Published online: 2019-09-30

Caries risk profiles in 2- to 6-year-old Greek children using the Cariogram

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ABSTRACT

Objective: To assess the caries risk profiles in 2- to 6-year-old Greek children using a computer-based program and to evaluate the contribution of various risk factors.

Methods: The study group consisted of 814 preschool children. A questionnaire on family, demographic and socioeconomic factors, general health, oral hygiene and dietary behavior was completed by the parents. Children were examined for cavitated and white-spot lesions (WSL). Salivary mutans streptococci *(MS)* and buffer capacity were estimated. Caries risk profiles were assessed with Cariogram.

Results: Cavitated lesions were found in 30% of the children; WSL were found in 26% of those included. *MS* and low buffer capacity were detected in 28% and 26% of the children, respectively. The majority (70%) displayed neglected oral hygiene. Based on the questionnaires, 83% of the children had a cariogenic diet, and 17% did not use any form of fluoride. The Cariogram revealed that 26% of the children had high caries risk, while only 9% exhibited low caries risk. The most significant caries risk variables, determined by regression analysis (R2=0.88), were insufficient fluoride exposure (ß =0.160) and the presence of WSL (ß= 0.159).

Conclusions: One-fourth of the children were categorised as high caries risk. The presence of WSL and lack of fluoride exposure were the most significant caries risk determinants. (Eur J Dent 2012;6:415-421)

Key words: Cariogram; caries; mutans streptococci; preschool children; risk assessment.

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INTRODUCTION

Caries prediction has always been a challenge for both clinicians and researchers. The multifactorial etiology of the disease necessitates the evaluation and combination of multiple factors.[1] Although past caries experience has been recognized as the best single caries predictor, other factors must be assessed, especially in children who

have not yet developed clinical signs of the disease.[2] In very young children, several single caries risk factors have been studied. The highest accuracy (92%) was reported for the presence of upper labial plaque[3] followed by mutans streptococci (MS) levels (75%).[4] The combination of salivary *MS* and the presence of white-spot lesions has shown a prediction accuracy of 80%.[5] High predictive values in preschool children have been demonstrated in statistical models when several factors, such as *MS* levels, sugar consumption, salivary parameters, parental background, and maternal education, have been included.[6,7] The drawback of such models is, however, the difficulty of their application in routine clinical settings.

Several organizations have incorporated the evidence from the literature into daily dental practice by constructing caries risk assessment models for different age groups. However, these models do not normally provide a grading scale and do not disclose the weight and importance of each caries risk factor. The Cariogram is a simple and handy tool for caries risk assessment.[8] This computerized program considers the interaction of ten different caries risk factors, assesses the risk for new carious lesion development within the next 12 months and graphically presents the caries risk profile of an individual. In prospective trials, the Cariogram has been satisfactorily validated in teenagers[9] and adults,[10] although it was found to be less useful in younger schoolchildren[11] and preschool children.[12,13] In cross-sectional studies, the Cariogram has been used to explore the caries risk profiles of adults,[10,14] young adults,[15,16] teenagers[9,17,18] and schoolchildren.[19] In only one previous cross-sectional study, the Cariogram was used for 2-year-old children.[20] As that study group was limited in size, it was of interest to further investigate the Cariogram concept in a broader preschool setting. The aim of this study was therefore to assess the caries risk profiles in 2- to 6-year-old Greek children with the aid of Cariogram software and to evaluate the contribution of various risk factors among preschool children of different ages.

METHODS

Study population

The study group consisted of 2- to 6-year-old children attending public day care centers and kindergartens in the Athens metropolitan area. The mean age of the children was 54 months, ranging between 24 and 72 months. The sample was drawn with the one-stage cluster-sampling method. The study included children i) who were born in Greece, ii) who were cooperative for oral clinical examination, iii) who had not taken antibiotics for 15 days prior to the examination, and iv) whose parents had returned their written informed consent and a completed questionnaire. Among the 936 children who were initially eligible, 814 fulfilled the inclusion criteria and were included in the study. No dental care was routinely offered to these children, and there was no water fluoridation in this area.

Study design

This was a cross-sectional study, and the protocol was approved by the Ethics Committee of the School of Dentistry, University of Athens. A letter explaining the procedures, a consent form, and a questionnaire were sent to the parents. The questionnaire consisted of closed-type questions regarding the family, demographic and socioeconomic factors, general health, oral hygiene and dietary behaviour of the child. Parents with an immigrant background and a language barrier were assisted by the child's teacher when filling out the forms.

