Maxillary Anterior Caries as a Predictor of Posterior Caries in the Primary Dentition in Preschool Brazilian Children

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ABSTRACT

Purpose: The purpose of this study was to assess the use of maxillary anterior (**MA**) caries as a predictor of posterior (**PO**) caries at different dmf thresholds in Brazilian preschoolers. **Methods:** Clinical examinations were carried out during a National Day of Children Vaccination in Diadema, S.P.,Brazil. Caries experience was measured using dmfs index (WHO criteria), including white spots (D1). Odds ratio (OR), specificity (Sp), sensitivity (Se), and positive and negative prediction values (PV+, PV-) were calculated at different dmfs thresholds for maxillary anterior teeth. The area under the ROC curve (AUC) was used as a measure of the discriminant ability of MA caries on posterior caries. **Results:** A total of 987 children 5 to 59 months old were examined: 33% had caries; 22% had MA caries; and 68% had PO caries. In children older than 36 months, an association was found between MA and PO caries. Presence of MA caries increased the chances of children presenting PO caries at all dmfs thresholds. Predictive values (Sp, Se, PV+, PV-) varied according to dmfs thresholds. The total AUC was 0.75. **Conclusions:** Caries in the anterior maxillary region was positively associated with posterior caries in 5- to 59-month-old children. Early onset of caries in maxillary anterior teeth may be a good predictor of the development of caries in posterior teeth in preschoolers.
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Early childhood caries (**ECC**) is still recognized as a significant public health problem since its consequences not only lead to a widespread destruction of the dentition, but also affects children's quality of life and their development.[1-3] ECC mainly affects socially and economically disadvantaged minorities, especially in developing countries.[1,3,4] In Brazil, the prevalence of ECC ranges from 12% to 30%.[1,5,6]

Researchers have assessed probable and putative risk factors for ECC in cross-sectional studies.[5-7] Despite their efforts, there are still many unanswered questions regarding the caries risk factors and indicators, especially in very young children. One of the most accurate predictor of future caries development in both mixed and permanent dentitions is past caries experience.[8-12] For the primary dentition, patterns of dental caries onset have been proposed as risk indicators for future caries development in the same dentition in both cross-sectional and longitudinal studies.[8,13-19]

In preschool children, caries in maxillary anterior teeth (**MA caries**) is recognized as being a specific pattern of ECC associated with the development of caries in primary molars (PO caries).[18] More children with and without PO caries

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had MA caries.[8,13-19] In addition, young children with MA caries had a higher annual increment of caries lesions compared with children that had PO caries only.[19] Therefore, the MA caries pattern could be used as a risk indicator for the future development of new caries lesions in the primary dentition.[12,13-19] The association between MA caries and PO caries, however, varies with the populations studied, sample size, diagnostic criteria, and thresholds for ECC and the analytical methods used.[7,8,11,20-22] No study has previously addressed the usefulness of maxillary anterior teeth patterns as a possible predictor for future caries development considering different caries severity thresholds in a representative population sample of Brazilian preschool children.

Therefore, this study's purpose was to assess the use of caries in maxillary anterior teeth as a risk indicator for caries in molars and the predictive values of MA caries at different dmf thresholds in a large representative sample of preschool children living in Diadema, S.P. Brazil. From a public health perspective, this information could be useful in planning public health strategies to prevent the extension of caries into the late primary dentition, since caries in primary incisors appear to be the first signs of ECC in young children.

METHODS

A cross-sectional survey was conducted on a representative sample of 5- to 59-month-old children of Diadema, S.P. Diadema has an estimated population of 357,064, including 35,034 children under 5 years old. According to information provided by local authorities and a previous study,[1] socioeconomic status in the area of the survey is essentially homogeneous in this age group. Children are mainly from low socioeconomic backgrounds. The city has a fluoridated water supply (0.7 ppm) provided for all inhabitants since 1988. Data from a previous study indicated that caries prevalence was 20% in 5- to 59-month-old children.[1] No preventive oral health program has been undertaken exclusively for this age group in the city. Oral health strategies have been focused on the whole population.

