DOI: 10.1111/j.1365-263X.2010.01064.x

INTERNATIONAL JOURNAL OF PAEDIATRIC DENTISTRY

Caries risk profiles in schoolchildren over 2 years assessed by Cariogram

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International Journal of Paediatric Dentistry 2010; 20: 341–346

Background. Caries risk assessment is an important tool in clinical decision making.
Aim. To evaluate longitudinal changes in caries risk profiles in a group of schoolchildren in relation to caries development.
Design. The Cariogram model was used to create caries risk profiles and to identify risk factors in 438 children being 10–11 years at baseline. The assessment was repeated after 2 years and the caries increment was recorded. The frequency of unfavourable risk factors were compared between those considered at the lowest and the highest risk.
Results. Fifty percent of the children remained in the same risk category after 2 years. One third of the children were assessed in a higher-risk category while 18.4% showed a lower risk. Those with increased risk compared with baseline developed significantly more caries than those with an unchanged risk category. The most frequent unfavourable risk factors among those with high risk at baseline were high-salivary mutans streptococci and lactobacilli counts as well as frequent meals.
Conclusion. Half of the children showed a changed risk category after 2 years, for better or for worse, which suggests that regular risk assessments are needed in order to make appropriate decisions on targeted preventive care and recall intervals.

Introduction

Although the caries prevalence has declined among children and adolescents in many countries[1], the distribution is skewed within the populations[2]. This indicates that there are large groups of individuals who have not gained from preventive efforts and these individuals should be identified at an early age in order to hinder the disease to occur. Therefore, risk assessment is an essential component in the decision-making process for the correct prevention and management of dental caries[3]. The objective is to identify those at risk and to design appropriate preventive interventions and also to establish a suitable interval to the next appointment. As caries is a multi-factorial disease[4], a comprehensive risk assessment should evaluate the major factors involved with the disease, like in the computer-based Cariogram model[5]. This seems however not always be the case in clinical practice. A recent study from Sweden indicated that dentists mainly based their risk assessment on past caries experience[6], which in fact was in agreement with the conclusions of a systematic review of literature[7]. Yet, from a management perspective it is a severe shortcoming that the disease is actually manifested before it can be accurately predicted. Another clinical question of interest is how often a risk assessment should be made. A common recommendation is that risk assessments should be repeated regularly but to our knowledge, the scientific background for this is sparse. Lif Holgerson *et al.*[8] have reported that less than 50% of a group of preschool children remained in the same risk category assessed by a modified Cariogram but there is no similar information regarding schoolchildren. In a previous prospective study in 10–11-year-old children, the caries predictive characteristics of the Cariogram were established[9]. It was therefore thought of interest to re-evaluate

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the data with respect to risk group changes. The primary aim of this study was therefore to evaluate longitudinally changes in caries risk profiles over 2 years and to answer the question whether or not the risk factors remained stable in a group of schoolchildren. A second aim was to identify the particular risk factors that were most frequent in patients considered being at low and high risk for caries.

Materials and methods

Study population

The material consisted of schoolchildren that participated in a 2-year caries risk assessment study performed in southern Sweden[9]. The study population consisted of 438 individuals at baseline with a mean age of 10 years and 10 months. At the re-examination 2 years later, 392 children were available with a dropout of 46 participants (10.5%). All the participants were residents of urban and suburban areas with low natural fluoride content (0.1 ppm) in the drinking water and all subject reported a daily use of fluoridated tooth paste.

Study design

The study design was approved by The Ethical Committee at Lund University, Lund, Sweden. The baseline and follow-up registrations included a questionnaire concerning dietary habits and fluoride exposure followed by an individual interview to clarify or discuss the answers together with the child. Data from a clinical estimation of oral hygiene and saliva samplings were entered to create the Cariogram. Caries prevalence was extracted from the dental records and bitewing radiographs. Caries scores were limited to dentin; a radiolucency with a broken enamel-dentin border with obvious progression into the dentin was recorded as a caries lesion. The 2-year caries increment was calculated and expressed as ΔDMFS. Cohen's κ-value was used to test intraexaminer agreement. The result, based on 29 re-examinations, was 0.961.

Saliva tests

Stimulated whole saliva was sampled during 5 min and the secretion rate (mL/min), buffer capacity (Dentobuff® Strip), mutans streptococci (Dentocult® SM-Strip mutans) and lactobacilli (Dentocult® LB) counts were estimated. All chair-side tests were from Orion Diagnostica, Espoo, Finland and handled according to the manufacturers instructions.

