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ORIGINAL ARTICLE

Caries risk assessment in young adults using Public Dental Service guidelines and the Cariogram—a comparative study

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Abstract

Objectives. To investigate the caries risk profiles in young adults and to compare the risk classification using the Public Dental Service (PDS) guidelines with a risk assessment program, the Cariogram. ***Materials and methods.*** All 19-year-old patients registered at eight public dental clinics were invited to participate (n = 1699). The study group who completed the baseline examination consisted of 1295 subjects representing 10% of all 19 year-olds attending dental care at the PDS in Skåne, Sweden. A risk classification of each patient was made by the patient's regular team according to the PDS guidelines. A research team collected whole saliva samples and information from a questionnaire and a structured interview in order to calculate risk according to the Cariogram model. ***Results.*** The mean DFS value was 4.9 and 23% of the patients were registered as caries-free (DFS = 0). The PDS risk classification was predominantly based on past caries and/or present caries activity. The majority was classified as 'some risk', while 16.7% were assessed as being of 'high' or 'very high risk'. The corresponding value for the two highest risk groups in the Cariogram model was 17.4%. The agreement between the two models was found acceptable (77.5%) for those assessed as low risk, while discrepancies were disclosed among those classified with higher risks. ***Conclusions.*** Although the proportion of subjects assessed with high or very high risk was similar using the PDS guidelines and the Cariogram model, the agreement between the models was fair. An acceptable agreement was only disclosed for the low risk category.

Key Words: *lactobacilli, mutans streptococci, risk factors, saliva*

Introduction

Risk assessment in general dental practice has become increasingly common and is today considered an essential component for the prevention and management of dental caries [1–3]. Several organizations have incorporated evidence from the literature into daily dental practice by constructing caries risk assessment models for different age groups of patients. This has led to guidelines which aim to act as a framework for the categorization of risk level, treatment decision-making and determination of individual recall intervals. In general, multiple risk factors and indicators based on general health, diet, oral hygiene and past caries experience have been proposed, varying with the age group at which they are targeted [4–6]. For adults, the Public Dental Service (PDS) in the Skåne Region have adopted guidelines based on past and present caries, periodontal conditions, general risk and technical risk. The examining dentist or dental hygienist scores the risk of each individual patient into one of four risk categories based on this protocol, paired with their own clinical judgment. However, the model does not provide a grading scale and does not disclose the weight and importance of each risk factor. Cariogram is a software program that takes the interaction of 10 different caries risk factors into account [7]. The risk for new carious lesions within the near

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future is graphically illustrated together with the caries risk profile of the individual patient. In previous prospective trials, Cariogram has been satisfactory validated in schoolchildren [8–10] and adults or elderly [11,12], while it was found less useful in younger schoolchildren [13] and in pre-school children [14]. The caries risk profiles of young adults have, however, gained limited attention [15], although Swedish national data indicate that ~15–20% of the adolescent's present high caries risk or high caries activity [16]. It was therefore thought of interest to further investigate the caries risk profiles in young adults regularly attending the public dental service. The aims of this study were to investigate the caries risk profiles in 19 year-olds living in southern Sweden and to compare the risk classification using the Public Dental Service guidelines with a computerized risk assessment program, the Cariogram. The null hypothesis was that no significant differences would be displayed between the two models.

Materials and methods

Study group

An invitation to take part in a prospective, longitudinal study over 3 years was sent to all public dental clinics in the Skåne region, located in southern Sweden. In 2006, there were 65 chief dental officers serving in the region. They were all willing to participate, but 23 had no possibility to house the investigators. From those who responded positively (60%), a convenient sample was selected due to geographic regions, city and rural areas, socioeconomic areas and small and large clinics. In the event of two or more clinics in, for example, a city area, the clinic with the largest number of 19 year-olds was selected. All 19-year-olds registered at the eight dental clinics were potentially eligible (n = 1699) and invited to participate in the study. The actual study group who completed the baseline examination consisted of 1295 subjects, representing 10% of all 19 year-olds living in the region at the time when the study was performed. A flow-chart with the main reasons for exclusion and drop-out is shown in Figure 1. On average, 76% of all registered 19-year olds at the eight clinics were enrolled, ranging from 64% in a low or mixed socioeconomic urban area to 87% in a rural upper socioeconomic district. All the participants were residents in areas with low natural fluoride content in the drinking water supply, but they reported use of fluoridated dentifrice on a regular basis. The baseline of the study was performed during 2006–2007 and the study design was approved by the Ethical Committee, Lund University, Sweden.

