Assessment of Dental Caries Predictors in a Seven-year Longitudinal Study

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Abstract

Objective: *To identify, in a group of 6-8-year-old schoolchildren, risk factors for dental caries increment in permanent dentition.* ***Methods:*** *Two hundred and six children from three different schools in Piracicaba, Brazil, were examined at baseline and after 7 years by the same two calibrated dentists. Data on dental caries (dmfs, DMFS, presence of initial lesions), fluorosis, oral hygiene and presence of sealant were collected at the clinical examination that was performed in an outdoor setting, under natural light, using a dental mirror and probe following the WHO recommendations. Information on socioeconomic level, fluoride usage, dental service utilization, dietary and oral hygiene habits was also obtained at baseline in a semi-structured questionnaire sent to the parents. The dependent variable was the 7-year DMFS increment. A univariate analysis was performed to test the association of independent variables in caries increment. Then a logistic regression model was used to estimate the adjusted Odds Ratio for caries increment.* ***Results:*** *Clinical (dmfs, DMFS) and non-clinical variables (daily toothbrushing, use of preventive topical methods, parents' educational level) were entered in the multiple logistic regression analysis. The prediction model included the clinical and socioeconomic variables, DMFS, dmfs and mother's educational level. The best caries predictor was the dmfs variable.* ***Conclusion:*** *Caries experience and mother's educational level were predictors of caries increment in permanent dentition.*

Key Words: Dental caries, prediction, logistic regression

Introduction

Caries risk assessment is a relevant issue in dentistry since the skewed distribution of the disease has been requiring the development or the optimization of preventive strategies targeted for high-caries risk individuals. The early identification of these subjects at individual or population level allows program planners to plan measures for caries prevention and to increase the efficiency of preventive programs.

During the past decades several studies have been published regarding caries prediction (1-10); many have found the most powerful predictor for dental caries to be past caries experience (1,3,5,7-9,11). Poor oral hygiene has been detected as a significant risk factor by some researchers (4,5,7) whereas others have not found similar results (3,8). Data on salivary and dental biofilm microbiological characteristics, such as Streptococcus mutans, lactobacillus, and candida counts have also shown contrasting results regarding caries prediction (3,4). According to Disney *et al.* (1) and Hausen (11), the presence of cariogenic bacterial levels moderately improves caries prediction models. Socioeconomic and demographic variables have been associated with caries increment only in prediction models for young children (12,13). On the other hand, some variables such as buffer capacity, salivary rate, presence of gingivitis (3), dental morphology especially related to retentive pit and fissures(5), calcium, phosphorus and fluoride plaque concentration (8), fluoride history (5,7), and dietary habits (4,7,8) have not been identified as significant caries predictors for children aged up to 14 years.

In this context, an accurate caries risk assessment is difficult (14). Moreover, most studies have been conducted for short periods - between 11 and 48 months (1,3-5,7,8). Longer studies are scarce in the literature and encompass only clinical variables in the prediction models (6,9,15). Therefore, the aim of this research was to identify, in a group of 6-8-year-old schoolchildren, which clinical, behavioral, demographic and socioeconomic variables could be considered predictors of caries increment in permanent dentition.

Methods

Ethical aspects. The study was approved by the Research Ethics Committee of the School of Dentistry of Piracicaba, State University of Campinas. The parents' consent was also obtained prior to the survey.

Sample. All 6-8-year-old children (n=480, mean age 7.1 years), attending three different schools in Piracicaba, Brazil (average fluoride concentration=0.7 ppm in drinking water, since 1971) participated in this seven-year longitudinal study. The sample included children of both genders (251 boys and 229 girls), with no systemic diseases or communication and/or neuromuscular problems, whose had parental consent. The individuals were examined by

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two trained dentists while their parents were asked to complete a semi-structured questionnaire. In 2004, the dentists re-examined the individuals (n=274) for dental caries and fluorosis status. For this study, 206 13-16-year-old (mean age=14.4 years) individuals were considered full participants, since they were examined both at baseline and after 7 years, and their parents had completed the semi-structured questionnaire in 1997.

