Impact of Prolonged Breastfeeding on Dental Caries: A Population-Based Birth Cohort Study

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abstract

BACKGROUND: Few studies have assessed the effect of breastfeeding, bottle feeding, and sugar consumption on children's dental caries. We investigated whether the duration of breastfeeding is a risk factor for dental caries in the primary dentition, independently of sugar consumption.

METHODS: An oral health study (n = 1303) nested in a birth cohort study was carried out in southern Brazil. The average number of decayed, missing, and filled primary tooth surfaces (dmfs) and severe early childhood caries (S-ECC: dmfs ≥6) were investigated at age 5 years. Breastfeeding was the main exposure collected at birth and at 3, 12, and 24 months of age. Data on sugar consumption were collected at 24, 48, and 60 months of age. Marginal structural modeling was used to estimate the controlled direct effect of breastfeeding (0–12, 13–23, and ≥24 months) on dmfs and on S-ECC.

RESULTS: The prevalence of S-ECC was 23.9%. The mean number of dmfs was 4.05. Children who were breastfed for ≥24 months had a higher number of dmfs (mean ratio: 1.9; 95% confidence interval: 1.5–2.4) and a 2.4 times higher risk of having S-ECC (risk ratio: 2.4; 95% confidence interval: 1.7–3.3) than those who were breastfed up to 12 months of age. Breastfeeding between 13 and 23 months had no effect on dental caries.

CONCLUSIONS: Prolonged breastfeeding increases the risk of having dental caries. Preventive interventions for dental caries should be established as early as possible because breastfeeding is beneficial for children's health. Mechanisms underlying this process should be investigated more deeply.

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WHAT'S KNOWN ON THIS SUBJECT: Despite some evidence on the increased risk of dental caries in children breastfed beyond 12 months of age, these findings are derived from highly heterogeneous studies and lack controlling for key confounders.

WHAT THIS STUDY ADDS: Breastfeeding up to 24 months of age or beyond has a controlled direct effect on the severity of primary dental caries. This risk is noteworthy independent of lifetime sugar consumption.

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Untreated dental caries in the primary dentition affects 9% of the world's population.[1] This condition, together with untreated dental caries in permanent teeth, ranked 80th in detailed causes of years lived with disability among 291 investigated health conditions.[1] Untreated dental caries may cause pain and suffering, affecting children's and families' day-to-day life.[2,3,] A contemporary publication reinforces dental caries as a sugar-dependent disease.[4]

The American Academy of Pediatrics recommends breastfeeding for at least 12 months, continued subsequently as long as mutually desired by the mother and child, whereas the World Health Organization recommends breastfeeding for ≥24 months.[5] There are well-known benefits of breastfeeding for children's health, such as the reduction of infant mortality[6] and several general health infant diseases[5,7,8,] and malocclusions.[9] A previous study, however, has suggested that lactation beyond a certain period of time can increase the risk of dental caries,[10] whereas another study was not able to confirm this association.[11] Results often vary depending on the definition of the duration of breastfeeding, the sample used, and whether the investigators adjusted for potential confounders. A systematic review and meta-analysis showed a reduced risk of dental caries in children breastfed up to 12 months, but the reliability of the studies was considered weak.[12] Nevertheless, children breastfed for >12 months had more dental caries when compared with children breastfed for <12 months. This review pointed out the lack of studies that assessed the role played by breastfeeding, bottle feeding, and sugar consumption on children >12 months of age.[12]

One of the most challenging aspects of the reviewed literature is the extent to which children are selected into breastfeeding based on several socioeconomic and demographic components that are concurrently associated with infant feeding practices and long-term child outcomes. Fluoride exposure, certain dietary habits, and oral hygiene practices may influence the effect of breastfeeding on dental caries, particularly considering their long-term effects.[13,14,]

Some methodological aspects may improve the quality of research seeking causal inference, such as a prospective design and the use of analytical tools where potential confounders are considered. For example, by using marginal structural modeling (MSM), it is possible to estimate the controlled direct effect (CDE) of an exposure on an outcome. The CDE quantifies the effect of a given exposure under intervention (eg, prolonged breastfeeding) that sets the mediator (eg, sugar consumption) to a specific value for all individuals in the population creating unobserved (counterfactual) quantities. The CDE can be theorized as a hypothetical experiment using observational data, which allow us to reproduce a randomized controlled trial.[15] Given the aforementioned existing gaps in the literature, this study aimed to address the following research question: Is there a CDE of prolonged breastfeeding (PB) on dental caries at age 5 years?