Clinical examination and caries risk classification

Prior to the study implementation, each selected clinic was visited by the principal investigator (GHP) and all dental personnel were provided detailed information on the aim and performance of the study. All clinical examinations were performed in connection with the subject's ordinary recall visit at the clinic. After written and verbal information about the outline of the study, written consent was given by the participants. The clinical visual–tactile examination, including bitewing

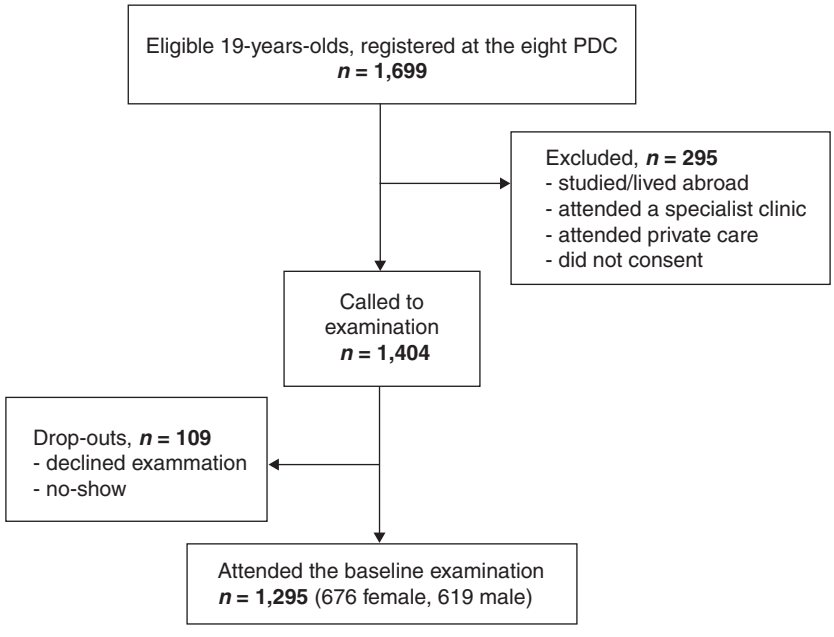

Figure 1. Flow-chart indicating attrition and drop-outs.

Table I. Guidelines for risk assessment in adults issued by the Public Dental Service in Skåne region. Patients are categorized based on caries risk, periodontal risk, general risk and technical risk. The highest score obtained decides the final classification.

	Low risk	Some risk	High risk	Very high risk
Caries	■ No progression last 2 yrs	■ Progression of enamel lesions within 2 years ■ 1–2 new cavities	■ Several new lesions and/or progression of lesions ■ 2–3 new cavities	■ Massive progression ■ ≥3 new cavities ■ Extensive need of restorative care
Perio	■ Healthy periodontium ■ No bleeding pockets ≥5 mm ■ No radiographic bone loss	■ Bleeding pocket ≥5 mm ■ Slight radiographic bone loss	■ Bone loss <1/3 of root length ■ Initial furcation involvement ■ Subgingival calculus	■ Bone loss >1/3 of root length ■ Furcation involvement ■ Vertical bone pockets
General	■ No disease/medication/unfavorable habits	■ Slightly compromised health/unfavorable habits ■ Fear of dental treatment	■ Moderate medical condition/unfavorable habits ■ Frequent cancels or no-shows ■ Communication problems	■ Severe medical problems/unfavourable habits ■ Dental avoidance
Technical	■ Few proximal fillings	■ Several restorations with risk of fracture ■ Deep fillings with potential endodontic complications	■ Root fillings/deep fillings of mixed quality ■ Risk of endodontic treatment ■ Evidence of parafunction	■ Crowns/prosthetics of questionable quality ■ Large treatment need ■ Parafunction, bruxism

radiographs, was carried out by the regular dentist or dental hygienist according to WHO criteria 1987 [17]. Caries prevalence and experience was registered at the decayed-filled-teeth/surface (DFT/DFS) level together with enamel lesions (EC) recorded from the clinical examination and bitewings. In addition, periodontal status was recorded through bleeding on probing and horizontal/vertical bone loss. Based on the findings, the estimated risk level was classified in four categories according to the 'adult guidelines for risk assessment of oral diseases' issued by the Public Dental Service; 'low risk', 'some risk', 'high risk' or 'very high risk'. The criteria used for the different risk categories are shown in Table I.