Clinical procedures

The oral examination was performed in the classroom by three calibrated examiners, under a light source, using a dental mirror and a probe. The level of oral hygiene was estimated with the visible plaque index (VPI), and the percentage of tooth surfaces with plaque was calculated for each child. Caries was recorded as "cavity in the dentin and/or enamel" according to WHO criteria[21] after visual inspection of the smooth surfaces and visual and tactile inspection of the pits and fissures. Missing teeth were scored only if it was verified that the loss was due to caries. Very few children had restorations. The total caries experience was expressed as dmft. The presence of white spot lesions (WSL), chalky white spots with unbroken surfaces, was recorded separately. No radiographs were taken. To assess the degree of inter-examiner agreement, 20 children were examined by each of the 3 examiners on the same day. The degree of intra-examiner agreement was established through an examination of 20 children

by each examiner, and the procedure was repeated after 4 weeks. The mean inter-examiner and intra-examiner Kappa values were k=0.89 and k=0.86, respectively.

Mutans streptococci levels were estimated by sampling the upper anterior teeth with a cotton swab according to the protocol proposed by Twetman and Grindefjord.[22] The swab was rolled on a Dentocult SM strip (Orion Diagnostica, Helsinki, Finland) and incubated at 37°C for 48 hours. The density of colonies was compared with a chart and classified using four categories. The readings were performed by a single examiner, and 30 strips were reassessed after 15 days' storage at 4°C. Buffer capacity was categorized as high/medium or low using a Dentobuff Strip (Orion Diagnostica). Unstimulated saliva was collected from the floor of the mouth with a pipette and placed on the strip; the color changes were registered after 5 minutes. Thirty strips were photographed and re-evaluated after 15 days. The intra-examiner reliability was k=0.87 for the buffer test and k=0.82 for the *MS* test.

Calculation of caries risk profiles

The scored data from the clinical examinations and the questionnaire were entered in the Cariogram software. The chance to avoid caries over the next 12 months was graphically illustrated. Of the ten original Cariogram variables, nine were used in this study. "Salivary secretion rate" was omitted as a variable, because it was considered difficult to adequately determine the stimulated saliva flow in this age group. Moreover, the scores described in the Cariogram manual for adults were modified to fit the present age group, as shown in Table 1. For example, "previous caries experience" was scored in only two groups: those having caries and those who were caries free. Any existing systemic disease was taken into consideration only if it directly or indirectly influenced the caries process (asthma, diabetes, heart problems). The content of unfavorable carbohydrates in the diet (muffins, cookies, chocolate, honey, marmalade, juice, candies, beverages and sweetened yogurt) was extracted from the questionnaire. The diet frequency was modified by merging two categories into one and taking the frequency of 4-5 meals/day as normal for the age group. Medium and high buffer capacity scores were incorporated into one group. In the "clinical judgment" section of the Cariogram, children with WSL were given an elevated score. The chance to avoid caries was finally grouped in three levels: low chance 0%-20% (high caries risk), moderate chance 21%-60% (moderate caries risk), and high chance 61%-100% (low caries risk).

Statistical analysis

All data were processed by Stata software (Stata 9, Stata Corp LP, Texas, USA). In addition to descriptive statistics, multivariate regression analysis was used to associate the Cariogram variables with caries risk. A P-value <.05 was considered statistically significant.

RESULTS

Descriptive data for the total material and the different age groups are presented in Table 1. The caries prevalence for all children was 30%, increasing from 13% in the youngest age group to 43% among the 5- to 6-year-olds. Non-cavitated initial lesions (WSL) were recorded in 26% of the children. Eight per cent reported a general disease that could influence caries susceptibility. The vast majority (83%) reported unfavorable dietary habits (≥3 intakes of sweets per day); this figure was fairly stable in the different age groups. The questionnaire revealed that 62% of the 2- to 3-year-old children were exposed to systemic or topical fluoride; this value increased to 96% among the 5- to 6-year-old children. Less than satisfactory oral hygiene was recorded in 67% of all children and 23% displayed poor oral hygiene. The saliva tests showed that less than 17% had moderate or high counts of mutans streptococci and that 26% displayed impaired buffer capacity.