METHODS

Data Setting and Sample Selection

A population-based birth cohort of 4231 live births in Pelotas, Brazil started in 2004. Infants were examined within 24 hours of birth (99%), and follow-up occurred at 3 months (96%), at 12 months (94.2%), and 4 years of age (93.5%).[16] During these follow-ups, mothers were interviewed face to face, and anthropometric measures were collected from mothers and children.

All children who were born between September and December 2004 and who had participated in the 4-year-old follow-up (n = 1303) were eligible to participate in the 2009 oral health assessment. Pelotas has had a public fluoridated water supply since 1962. At age 5 years, 37.0% of the children had visited a dentist, and 45.7% still received assistance when toothbrushing.[17] This sample size was sufficient to estimate the effect of PB on the presence of severe early childhood caries (S-ECC) with a statistical power of at least 80% (β = 20%). The prevalence of S-ECC in the nonexposed group (breastfeeding <24 months) was equal to 17%, a relative risk of ≥1.5 (α = 5%). Household interviews and dental examinations were scheduled by phone using contact details from previous cohort waves. When this approach failed, a household visit was the option.

Outcome

Dental caries was investigated by using the decayed, missing, or filled primary tooth surfaces (dmfs) index according to World Health Organization[18] criteria. Children were examined while seated in an ordinary chair under artificial illumination (head lamp). Two different outcomes were assessed in this study: (1) the average number of dmfs; and (2) the presence of S-ECC (number of dmfs ≥6). Eight dentists were trained and calibrated to perform dental examinations, which involved 100 preschool children excluded from the sample. The minimum intraclass correlation coefficient for dmfs values was 0.92.

Main Explanatory Variable

PB was the main explanatory variable, and information was collected immediately after the participant's birth and at 3, 12, and 24 months and 4 years of age by using the following questions: "Is your child being breastfed? If 'No,' when did she/he stop being breastfed?" "Based on the literature,[12] 1 variable with 3 categories was created as follows: (1) Breastfeeding up to and including 12 months; (2) breastfeeding for 13 to 23 months; and (3) breastfeeding ≥24 months.

Covariates

A directed acyclic graph was drawn to depict the proposed conceptual framework and to identify possible causal pathways (Fig 1). The baseline confounders in the causal relationship between PB and dental caries included socioeconomic conditions and maternal age at child's birth. Information on family income was collected in Brazilian reals (1 US dollar = 3.15 Brazilian reals during the data gathering) and then categorized into quintiles. Maternal level of education was categorized into 4 groups (≤4, ≥5–8, 9–11, and ≥12 full years of schooling), and maternal age was collected in years and analyzed in 4 groups (<20, 20–29, 30–39, ≥40 years of age).

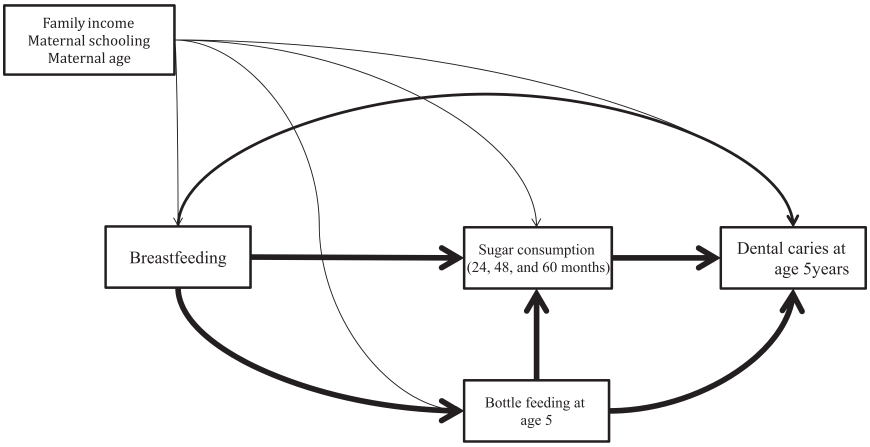

FIGURE 1
Directed acyclic graph to depict the relationship between PB and dental caries at age 5 years. The 2004 Pelotas Birth Cohort, 2004 to 2009, Pelotas, Brazil.

