

## Caries Risk Assessment Among School Children in Davangere City Using Cariogram

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### ABSTRACT

**Background:** To assess the caries risk among 12-years old children using the Cariogram and to evaluate it by comparing with the actual change in DMFT and DMFS over a period of two year.

**Methods:** A two year prospective study was conducted among 12 years age group school going children in Davangere city. At the baseline relevant and required information regarding the oral hygiene, diet, fluoride usage were obtained using a specially prepared pro forma and the saliva samples were collected from study subjects and the required microbiological analysis was done, as per the instructions of Cariogram version 1997. Caries experience was assessed using DMFT and DMFS index. Re-examination was done after two years and caries increment was calculated. The data so obtained was fed into the Cariogram software based on which they were divided in five groups which were; 0-20% (high risk), 21-40%, 41-60%, 61-80% and 81-100% “Chance of avoiding caries”. The caries risk profile generated by the software was compared with caries increment over two years and subjected to statistical analysis.

**Results:** Eighty nine point twenty nine percent of the children in the very low risk group as predicted by Cariogram at baseline did not develop new caries lesions by the end of two years follow-up. Higher risk children at baseline developed higher number of new carious lesions.

**Conclusions:** Cariogram can be a reliable tool in caries prediction. It can aid in identifying different risk groups in a community and developing preventive strategies for reducing caries risk in children.

**Keywords:** Caries prediction, cariogram, dental caries, fluoride, risk factors

### INTRODUCTION

Dental caries is an important health problem public.<sup>[1]</sup> It is universally prevalent and its impact on both society and the individual is significant. It is the most prevalent chronic disease affecting the human race of both genders in all races, across all socioeconomic strata and every age group.

It has a multi factorial etiology having factors like – host (saliva and teeth), the micro flora (bio film), the substrate (diet)

and time. The modifiable risk factors are amenable to intervention. Whereas the unmodifiable risk factors are quite challenging to health care professionals. The risk factors should be comprehensively studied, tackled, modified so that the occurrence of dental caries can be prevented.<sup>[2]</sup>

Children have a greater incidence of carious lesions as they reach school age, mostly due to irregular and ineffective oral hygiene habits and of course not to say the least frequent snacking rich in carbohydrate and sugar. It becomes empirical to find ways to predict new carious lesions so that we can prevent their progression and occurrence. Cariogram is one of the recent models to predict dental caries. Cariogram, was presented in 1996 by Bratthall D, for illustration of the interactions of caries-related factors. It was further refined in the year 1997 by Bratthall *et al.* The modified Cariogram in addition to caries risk profile it also provides risk prediction in terms of - 'chance of avoiding dental caries'. The Cariogram predicts caries increment more accurately than any included single-factor model.<sup>[3]</sup> It can be a tool for motivating the patient, and the model can also serve as a support for clinical decision making while selecting preventive strategies for the patient.<sup>[4]</sup> Exploration of the available literature related to Cariogram revealed no studies conducted in India where children comprise 40% of the rapid growing population. The prevalence of dental caries varies from 33.7% to 90% is increasing at an alarming rate in child population. Hence, an attempt has been made in the current study to assess the caries risk profile and to evaluate the validity of Cariogram among the Indian population.

## METHODS

A two years prospective study was conducted from May 2005 to May 2007, among the 12-years school going children in Davangere city of Karnataka, India. The study population consisted of 200 school children, 12 years of age, who volunteered after informed consent given by their parents. The sample size was based on the data gathered from the pilot study. Fixing  $\alpha$  at 5% [ $P < 0.05\%$ ],  $\beta$ - 20% and power of the study 80% sample size was fixed at 200. Ethical

clearance was obtained from the ethical review board of Bapuji Dental College and Hospital Davangere.

### Method employed to obtain the desired sample

Multistage sampling was employed to get the required number of sample. The risk assessment consisted of: (1) a questionnaire, (2) an interview, (3) estimation of oral hygiene, (4) saliva sampling, (5) clinical examination and (6) creating a risk profile for each child using a Cariogram. Questionnaire and interview was employed to collect data pertaining to diet, frequency of eating (snacks/meals) per day, related general diseases, the use of fluoride toothpaste, tooth brushing habits and other fluoride supplements [Table 1].