Examination methodology. The dental examinations carried out in 1997 and in 2004 followed the same protocol. Prior to the examinations, a calibration process on caries diagnosis was performed between the two examiners. The consistency intra and inter-examiner was assessed by Kappa statistics (16) with values higher than 0.85.

The dentists examined all children using a dental probe and mirror, under natural light in outdoor setting. Data were collected on dental caries status, number of sealed surfaces, presence of dental fluorosis, and plaque score at baseline. At the final examination (2004) children were re-examined for dental caries and fluorosis status.

Prior to the examination, each individual received a toothbrush with fluoridated dentifrice and performed toothbrushing supervised by a dental hygienist. Dental caries were registered using the DMFS and dmfs indexes according to World Health Organization recommendations (17). Initial caries lesions detected in any dental surface were also diagnosed (18). Plaque score was performed using the Simplified Oral Hygiene Index (19). Presence of dental fluorosis was examined in all buccal surfaces of teeth that showed more than 2/3 of erupted crown and no filling, using the Dean index (20). The differential diagnosis between very mild signs of dental fluorosis and nonfluorotic enamel opacities followed the Russel criteria (21).

Questionnaire. The children's parents were asked to complete a semi-structured questionnaire concerning their socioeconomic level, fluoride usage, dental service utilization, dietary and oral hygiene habits of their children at baseline in 1997.

Table 1
Caries prevalence (%), mean (SD) of caries indexes, white spots lesion, and pit and fissure sealants according to year of examination, for full participants

Variable	Year of examination	
	1997	2004
Caries prevalence (%)	60.19%	48.54%
dmfs	3.38 (4.32)	0.02 (0.28)
dmft	2.14 (2.54)	0.01 (0.14)
DMFS	0.29 (0.85)	2.91 (4.29)
DMFT	0.24 (0.71)	2.16 (3.05)
White spots lesion	0.21 (0.71)	0.32 (0.96)
Pit and fissure sealants	1.07 (1.69)	3.50 (4.31)

n=206

Data analysis. The Chi-square test (a=0.05) was used to compare the caries prevalence between full participants and those lost before the follow-up. The McNemar test (a=0.05) was used to compare the caries prevalence of full participants between 1997 and 2004.

The dependent variable (DMFS increment or any caries increment) was dichotomized in presence or absence of any caries increment over the 7-year period. The independent variables (clinical, socioeconomic and behavioral variables) were also dichotomized. A univariate analysis was performed to test the influence of independent variables in the DMFS increment, using the Chi-square and Fisher's Exact tests (a=0.05). The multiple logistic regression analysis using the stepwise procedure was performed in order to identify the risk factors for caries increment. In order to eliminate variables that would make little contribution to the model, only the independent variables that showed $p \leq 0.15$ in the univariate analysis were selected for logistic regression model. Adjusted Odds Ratios (OR), their 95% confidence intervals and significance levels were estimated. A variable was considered a significant caries predictor if it remained in the final model at $p<0.05$. Then sensitivity, specificity, predictive values and area under the receiver-operating characteristic (ROC) curve (A_z) were determined for the predictor variables remained in the prediction model (22). All statistical tests were performed using the software SAS (23) at 5% significance level.

Results

For 480 children examined at baseline, 350 questionnaires had been completed by a parent (response rate for questionnaire = 72.9%). At final examination 274 individuals, including those with and without questionnaires were reexamined (response rate for clinical examination = 57.1%) and among them 206 were considered full participants since they were examined both at baseline and final examination and their parents had completed the questionnaire (response rate for questionnaire + final examination = 42.9%). Many individuals had moved out of the schools where the research was conducted, and some refused to take part in the final examination. Baseline caries prevalence was not significantly different (p=0.4) between full participants and those lost to follow-up.