The calculated caries risk is presented in Table 2. The Cariogram profiles showed that 26%, 65% and 9% of all children were assessed with high, moderate and low caries risk, respectively. To explore which of the Cariogram variables best explained the caries risk levels, multivariate linear regression analysis models were calculated for the total study group (Table 3) and for the different age groups. For the total sample, the most significant risk variables were insufficient fluoride exposure and the presence of white-spot lesions, followed by the previous caries experience. When regression analysis was performed for the different age groups, the most significant variable

Table 1. Cariogram variables distribution of scores in 2-6 year old Greek children (%).

Cariogram variables and scores	Age				
	2-3 yr	3-4 yr	4-5 yr	5-6 yr	2-6 yr
	n=92	n=169	n=287	n=265	n=814
Caries experience					
2 : dmft =0	87	81	69	57	70
3: dmft >0	13	19	31	43	30
Related disease					
0: no disease, healthy	95	92	92	92	92
1: general disease, indirect influence on caries	2	5	4	4	4
2: general disease, direct influence on caries, medication	3	3	4	4	4
Plaque amount					
0: VPI <5%	16	13	9	12	10
1: VPI 5-20%	23	34	29	34	32
2: VPI 21-50%	29	32	40	33	35
3: VPI >50%	32	21	22	21	23
Mutans streptococci					
0: $<10^3$ CFU/ml	80	74	68	73	72
1: 10^3 - $<10^4$ CFU/ml	8	11	12	10	11
2: 10^4 - 10^5 CFU/ml	6	4	9	7	7
3: $\geq 10^5$ CFU/ml	6	11	11	10	10
Diet content					
0: no sweet intake	3	0	4	4	3
1: 1/day	5	1	6	13	7
2: 2/day	5	0	10	10	7
3: ≥3/day	87	99	80	73	83
Diet, frequency					
0: ≤3 meals	8	11	16	17	14
1: 4-5 meals	90	85	82	81	83
3: >5 meals	2	4	2	2	3
Fluoride programme					
0: topical fluoride, >2/yr	0.0	1	5	7	4
1: topical fluoride, 1-2/yr	1	0	0	1	1
2: only toothpaste	61	78	84	88	78
3: no fluoride	38	21	11	4	17
Saliva buffering capacity					
0: high/medium (blue/green)	90	66	74	75	74
1: low (yellow)	10	34	26	25	26
Clinical judgement					
1: normal setting	85	79	77	65	74
2: presence of WSL	15	21	23	35	26

Abbreviations: VPI = visible plaque index; CFU = colony forming units; WSL = white spot lesions;

for the 2- to 3-year-olds was insufficient fluoride exposure (R^2=0.93, ß= 0.31, P<.001). For the 3- to 4-year-olds, the presence of dental plaque (R^2=0.91, ß= 0.71, P<.001) was most prominent, while for the 4- to 5- (R^2=0.89, ß= 0.163, P<.001) and 5- to 6-year-olds (R^2=0.91, ß=0.2, P<.001), the presence of white-spot lesions showed the strongest association. The dmft was found to be a significant caries variable for all age groups.

DISCUSSION

The present study was undertaken to gain information about the caries risk profiles of 2-to 6-year-old Greek children. This information will help in implementing and targeting preventive strategies for this population. The Cariogram is based on the interpretation of data from numerous clinical studies on adults.[23] Consequently, the scoring of some of the present variables was modified to fit this young age group. Two previous studies have used the Cariogram in preschool children,[12,13] one of which used modified variables.[12] The accounting for age is most likely a key factor explaining the validity of the Cariogram as a predictive tool in caries risk assessment models. The clinical examinations and scoring procedures displayed high inter- and intra-examiner agreements; the results should therefore be regarded as reliable. Whether the data from the questionnaires reflect the full truth may, however, always be debated. The large size of the present study group allowed sub-grouping with respect to age, which provided some novel and interesting information.