### Clinical examination

After the interview, caries prevalence, DMFT and DMFS were recorded using the WHO standard criteria for oral health surveys. Oral hygiene was estimated by employing plaque index.<sup>[5]</sup> The kappa co-efficient value for Silness and Loe plaque index was 0.94 and for DMFT and DMFS it was 0.92, respectively.

### Salivary analysis

Paraffin-stimulated whole saliva was collected from all the children to measure the (1) saliva secretion rate (expressed as ml/min),<sup>[6]</sup> (2) buffering capacity of saliva, (3) *Lactobacillus* and *Streptococcus mutans* counts.<sup>[7]</sup>

#### Saliva buffering capacity

Dental saliva pH indicator strip (GIC strips-GC Asia dental Pvt. Ltd. Changi. Logistics Center) was used to measure buffering capacity of saliva. It is a quick and easy way to determine salivary buffering capacity. A drop of collected saliva is added to the test pad of the strip, the saliva starts to dissolve acids which have been dried into the test pad, which also contains pH sensitive dyes. The change in color of the strip determines the buffering capacity of the saliva. This system discriminates between low (red), medium (yellow) and high (blue) buffering capacity.

### Risk assessment using cariogram<sup>[6]</sup>

When all the information described above was available, the relevant information was entered

**Table 1:** Caries related factors and the data needed to create a cariogram

Factor	Information and data collected	Cariogram scores
Caries experience	Past caries experience at baseline, including cavities, fillings and missing teeth due to caries	0=Caries-free, no fillings 1=Better than normal 2=Normal for that age group 3=Worse than normal
Related diseases	General disease or conditions associated with dental caries. Medical history, medications; data from interviews and questionnaire results	0=No disease, healthy 1=A general disease, which can indirectly influence the caries process to a mild degree 2=A general disease, which can indirectly influence the caries process to a high degree
Diet frequency	Estimation of number of meals and snacks per day, mean for 'normal days'; data from interview results	0=Maximum 3 meals per day [including snacks] 1=Maximum 5 meals per day 2=Maximum 7 meals per day 3=More than 7 meals per day
Diet contents	In this study, lactobacillus counts were used as a measure of cariogenic diet; data from lactobacillus test count. Rogosa SL agar was used to grow lactobacillus	0=Very low, <10 <sup>3</sup> CFU/ml 1=Low, >10 <sup>3</sup> -10 <sup>4</sup> CFU/ml 2=Moderate, >10 <sup>4</sup> -10 <sup>5</sup> CFU/ml 3=High, >10 <sup>5</sup> CFU/ml
Plaque amount	Data from the clinical examination of oral hygiene. Plaque index <sup>[5]</sup>	0=No plaque 1=A film of plaque adhering to the free gingival margin area of the tooth. The plaque may be seen in situ only application of disclosing solution or by using the probe on the tooth surface 2=Moderate accumulation deposits within the gingival or the tooth and gingival which can be seen with the eye 3=Abundance of soft matter within the gingival pocket and/or on the tooth and gingival margin
<i>Streptococcus mutans</i>	Estimation of levels of Mutans streptococci in saliva. Mitis-salivarius-bacitracin (MSB) agar plates were used to grow mutans streptococci <sup>[20]</sup>	0=Very low, <10 <sup>4</sup> CFU/ml 1=Low, >10 <sup>4</sup> -10 <sup>5</sup> CFU/ml 2=Moderate, >10 <sup>5</sup> -5×10 <sup>5</sup> CFU/ml 3=High, >5×10 <sup>5</sup> -10 <sup>6</sup> CFU/ml
Fluoride program <sup>[6]</sup>	Estimation of the extent of fluoride available in the oral cavity; data from interview results	0=A 'maximum' fluoride program 1=Fluoride supplements. 2=Fluoride toothpaste only, no supplements. 3=No fluorides
Saliva secretion	Estimation of flow rate of paraffin-stimulated saliva	0 = > 1.1 ml/minute 1 = >0.9-1.1 ml/minute 2=0.5-0.9 ml/minute 3 = < 0.5 ml/minute
Saliva buffering capacity	Estimation of capacity of saliva to buffer acids	0=pH <6.0 1=pH 6.2-6.8 2=pH >6.8

CFU=Colony forming units

into the Cariogram computer program to calculate the caries risk for each child. Cariogram assesses the risk of future caries activity and expresses the result as the chance of avoiding caries. To create a Cariogram, nine factors/parameters of direct

relevance to caries are entered into the computer program. The various parameters are given a score according to predetermined scales for each factor [Table 1]. A sample of the cariogram generated for an individual is depicted in Figure 1.