A systematic sampling procedure was used to select the sample. It was estimated that a minimum sample size of 625 children was required to achieve a level of precision with a standard error of 1.6% or less. The 95% confidence interval level and a prevalence of caries experience of 20% were used for the calculation according to a similar epidemiological survey carried out in Diadema.[1]

Participants were randomly selected from all children attending a National Day of Children Vaccination carried out in Diadema. The Diadema vaccination program had an uptake rate of over 90% among 5- to 59-month-old children living in Diadema.[1] A sample was selected from all children attending each of 15 health centers in Diadema. Health centers were used as sampling points because the city is administratively divided into 15 regions and each has a public health center responsible for the vaccination of those living in that area. Each fifth child in the queue for vaccination was invited to participate. If parents did not agree to participate, the next parent in the queue was selected. To avoid selection bias, relatives were excluded. This random process was the same for all of the 15 health centers. The same number of children per center was selected.

Fifteen dentists previously trained and calibrated by 2 researchers carried out clinical examinations for recording dental caries. Theoretical and clinical training and calibration exercises were arranged for a total of 36 hours. World Health Organization criteria, including the incipient caries lesions, were used.[23] During the calibration process, children were examined twice by the same examiner—with an interval of 2 weeks between each examination—to assess intraexaminer reliability. A benchmark dental examiner conducted the complete examiner training and the calibration process.

During the survey, children were examined seated on a dental chair under a standard conventional dental light. Before the clinical examination, wet gauze pads were used to clean the tooth surfaces. A visual examination with a dental mirror was conducted, and no dental probing or radiographs were used. Caries experience was recorded at tooth and surface levels using a dmfs index according to WHO criteria.[23] Incipient caries lesions (D1) were also recorded, as recommended by the workshop on diagnosing and reporting ECC for research purposes.[25] The following criteria were used[26]:

a. D1=clinically detectable enamel lesion with intact surface;
b. D2=clinically detectable cavity limited to enamel; and
c. D3=clinically detectable lesion in dentin.

Incipient caries lesions (D1) were not recorded on approximal surfaces as no radiographs were taken.

The prevalence of dental caries in maxillary incisors and/or canines was defined as maxillary anterior teeth (MA caries) and dental caries in primary maxillary and/or mandibular first and second molars were defined as posterior teeth (PO caries).

This study was approved by the Ethics in Research Committee of the Faculty of Dentistry, University of São Paulo, São Paulo, Brazil, and consents were obtained from all parents and/or legal guardians prior to beginning the study.

DATA ANALYSES

Data analyses were performed with SPSS software v. 11.0 (SPSS Inc, Chicago, Ill). Caries prevalence and severity were calculated, and the results were expressed with and without the inclusion of incipient carious lesion (D1). Chi-square test was used to compare caries prevalence between age groups and sexes. Cohen's kappa statistic coefficient was used to assess intra- and inter-reliability between examiners.

To assess the reliability of MA caries pattern as a predictor to PO caries, the sample was divided into 2 large groups:

1. children with MA caries—having 1 or more caries lesion in maxillary anterior teeth, including D1; and

Table 1. Number and Percentage of Preschool Children With Caries Experience in Diadema and Mean Number of Teeth Evaluated, by Age

Age groups (mos)	No. of children	No. of teeth Mean±(SD)	With caries* N (%)	With caries† N (%)	Mean±(SD) dmfs*	Mean±(SD) dmfs†
5-12	146	3.51±2.32	2 (1)	2 (1)	0.03±0.32	0.06±0.49
12-24	210	10.62±4.71	10 (45)	24 (11)	0.12±0.81	0.36±1.68
24-36	210	18.50±2.09	56 (25)	81 (36)	1.15±3.31	2.13±4.71
36-48	212	19.87±0.57	76 (39)	96 (49)	1.94±4.13	3.04±5.41
48-60	209	19.89±0.42	106 (51)	124 (59)	3.29±5.91	5.05±7.72
All	987	15.21±6.60	250 (25)	327 (33)	1.38±3.94	2.25±5.20

** Not including incipient caries lesions.* *† Including incipient caries lesions.*

2. children without MA caries—having a caries lesion in maxillary anterior teeth, including D1.

Subsequently, the 2 groups were then divided into 2 subgroups:

1. children without PO caries—having 1 or more caries lesions (including D1) only in maxillary anterior teeth (incisors and/or canines) without any sign of caries in molars; and
2. children with PO caries—having 1 or more caries lesions (including D1) in both maxillary anterior and posterior teeth (maxillary and/or mandibular molars).

