

# Evaluation of a computer-based caries risk assessment program in an elderly group of individuals

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The aim of this study was to evaluate a caries risk assessment computer program, the Cariogram, by comparing the risk assessment of the program with the actual caries increment in a group of elderly individuals over a period of 5 years. The participants were examined and interviewed at baseline about their general health and dietary habits. Data on oral hygiene and use of fluoride were obtained and saliva analyses included mutans streptococci, lactobacilli, buffering capacity, and secretion rate. Based on the baseline recordings, the individuals were divided into 4 risk groups according to the Cariogram. Where the program predicted 0%–20% (high risk), 21%–40%, 41%–60%, and 61%–100% (low/rather low risk) “chance of avoiding caries”, 13, 32, 23, and 48% respectively, had no new DFS over 5 years and 18, 40, 72, and 84%, respectively, had no new lesions at the 5th year. The mean DMFS increment over 5 years was 12.8 in the high/rather high risk group (0%–40% “chance of avoiding caries”), which included 43% of the individuals. In the low/rather low risk group (61%–100% “chance of avoiding caries”), the corresponding value was 5.2%, and 21% of the participants were sorted to this group. The mean DMFS increment for the whole group of elderly individuals was 9.5. In this particular study the Cariogram was able to sort the elderly individuals into risk groups that reflected the actual caries outcome. □ *Caries risk; Cariogram; dental caries; elderly; risk assessment*

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The retention of natural teeth among the elderly is increasing, and the number of edentulous individuals decreasing (see WHO global database). Today's elderly carry numerous fillings, crowns, and bridges, all subject to the risk of secondary caries. Studies of the causal factors of tooth extraction have shown that caries is an important reason for the loss of teeth even in the oldest age groups (1). In addition, secondary caries is the main reason why crowns and bridges need to be replaced (2, 3).

Aging also implies higher rates of disease and use of medication with xerostomic side effects (4–7). The social situation of many of the elderly undergoes change that perhaps influences their behaviour in a caries-promoting way (8). Caries risk assessment, i.e. identification of factors in the case history of the elderly, factors which may increase the risk of new caries, is therefore important as a basis for placing a patient on the best caries-preventive regimen (9).

Caries risk assessment is complex and the results so far are not very encouraging, not even in young individuals (10, 11). We believe though that by identifying several risk factors and weighing them together would increase the possibilities of creating a valid ‘risk profile’ of an individual. For that reason, a computer program, the ‘Cariogram’, was developed. When using this program, a set of data from clinical investigation, interviews, and saliva tests is needed. The program has already been tested twice. On the first occasion, its assessment was compared with the ‘opinion’ of dentists, dental instructors, dental hygienists, and dental students on a set of clinical cases.

The results showed that the Cariogram risk assessment was in line with the opinions of the majority of these groups, in particular the dentists (12, 13). Secondly, it was tested for the actual caries increment in a longitudinal, prospective study on nearly 400 schoolchildren who were between 10 and 11 years old at the start (14). The children were divided into 5 risk groups and the results showed a significant correlation to the caries increment over 2 years.

The aim of this study was to evaluate the Cariogram in a group of elderly individuals by comparing the caries risk assessment of the program with the actual caries increment over a 5-year period.

*Hypothesis:* A caries risk assessment model that evaluates several factors together, and where the factors are simultaneously weighted to each other—as in the Cariogram—should be able to sort elderly individuals into high, medium, or low caries risk profiles.

## Materials and methods

### *Study population*

The study population consisted of individuals who participated in a 5-year incidence study on coronal and root caries performed in Sweden (15, 16). Initially, a random sample of 55-, 65-, and 75-year-olds—a total of 208 individuals—was examined. At the follow-up examination in 1992, 5 years later, 148 (71%) participated, distributed as 69, 51, and 28 individuals in age groups 60-

70-, and 80 years, respectively. The mean age was 67.2. Reasons for not participating in the follow-up study included severe illness (6.7%), lack of time (6.2%), or relocation away from the district (4.3%). Eleven percent had died and 2 persons had lost all their remaining teeth. Eighty-two percent of the participants had visited their dentist less than 1 year previously.

### Study design

The clinical and radiographic examinations were carried out by the same examiners and, using the same techniques, both at baseline and 5 years later (15, 16). The DMFT (decayed-missed-filled-teeth) and DMFS (decayed-missed-filled-surfaces) were calculated on both occasions.