Re-examination was performed after two years and the actual caries increment was calculated. DMFT and DMFS were recorded using the WHO standard criteria for oral health surveys.

**Statistical methods**

The data so obtained was compiled systematically. Statistical analysis was done using personal computer with SPSS (Version 12) software. Results are shown as mean ± SD. To evaluate the statistical significance of difference in DMFT scores across categories of different factors that were recorded at baseline and follow-up, a factorial analysis of variance was ANOVA was employed.

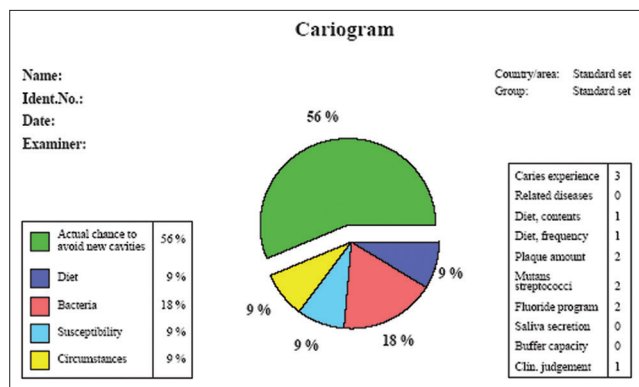
**RESULTS**

There were totally 200 subjects, 109 of them were boys and 91 girls at baseline. At the end of two years follow-up period, six boys and 13 girls a total of 19 subjects were lost due to migration. Finally there were 103 boys and 78 girls at the end of the study, these amounts to 9.5% dropout rate [Graph 1]. The mean DMFT/DMFS at

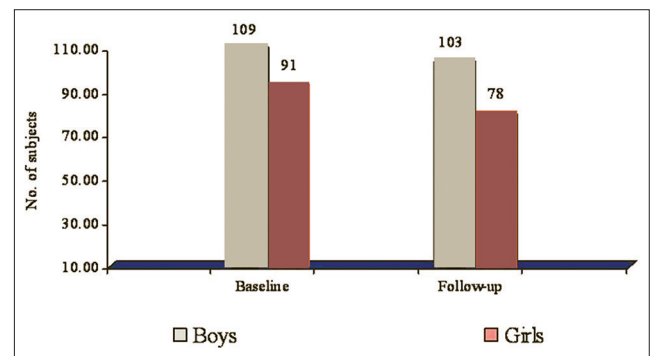
baseline and over two years period with respect to percentage chance of avoiding caries is presented in Table 2. Children in the (high risk group) 0-20% chance of avoiding caries had a mean DMFT of  $3.54 \pm 1.33$  and DMFS of  $3.81 \pm 1.72$ , 21-40% chance of avoiding caries group had a mean DMFT of  $2.30 \pm 1.14$  and DMFS of  $2.37 \pm 1.11$ , the least was a mean DMFT of  $0.04 \pm 0.19$  and mean DMFS of  $0.04 \pm 0.19$  in 81-100% chance of avoiding caries group. The mean DMFT in high risk group (0-20%) is almost 90 times higher when compared to the mean DMFT in low risk group (81-100%).

The mean DMFT and DMFS increments for each of the caries related factors evaluated are shown in Table 3 *Streptococcus mutans*, *lactobacillus*, salivary secretion rate and fluoride usage showed a significant association with dental caries. The relation of diet frequency, plaque amount to dental caries was not significant, whereas saliva buffering capacity was significant related to caries at baseline.