Information on sugar consumption was obtained at 24 and 48 months and at 5 years of age. Food consumption at 24 and 48 months was assessed by using a list of food items or food groups consumed in the 24 hours before the interview. The mother was asked whether each food item in a list had been consumed in each of 7 meals or periods of the day: on waking, morning, lunch, afternoon, dinner, evening, and night.[19] The list was as follows: breast milk, cow's milk, milk powder, coffee, water or tea, juice, bread/cookies, yogurt, fruits, eggs, rice, beans, vegetables/legumes, pasta, potato or cassava, meat, and powdered chocolate milk drinks. Soft drinks were added to the food list for children aged 48 months. The frequency of habitual consumption of chocolate, powdered chocolate milk drinks, candies, lollipops, soft drinks, and chewing gums was compiled in a single sugar group and was categorized by time of day at 24 months of age as follows: "low sugar consumption" (0 or <2 times per day) and "high sugar consumption" (≥2 times per day). Information at 48 months was categorized as "low sugar consumption" (≤2 times per day) and "high sugar consumption" (>2 times per day). Finally, dietary information at age 5 years was collected by using the question "How many times a day does <child> eat sweet foods between meals (eg, cookies, candies, lollipops, chewing gum, chocolate)?" and was categorized as "low sugar consumption" (≤2 times per day) and "high sugar consumption" (>2 times per day). Because not only the frequency of sugar exposure[20] but also the pattern of sugar consumption over time[4] may be important for the progress of dental caries, a categorical variable was created as follows: (1) low (low sugar consumption during the 3 analyzed periods); (2) infrequently (high sugar consumption only at 48 months and/or at 60 months); (3) infrequently but including a critical period (high sugar consumption only at 24 months, or at 24 and 48 or 60 months; (4) high (high sugar consumption in 3 analyzed periods). The critical period (24 months of age) was considered when the teeth are most susceptible to dental caries soon after they erupt.

Sugar consumption was considered a later exposure to dental caries because it is chronologically placed between the main exposure and the outcome. Information on the use of bottle feeding at night was collected at 5 years of age (never/yes, but stopped versus yes, still in use). This variable was considered a sugar consumption-dental caries confounder (Fig 1).

Oral behavior variables (frequency of tooth brushing and dental visits) were not included in the analyses because there is no direct path from oral behaviors to dental caries. Additionally, the only possible backdoor path between oral behaviors and breastfeeding was blocked after controlling for the sociodemographic variables (Supplemental Fig 2).

Data Quality Control

A total of 15% of the interviews were repeated by telephone to assess data quality. The questionnaire was pretested, including questions regarding the pattern of dental attendance during the child's life, age at the first dental visit, and the reason for the first dental visit.

Statistical Analyses

Descriptive analysis included absolute and relative frequencies and outcome prevalence estimates according to independent variables. Both multiplicative and additive interaction between PB and sugar consumption were tested, including the cross-product term in the analytical model (Supplemental Tables 3 and 4). Because an interaction was not detected, the cross-product term was not included in the analysis.[21] Since the use of the conventional regression approach provides biased estimates when conditioning on later exposure of the effect between the exposure and the outcome (collider bias),[22] we used MSM to estimate the CDE of PB on dental caries taking into account the pattern of sugar consumption throughout the life course.[23] Detailed information of how MSM was applied to estimate the CDE can be found in the MSM section of the Supplemental Material.

Ethical Considerations

The Ethics Committee of the Federal University of Pelotas approved the project (number 100/2009). All examinations and interviews were carried out after authorization by the parent or the legal guardian of the participant through a consent letter.

RESULTS

Out of the 1303 eligible children, 86.6% (1129) had complete data on dental caries and had responded to the questionnaire at age 5 years. The prevalence of S-ECC was 23.9% (Table 1); 542 (48%) children had at least 1 surface affected by dental caries (mean number of dmfs: 4.05; SD: 7.38; median: 0; range: 0–69). Among those who had experienced dental caries, the mean number of dmfs was 8.40 (SD: 8.75), whereas the median number of dmfs was 5 (range: 1–69). Approximately half of the children's mothers were between 20 and 29 years of age and had between 5 and 8 years of schooling. Nearly one-quarter of the sample was breastfed for ≥24 months. About 7% of the children had never consumed sugar, whereas 11% consumed sugar at 24, 48, and 60 months of age. Almost half of the sample was still bottle fed at age 5 years.