Among full participants, 45% were male and 55% female. The majority of individuals had not visited a dentist in the year prior to baseline examination (86.9%) and had not used topical preventive method other than fluoridated dentifrices (74.8%). Concerning socioeconomic variables, most fathers (61.2%) and mothers (71.8%) had attended school for 5 to 11 years and most families (52.4%) received wages from 1 to 5 times the Brazilian minimum wage in 1997.

Table 1 shows the dmfs, dmft, DMFS, DMFT indexes, mean number of white spot lesion and pit and fissure sealants according to year of examination, for full participants. Dental caries prevalence had not reduced significantly (p=0.3) among full participants over the study period. Over two fifths (44.2%) of the children exhibited one or more DFS, and the mean caries increment for these was 2.63 ± 4.06.

The univariate analysis showed that the variables dmfs (p=0.001), DMFS (p=0.01), daily toothbrushing frequency (p=0.05), type of preventive topical method (p=0.1), father's (p=0.06) and mother's (p=0.04) educational level presented $p \leq 0.15$ under the Chi-square test. On the other hand, number of white spot lesions, plaque score, number of dental sealants, dental fluorosis, gender, race, number of working people living in the household, monthly family income, dental visits in the year prior to baseline, reason for dental visit, daily sugar consumption, number of sugar spoons in beverages, number of between-meal snacks presented $p>0.15$ when in association with any caries increment.

The final prediction model showed that dmfs (OR=2.29), DMFS (OR=2.49) and mother's education (OR=1.88) were risk factors for caries increment over the period at $p<0.05$ (Table 2). No sign of models inadequacy was observed.

Predictive values, sensitivity, specificity and A_z are presented in Table 3. Out of the predictor variables, caries in primary dentition (dmfs>0) showed the highest sensitivity (69%) and the highest A_z (0.61). Caries in permanent dentition (DMFS>0) exhibited the highest specificity (92%).

Discussion

This is the first long-term Brazilian study on caries risk assessment. The major hindrance in this type of study is that a great number of individuals may move out of the school, making it difficult to follow up. Out of the 480 children, 206 took part in the present study, since they were examined both at baseline and final examination and their parents completed a semi-structured questionnaire. Caries prevalence at baseline was not significantly different between full participants and those lost to follow-up, providing more confidence that the model's findings might be generalizable to the population studied.

The results showed that the mean value for DMFT among full participants examined in 2004 was 2.16. According to the last national epidemiological survey carried out in 2002-2003 (24) the mean DMFT for 15-19-year-old individuals was 6.17 in Brazil and 5.94 in the Southeast region where Piracicaba is located. It may be observed that the caries experience among full participants was much lower than that reported for 15-19-year-old individuals and even lower for 12-year-old children, for whom DMFT has ranged from 2.6 to 4.8 in recent Brazilian surveys (24,25). Between baseline and final examinations, the mean number of sealants more than tripled (Table 1). All children from the schools participated in a preventive program with application of dental sealants in sound permanent teeth, regardless of their caries risk.

Predicting future caries is important for monitoring individuals at risk of developing caries (9). This study has attempted to collect socioeconomic, demographic and behavioral characteristics in addition to clinical variables and to use them in a multiple regression analysis based on 7-year caries increment since the etiology of dental caries is multifactorial. Clinical variables (dmfs and DMFS) collected at baseline were risk factors for caries increment in the permanent dentition (Table 2) and caries in deciduous teeth (dmfs) were the best predictors. Children with caries in primary teeth were 2.3 times more likely to experience new caries over the 7-year period. In other words, no caries experience at baseline was a protector factor against caries increment. A few long-term studies (6,9,15) and many others (1,3,5,7-9,11) have demonstrated that past caries experience is a good predictor for future caries. According to van Palenstein Helderman *et al.* (6) past caries activity with no changes in the oral health habits will remain and can provide useful information on future caries activity. However, Tinanoff (2) emphasized that caries risk assessment based on past caries may not be enough for public health since it only may be used if an individual has the disease. In fact, an accurate caries risk assessment is difficult (14), especially for caries-free individuals, demanding the accomplishment of studies only with individuals free of caries.