Graph 2 illustrate the percentage of subjects developed new carious lesion after two years period. In the 81-100% chance of avoiding caries (low risk) group, the outcome showed that 89.2% of



**Figure 1:** Example of the cariogram from the present study



**Graph 1:** Distribution of study subjects according to gender at baseline and follow-up

**Table 2:** Mean DMFT and DMFS with respect to percentage chance of avoiding caries at baseline and follow-up

Groups	Chance of avoiding caries				
	0-20%	21-40%	41-60%	61-80%	81-100%
Baseline					
Mean DMFT (SD)	3.54 (1.33)	2.30 (1.14)	2.04 (1.06)	1.09 (0.8)	0.04 (0.19)
Mean DMFS (SD)	3.81 (1.72)	2.37 (1.11)	2.32 (1.77)	1.11 (0.91)	0.04 (0.19)
Follow-up					
Mean DMFT (SD)	3.50 (1.22)	2.48 (1.43)	1.98 (0.94)	1.43 (0.85)	0.10 (0.30)
Mean DMFS (SD)	3.83 (1.76)	2.83 (1.98)	2.36 (1.69)	1.70 (1.9)	0.13 (0.43)

SD=Standard deviation, DMFT=Decayed missing and filled tooth, DMFS=Decayed missing and filled surfaces

**Table 3:** Comparison of caries related factors as estimated at baseline with corresponding DMFT/DMFS values

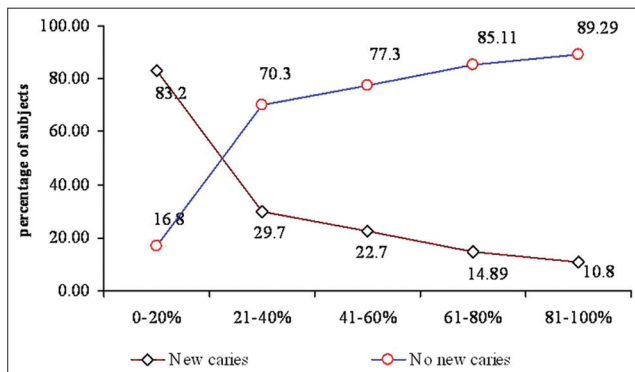
Factor	Baseline		Follow-up	
	Mean DMFT	Mean DMFS	Mean DMFT	Mean DMFS
Diet content ( <i>lactobacillus</i> count)				
0=Very low, (<10 <sup>3</sup> CFU/ml)	1.3±1.1	1.5±1.6	1.2±0.8	1.3±1.1
1=Low, (>10 <sup>3</sup> -10 <sup>4</sup> CFU/ml)	2.0±1.5	2.2±1.8	1.9±1.4	2.3±2.2
2=Moderate, (>10 <sup>4</sup> -10 <sup>5</sup> CFU/ml)	2.1±1.3	2.1±1.3	2.6±1.5	2.9±1.9
3=High, >10 <sup>5</sup> CFU/ml	4.1±2.1	4.1±2.1	3.0±2.8	3.0±2.8
ANOVA <i>P</i> value	0.000	0.000	0.000	0.001
Diet frequency				
0=maximum 3 meals per day [including snacks]	0.3±1.6	0.7±2.6	0.5±1.2	1.6±1.3
1=maximum 5 meals per day	1.6±1.4	1.7±1.6	1.8±1.4	2.1±2.0
2=maximum 7 meals per day	2.1±1.2	2.1±1.2	2.0±1.4	2.7±2.5
3=more than 7 meals per day	-	-	-	-
ANOVA <i>P</i> value	0.157	0.106	0.5206	0.389
Plaque amount				
0-very good oral hygiene	0±0	0±0	1.8±1.4	3.6±5.3
1-good oral hygiene	1.9±1.5	2.0±1.8	1.5±1.2	1.8±1.8
2-poor oral hygiene	2.0±1.0	2.0±1.0	2.0±1.5	2.3±1.8
3-very poor oral hygiene	-	-	-	-
ANOVA <i>P</i> value	0.077	0.099	0.057	0.070
<i>Mutans streptococcus</i>				
0=Very low, <10 <sup>4</sup> CFU/ml	0.8±0.9	1.0±1.4	1.1±1.2	1.4±2.1
1=Low, >10 <sup>4</sup> -10 <sup>5</sup> CFU/ml	1.3±1.1	1.4±1.5	1.3±1.1	1.6±1.9
2=Moderate, >10 <sup>5</sup> -5×10 <sup>5</sup> CFU/ml	2.2±1.1	2.4±1.5	2.6±1.0	2.8±1.2
3=High, >5×10 <sup>5</sup> -10 <sup>6</sup> CFU/ml	3.3±1.8	3.3±1.8	4.3±1.2	4.7±1.7
ANOVA <i>P</i> value	0.000	0.000	0.000	0.000
Fluoride program				
1=Additional fluoride measures, infrequently	0.8±0.8	0.8±0.8	1.0±0.0	1.5±0.7
2=Fluoride tooth paste only	1.4±1.3	1.6±1.6	1.5±1.2	1.7±1.9
3=Avoiding fluorides, no fluoride	2.5±1.4	2.7±1.7	2.6±1.4	3.0±1.9
ANOVA <i>P</i> value	0.000	0.0002	0.000	0.001
Saliva secretion				
0=Normal saliva secretion, more than 1.1 ml stimulated saliva per minute	1.1±1.2	1.0±1.2	1.1±1.0	1.1±1.2
1=Low, from 0.9 to less than 1.1 ml stimulated saliva per minute	1.9±1.8	1.6±1.6	1.6±1.2	1.9±1.8
2=Low, 0.5 to less than 0.9 ml stimulated saliva per minute	3.1±2.2	2.7±1.8	2.6±1.6	3.1±2.2
3=Very low saliva secretion, dry mouth, less than 0.5 ml saliva per minute	-	-	-	-
ANOVA <i>P</i> value	0.000	0.000	0.000	0.001
Saliva buffering capacity				
0=Low, strip red	2.7±1.8	2.8±1.8	3.0±2.0	3.0±2.7
1=Reduced, strip yellow	1.7±1.3	1.9±1.7	1.7±1.3	2.0±1.9
2=Adequate, strip green	0.8±1.2	0.8±1.2	1.6±1.2	1.9±1.9
ANOVA <i>P</i> value	0.0001	0.0009	0.838	0.1899