Unadjusted analyses revealed that the lower the family income and the less maternal schooling, the greater the level of dental caries and risk of having S-ECC. PB was associated with both outcomes, and high sugar consumption was only associated with a greater risk of having S-ECC when compared with those who consumed little sugar (Table 1).

Table 2 shows the CDE of PB on the outcomes. Those children who were breastfed for ≥24 months presented higher levels of dental caries than those who were breastfed for <12 months (mean ratio: 1.9; 95% confidence interval [CI]: 1.5–2.4). Moreover, children breastfed for ≥24 months had a 2.4 times higher risk of S-ECC than those breastfed for <12 months (risk ratio: 2.4; 95% CI: 1.7–3.3).

Supplemental Table 5 presents the results of the sensitivity analysis for unmeasured confounders (U). This table presents hypothetical scenarios where the presence of U would eliminate the CDE of PB on dental caries. For example, to eliminate the CDE of PB on S-ECC, a U not included in the analysis should increase the risk of dental caries by at least 3.0 times (γ in column 6, line 6) and should be 9.0 times more prevalent among those exposed (P1) than those unexposed (P2). In this case, the probability of the presence of U should be equal to 80% (P1 – P2).

DISCUSSION

Being breastfed for ≥24 months increased the risk of having dental caries at 5 years of age. Likewise, those children were more likely to develop S-ECC. These effects were not mediated by sugar consumption during the life course. Our finding corroborates studies conducted in another Brazilian city[10,14,] as well as in high-income countries.[24,25,] However, these studies investigated different cut-off points for breastfeeding. For example, any type of breastfeeding for ≥20 months was significantly associated with dental caries in Southern Italy,[24] whereas breastfeeding for >12 months increased the risk of S-ECC in Germany.[25]

Some mechanisms have been proposed to explain such a relationship. First, PB may be associated with a higher frequency of breastfeeding[10] and nocturnal breastfeeding on demand,[26,27,] when cleaning teeth is difficult. A meta-analysis with 5 studies, including only 1 cohort study, reported an ∼7 times greater risk of having dental caries among children who were exposed to longer nocturnal breastfeeding versus shorter periods of nocturnal breastfeeding.[12] Second, some authors highlighted the concept that genes and environmental components can modify the susceptibility to caries in children, even within the same dentition[28]; however, the role of breastfeeding in this relationship has not been investigated. A recent study[29] suggested that the genetic diversity of *Streptococcus mutans*, the most common bacterium associated with the development of dental caries, may be associated with caries susceptibility in those children who present such bacteria. Nevertheless, the presence of PB remained associated with S-ECC despite the presence of *S mutans* in this study.[29] PB may contribute to S-ECC because it facilitates the colonization of *S mutans*.[30] Another potential explanation is related to the composition of human milk and its potential cariogenicity, because dental caries is a sugar-dependent disease. Human milk produces more caries than cows' milk on smooth surfaces, but exhibits lower cariogenicity than infant formula or sucrose. The high concentration of lactose found in human milk has the potential to reduce the pH of dental plaque, leading to dental caries.[31]

The major strengths of this study are the population-based study design, the high response in all cohort waves, the high level of diagnostic