The mother's educational level was also a risk factor for caries increment since children whose mothers had attended school for less than 8 years exhibited 1.9 more chance of caries increment. It has been claimed that lower educational level indicates less understanding of disease-preventive behavior (26). Some studies have included socioeconomic variables (1,7,8,12,13), and only a few have found they are good predictors of caries increment. Demers *et al.* (12) collected clinical, microbiological, socioeconomic and fluoride usage variables on 5-year-old children who were followed during 12 months. They found that caries experience, lactobacillus counts and parents' education were significant predictors of caries increment. Grindefjord *et al.* (13) followed up 1-year-old children during 3.5 years and found that one of the significant predictors of caries increment were mother's education equal to or lower than 9 years of schooling. The present study demonstrated that with the exception of mother's educational level, socioeconomic variables were not good predictors of future caries. The results of this study suggest that schoolchildren with caries experience and those whose mothers have less than eight years of schooling are at higher risk for future caries and should thus be continuously monitored.

The results also showed the lack of association between dietary habits (sugar consumption) and caries increment, which is in line with previous reported data (4,8).

Table 2
Stepwise logistic regression with DMFS increment as dependent variable

Predictor	DMFS increment ≥1				
	n	%	OR*	95%CI†	p value
DMFS					
0	73	40.78	1.00		
> 0	18	66.67	2.49	1.02-6.04	0.04
dmfs					
0	28	31.46	1.00		
> 0	63	53.85	2.29	1.24-4.23	0.001
Mother's education					
> 8 years of schooling	32	35.96	1.00		
≤ 8 years of schooling	58	50.43	1.88	1.03-3.45	0.03

n=206
*OR = odds ratio
†$CI_{95\%}$ = 95% confidence interval

Table 3
Sensitivity [Sn (%)], specificity [Sp (%)] predictive values [PV (%)], area under ROC curve (A_z) and its 95% Confidence Interval (CI) of the variables remained in the prediction model

Variables	Sn	Sp	PV+	PV-	A_z	95%CI
DMFS>0	20%	92%	67%	59%	0.56	0.33-0.79
dmfs>0	69%	53%	54%	69%	0.61	0.51-0.71
Mother's education						
≤8 years of schooling	64%	50%	50%	64%	0.57	0.47-0.67

To measure the prognostic ability of caries predictors, the sensitivity, specificity, predictive values and area under the ROC curves (A_z) were determined. The A_z obtained in this study varied from 0.56 to 0.61. There were no variables with both high sensitivity and specificity for the identification of individuals at risk before they develop caries. Future research varying the percentage of individuals at risk of developing caries as well as in populations with different levels of caries occurrence should be carried out in order to reach the optimal balance between sensitivity and specificity.

The variable DMFS>0 showed the highest specificity (Sp=92%), which means that the absence of caries in permanent teeth (DMFS=0) accurately predicted no caries increment over the period. Nevertheless, it presented poor sensitivity (Sn=20%) not predicting well individuals at risk to caries increment. The variable mother's educational level showed better sensitivity than DMFS, but lower specificity than clinical variables.

The variable dmfs>0 was the best predictor for caries increment. Most children (69%) who developed caries in permanent dentition presented caries in primary teeth at baseline examination. However, this variable did not predict successfully those individuals who would not develop caries increment (Sp=56%, Table 3).

Considering that the sensitivity cannot be useful if this value is less than 50%, that a balance with the specificity is desired, and that a variable with some predictive power presents A_z>0.5 (7) the variable caries experience in primary teeth (dmfs>0) was the main contributor to the accuracy of caries prediction. It should be noted that a comparison among different studies concerning sensitivity and specificity is impossible since statistical uncertainty (standard error) is not given for these estimates (13).

According to the results, it can be concluded that 6-8-year-old children who presented caries experience at baseline and/or mother's educational level lower than 8 years of schooling had more chances of developing caries in the permanent dentition over the studied period.

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