Caries risk assessment with Cariogram

The background variables for the Cariogram model were collected by designated research personnel, not involved in the recall care of the patient. Immediately after the regular clinical examination, the participants completed a structured questionnaire concerning general health and medication, diet and oral hygiene habits, including tooth brushing frequency and the use of fluoride and tobacco. The answers were followed up with an interview by two experienced dental nurses who also collected samples of stimulated whole saliva. All clinical examinations, including the saliva test, were performed in connection with the subject's ordinary recall visit at the clinic. Data for the computerized risk assessment program were then, by the researchers, entered into the Cariogram to obtain an individual caries risk profile as previously described [7,8,11]. The results of the Cariogram risk assessment were not communicated to the regular dental personnel.

Chair-side procedures

Paraffin-stimulated whole saliva was collected for 5 min for estimation of secretion rate and expressed as ml/min. Salivary *mutans streptococci*, *lactobacilli* and buffer capacity were determined with Dentocult® SM - Strip mutans, Dentocult® LB and Dentobuff® Strip, respectively. All chair-side tests were obtained from Orion Diagnostica (Espoo, Finland) and handled according to the instructions of the manufacturer.

Statistical methods

All data were processed with the IBM-SPSS software (version 19.0, Chicago, IL). Descriptive statistics and correlations were calculated. An acceptable agreement between the two modes of risk assessments was considered as follows: PDS 'low risk' = Cariogram 61–100% chance to avoid caries; PDS 'some risk' = Cariogram 41–80% chance to avoid caries; PDS 'high risk' = Cariogram 21–60% chance

Table II. Percentage distribution of caries risk according to the PDS guidelines and caries prevalence and experience expressed as mean DFT, DFS and EC ± SD in the various risk groups (n = 1295).

Risk group	n (%)	Caries-free	DFT (SD)	DFS (SD)	EC (SD)
Low risk	497 (38.0)	43.3%	1.55 (1.93)	1.90 (2.63)	1.69 (2.85)
Some risk	583 (45.5)	13.6%	3.77 (2.95)	5.23 (4.84)	4.90 (4.66)
High risk	175 (13.4)	3.4%	6.36 (3.42)	9.93 (6.66)	7.77 (7.23)
Very high risk	40 (3.1)	2.5%	8.48 (4.26)	14.73 (9.65)	9.75 (9.43)
ANOVA p-value			$p < 0.001$	$p < 0.001$	$p < 0.001$

DFT, Decayed Filled Teeth; DFS, Decayed Filled Surfaces; EC, Enamel Caries.

to avoid caries; PDS 'very high risk' = Cariogram 0–40% chance to avoid caries. Caries prevalence was analyzed with a one-way ANOVA. Gender differences between risk categories were subjected to χ^2 test. A p-value less than 0.05 was considered statistically significant.

Results

Twenty-three per cent of the study group was registered as caries-free (DFS = 0) and 62% had no proximal fillings or lesions (DFS-a = 0). The mean DFS and DFS-a values (SD) were 4.9 (5.6) and 1.2 (2.4), respectively. Ten per cent had >4 proximal lesions, while initial lesions were disclosed in 37.5% of the patients. The distribution of caries risk categories as assessed by the clinicians is presented in Table II, together with the actual caries data. In the vast majority (93.2%), the determination of risk category was based on the caries situation. Periodontal risk was evident in 4.4% of the subjects, general risk in 0.1% and technical risk in 2.3% of the patients. Most patients were placed in the 'some risk' category, while 16.7% were thought being at 'high' or 'very high' caries risk. The caries prevalence increased significantly with increasing caries risk (Table II). Of all patients, 10.4% were examined by dental hygienists. In general, dental hygienists scored the patients in a lower risk category than dentists; 47% were placed in the lowest risk group by hygienists compared to 37.5% by dentists. For the highest risk levels ('high risk' and 'very high risk'), the corresponding values were 8.9% vs 17.6%. Twenty-eight per cent of the young adults were regular tobacco users (smoke, snuff), males significantly more frequent than females ($p < 0.001$). Tobacco users were also significantly more common in the 'very high risk' group (45%) compared with the low risk group (21%).

The mean Cariogram value, expressed as 'per cent chance to avoid new lesions in the near future' was 60.9% (SD = 22.9). With the Cariogram model, 17.4% (n = 225) of all participants were categorized as being of high or very high risk (<40% chance of avoiding new caries, Table III). The agreement between the clinical assessment routinely made by dentists and dental hygienists using the PDS guidelines and the Cariogram is illustrated in Figure 2. The agreement ranged between 77.5% and 57.7%; the best was obtained for those assessed with low risk and the poorest agreement was obtained for the high risk subjects. The scores of the Cariogram variables in relation to the PDS risks categories are summarized in Table IV. The proportion of unfavorable scores increased with increasing risk with the exception of 'diet frequency' and salivary '*lactobacilli* counts' that were similar in the different risk categories. The use of additional fluorides on top of fluoride toothpaste was higher in the two lowest risk categories.