TABLE 1 Sample Description According to Independent Variables and Outcomes

Variables	Sample n (%)	Mean dmfs	95% CI	Crude Rate Ratio[a]	95% CI	S-ECC	95% CI	Crude Risk Ratio[b]	95% CI
Maternal age, y (*n* = 1121)									
<20	214 (18.9)	5.1	4.1 to 6.0	1.0	—	32.9	26.5 to 39.2	1.0	—
20–29	544 (48.2)	4.1	3.5 to 4.8	0.8	0.6 to 1.1	23.4	19.8 to 26.9	0.6	0.4 to 0.9
30–39	340 (30.1)	3.2	2.5 to 3.9	0.6	0.4 to 0.9	18.6	14.4 to 22.7	0.5	0.3 to 0.7
≥40	30 (2.7)	5.3	2.1 to 8.4	1.0	0.5 to 2.3	30.0	12.6 to 47.4	0.9	0.4 to 2.0
Family income quintiles (Brazilian real)[c] (*n* = 1129)									
5 (highest)	225 (19.9)	2.2	1.6 to 2.9	1.0	—	15.2	10.4 to 19.9	1.0	—
4	187 (16.6)	3.1	2.2 to 4.0	1.37	0.9 to 2.0	19.9	14.1 to 25.7	1.4	0.8 to 2.3
3	265 (23.5)	4.0	3.2 to 4.8	1.8	1.2 to 2.6	23.9	18.8 to 29.1	1.8	1.1 to 2.8
2	190 (16.8)	4.3	3.4 to 5.3	1.9	1.3 to 2.9	27.0	20.6 to 33.4	2.1	1.3 to 3.3
1 (lowest)	262 (23.2)	6.1	4.9 to 7.3	2.7	1.9 to 3.9	31.9	21.2 to 37.6	2.6	1.7 to 4.1
Maternal level of education, y (*n* = 1106)									
≥12	123 (11.2)	1.8	0.9 to 2.8	1.0	—	10.5	5.0 to 16.1	1.0	—
9–11	394 (35.7)	3.2	2.6 to 3.8	1.7	1.1 to 2.6	20.7	16.7 to 24.7	2.2	1.2 to 4.1
5–8	445 (40.2)	4.6	4.0 to 5.3	2.5	1.6 to 3.8	28.1	23.9 to 32.3	3.3	1.8 to 6.1
≤4	144 (13.0)	6.9	5.1 to 8.6	3.7	2.2 to 6.1	32.6	24.9 to 40.4	4.1	2.1 to 8.0
Breastfeeding (*n* = 1128)									
0–12	741 (65.7)	3.4	2.9 to 3.9	1.0	—	19.8	16.9 to 22.7	1.0	—
13–23	129 (11.4)	3.1	2.2 to 4.0	0.9	0.6 to 1.3	20.1	13.1 to 27.2	1.0	0.6 to 1.6
≥24	258 (22.9)	6.4	5.3 to 7.5	1.9	1.4 to 2.5	37.5	31.5 to 43.5	2.4	1.8 to 3.3
Sugar consumption during lifetime (*n* = 1065)									
Low[d]	74 (6.9)	2.8	1.5 to 4.1	1.0	—	18.9	9.8 to 28.1	1.0	—
Infrequently[e]	531 (49.9)	3.8	3.2 to 4.4	1.3	0.8 to 2.3	22.2	18.7 to 25.8	1.2	0.7 to 2.2
Infrequently with critical period[f]	346 (32.5)	4.1	3.3 to 4.9	1.4	0.8 to 2.5	23.1	18.6 to 27.6	1.3	0.7 to 2.4
High[g]	114 (10.7)	4.9	3.7 to 6.1	1.8	0.9 to 3.2	35.1	26.2 to 44.0	2.3	1.1 to 4.6
Bottle feeding at night – 5 y (*n* = 1126)									
Never/yes, but stopped	565 (50.2)	4.4	3.8 to 5.0	1.0	—	26.5	22.8 to 30.1	1.0	—
Yes, still use	561 (49.8)	3.7	3.1 to 4.3	0.9	0.7 to 1.1	21.1	17.6 to 24.4	0.8	0.6 to 1.1
S-ECC (*n* = 1122)									
dmfs <6	854 (76.1)	0.9	0.7 to 1.0	—	—	—	—	—	—
dmfs ≥6	268 (23.9)	14.2	13.1 to 15.3	—	—	—	—	—	—

—, reference category.

[a] Mean ratio estimated by negative binomial regression for level of dmfs as the outcome.

[b] Risk ratio estimated by log-linear regression for S-ECC as the outcome.

[c] 1 US dollar = 3.15 Brazilian reals (January 6, 2004).

[d] Low, low sugar consumption (0 or <2 times per day) at 12 and 24 months and 5 years of age.

[e] Infrequently, high sugar consumption (>2 times per day) only at 48 months and/or at 5 years of age.

[f] Infrequently with critical period, high sugar consumption (>2 times per day) only at 24 months, or at 24 and 48 months of age, or at 24 months and 5 years of age.

[g] High, high sugar consumption (>2 times per day) at 12 and 24 months and 5 years of age.

