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Social and biological early life influences on the prevalence of open bite in Brazilian 6-year-olds

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Objective. Little is known about the effects of social and biological risk factors for open bite on the primary dentition. The aim of this study was to assess the early-life risk factors affecting anterior open bite.

Methods. A cross-sectional study using a birth cohort was carried out in Pelotas, Brazil. A sample of 400, 6-year-old children was employed. The Foster and Hamilton criteria were used to classify open bite. Data concerning social conditions, and perinatal and childhood health and behaviour were obtained from birth to 12 months of age and during the fifth year of the children's lives. Unconditional bivariate and multiple logistic regression analysis were performed.

Results. The prevalence of anterior open bite was 46.3%. Risk factors included: a maternal age of between 30 and 39 years, as compared with children whose mothers were younger; breast-feeding for < 9 months; dental caries experience; pacifier sucking between 12 months and 5 years, as compared to no sucking or a shorter duration of sucking; and the presence of finger-sucking at 6 years of age.

Conclusion. Open bite in the primary dentition was associated with older mothers, early weaning, dental caries occurrence, long-term use of a pacifier and finger-sucking at 6 years of age. These findings support the common risk approach for intervention to prevent open bite in the primary dentition.

Introduction

The aetiology of malocclusion in the primary dentition has been described in two different ways: some authors consider the genetic factors influencing skeletal development to be the most important determinants for malocclusion[1], while, on the other hand, the authors of anthropological studies of the secular trends of malocclusion have indicated that environmental conditions affect the variation in occlusal traits[2,3]. The most frequently mentioned environmental factors are changes in feeding habits, including: the trend towards a more refined diet demanding less powerful masticatory action[2]; premature primary tooth loss caused by caries[2]; non-nutritive sucking habits[4]; bottle-feeding[4,5]; and early weaning[4]. Therefore, the development of malocclusion depends on the effects of various orofacial functions in the early postnatal period. In addition, some studies have suggested that parental behaviours in relation to breast-feeding and diet are determined by social and economic conditions[5]. Recent studies of risk factors for open bite have shown that a non-nutritive sucking habit is the main risk factor associated with this type of malocclusion[6–8]. Because of the shortcomings of most published research, however, little is known about when and how the recognized risk factors for open bite occur.

Therefore, a study using the life course approach was conducted to investigate social and biological risk factors for open bite acquired in the first years of life. The life

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course approach theory offers an alternative way of linking early-life factors to later disease or chronic disorders[9]. Social and biological risks accumulated during the course of life, especially in initial periods during early life, are the key determinants of health in later years. The risk of chronic disease is increased if there are numerous insults along the life course[9].

The aim of this study was to identify risk factors for open bite in 6-year-old children using a life course approach.

Subjects and methods

The Pelotas birth cohort

This study was conducted in Pelotas, Rio Grande do Sul, a 323 000-inhabitant city located in a relatively developed area of Southern Brazil[10]. A birth cohort study was initiated in 1993. The main objective was to assess perinatal and infant health using five subgroups: perinatal, follow-up, infant mortality, hospital admissions and psychological development[10]. In the perinatal subgroup, 99% of the live-born children in the study area were identified, and questionnaires collecting data on social and economic variables, as well as demographic, antenatal, behavioural, healthcare and morbidity characteristics were administrated to mothers shortly after the delivery. The mothers were weighed and measured, and the children were weighed, measured and examined. For the follow-up study, a sample of children was selected and followed up at 1, 3, 6 and 12 months. In 1998, a sample including all low-birth-weight infants and 20% of the remainder was sought at home; of the 1460 births in this sample, 87% (1273 children) were located. The details and results of the five subgroups have been described elsewhere[10].

Sample size calculation

The Oral Health Study started in 1999 as a cross-sectional survey nested in the birth cohort study. A minimum sample size to estimate the prevalence of open bite was randomly selected from the 1998 follow-up study sample ($n = 1273$). Since the detection rate of the relative risk of anterior open bite is ≥ 1.9, with a prevalence of 54% in children breast-fed for less than 9 months (exposed)[11], a sample of 342 children was needed, providing a power test of 80% at a significance level of 5%. The sample was increased by 10% to allow for losses or refusals, resulting in a round number of 400 children. Since low-birth-weight children (9.7% in the perinatal study) were over-represented in the sample (29.7%), the analyses were done using weighted values: 0.34 was used for low-birth-weight children and 1.27 otherwise.