The participants were interviewed about their general and oral health. Their intake of medications that could have xerostomic side effects, the use of antimicrobial treatments during the previous 2 months and their dietary habits and food consumption within the previous 24 h were noted. The number of occasions on which fermentable carbohydrates, solid or liquid form, consumed was recorded, irrespective of the amount. When entering the scores in the Cariogram, the lactobacillus count was used as an indicator of the cariogenicity of the diet (17, 18).

Questions were asked about frequency of tooth brushing and use of fluoride dentifrice, rinsing, and tablets, and the percentage of surfaces harbouring plaque was calculated during the examinations. Saliva samples were obtained from each individual with measurements of saliva secretion rate of paraffin-stimulated saliva. The buffer capacity of stimulated saliva was determined. Microbiological examination included counts of mutans streptococci and lactobacilli. For details, see Fure (19).

### Diagnostic criteria and indices

**Coronal caries:** Coronal caries was detected according to the WHO criteria (20), caries is recorded as present when a lesion in a pit or fissure, or on a smooth tooth surface, has detectably softened or, undermined enamel or softened wall. A tooth with a temporary filling should also be included in this category.

**Root surface caries:** The criteria described by Banting et al. (21) for the identification of root caries were used. '1) A discrete, well-defined and discoloured soft area 2) an explorer enters easily and displays some resistance to withdrawal; 3) the lesion is located either on to the cemento-enamel junction or wholly on the root surface.'

**X-ray:** Any enamel or root decalcification which was identified radiographically was also examined clinically in order to verify or reject this diagnosis.

**Arrested caries:** When a tooth surface, coronal, or root exhibited a well-defined discolored area and appeared to be hard and smooth, caries was recorded as arrested.

**Secondary caries:** Carious lesions adjacent to restorations were recorded as secondary caries on coronal and root surfaces, respectively.

**Restored surfaces:** Restorations were noted as fillings or prosthetic crowns, and the type of filling was recorded.

**DFS: Decayed-filled-surface.** The number of decayed and/or filled tooth surfaces (including the root surfaces) was calculated. When a surface was both decayed and filled it was recorded as decayed. Each tooth surface was recorded just once, irrespective of whether the lesion was situated on the surface of the crown, on the root, or both.

**DFS increment: Decayed-filled-surface increment.** The number of tooth surfaces that became decayed and/or had been filled during the 5-year period.

**DFRS: Decayed-filled-root-surface.** The number of decayed and/or filled root surfaces was calculated. When a surface was both decayed and filled it was recorded as decayed.

**DFRS increment: Decayed-filled-root-surface increment.** The number of root surfaces that became decayed and/or had been filled during the 5-year period.

**DFS% increment:** The number of tooth surfaces (coronal and root surfaces counted as one surface) that had become decayed or had been filled during the 5-year period as a percentage of the number of tooth surfaces at risk.

**DFRS% increment:** The number of root surfaces (RS) that had become decayed or had been filled during the 5-year period as a percentage of the number of root surfaces at risk.

Diagnostic criteria and indices have been described in detail by Fure & Zickert 1997 (16). The third molar was included in all calculations.

### Risk assessment using the Cariogram

The Cariogram computer program presents the caries risk profile of an individual in accordance with its built-in algorithm (see Appendix for details). The information described above was entered into the Cariogram program to calculate the caries risk for each individual and to assess the risk for future caries activity and express the result as *the chance of avoiding caries* (14, 22, 23). To create a Cariogram, 9 factors/parameters of direct relevance to caries are entered into the program. The various parameters are given a score according to predetermined scales for each factor (Table 1). Depending on the weighted formula, the program presents a pie diagram in which the risks associated with bacteria-, diet-, and susceptibility-related factors (fluoride programme, saliva secretion, and saliva buffering capacity, respectively) are represented by the sector size. In addition, 'circumstances' (past caries experience plus general diseases) are presented as an additional sector. What is left represents the 'chance of avoiding caries' and if this sector is large the caries risk is low, and vice versa.