TABLE 2 CDE of Breastfeeding on Dental Caries From MSM

	Dental Caries	Severe Dental Caries
	MSM: Mean Ratio[a] (95% CI)	MSM: Relative Risk[a] (95% CI)
Breastfeeding		
Up to 12 mo	1.0	1.0
13–23 mo	0.9 (0.6 to 1.3)	1.0 (0.6 to 1.6)
≥24 mo or beyond	1.9 (1.5 to 2.4)	2.4 (1.7 to 3.3)
Sugar exposure		
Low	1.0	1.0
Infrequently	1.4 (0.8 to 2.4)	1.3 (0.7 to 2.6)
Infrequently including critical period	1.6 (0.9 to 2.7)	1.5 (0.7 to 2.9)
High	1.8 (1.0 to 3.1)	2.3 (1.1 to 4.9)

2004 Pelotas Birth Cohort, Pelotas, Brazil, 2004 to 2009.

[a] Adjusted for family income, maternal schooling, maternal age, sugar consumption, and bottle feeding at age 5 years.

reliability, and the methodological and analytical approach employed. The sample distribution of our study was similar to that of the general cohort study,[16] suggesting no selection bias. Recall bias was unlikely, because the information used was collected during or shortly after exposure, leading to short recall periods. Observation bias is also unlikely to have occurred, because observers, when performing oral examinations, were unaware of the duration of breastfeeding for the children. MSM provided estimates that allowed a causal interpretation between PB and dental caries at age 5 years. The strength of our findings is ensured by the fulfillment of conditions required by MSM, such as positivity and correct model specification. The sensitivity analysis for unmeasured confounding ensured the robustness of our findings. To eliminate the CDE of PB on dental caries, the difference in the prevalence of U and the effect of U on the outcome showed rates that are unlikely to be observed in the real world. However, a certain degree of unmeasured confounding can always exist in observational studies.

This study helps to close existing gaps in the literature by including information on the use of bottle feeding and dietary habits suggested in a recent systematic review.[12] Moreover, it included some key confounders, such as socioeconomic conditions, and, therefore, a range of food/drink consumption over the studied period, information that is absent from many earlier studies. However, the generalizability of our findings is uncertain and may only be warranted for populations with similar patterns of breastfeeding and fluoride exposure.

Our study has limitations; for example, we did not collect information on other potentially cariogenic sources and the frequency of nocturnal breastfeeding, which may have led to residual confounding. The absence of information on dental caries experience before the age of 5 years did not permit a better understanding of the long-term effect of breastfeeding on dental caries experience in the earlier stages. Furthermore, the presence of only cavitated smooth surfaces was not considered S-ECC,[32] which may have underestimated the prevalence of S-ECC. Nevertheless, children with severe caries are still the focus of our research. Finally, another limitation is related to the period when information regarding sugar consumption was collected. Patterns of sugar consumption are established in early childhood[33] and may be associated with S-ECC.[34]

We distinguish between different effects of PB; first, the average number of teeth with dental caries, and second, the severity of dental caries. Breastfeeding exclusively for 6 months and breastfeeding until 12 months of age protect against malocclusion[9] and dental caries,[12] respectively, and these practices should be encouraged in public policies, meeting the rationale of the common risk factor approach.[35] From the health practitioner's perspective, a positive and informative relationship with mothers may include emphasizing the importance of breastfeeding for oral health and allows tooth brushing recommendations to be provided. Mothers may be encouraged to clean their children's teeth before going to bed and to use fluoride toothpaste in adequate amounts, avoiding demineralization of teeth.[36] Fluoride toothpaste can reduce tooth demineralization, but this depends on sugar consumption. However, the effect of PB on S-ECC was not mediated by dietary factors.

S-ECC is a public health issue because it is a major but preventable condition that leads to pain and suffering that may affect children's quality of life.[37] S-ECC impacts on the wider society; it is the most common reason for hospitalization and the use of general anesthesia among children in some countries, particularly for those from disadvantaged socioeconomic groups.[38] This intervention is resource-intensive, costly, and not without risk for individuals and society.[39]

CONCLUSIONS

Breastfeeding for ≥24 months increases the risk of having S-ECC. We suggest adopting measures to prevent dental caries in childhood as early as possible, because breastfeeding is beneficial for children's health.

ABBREVIATIONS

CDE: controlled direct effect
CI: confidence interval
dmfs: decayed, missing, and filled primary tooth surface
MSM: marginal structural model
PB: prolonged breastfeeding
S-ECC: severe early childhood caries
U: unmeasured confounder

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