The main results showed that 26% of the total sample had a high risk of developing caries within the coming year. In the youngest age group, the proportion of high-risk children was even higher (36%) but still somewhat lower than previously reported among Swedish 2-year-olds.[20] The present study was, however, the first to apply multivariate regression analysis to explore the various Cariogram variables in preschool children, although a similar model was previously used for young adults.[15] The regression model explained 88% of the risk variability, and an apparent age-dependent shift in the results was demonstrated. The strongest caries risk variable for the 2- to 3-year-olds was insufficient fluoride exposure, whereas neglected oral hygiene was most marked for children between 3 and 4 years old. Based on the questionnaire, the main fluoride source for the children was toothpaste. Thus, emphasizing daily supervised tooth brushing with fluoridated toothpaste is of paramount importance for the youngest individuals residing in a non-fluoridated area and without access to regular dental care. The anti-caries effect of fluoride is well established. The best form of delivering fluoride to this age group is through self-applied toothpaste and professional topical applications.[24,25]

The finding that previous caries experience and the presence of white-spot lesions were strong

Table 2. Percentage distribution of caries risk as assessed by Cariogram for the total material and for the different age groups (%).

Chance to avoid caries	Caries risk	Age				
		2-3 yr	3-4 yr	4-5 y	5-6 yr	2-6 yr
0-20%	High	36	29	23	23	26
21-60%	Medium	54	70	67	66	65
61-100%	Low	10	1	10	11	9

Table 3. Multivariate regression analysis of Cariogram variables for all children in relation to caries risk.

Predictive Variables	Standard (ß-coeff)	Significance (P)
Fluoride program	0.16	< .001***
Presence of white spot lesions	0.16	< .001***
Dmft index	0.10	< .001***
Mutans streptococci levels	0.07	< .001***
Buffer capacity	0.04	< .001***
Plaque amount	0.05	< .001***
Diet frequency	0.00	< .001***
Diet content	0.00	< .001***
Related disease	0.00	.57

markers of caries risk, especially for children over 4 years old, was in agreement with conclusions from previous studies and systematic reviews.[1,4,26] Thus, parental education on detecting WSL and seeking early preventive dental care in young children is likely an important measure to prevent and control caries.[27] Furthermore, a review by Thenisch et al suggested that the level of salivary mutans streptococci is a strong risk factor for caries.[28] A recent study has also shown that the quantification of mutans streptococci levels is the most important salivary variable in Cariogram predictions.[29] Interestingly, buffer capacity was a significant caries risk determinant in all of the models except for those applied to the 3- to 4-year-old children. The role of buffer capacity in young children remains to be comprehensively characterised.[6] Because the association with caries is subject to doubt, the buffer capacity of saliva is not considered as a sole accurate diagnostic method for caries detection in young children.[30]

The diet content of fermentable carbohydrates has not previously been applied in Cariograms performed among preschool children. The frequency of carbohydrate-containing meals is generally considered an important factor for caries risk, but in this analysis, the dietary content of sugar was not among the primary caries risk variables. Several previous studies have demonstrated a correlation between the consumption of fermentable carbohydrates and caries, especially in the absence of oral hygiene and fluoride use.[31] Although there is no general consensus on a safe amount of cariogenic food intake,[32] the frequent consumption of fermentable carbohydrates has been associated with high mutans streptococci levels[33] in preschool children, as well as with high caries risk.[4,26] A high level of carbohydrate consumption is deleterious not only for oral health but also for the general health of the individual, because of the risk that unhealthy dietary habits will persist throughout adulthood.[34]

The present study will form the basis for a suitable preventive program to be implemented for Greek children early in life. The findings suggest that the preventive program should be focused on the regular use of fluoridated toothpaste and professional fluoride varnish applications rather than extensive dietary counselling. Furthermore, parental detection of white-spot lesions as well as regular check-ups and treatment should be strongly encouraged.

CONCLUSIONS

- High caries risk was found for 26% of the children examined, whereas 9% exhibited low caries risk.
- The most significant caries risk variables were insufficient fluoride exposure and the presence of white-spot lesions.
- The caries risk profiles varied among the various age groups. Insufficient fluoride exposure had the strongest impact for the 2- to 3-year-old children, while impaired oral hygiene had the strongest impact for those aged 3-4 years, and the presence of white-spot lesions was most important among children over 4 years old.

ACKNOWLEDGEMENTS

The study was supported by the Live.Learn. Laugh. programme by FDI/Unilever. The authors have no conflict of interest. Cariogram can be downloaded free of charge from www.mah.se. All authors have made a substantive contribution to this study and manuscript, and all have reviewed the final paper prior to its submission.

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