 134 (24.5)            | 1.08 (0.97 – 1.19)       | 0.136 | -                         | -            |
| > 11  | 158 (69.3)                 | 70 (30.7)             | 1                        | -     | -                         | -            |
| <b>Family income (brazilian minimum wage – 1MW = R\$937.00)</b> |                            |                       |                          |       |                           |              |
| < 1   | 147 (77.4)                 | 43 (22.6)             | 1.19 (1.05 – 1.36)       | 0.007 | <b>1.23 (1.08 – 1.40)</b> | <b>0.001</b> |
| 1 – 3   | 353 (75.8)                 | 113 (24.2)            | 1.18 (1.05 – 1.32)       | 0.006 | <b>1.20 (1.06 – 1.35)</b> | <b>0.002</b> |
| > 3   | 121 (64.0)                 | 68(36.0)              | 1                        | -     | <b>1</b>                  | -            |
| <b>Exclusive breastfeeding (months)*</b>                        |                            |                       |                          |       |                           |              |
| ≤ 6   | 551 (77.4)                 | 161 (22.6)            | 1.30 (1.14 – 1.49)       | 0.001 | <b>1.32 (1.16 – 1.51)</b> | <b>0.001</b> |
| > 6   | 102 (59.3)                 | 70 (40.7)             | 1                        | -     | <b>1</b>                  | -            |
| <b>Ab lactation (months)</b>                                    |                            |                       |                          |       |                           |              |
| < 6   | 121 (81.2)                 | 28 (18.8)             | 1.13 (1.03 – 1.24)       | 0.008 | -                         | -            |
| ≥ 6   | 534 (72.2)                 | 205 (27.8)            | 1                        | -     | -                         | -            |
| <b>Total</b>  | <b>655 (73.8)</b>          | <b>233 (26.2)</b>     |                          |       |                           |              |

\*Data with loss of information. \*\*Poisson Regression. PR: Prevalence Ratio; CI: Confidence Interval.

Figure 1 shows the foods with sugar introduced into the diet of preschoolers before the age of six months: tea with sugar and white sugar were the most frequent foods introduced early.



**Figure 1.** Cariogenic foods introduced into the diet of preschoolers before six months of age (n = 287).

Of the total number of preschoolers evaluated, 42.3% had dental caries. The average of the ceod was 1.68 ( $\pm$  2.83) teeth affected by dental caries, with 1.43 ( $\pm$  2.54) decayed, 0.04 ( $\pm$  0.29) extracted due to caries and 0.21 ( $\pm$  0.77) restored.

The factors associated with tooth decay are described in Table 3. There was no association between tooth decay and the timing of sugar introduction; however, preschoolers who consumed sweet treats more than three times a week (PR = 1.35; 95% CI = 1.10–1.66) or once or twice a week (PR = 1.31; 95% CI = 1.05–1.63), whose mothers had maternal education of less than eight years of formal study (PR = 1.80; 95% CI = 1.33–2.44) or 8 to 11 (PR = 1.36; 95% CI = 1.04–1.77) and a monthly family income below one minimum wage (PR = 1.43; 95% CI = 1.06–1.93) had a higher prevalence of dental caries ( $p < 0.05$ ). The use of fluoride infant toothpaste (PR = 0.74; 95% CI = 0.59–0.93) and adult toothpaste (PR = 0.79; 95% CI = 0.63–0.99) decreased the prevalence of dental caries by 26% and 21%, respectively (Table 3).

**Table 3.** Association between dental caries experience and sociodemographic characteristics, time of sugar introduction, use of toothpaste and frequency of ingestion of sugar treats.

| Variables   | Dental caries |            |                    |        |                    |        |
|---|---------------|------------|--------------------|--------|--------------------|--------|
|   | Absent        | Present    | Unadjusted PR      | p**    | Adjusted PR        | p**    |
|   | n (%)         | n (%)      | (CI95%)            |        | (CI95%)            |        |
| <b>Sex</b>  |               |            |                    |        |                    |        |
| Female  | 244 (56.5)    | 188 (43.5) | 1.05 (0.90 – 1.23) | 0.556  |                    |        |
| Male  | 268 (58.8)    | 188 (41.2) | 1                  |        |                    |        |
| <b>Maternal education (years of formal study) *</b>             |               |            |                    |        |                    |        |
| < 8   | 43 (38.1)     | 70 (61.9)  | 2.28 (1.76 – 2.94) | <0.001 | 1.80 (1.33 – 2.44) | <0.001 |
| 8 – 11  | 305 (55.9)    | 241 (44.1) | 1.56 (1.23 – 1.97) | <0.001 | 1.36 (1.04 – 1.77) | 0.024  |
| > 11  | 164 (71.9)    | 64 (28.1)  | 1                  |        | 1                  |        |
| <b>Family income (brazilian minimum wage – 1MW = R\$937.00)</b> |               |            |                    |        |                    |        |
| < 1   | 80 (42.1)     | 110 (57.9) | 1.95 (1.51 – 2.50) | <0.001 | 1.43 (1.06 – 1.93) | 0.020  |
| 1 – 3   | 274 (58.8)    | 192 (41.2) | 1.39 (1.09 – 1.78) | 0.008  | 1.13 (0.86 – 1.49) | 0.377  |
| > 3   | 133 (70.4)    | 56 (29.6)  | 1                  |        |                    |        |
| <b>Time of sugar introduction (months)</b>                      |               |            |                    |        |                    |        |
| ≤ 12  | 363 (55.4)    | 292 (44.6) | 1.19 (1.02 – 1.49) | 0.028  | -                  | -      |
| > 12  | 149 (63.9)    | 84 (36.1)  | 1                  |        |                    |        |
| <b>Frequency of Ingestion of treats (times per week)</b>        |               |            |                    |        |                    |        |
| ≥ 3   | 199 (52.1)    | 183 (47.9) | 1.41 (1.15 – 1.73) | 0.001  | 1.35 (1.10 – 1.66) | 0.003  |
| 1 – 2   | 147 (57.6)    | 108 (42.4) | 1.25 (1.00 – 1.57) | 0.047  | 1.31 (1.05 – 1.63) | 0.016  |
| < 1   | 166 (66.1)    | 85 (33.9)  | 1                  |        | 1                  |        |
| <b>Use of toothpaste*</b>                                       |               |            |                    |        |                    |        |
| Adult   | 177 (53.8)    | 152 (46.2) | 0.86 (0.69 – 1.08) | 0.214  | 0.79 (0.63 – 0.99) | 0.047  |
| Infant fluoridated  | 291 (62.4)    | 175 (37.6) | 0.70 (0.56 – 0.88) | 0.002  | 0.74 (0.59 – 0.93) | 0.010  |
| Infant not fluoridated  | 43 (46.7)     | 49 (53.3)  | 1                  |        | 1                  |        |
| Total   | 512 (57,7)    | 376 (42,3) |                    |        |                    |        |