Clinical examinations

Dental examinations were carried out by a team of three dentists and three clerks in order to assess malocclusion, dental caries and oral mucosal lesions. The diagnosis of malocclusion was based on the criteria of Foster and Hamilton[12]: presence of open bite (anterior and/or posterior), unilateral or bilateral crossbite (anterior and/or posterior) considered as reverse buccal overjet with or without a midline shift, and primary canine relationships on the right and left sides (classes 1, 2 and 3). The children were examined in their homes, sitting on a chair. When necessary, the child's mandible was gently guided into centric occlusion by the examiner. The World Health Organization clinical definition of dental caries[13] was used in order to standardize the observation of different dental examiners in the field work.

Outcome

This paper presents the results relative to anterior open bite, classified as a dichotomous variable (present or absent). Other outcomes will be addressed in further papers.

Diagnostic reliability

Before the children were examined, the reliability of the examiners was assessed. The examiners were calibrated in December 1998 and May 1999. One of the authors (M.A.P.) was the standard examiner. The kappa statistic was calculated for each type of malocclusion to assess the intra- and interexaminer agreement.

Exploratory variables

A questionnaire was administered to the mothers after the child's dental examination. The questions were about bottle-feeding (yes, no and when started), pacifier sucking (yes, no and when), thumb- and finger-sucking (yes, no and when started) and mouth breathing (yes, no and when started). The data concerning perinatal, socioeconomic and childhood health were derived from the data from the large cohort study, and covered birth, 1, 3, 6 and 12 months of age, and the fifth year of life[10]. These included social and economic conditions such as social class, family income, parent's education, number of children under 5 years of age and household conditions. The maternal independent variables were age (at the beginning of pregnancy), parity, breast- or bottle-feeding, work, cigarette smoking, marital status and child care. The characteristics of the child that were analysed included type of delivery, birth weight, number of teeth, non-nutritive sucking habits, sleeping arrangement and respiratory disease. The child's sex was also recorded.

Data entry and statistical analysis

Bivariate analysis between the dependent and each of the independent variables were tested, and the odds ratios were measured with 95% confidence intervals. To analyse the potential risk factors for open bite, a hierarchical approach to variable selection was used. The variables were grouped from distal to proximate determinants, as shown in Fig. 1. Unconditional crude and adjusted logistic regression analyses were performed for each level of determination in order to select variables associated with the outcome. Variables were kept in the logistic regression model if their *P*-value was less than 0.2 in the likelihood ratio test. The final model included all variables that had a P-value ≤ 0.05 after adjustment for variables in the same level and above, or it was kept according to the theoretical framework.

Multivariate analysis is required for evaluating determination. The choice of factors included in the multivariate model was not based purely on statistical association. They were also based on a conceptual framework describing the hierarchical relationships between risk factors[14]. In this study, the authors assumed three different levels of malocclusion determination: the first included socioeconomic variables, the second maternal characteristics, and the third was composed of the children's biological and behavioural characteristics. It was hypothesized that the first level influences the second and so on. Data on all factors were not available for all children. The analyses were done using the SPSS for Windows, Version 10.0, computer program.

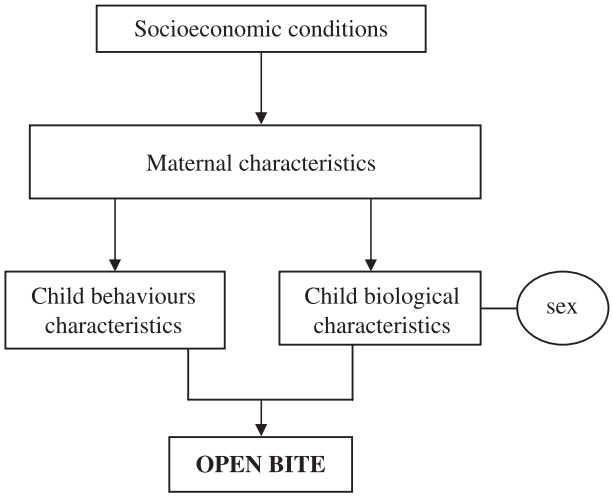

Fig. 1. Theoretical framework of potential risk factors for open bite.