Risk profiles by Cariogram

The caries risk assessments were carried out by using a risk assessment program, the Cariogram. When all the information described above was available, the relevant information was entered into the Cariogram computer program to calculate the caries risk for each child. The risk for future caries activity was estimated and expressed as a pie diagram displaying 'percent chance of avoiding caries'[10,11]. Five risk categories were used: very low risk = 81–100% chance of avoiding caries, low risk = 61–80% chance of avoiding caries, medium risk = 41–60% chance of avoiding caries, high risk = 21–40% chance of avoiding caries, very high risk = 0–20% of avoiding caries. No intervention based on the baseline Cariogram was given.

Unfavourable risk factors

Each risk factor forming the Cariogram was dichotomized in a favourable or unfavourable score. The cut-off levels for unfavourable values were set as follows: salivary mutans streptococci and lactobacilli counts = $\geq 10^5$ cfu, salivary secretion rate = < 0.7 mL/min, saliva buffering capacity = pH ≥ 6, and, intake frequency = > 5 meals/day. Oral hygiene was scored unfavourable when a poor or very poor hygiene was registered based on the amount of plaque.

Statistical methods

All data were processed with the SPSS software (version 17.0, SPSS, Inc., Chicago, IL, USA). Differences between risk categories and

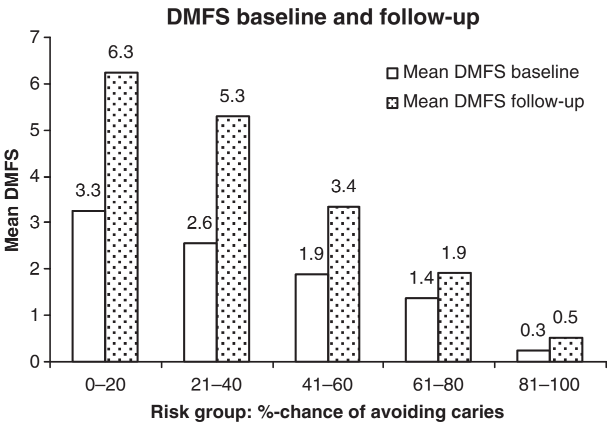

Fig. 1. Caries prevalence (DMFS) in relation to caries risk category at baseline and follow-up after 2 years.

between baseline and follow-up examinations were subjected to chi-square tests. In all tests, *P*-values less than 0.05 were considered as statistically significant.

Results

The mean DMFS increment during 2 years in relation to baseline Cariogram predictions is shown in Fig. 1. Children in the highest-risk group developed, as a mean, about 10 times more caries lesions than the lowest risk group.

The median value for the Cariogram, expressed as 'percent chance of avoiding caries', for all children that attended the baseline and the follow-up examinations ($n = 392$) was 80% at baseline (Q1: 61%, Q3: 90%) and the corresponding figure at follow-up after 2 years was 75% (Q1: 55%, Q3: 85%). The longitudinally changes in risk categories are shown in Fig. 2. The results displayed that 50% ($n = 196$) of the children remained in the same risk category at baseline and after 2 years. Thus, for those assessed in the highest-risk categories at baseline, only 21.8% remained in the same category after 2 years. Around one third of the children (31.6%) were assessed into a higher-risk category after 2 years while 18.4% exhibited a decreased risk category ($P < 0.001$). The transitions between the risk categories over 2 years and the caries increment dichotomised as new caries/no caries over 2 years are shown in Table 1. Among those that remained in the same risk category at both examinations, 17.9% experience new lesions or proximal caries progression. The corresponding figures among those classified in a higher- or lower-risk category were 46.8 and 38.8%, respectively. The differences between the unchanged group and the groups with increased or decreased caries risk were statistically significant ($P < 0.05$). The odds ratio for having caries increment in the group with increased risk *versus* the unchanged group was 4.0 (95% CI 2.4–6.7). There was however no difference in caries increment between those that displayed increased risk compared to those with decreased caries risk (OR 1.4; 95% CI 0.8–2.5).