Traditional screening measures used to quantify caries risk indicators, such as odds ratio (OR), sensitivity (Se), specificity (Sp), and positive and negative prediction values, were used.[21,22] These measurements were calculated at different dmfs thresholds in the maxillary anterior region. The thresholds indicate the target values of caries lesions in the MA regions (including D1) for screening the number of children considered in the analyses. These values were >0, ≥2, ≥4, and ≥6. To summarize the information obtained, the area under the ROC curve (AUC) was calculated as a measure of the discriminant ability of anterior caries on posterior caries.

RESULTS

A total of 987 children, 49% boys and 51% girls, were enrolled in the study. The response rate was 98% of all children invited. As this study was part of a major project aimed to assess the oral health status of preschool children in Diadema, sample size was estimated in accordance with different outcomes (dental caries, dental trauma, and malocclusion) assessed in this survey. Therefore, the sample size was larger than the minimum size to satisfy the requirements (N=625) for caries status. Interexaminer and intraexaminer kappa values ranged from 0.70 to 0.80 and from 0.75 to 0.90 for dmfs and dmft, respectively. There was no statistically significant difference in caries prevalence between the sexes (chi-square: P=.20). Caries prevalence was 33% and 25% (when including and not including incipient lesions, respectively). Caries prevalence increased with age (chi-square: P=.001; Table 1). Missing and filled surfaces (mfs) were only present in children older than 23 months. The mfs percentage was 9%, varying from 3% to 11% for 2- to 5-year-old children, respectively (Table 1).

MA caries was present in 22% of children (N=217); 68% of these children (N=147) also had posterior caries (Table 2). In children older than 36 months, there was an association between the presence of maxillary anterior caries and posterior caries (Spearman's correlation test: P=.003; Table 2).

Sensitivity, specificity, and positive and negative predictive values are shown in Table 3. Sensitivity and negative predictive values decreased as the dmfs threshold increased, while specificity and positive predictive values increased when dmfs thresholds increased.

Table 4 shows the values of the screening measurements (sensitivity, specificity, and positive and negative predictive values) by age groups when using one of the dmfs thresholds (dmfs>0). This cutoff point was used because its shows the best sensitivity value (59%) and only a slight difference on specificity when compared to the higher dmfs threshold (dmfs≥6; Table 3). In all age groups, specificity and negative predictive values were greater, respectively, than sensitivity and positive predictive values (Table 4).

The presence of maxillary anterior caries may be a good predictor of developing posterior caries. The corresponding total value of the area under the curve was 0.75 (95% confidence interval [CI]=0.72, 0.79). The chance of children presenting with PO caries was higher among those with MA caries than those without MA. These chances were calculated by child's age and at different dmfs thresholds (including D1). For example, at dmfs>0, the chance changes from 2.2 (95% CI=1.0, 3.4.) to 3.9 (95% CI=1.7, 6.9) for 3- and 4-year-old children, respectively. In addition, for

Table 2. No. and Percentage of Children With and Without Caries in Anterior Maxillary Teeth (MA) that Had Caries in Molars (PO), by Age

Age group (mos)	With MA caries						Without MA caries					
	Without posterior caries		With posterior caries		**Total**		Without posterior caries		With posterior caries		**Total**	
	N	%	N	%	N	%	N	%	N	%	N	%
5-12	2	100	0	0	**2**	**1**	144	100	0	0	**144**	**19**
12-24	8	67	4	33	**12**	**6**	191	97	7	3	**198**	**26**
24-36*	24	41	35	59	**59**	**27**	145	*87*	21	13	**166**	**22**
36-48*	20	31	45	69	**65**	**30**	101	77	31	23	**132**	**17**
48-60*	16	20	63	80	**79**	**36**	86	66	44	34	**130**	**17**
Total	**70**	**32**	**147**	**68**	217	100	**667**	**87**	**103**	**13**	**770**	**100**

* Association statistically significant between MA and PO (Spearman's correlation test: P=.003).