Ethical issues

The children's parents were informed about the objectives of the study, and consent was obtained for interviews and dental examinations. The Ethics Committee of the Federal University of Pelotas Medical School approved the project.

Results

Relative to children who had been followed up until 1998 (90% of the original cohort), the response rate for the oral health study was 89.7% ($n = 359$). Non-response was mainly a result of families moving out of the city. The sample was composed of 190 (53.8%) males and 169 (46.2%) females. All the results are presented as weighted values. The prevalence

Table 1. Socioeconomic (level 1) and maternal behavioural/demographic (level 2) variables: crude and adjusted analyses (Pelotas, Brazil, 1999).

Variable	Number	Open bite (%)*		Odds ratio (95% CI) (crude)	*P*-value (χ^2 test)	Odds ratio (95% CI) (adjusted)	*P*-value
		No	Yes				
Level 1: socioeconomic							
Family income (BMW†):					0.529	–‡	–‡
> 6.0	48	59.3	40.7	1.0			
1.1–6.0	247	51.6	48.4	1.4 (0.8, 2.5)			
≤ 1.0	64	56.5	43.5	1.1 (0.5, 2.3)			
Maternal schooling (years):					0.221	–‡	–‡
8	86	58.8	41.2	1.0			
≤ 8	273	51.9	48.1	1.3 (0.8, 2.1)			
Paternal schooling (years):					0.354	–‡	–‡
8	93	57.8	42.2	1.0			
≤ 8	239	52.4	47.6	1.2 (0.8, 2.0)			
Level 2: maternal behavioural and demographic							
Maternal work at 12 months of age:					0.218	–‡	–‡
yes	144	49.7	50.3	1.0			
no	214	56.8	43.2	0.8 (0.5, 1.2)			
Household work at birth of child:					0.468	–‡	–‡
others	160	56.2	43.8	1.0			
mother	199	51.8	48.2	1.2 (0.8, 1.8)			
Mother smoked during pregnancy:					0.106	–‡	–‡
no	241	56.7	43.3	1.0			
yes	118	46.7	53.3	1.5 (1.0, 2.4)			
First pregnancy:					0.272	–‡	–‡
no	233	51.5	48.5	1.0			
yes	126	58.2	41.8	0.8 (0.5, 1.2)			
Parity					0.959	–‡	–‡
4	323	53.6	46.4	1.0			
≥ 4	36	55.6	44.4	0.9 (0.5, 1.8)			
Intrapartum interval (months):					0.592	–‡	–‡
18	191	49.2	50.8	1.0			
≤ 18	15	60.0	40.0	0.6 (0.2, 1.9)			
Maternal age (years):					0.012		0.022
14–19	55	60.0	40.0	1.0		1.0	
20–29	203	56.4	43.6	1.2 (0.7, 2.2)		1.1 (0.6, 2.1)	
30–39	90	43.6	56.4	1.9 (1.0, 3.8)		2.3 (1.1, 4.8)	
40–46	11	63.6	36.4	0.9 (0.2, 3.3)		0.9 (0.2, 3.4)	
Breast-feeding (months):					0.001		0.001
≥ 9	78	71.8	28.2	1.0		1.0	
< 9	279	48.2	51.8	2.8 (1.6, 4.7)		2.8 (1.6, 4.8)	

*Weighted prevalence. †Brazilian minimum wage. ‡Excluded after adjusting for other variables; (95% CI) 95% confidence interval.

of low birth weight and dental caries was 9.7% and 62.5%, respectively. The mean dmft was 3.30 (SD = 3.29), showing that the decay component was the most prevalent (96.7%). Anterior open bite was detected in 46.3% (95% confidence interval = 41.2–51.4) of children. The minimum kappa value for inter-observer agreement was 0.85.

In the initial analyses, the crude effect of each independent variable was assessed, and then its effect was adjusted for other variables on the same hierarchical level. The bivariate analysis relating to socioeconomic variables showed no significant association with anterior open bite (Table 1). Although none of the socioeconomic variables was associated with the outcome, maternal schooling was kept in the final model in order to represent socioeconomic characteristics and to control variables belonging to lower hierarchical levels. The adjusted model for the second level showed that maternal behavioural and demographic variables associated with open bite after adjustment included a maternal age of between 30 and 39 years ($P = 0.031$), and a breast-feeding duration of < 9 months ($P = 0.001$) (Table 1).