Table 2 displays the longitudinally changes of the various risk factors that forms the pie

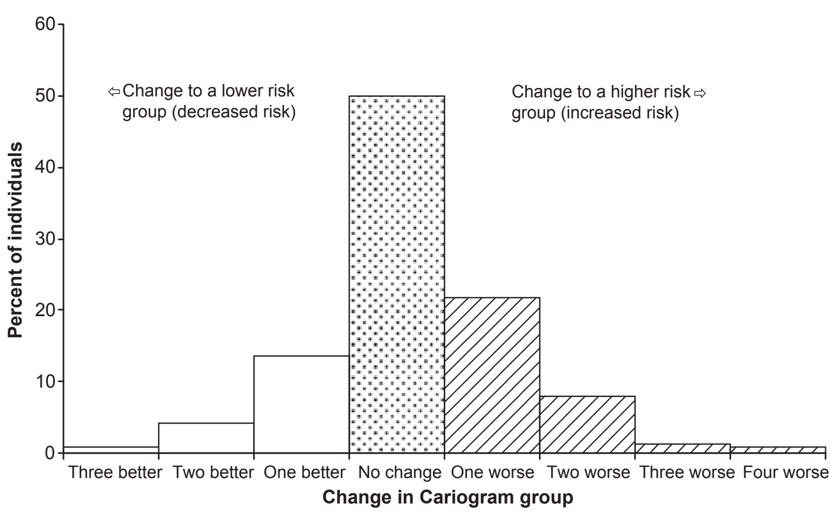

Fig. 2. Change in risk categories over 2 years.

Table 1. Changes in the distribution of Cariogram risk categories over 2 years and caries increment in the different risk categories. Risk grouping were based on percent chance of avoiding caries. Values in table denote percent or (n) and figures in bold denote unchanged risk category.

	Risk group at follow-up									
	Very low risk		Low risk		Medium risk		High risk		Very high risk	
Risk group at baseline	% (n)	Increment*	% (n)	Increment*	% (n)	Increment*	% (n)	Increment*	% (n)	Increment*
Very low risk	***64.3*** (126)	4.8 (6)	23.5 (46)	34.8 (16)	8.7 (17)	47.1 (8)	2.0 (4)	50.0 (2)	1.5 (3)	33.3 (1)
Low risk	23.3 (24)	0 (0)	***41.7*** (43)	25.6 (11)	24.3 (25)	40.0 (10)	9.7 (10)	70.0 (7)	1.0 (1)	0 (0)
Medium risk	10.9 (6)	16.7 (1)	25.5 (14)	42.9 (6)	***32.7*** (18)	61.1 (11)	23.6 (13)	76.9 (10)	7.3 (4)	100 (4)
High risk	11.5 (3)	66.7 (2)	23.1 (6)	33.3 (2)	34.6 (9)	77.8 (7)	***26.9*** (7)	85.7 (6)	3.8 (1)	0 (0)
Very high risk	– (–)	– (–)	– (–)	– (–)	33.3 (4)	100 (4)	50.0 (6)	100 (6)	***16.7*** (2)	50.0 (1)

Very low risk, corresponding to Cariogram group 81–100% chance of avoiding caries; low risk, corresponding to 61–80% chance of avoiding caries; medium risk,corresponding to 41–60% chance of avoiding caries; high risk, corresponding to 21–40% chance of avoiding caries; very high risk, corresponding to Cariogram group 0–20% chance of avoiding caries and increment*, proportion of subjects with new or progression of proximal lesions on bitewing radiographs over 2 years.

Table 2. Unfavourable values expressed in percent of the children in the low risk (61–100% chance of avoiding caries) and high risk (0–40% chance of avoiding caries) category at baseline and after 2 years. Data for fluoride exposure and general health, normally used in the Cariogram model, were not shown since all participants used fluoride dentifrice (favourable value) and all participants were healthy (favourable value).

		Low risk (*n* = 299)		High risk (*n* = 38)			
		Unfavourable value (%)		Unfavourable value (%)		*P*-values	
Variable	Cut-off value	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Past caries experience	DMFT > 0	27.1	39.8**	86.8	92.1	0.000	0.000
Mutans strept. in saliva	≥ 10^5 CFU/mL	32.4	46.2**	94.7	71.1**	0.000	0.004
Lactobacilli in saliva	≥ 10^5 CFU/mL	18.7	22.4	78.9	39.5**	0.000	0.021
Buffering capacity	≤ pH 6,	19.1	11.4**	36.8	26.3	0.011	0.018
Stim. secretion rate	< 0.7 mL/min	18.7	12.4**	28.9	15.8	0.137	0.552
Plaque/oral hygiene	code 2 and 3*	20.1	23.4	44.7	47.4	0.001	0.002
Intake frequency	> 5 meals/day	36.8	48.8**	84.2	63.2**	0.000	0.096