Table 3. Sensitivity (Se), Specificity (Sp), Positive (PV+) and Negative (PV−) Predictive Values, and Percentage of Children Considered at Risk in the Analysis (CR), by Different dmfs Thresholds in Anterior Teeth (MA)

Thresholds: (dmfs in MA)	Se (%)	Sp (%)	PV+ (%)	PV- (%)	CR (%)
>0	59	91	68	87	22
≥2	34	96	73	81	12
≥4	23	99	84	79	7
≥6	15	99	90	78	4

Table 4. Sensitivity (Se), Specificity (Sp), and Positive (PV+) and Negative (PV−) Predictive Values According to the Best dmfs Thresholds (dmfs>0) in Anterior Teeth (MA), by Age Groups

Age groups (mos)	Se (%)	Sp (%)	PV+ (%)	PV- (%)
24-36	62	85	59	87
36-48	59	80	65	76
48-59	58	84	79	66

3-year-old children, when the dmfs thresholds increased from dmfs>0 to dmfs≥4, the chances changed from 2.2 (95% CI=1.0, 3.4.) to 7.0 (95% CI=1.1, 17.3).

DISCUSSION

In this study, the use of a simple method—the presence of caries in maxillary anterior teeth (MA caries)—was tested to predict the future occurrence of caries in molars in preschool children. Judging by the hierarchy in which caries occurs,[27] children with MA caries have a greater susceptibility to develop PO caries.[8,13-19] This study showed that caries in the anterior maxillary region was positively associated with posterior caries in 5- to 59-month-old children. The presence of MA caries increased the chances of a child also presenting with PO caries (odds ratio [OR]=2.1; 95% CI=1.9, 2.6). This confirms findings that young children with a predefined pattern of ECC in the maxillary anterior region have an increased caries risk of having caries in molars.[18,17-20]

When caries in maxillary anterior teeth is considered a risk indicator for future development of caries in molars, the commonly used and most pragmatic characteristics of tests are sensitivity, specificity, and predictive values. These parameters are relevant for assessment of caries risk indicators, since they give numeric values of the number of children that may benefit from preventive measures.[21,22] The relationship between these predictive values and sensitivity/specificity with the different dmfs thresholds is shown in Table 3. In this study, the thresholds provided a decision rule for classifying a child who has MA caries as having a high or low probability of presenting molars with caries. Thus, when evaluating the results of a prediction study, it is important to consider the threshold levels used.[22] Previous investigations considered a fixed threshold value.[14,15] In this study, the threshold level was considered as a variable rather than a fixed value. This permits calculation of the predictive values in relation to the threshold used. This approach has been described before[14,15,28] and allows a more ready comparison with other investigations.[28]

Sensitivity, specificity, and predictive values varied with the dmfs thresholds (Table 3). For example, when the thresholds increased from dmfs>0 to dmfs≥6, specificity ranged from 91% to 99% and positive predictive values ranged from 68% to 90%. On the other hand, given the same thresholds (dmfs>0 and dmfs≥6), sensitivity ranged from 59% to 15%, and negative predictive values varied from 87% to 78%, respectively. The results indicate that selecting a high threshold value of dmfs may give an increased specificity and positive predictive value. Alternatively, low threshold values may result in increased sensitivity and negative predictive values, as shown in previous studies.[7,21,22,29,30] This illustrates the difficulty in obtaining a specific threshold that is good for selecting children with MA caries who have a high or low probability of presenting with caries in molars.[21]

Table 4 shows a relationship between the screening measurements (sensitivity, specificity, and positive and negative predictive values) and age groups when using one of the dmfs thresholds, namely dmfs>0. Because of the difficulty in assessing the best thresholds, the lower threshold was used (dmfs>0) because it gave the best sensitivity value (59%; Table 3). Using this threshold results in the highest combination of sensitivity and specificity (150%; Table 3). In addition, only a slight difference existed for specificity with the variation of a cutoff point from dmfs>0 (91%) to dmfs≥6 (99%). That means that the specificity ranged from an optimum to a very good value (Table 3). Such variation in specificity results in a low false positive rate (1-specificity) that ranged only from 9% to 1%. Therefore, in the particular population studied, this slight variation did not result in a great difference in the true negative rate when choosing a lower cutoff point (dmfs>0) instead of the highest cutoff point.