Table 2. Child biological variables (level 3): crude and adjusted analyses (Pelotas, Brazil, 1999).

Variable	Number	Open bite (%)*		Odds ratio (95% CI) (crude)	*P*-value (χ^2 test)	Odds ratio (95% CI) (adjusted)	*P*-value
		No	Yes				
Level 3: child biological							
Sex:					0.917		0.943
male	190	53.9	46.1	1.0		1.0	
female	169	53.3	46.7	1.0 (0.7, 1.6)		1.1 (0.7, 1.5)	
Type of delivery:					0.555	–†	–†
normal	262	52.5	47.5	1.0			
Caesarean	97	56.7	43.3	0.8 (0.5, 1.3)			
Gestational age (months):					0.157	–†	–†
37–42	295	55.0	45.0	1.0			
< 37	60	41.4	58.6	1.7 (0.8, 3.7)			
Birth weight (g):					0.408	–†	–†
≥ 2500	256	54.6	45.4	1.0			
< 2500	103	45.7	54.3	1.5 (0.7, 3.0)			
Head circumference (tenth percentile) (%):					0.107		0.091
> 10	245	55.8	44.2	1.0		1.0	
≤ 10	110	43.8	56.3	1.6 (1.0, 2.8)		1.6 (0.9, 2.8)	

*Weighted prevalence. †Excluded after adjusting for other variables; four missing values for the gestational age and head circumference variables; (95% CI) 95% confidence interval.

Nine months was chosen because this was the cut-off point that fitted the model best.

The result of stepwise logistic regression for the third level confirmed that there was no statistical association ($P > 0.05$) between the demographic and biological variables of the child and anterior open bite (Table 2). In spite of this, the child's sex was kept in the final multiple regression model as a control variable.

The unadjusted and adjusted models related to child behavioural and dental status variables, and anterior open bite are shown in Table 3. Despite the fact that several child behavioural variables had been significant in the bivariate analysis, only pacifier sucking between the ages 12 months and 5 years ($P < 0.001$), dmft ≥ 1 ($P < 0.001$) and finger-sucking in 6-year-olds ($P = 0.026$) remained statistically significant after controlling for other variables on the same level.

The final hierarchical model including all selected variables from each level of determination is shown in Table 4. The conceptual model approach determines that variables on each level should be adjusted for those belonging to higher levels as well as for variables on the same hierarchical level. Children whose mothers were between 30 and 39 years of age when the child was born were more likely to have open bite compared with children whose mothers was aged < 20 years ($P = 0.011$). Children who were breast-fed for less than 9 months showed a higher risk of developing anterior open bite than those who were breastfed for ≥ 9 months (< 0.001). In addition, significant differences in open bite were also found among children with a longer duration of pacifier sucking compared to no sucking or a shorter duration of sucking ($P = 0.001$), experience of dental caries ($P = 0.017$), and finger-sucking ($P = 0.011$). The general pattern demonstrated on the last level of the hierarchical model remained after controlling for sex.

Discussion

This paper reports a cross-sectional assessments of open bite prevalence nested in a birth cohort study. Positive aspects of the design include its high response rates during the follow-up study and the prospective nature of the data on risk factors, which helps to establish the chronology of events and avoids recall bias. Nevertheless, the present results should be viewed with some caution, particularly because of the relatively good socioeconomic conditions in Pelotas when compared with other cities in Brazil. In addition, despite all

Table 3. Child behavioural variables and dental status (level 3): crude and adjusted analyses (Pelotas, Brazil, 1999).