Table III. Distribution of caries risk according to Cariogram and caries experience expressed as mean DFT, DFS and EC ± SD in the various risk groups (n = 1295).

Chance of avoiding new caries		n (%)	Caries-free	DFT (SD)	DFS (SD)	EC (SD)
Very low risk	81–100%	302 (23.3)	63.2%	1.28 (2.35)	1.69 (3.50)	2.38 (3.87)
	61–80%	424 (32.7)	18.2%	2.83 (2.59)	3.89 (4.21)	3.75 (4.45)
	41–60%	344 (26.6)	5.2%	4.85 (3.26)	6.92 (5.82)	5.10 (5.89)
	21–40%	116 (9.0)	7.8%	5.27 (3.80)	8.22 (7.49)	6.09 (5.84)
Very high risk	0–20%	109 (8.4)	5.5%	5.07 (3.45)	7.57 (6.78)	6.15 (6.96)
ANOVA p-value				$p < 0.001$	$p < 0.001$	$p < 0.001$

DFT, Decayed Filled Teeth; DFS, Decayed Filled Surfaces; EC, Enamel Caries.

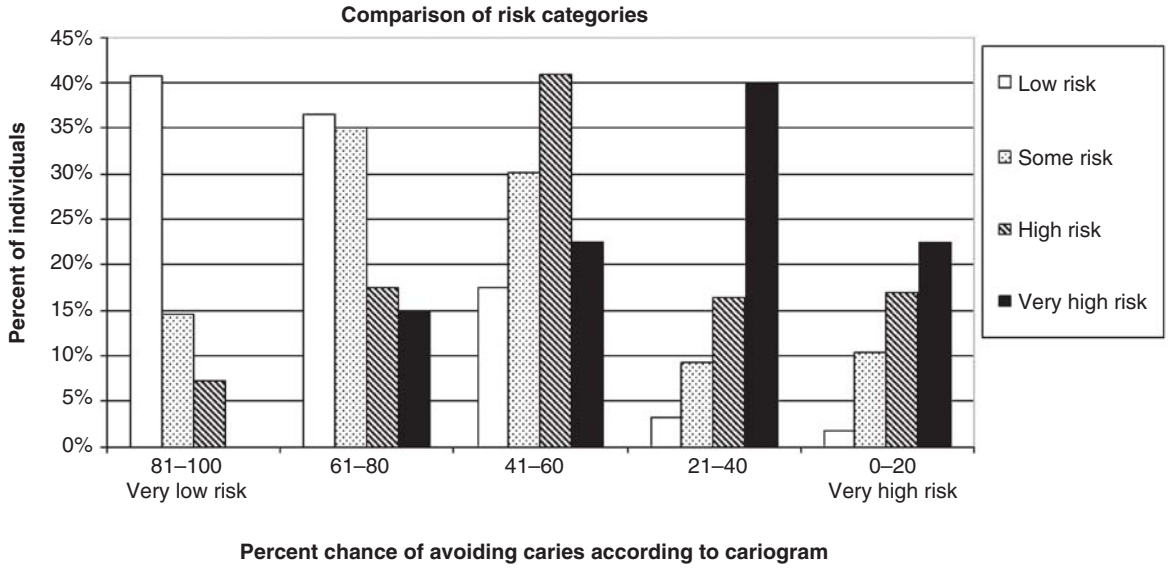

Figure 2. Comparison of caries risk categories obtained with the Cariogram model vs assessments by dentists and dental hygienists at eight selected public dental clinics (PDC).

Table IV. The distribution of Cariogram scores in the various PDS risk categories in young adults (n = 1295).

	PDS risk categories			
Cariogram component (score)	Low risk (n = 497)	Some risk (n = 583)	High risk (n = 175)	Very high risk (n = 40)
General health (impaired, score ≥1)	1.2%	1.4%	1.7%	2.5%
Diet, frequency (>7 times/day, score 3)	13.3%	12.0%	13.1%	12.5%
Oral hygiene (poor, score 3)	0.6%	3.4%	16.6%	37.5%
Secretion rate (<0.5 ml/min, score 3)	5.0%	7.7%	5.7%	15.0%
Buffer capacity (low, score 2)	2.4%	4.5%	7.4%	15.0%
Lactobacilli (high counts, score 3)	0.8%	5.5%	10.9%	5.0%
Mutans streptoccoci (high counts, score 3)	5.6%	9.3%	12.6%	12.5%
Fluoride program (additional, score ≤1)	15.3%	13.8%	13.2%	5.0%