In all age groups, specificity and negative predictive values were greater than sensitivity and positive predictive values (Table 4). For example, values of Sp and PV- ranged from 85% to 80% and from 87% to 66%, respectively. On the other hand, for the same age groups, Se and PV+ values ranged from 62% to 58% and from 59% to 79%, respectively (Table 4). It has been argued that, for the validity of the disease prediction test, the sum of specificity and sensitivity should be at least 160%.[31] This suggestion, however, did not account for the fact that errors related to poor sensitivity have consequences that are quite distinct from those related to poor specificity.[22] Nevertheless, Hausen[22] has shown that even the proposed minimum acceptable level of accuracy would result in a high rate of misclassification. In this study, the levels of specificity are higher than for sensitivity (Tables 3 and 4)—a finding confirmed previously when assessing caries experience as a risk indicator.[8,21] This means that a model of risk assessment based on caries experience is better to predict children who are not likely to develop caries than to predict the future development of caries. Previous investigators had reported that, in the primary dentition, sound teeth were better predictors of caries risk than decayed teeth.[8,28]

A comprehensive evaluation of caries patterns in this study should include the contribution of microbiological factors, which has been strongly associated with caries development in this age range.[8,12,24] In fact, one could argue that such results in predictability could be altered by different microbiological loads. This issue needs to be addressed in future research. It was not economically feasible, however, to use microbiological parameters in this survey. In addition, the aim of this study was to assess the reliability of feasible and simple predictors, such as MA patterns, in a population sample. Therefore, no microbiological tests were assessed.

Previous investigations have shown that specific caries patterns could be related to patterns of tooth eruption.[30,32] Any delay or alteration in tooth eruption could influence the results. No assessment of eruption dates was conducted in this population. According to the findings, however, the number of teeth present is compatible with the normal findings for erupted teeth for specific ages (Table 1). Although not reported here, there was no difference between boys and girls in relation to the number of erupted teeth (chi-square test: P=.09). Therefore, tooth eruption is unlikely to have influenced this study's results. Another point that needs to be considered when evaluating this study's results is that, even though the sample was relatively socioeconomically homogeneous, we did not assess how social factors could explain the specific caries patterns.

The findings reported here must be considered with some caution. Predictors were analyzed in a cross-sectional data. Therefore, it is not possible to establish a temporal relationship. In other words, the temporal relation between predictors and caries occurrence cannot be clearly determined. Due to the hierarchy of caries occurrence, however, it is likely that caries in MA preceded caries in PO.[32] Therefore, problems in using cross-sectional data should not be considered a major bias. Furthermore, it is useful to identify risk indicators through cross-sectional designs that can be tested in longitudinal studies.[28]

Even though our results were consistent with previous reports, they are different from previous studies carried out in this field. First, a representatively large sample of Brazilian preschool children was used. The sample was randomly selected using different sample centers and included children living in all of the city's administrative regions. This random process avoided bias, which might occur when a sample is selected, for example, in a clinical setting. Thus, it provides sound conclusions for all 5- to 59-month-old children living in Diadema. Nevertheless, all sensitivity, specificity, and positive and negative predictive values were calculated for each age group considering different thresholds for caries prevalence in MA. For the scientific community, such a refinement provides a more realistic assessment of variation in screening measurements according to the methodology used in a given study. This illustrates the ambiguity often inherent in the choice of cut-points when dealing with continuous criteria in assessing predictors.

Studies of predictors and patterns of disease are fundamentally important to help plan and evaluate community preventive activities and oral health promotion. The idea that MA caries patterns could be used as a predictor for PO caries is important from a public health perspective, since it is an easy and feasible tool to screen for in sections of the population for preventive and early treatment needs. A variety of clinical or public health approaches could be used based on a specific caries patterns. In this study children with caries in their maxillary teeth were at increased risk of having caries in their posterior teeth. This means that sections of a population with this specific caries pattern need closer monitoring. On the other hand, those who were caries free in MA tended to remain caries free in PO. This finding could be used to differentiate recall intervals for sections of the population, thus reducing the need for treatment.[33]

CONCLUSIONS

Based on this study's results, the following conclusions can be made:

1. Caries in the anterior maxillary region was positively associated with posterior caries in 5- to 59-month-old children. Children with caries in the anterior maxillary region had a significantly increased risk of having caries in their posterior teeth.
2. Risk assessment for caries in posterior teeth based on maxillary anterior caries had higher levels of specificity than sensitivity, suggesting that children without maxillary anterior caries tended to remain caries free in their posterior teeth.
3. Early onset of caries in maxillary anterior teeth may be a good predictor of the development of caries in posterior teeth in preschoolers.

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