Variable	Number	Open bite (%)*		Odds ratio (95% CI) (crude)	*P*-value (χ^2 test)	Odds ratio (95% CI) (adjusted)	*P*-value
		No	Yes				
Level 4: child behavioural and dental status							
When started pacifier:					0.050	–†	–†
never	46	77.6	22.4	1.0			
< 3 months of age	276	50.0	50.0	3.3 (1.6, 6.6)			
3–6 months of age	30	51.7	48.3	3.0 (1.1, 8.2)			
> 6 months of age	04	50.0	50.0	3.3 (0.6, 21.2)			
Pacifier sucking at 12 months of age:					< 0.001	–†	–†
no	62	80.3	19.7	1.0			
yes	297	47.6	52.4	4.6 (2.4, 8.8)			
Pacifier-sucking at 5 years of age:					< 0.001	–†	–†
no	29	90.0	10.0	1.0			
yes	326	50.2	49.8	11.5 (2.8, 38.8)			
Pacifier between 12 months and 5 years of age:					< 0.001		0.001
never or partially	142	81.8	18.2	1.0		1.0	
all the time	217	34.1	65.9	8.6 (5.2, 5.14)		9.3 (5.5, 6.15)	
Kindergarten at 12 months of age:					0.120	–†	–†
yes	22	73.7	26.3	1.0			
no	337	52.6	47.4	2.3 (0.8, 6.3)			
Child care at 6 months of age:					0.078	–†	–†
mother and/or father	304	51.5	48.5	1.0			
others	52	65.5	34.5	0.6 (0.3, 1.0)			
dmft:					0.022		0.029
0	129	61.9	38.1	1.0		1.0	
≥ 1	230	48.9	51.1	1.7 (1.1, 2.6)		1.7 (1.1, 2.8)	
Missing and decayed teeth at 6 years of age:					0.017	–†	–†
no	133	61.9	38.1	1.0			
yes	226	48.4	51.6	1.7 (1.1, 2.7)			
Respiratory disease at 12 months of age:					0.943	–†	–†
no	257	53.8	46.9	1.0			
yes	94	54.3	45.7	0.9 (0.6, 1.6)			
Finger-sucking at 6 years of age:					0.130		0.026
no	327	55.1	44.9	1.0	1.0		
yes	32	41.7	58.3	1.7 (0.9, 3.5)		2.5 (1.1, 5.8)	
Bottle-feeding at birth:					0.186	–†	–†
no	350	54.2	45.8	1.0			
yes	8	20.0	80.0	5.2 (0.6, 44.5)			
Bottle-feeding at 5 years of age:					< 0.001	–†	–†
no	123	66.7	33.3	1.0			
yes	236	46.8	53.2	2.2 (1.4, 3.5)			

*Weighted prevalence. †Excluded after adjusting for other variables; (95% CI) 95% confidence interval.

the information being derived from a cohort study, the same was not the case with respect to the outcome, i.e. open bite. Another weakness of this study is the fact that data on dental caries and finger-sucking habits were collected only from 6-year-olds. The authors are unaware if either variable presented before the occurrence of open bite. It is, however, plausible that these may have occurred previously because dental caries is a chronic and cumulative disease, and finger-sucking habits usually start early in life. There is a possibility that this was a possible cause since dental caries may, in fact, be an effect. This is a common bias in a cross-sectional study. On the other hand, all other explanatory variables were longitudinally assessed.

There are very few studies involving multiple dimensions of the aetiology of open bite. Most reports analyse each risk factor separately, which means that these do not measure any interactive joint effects. Furthermore, there is considerable variation in the results of epidemiological studies of the aetiology of open

Table 4. Multiple logistic regression to anterior open bite (Pelotas, Brazil, 1999).

Variable	Odds ratio (95% CI) (crude)	*P*-value	Odds ratio (95% CI) (adjusted)	*P*-value
Level 1: socioeconomic conditions				
Maternal schooling (years):		0.221		0.221
8	1.0		1.0	
≤ 8	1.3 (0.8, 2.1)		1.3 (0.8, 2.1)	
Level 2: maternal behavioural characteristics				
Maternal age (years):		0.012		0.014*
14–19	1.0		1.0	
20–29	1.2 (0.7, 2.2)		1.2 (0.6, 2.5)	
30–39	1.9 (1.0, 3.8)		1.8 (1.3, 6.1)	
40–46	0.9 (0.2, 3.3)		0.8 (0.2, 3.1)	
Breast-feeding (months):		0.001		0.001*
≥ 9	1.0		1.0	
< 9	2.8 (1.5, 5.2)		2.7 (1.4, 6.8)	
Level 4: child behaviour, demographic and dental status characteristics				
Pacifier between 12 months and 5 years of age:		0.001		0.001**
never or partially	1.0		1.0	
all the time	8.6 (5.2, 14.2)		8.3 (3.3, 20.6)	
dmft:		0.022		0.017**
0	1.0		1.0	
≥ 1	1.7 (1.1, 2.6)		1.9 (1.1, 3.1)	
Finger-sucking at 6 years of age:		0.130		0.011**
no	1.0		1.0	
yes	1.7 (0.9, 3.5)		3.0 (1.3, 7.1)	

**P*-value adjusted by maternal schooling and all the variables of level 2, ***P*-value adjusted by all the variables of levels 1, 2 and 4, and by sex; (95% CI) 95% confidence interval.

bite, depending on the population surveyed and on the recording method. The analytical approach using the hierarchical model emphasizes the theoretical hypothesis as well as the statistical technics.