ANOVA=Analysis of variance, CFU=Colony forming units, DMFT=Decayed missing and filled tooth, DMFS=Decayed missing and filled surfaces



the children had not developed any new caries lesions (10.8% developed new caries). In the group for which the Cariogram predicted 61-80% chance of avoiding caries, 85.1% of the children were free of new lesions (14.9% developed new caries). Seventy seven point three percent of the children were free of any new carious lesions in 41-60% groups (22.7% developed new caries). Seventy point three percent of the children were free of new carious lesions in 21-40% group (29.7% developed new caries) and 83.2% of the children with 0-20% chance of avoiding caries, developed new caries lesions.

Table 4 shows the mean DMFT and DMFS with respect to percentage chance of avoiding caries at follow-up after two years period. By the end of follow-up period the study subjects in the high risk group [0-20%] showed an increase in mean DMFS to  $4.60 \pm 1.76$ . In 21-40% chance of avoiding caries group there was an increase DMFS to  $3.10 \pm 1.98$ , followed by an increase in DMFS to  $2.80 \pm 1.69$  in 41-60% group. In 61-80% chance of avoiding caries group there was an increase in mean DMFS of  $1.50 \pm 1.90$ , and in 81-100% chance of avoiding



**Graph 2:** Percentage of subjects developed new caries lesion after two year period

caries group there was an increase in mean DMFS of  $0.13 \pm 0.43$ .

## DISCUSSION

Dental caries is a multifactorial disease in nature. Dental caries is a dynamic process of demineralization of the dental hard tissues by the products of bacterial metabolism, alternating with periods of remineralization. This pathologic process occurs on a continuum, in which any lesion may range from changes at the molecular level to gross tissue destruction and cavity formation.<sup>[8]</sup> There are practically no geographic areas in the world whose inhabitants do not exhibit some evidence of dental caries. It usually begins soon after the teeth erupt into the oral cavity.<sup>[9]</sup>

The age group of 12-years selected represents a crucial period of life with respect to the natural history of dentition in humans. All deciduous teeth are said to have exfoliated and the second molars would have just erupted or erupting in any child at this age, many permanent teeth but for second molars would have been exposed into oral cavity for few years. WHO considers 12-years age as the global indicator age for monitoring dental caries.

The view that any caries risk assessment model should be based on multiple caries factors and, more importantly, should consider the cumulative and combined interactive effect on caries was emphasized.<sup>[10]</sup> The idea of using several risk factors together is of course not new. However, the unique property of the Cariogram is that each factor, in each constellation, is 'weighted' for its cumulative input not just added. The Cariogram considers the total pattern of risk factors.<sup>[11]</sup>

The children participated in the present study were representative sample from Davangere city.