*Poor or very poor oral hygiene.
**Statistically significant change within groups between baseline and follow-up (McNemars χ^2, $P < 0.05$).

diagram of the Cariogram when the children were divided in two contrasting groups; the low risk group (61–100% chance of avoiding caries) and the high-risk group (0–40% chance of avoiding caries). The most frequent unfavourable factors among the high-risk children were high scores of salivary mutans streptococci and lactobacilli counts as well as past caries experience and frequent dietary intakes. At the follow-up, salivary mutans streptococci, past caries experience and intake frequency were the most pertinent. In the low risk category, the most prevalent unfavourable variable was poor oral hygiene, both at baseline and at the follow-up.

Discussion

The Cariogram model has been applied in various settings and populations during recent years[12–16] but prospective studies are still rare. The primary aim of this study was to evaluate the longitudinal variation in caries risk profiles over 2 years in a group of schoolchildren and thereby answer the question whether or not the risk profiles remained stable over 2 years. We found that half of the children exhibited a 1–4 steps change which was in agreement with previous findings among preschool children[8]. Therefore, the clinical recommendation that a risk assessment of each individual child patient should be carried out regularly seems justified. Knowledge about the variation in caries risk profiles over time is important for clinicians to establish an individually-formed preventive treatment plan and to decide appropriate recall intervals.

Obviously, it was more common to exhibit an increased caries risk with age, and the total median risk value actually increased. A striking finding was that children that moved to a higher-risk category had a four times higher risk for being decayed. Also the children that showed a diminished caries risk developed more caries than the unchanged group. This was likely explained by the fact that they mainly belonged to the high-risk groups at baseline, a group that was found to be most volatile. In the highest-risk category, only around 17% of the children remained in the same risk category at the follow-up compared with 64% in the lowest risk category. A clinical reflection based on these findings would be that it is more important to identify an increased caries risk than to unveil a diminished risk. Patients with increased caries risk should hopefully be attributed with an increased preventive care while our findings indicate that it would be premature to decrease the efforts with those with a risk improvement. Furthermore, it is generally thought that a high-caries activity in the primary dentition is associated with more caries in adolescence[17] and Broadbent *et al.*[18], have even suggested a linear caries incidence pattern over the first four decades in life.

The second aim was to investigate the different background variables included in the Cariogram over time and to identify which of them that had the highest impact for the high- and low-risk children respectively. The variables were dichotomized into favourable (positive) and unfavourable (negative) values according to the Cariogram model but the cut-off points can always be discussed and may vary between populations. For example, in this study group, any previous caries experience was denoted as an unfavourable value since the majority of the children actually were caries-free at baseline (median DMFT = 0). High counts of salivary mutans streptococci was the most frequent unfavourable factor in those categorised as high risk, both at baseline and after 2 years. This finding was quite expected since a systematic review of literature has concluded that increased salivary mutans streptococci counts are associated with higher caries outcomes in childhood[19]. Unfavourable diet variables, especially the intake frequency, were also common in the high-risk group at baseline which is line with the clear evidence of a relationship between sugar frequency and caries rather than sugar quantity and caries[20]. Interestingly, however, the frequency of unfavourable diet values decreased with time in the high-risk group while a slight increase was noted in the low risk group. In the low risk group, the proportion of unfavourable values was more or less evenly distributed between the various risk factors with the exception of the amount of plaque. We have no immediate explanation for the stable and high proportion of poor oral hygiene in the low risk group but it may reflect generally neglected tooth brushing habits in this age group as indicated by previous researchers[21,22].

Conclusion

Half of the school children remained in the same caries risk category after 2 years when assessed with the comprehensive Cariogram model. Around one third of the children exhibited increased risk and those children also had a significantly higher caries development. The findings support the recommendation that caries-risk assessment should be repeated regularly as an aid in the preventive and non-operative management of the caries disease.

What this paper adds

- This longitudinal study shows that the caries risk profile is relatively inconsistent in of schoolchildren over a period of 2 years. Those that move to a higher-risk category are more likely to develop new caries lesions.

Why this paper is important to paediatric dentists

- It highlights the importance of regular risk assessments to aid clinicians to an appropriate preventive treatment and recall interval.

Acknowledgements

We acknowledge all the children for their participation in the original study. This study was supported by grants from the Swedish Patent Revenue Research Fund for Preventive Odontology. The authors report no conflicts of interest and the authors alone are responsible for the content and writing of the paper.

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