Open bite affected 46.3% of the sample, a higher prevalence rate than that found in most previous studies[11,15,16]. Variations in prevalence could be explained by the differences in children's ages between studies. It is known that the frequency of harmful exposures, such as finger- and pacifier-sucking habits, vary according to a child's age. In addition, cultural habits may have influenced exposure to higher or lower risk factors, such as duration of breast-feeding and different types of non-nutritive sucking habits.

In this study, socioeconomic conditions were not associated with open bite. This corroborates results from other studies[11,17–19]. In spite of this, further research is needed because other studies have not found significant associations between socioeconomic factors and different types of malocclusion[19,20].

A maternal age of between 30 and 39 years was also statistically associated with open bite, after adjusting for the mother's schooling. This may reflect differences in maternal care depending on the age of the mother. It was an unexpected finding that needs further investigation.

A low prevalence and severity of open bite have been observed in children who breast-fed longer, a result supported by Meyers and Hertzberg's findings[21]. This was most probably a result of the impact of a nutritive sucking habit on oral facial tissue development. On the other hand, in their cross-sectional study, Warren and Bishara[7] found no relationship between duration of breast-feeding during the first year of life and the presence of open bite. In spite of their negative finding, the present authors do not exclude the possibility that more prolonged breast-feeding might have positive effects on preventing malocclusion, including open bite.

Birth weight, a key determinant in child health, was not associated with open bite, corroborating another Brazilian study[11]. This

finding supports the hypothesis that biological factors in early life have a relatively small effect compared to behavioural ones.

The use of a pacifier was also analysed. When this habit was introduced earlier in life, there was a high risk of developing open bite, but this excess risk disappeared after controlling for the length and frequency of the habit, suggesting that these latter variables are more important than early introduction, a finding supported by other studies[7,8,22–24]. A study in Campania, Italy[25], showed that non-nutritive sucking activity rather than the type of feeding in the first months of life was the main risk factor for the development of open bite in the primary dentition, corroborating the authors' finding that prolonged use of pacifier is a risk factor for open bite that is independent of duration of breast-feeding.

Warren *et al.*[22] found that older mothers, those with a higher level of education and primiparae were more likely to have children with non-nutritive sucking habits in comparison to younger mothers, with lower level of education and with more than one child. These findings were also confirmed by Farsi and Salama[23], and Paunio *et al.*[26]. In this study, the same pattern was observed when analysing the association between the duration of pacifier use and the mother's schooling (data not shown).

As demonstrated here, the main proximate risk factor for open bite was pacifier use, which is associated with other early events in the child's life, such as length of breast-feeding, which may in turn also influence other health problems in childhood[27].

The second most important proximate risk factor for open bite was the presence of dental caries. The authors hypothesized that a long duration of bottle feeding, mainly at night, may be a common risk factor for both dental caries and open bite[16].

Preventing open bite in the primary dentition may contribute to avoiding different types of malocclusion in the permanent dentition or, at least, reducing its severity[18]. The authors intended to analyse the association between open bite in the primary and permanent dentition in a follow-up study of the same sample. From a public health perspective, interventions should be implemented as early as possible, so as to increase the number of children with normal occlusions, or reduce the proportion of cases of severe malocclusion to socially and economically acceptable levels.

Policies to promote general and oral health must include an increase in maternity leave after delivery in order to support breast-feeding, regulations to prevent the consumption of unhealthy foods and drinks by children, and the use of clear warnings about food composition[28].

What this paper adds

- This paper has explored open bite in primary dentition in children aged 6 years using a life course approach.
- Few studies have explored malocclusion outcomes adopting this approach; none of them were carried out outside high-income countries nor did they adopt a prospective birth cohort design.

Why this paper is important to paediatric dentists

- This paper emphasizes the role of specific and general risk factors for open bite in children.
- The former included the importance to prevent dental caries while the last shows the contribution of common risk approach such as to promote breast-feeding in order to prevent open bite in primary dentition.

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