\*Data with loss of information. \*\*Poisson Regression. PR: Prevalence Ratio; CI: Confidence Interval. Final model adjusted for the time of sugar introduction.

## DISCUSSION

The introduction of sugar in the diet occurred before the first 12 months of life in most preschoolers and was associated with the interruption of exclusive breastfeeding and low family income. There was no association between the timing of sugar introduction and dental caries, probably because the introduction of sugar in the diet occurred during the first twelve months of life for most of preschoolers. However, there was an association between the disease and low level of maternal education, low family income and high frequency of eating sweet treats. The early

introduction of sugar modulates the child's taste, making them prefer sweet foods and the need to add ever greater amounts<sup>13</sup>, acting in the mediation of neurochemical responses that cause dependence<sup>14</sup>.

The food most frequently introduced before the age of six months was tea with sugar (sucrose), due to cultural factors that consider it as a medicine and sedative. However, this is not recommended for children, as it contains substances that can reduce the absorption of iron and minerals, increasing the risk of anemias<sup>15</sup>. Sucrose is a major component of food and drink, including tea, coffee, soft drinks and energy drinks<sup>6</sup>. Consumption of sugary drinks before the first 12 months of life was associated with early childhood caries<sup>13,16-18</sup>. In this study, the cutoff point was 12 months, due to the high percentage of early sugar introduction, despite the World Health Organization (WHO) suggesting sugar consumption should not start until the first thousand days of life.

The interruption of exclusive breastfeeding (EBF) was associated with the early introduction of sugar in the diet of the preschoolers in this study, which increases the chance of developing unhealthy eating habits<sup>19</sup> and, consequently, dental caries<sup>13,20</sup>. Despite WHO recommendations, supported by scientific evidences of the benefits of breastfeeding for the mother/baby binomial, overall rates of EBF are still low (approximately 40%)<sup>21</sup>.

In this study, low family income was associated with early introduction of sugar and dental caries in early childhood. Vulnerable populations are characterized by psychosocial risk, high levels of conflict, consumption of low-cost and easily accessed processed foods and inadequate oral hygiene<sup>22,23</sup>. The possibility for preschoolers to have healthy teeth when their parents have a higher educational level and good socioeconomic conditions are greater, because oral health is a reflection of family attitudes and behavior patterns<sup>22</sup>.

The prevalence of dental caries in the present study was high and associated with low maternal education and high frequency of ingestion of sweet treats, corroborating data from the literature<sup>10,23</sup>. According to the literature, the frequency of sugar intake has a greater influence than the amount in this relationship<sup>20</sup>.

Among the preschoolers evaluated, those who used fluoride toothpaste had a lower prevalence of dental caries. The indication of fluoridated toothpaste for children from the eruption of the first teeth is endorsed by pediatric and pediatric dentistry associations from different countries and based on evidence<sup>24</sup>. Preschoolers in general are not very cooperative with oral hygiene, and in the presence of frequent sugar consumption, the use of fluoridated toothpastes, despite not interfering with the etiological factors of the disease, is effective in controlling it. Even if brushing does not adequately remove dental biofilm, it promotes fluoride deposition in the remnants, which will act in the processes of demineralization and dental remineralization, controlling the disease progression<sup>25</sup>.

The bias of memory of parents/guardians was a limitation of this study, however the representative sample of the population base allowed statistical inferences and adds to the literature the importance of delaying the introduction of sugar consumption in children's diet. In addition, since most children of this age attend preschools, these results may also be extrapolated to all 5-year-old children from the city. Longitudinal studies are needed to reduce memory bias and advance knowledge about the timing of sugar introduction and its long-term consequences.

Early childhood caries remains a public health problem, lacking broad public policies for its control<sup>24</sup>, such as sugar taxing, mainly because it affects those children who are socially vulnerable<sup>25</sup>. Guidance for pregnant women, as well as the child's consultation with the dentist in the first months of life are essential to raise awareness among parents and guardians about the harm of sugar.

## CONCLUSION

In conclusion, the introduction of sugar in the diet occurred during the first year of life in most preschoolers and was associated with the interruption of exclusive breastfeeding and low family

income. There was no association between the timing when sugar was introduced and caries in early childhood. Early childhood caries was associated with low levels of maternal education and family income, the use of nonfluoridated toothpaste in addition to a high frequency of ingestion of sugary treats.

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## CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

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