Discussion

The skew distribution of caries within the population today calls for risk assessment and the challenge is to identify and estimate the probability for a patient of developing new caries lesions or progression of existing lesions during a specified period of time [18]. The present study was performed as the baseline for a longitudinal validation of two modes of caries risk assessment in young adults from a community with a polarized caries distribution. An important issue, therefore, was whether or not the selected study group was representative for the general population of that age group. Since the relative coverage was lowest at the clinic harboring the most vulnerable patients, the possibility that the general risk level was somewhat under-estimated could not totally be ruled out. However, the caries prevalence in the present study group corresponded well with the Swedish national data (mean DFT 3.1 vs 3.4; SoS, 2005). Moreover, the distribution of risk categories differed less than 1.5% compared with from the entire age group (~12 000 19-year-olds) attending dental care in the Public Dental Service (PDS) in Skåne, Sweden. Thus, our findings were considered being of high external validity.

The main and novel outcome of this comparative study was the acceptable agreement between the PDS and Cariogram models concerning low risk patients, while discrepancies were disclosed for those assessed with high risk. Consequently, the null hypothesis was rejected. This does not necessarily mean that any of the models are to be preferred before the other, a question that must be answered in a prospective setting. Another question that could be discussed is whether or not the guidelines for risk assessment were followed as intended? This was at least partly verified through the retrospective interview but still somewhat uncertain.

However, the implementation of risk grouping is highlighted after introduction of a 'capitation model' in Sweden which requires a more structured form of risk assessment. Consequently, its importance has been underlined through a mandatory education of dental personnel. The risk score of the PDS guidelines, expressed as low, some, high or very high risk, based on caries, periodontal, general and technical risk, do not show the considerations behind the decided score. A retrospective interview found that the vast majority (93.2%) of the 19-year olds were categorized *primarily* on their caries situation, but for example those based primarily on periodontal risk are also at risk for caries. The use of the PDS guidelines is straight-forward, quick and fairly objective, albeit the 'impression of the clinician' is undefined. The use of the Cariogram is more complex and time-consuming, although it may also be used in a simplified version without information from saliva tests [10]. The acceptable low-risk agreement between the two models was not surprising since past and present caries activity was the dominating predictor in the PDS model. It can be speculated that other, more 'soft' risk variables, such as smoking, self-efficacy or health beliefs evident for the clinicians may have influenced the high risk classifications to a larger extent. All patients were informed about their PDS risk category but not on the outcome of the Cariogram. The goal of risk grouping is of course to plan and perform an individual preventive and non-operative treatment plan. The extent and content of these means will be addressed in the follow-up reports.

As seen in the tables, the actual caries scores increased significantly with increasing risk category for both models except from the two highest risk groups with Cariogram. It was also comforting to find that the risk variables collected for the Cariogram model also was reflected by risk categories as classified by the clinicians. However, the variables associated with diet (frequency and salivary *lactobacilli* counts) were totally unrelated to the PDS risk categories which may indicate that they provide irrelevant information for young adults. The observation of a fairly high proportion of subjects using additional fluoride in the categories 'low risk' and 'some risk' and a low proportion of subjects using additional fluoride in the 'very high risk' category is somewhat surprising. One explanation could be that participants in the lower risk groups are often more aware of their oral health and use additional fluorides in spite of the fact that they do not really need them. This observation may also indicate that preventive strategies used by the dental teams are not always based on the result of risk assessment, but this needs to be further investigated. An obvious finding was that the dentists and dental hygienists based their risk assessment on the past caries situation in the vast majority of the patients. This was in accordance to previous reports from Sweden [19] and clearly in agreement with the conclusions of a systematic review of literature [1]. The observation that dental hygienists in general scored lower than dentists was interesting since it is well known that the specificity of predictors often are higher than the sensitivity, which means that the precision in finding low risk subjects is higher than actually identifying those with high risk. One explanation could be that patients examined by the dental hygienists were a selected sample of patients. The large size of the present study group will allow for a separate analysis concerning the accuracy of the risk assessment procedure made by the two professional groups. Patients at low risk may not need additional preventive interventions and should be offered extended recall intervals [20]. However, to our knowledge, estimations on the health-economic consequences of adequate risk assessments are not yet available.

In conclusion, within the limitations of this comparative study, the results suggest an acceptable agreement between the two caries risk assessment models for young adults with 'low' or 'some' risk, while the agreement was fair for those with high risk. Both models will be validated against the true caries increment during 3-years as a continuation of this project.

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