**Table 4:** Mean DMFT and DMFS with respect to percentage chance of avoiding caries at follow-up and after two years

Groups	Chance of avoiding caries				
	0-20%	21-40%	41-60%	61-80%	81-100%
Baseline					
Mean DMFT (SD)	3.54 (1.33)	2.30 (1.14)	2.04 (1.06)	1.09 (0.80)	0.04 (0.19)
Mean DMFS (SD)	3.81 (1.72)	2.37 (1.11)	2.32 (1.77)	1.11 (0.91)	0.04 (0.19)
Follow-up					
Mean DMFT (SD)	4.1 (1.2)	2.73 (1.43)	2.44 (0.94)	1.43 (0.85)	0.10 (0.30)
Mean DMFS (SD)	4.6 (1.76)	3.10 (1.98)	2.8 (1.69)	1.50 (1.9)	0.13 (0.43)

SD=Standard deviation, DMFT=Decayed missing and filled tooth, DMFS=Decayed missing and filled surfaces

At baseline, based on comprehensive evaluation of the data collected Cariograms were created. About 15.5% of the study population belonged to low caries risk group [81-100% chance of avoiding caries] had a mean DMFT of 0.04 and DMFS of 0.04. Fourteen point four percent of the children belonged to high caries risk group [0-20% chance of avoiding caries] had a mean DMFT of 3.54 and DMFS of 3.81 at baseline.

In the present study a co-relationship between mean DMFT and DMFS with respect to percentage chance of avoiding caries measured at baseline and follow-up was observed [Table 2]. The subjects with least chance of avoiding caries [0-20%], which means subjects with high caries susceptibility had the highest mean DMFT of 3.54 and highest mean DMFS of 3.81 at baseline and 4.1 and 4.6 respectively after two years. The subjects with highest chance of avoiding caries [to the extent of 81-100%] showed very low mean DMFT and mean DMFS. This signifies the importance of the existing caries experience as a predictor of future caries. Higher the caries experience of a person lower the chance of avoiding caries, and lower the existing caries experience, higher the chance of avoiding caries. Similar relationship is seen in other studies.<sup>[4,11,12]</sup>

The results of the current study [Table 3] regarding the individual caries related factors are consistent with those obtained in various other studies.<sup>[13]</sup> Children with high counts of *Mutans streptococci* and *lactobacilli* and low saliva buffer capacity often show higher DMFT values.<sup>[14-16]</sup> Fluoride usage resulted in lower caries experience.<sup>[17]</sup> Weak correlation was observed between oral hygiene and dental caries experience.<sup>[18-20]</sup>

Graph 2 is the most important, with respect to the objectives of the study. It gives the distribution of subjects under each category of 'chance of avoiding caries', after two years follow-up period by dividing them into those who experienced new caries and who did not develop new caries. Highest percentages of individuals (83.2%) developing new caries lesions were observed in the category of 0-20% chance of avoiding caries.

Lowest percentages of individuals (10.8%) to develop new lesions were observed in the category of 81-100% chance of avoiding caries. The risk of developing new carious lesions consistently reduced from the category of 0-20% chance of avoiding caries to the category of 81-100% chance of

avoiding caries, reflecting the ability of Cariogram in accurately estimating future caries. Hence a Cariogram can be said to be a useful tool for caries prediction. These findings are in conformity with other studies reported in the literature.<sup>[6,8,9]</sup>

In this endeavour Cariogram may be utilized as a powerful tool at community level in identifying high risk groups for dental caries and can also enable the policy makers to plan for the future, based on the caries prediction.

### Clinical relevance

- Helps in developing specific preventive, promotive, curative strategies at community level, by the government, semi-government, NGO's etc.
- In a developing country like India the annual budget for health sector is as such very less. Cash trapped health sector cannot cope up with the multiple demands with respect to multiple diseases found at any given instance hence prevention would be the best option.
- Helps in identifying risk groups accurately and label them as special target groups, so that a high risk strategy can be adopted and employed to control and prevent the disease.

## CONCLUSIONS

The Cariogram program is an effective and has some advantages such as making recommendations for preventive care and increasing patient motivation. The cariogram model has been evaluated in scientific studies both children and adult population. It is a useful pedagogic tool for dentists, dental hygienists and assistants in discussion with patients about their caries risk. The cariogram complements the current trends towards computerized record keeping and management.

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