### Statistical methods

In evaluating the statistical significance of differences in caries increment scores across categories of different prediction groups that were recorded at baseline, a

Table 1. Caries-related factors/parameters used at baseline for the Cariogram

Factor	Information and data collected*	Cariogram scores
Caries experience	Past caries experience at baseline, including cavities, fillings, and missing teeth due to caries. Data from dental records and bitewing radiographs.	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, 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 lactobacilli.	0: $\leq 10^3$ CFU/ml 1: $10^4$ CFU/ml 2: $10^5$ CFU/ml 3: $\geq 10^6$ CFU/ml
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 1: 4–5 meals per day 2: 6–7 meals per day 3: >7 meals per day
Plaque amount	Data from the clinical examination of oral hygiene. Plaque index value (PI%).	0: <5% surfaces with plaque 1: 5–20% surfaces with plaque 2: >20–50% surfaces with plaque 3: >50% surfaces with plaque
Mutans streptococci	Estimation of levels of Mutans streptococci ( <i>Streptococcus mutans</i> , <i>Streptococcus sobrinus</i> ) in saliva. Mitis-salivarius-bacitracin (MSB) agar plates (24) were used to grow mutans streptococci.	0: <20,000 CFU/ml saliva 1: 20,000–100,000 CFU/ml saliva 2: >100,000–1 million CFU/ml saliva 3: >1 million CFU/ml saliva
Fluoride programme	Estimation of the extent of fluoride available in the oral cavity; data from interview results.	0: Maximum fluoride program 1: Fluoride supplements 2: Only fluoride toothpaste 3: No fluoride
Saliva secretion	Estimation of flow rate of paraffin-stimulated saliva (other breakpoints if the Cariogram is used for children).	0: >1.1 ml/min 1: >0.9–1.1 ml/min 2: 0.5–0.9 ml/min 3: <0.5 ml/min
Saliva buffering capacity	Estimation of capacity of saliva to buffer acids. The buffer capacity of stimulated saliva was determined according to the Ericsson method (25).	0: pH $\geq 6.0$ 1: pH 4.5–5.5 2: pH $\leq 4.0$

\* For each factor, the examiner thus has to gather information by interviewing and examining the patient, including some saliva tests. The information is then given a score on a scale ranging from 0 to 3 (0–2 for some factors) according to predetermined criteria. The score '0' is the most favorable value and the maximum score '3' (or '2') indicates a high, unfavorable risk value.

factorial analysis of variance, ANOVA, using the statistical package was used (SPSS for Windows, version 10; SPSS Inc. Chicago, Ill., USA). The level of significance was set at  $P < 0.05$ .

## Results

Fifty-one percent of the elders developed new coronal caries lesions and 61% new root caries lesions during the 5-year period. Of the total group, 27% had not developed coronal or root caries during the period.

Based on baseline data, the 148 individuals were divided into 4 risk groups according to the Cariogram: 61–100% (low/rather low risk), 41–60%, 21–40%, and 0–20% (highest risk) 'chance of avoiding caries'. The numbers of individuals in each group were 39, 25, 53, and

31, respectively. Previous studies had one further group (81–100% chance, low caries risk), but in this study there were only 3 in this group, which led to combining both groups to 61–100%. The mean Cariogram percentage (percent 'chance of avoiding caries') at baseline ( $n = 148$ ) was  $41\% \pm 20.55$  and the median value 44%; 43.3% of the elderly were predicted as belonging to the 'high/rather high' risk groups.

A frequency distribution of the risk, the number of participants in each risk group, and the caries increment (DMFS increment) over 5 years is presented in Table 2. Mean DMFT at baseline for the whole group ( $n = 148$ ) was  $23.45 \pm 4.19$ ; the corresponding value for DMFS was  $89.53 \pm 25.07$ . The mean DMFS increment was  $9.46 \pm 11.81$ .

Mean decayed filled surfaces (DFS) increment over 5 years in relation to baseline Cariogram predictions is

Table 2. Caries risk (at baseline) expressed as ‘% chance of avoiding caries’, number of individuals, and caries increment (DMFS increment) over 5 years

Percent chance of avoiding caries according to the Cariogram	0–20% ‘high risk’	21–40%	41–60%	61–100% ‘rather low/low risk’
No. of individuals (%)	39 (26.4)	25 (16.9)	53 (35.8)	31 (20.9)
Mean DMFS increment over 5 years	16.21 ± 15.97	7.36 ± 9.34	7.96 ± 9.52	5.23 ± 6.97

Total group: Mean DMFS increment 9.46 ± 11.81.

shown in Fig. 1. The individuals in the highest risk group showed a mean DFS increment of 9.54, while the lowest risk group had 1.74. The mean DFS increment for the total group was 5.93 ± 9.35 (ANOVA *P* value 0.012).

Figure 2 shows the mean ‘decayed surfaces’ (DS) when the participants were examined at the 5th year, according to the risk groups defined by the Cariogram 5 years earlier. The highest risk group had 5 times higher mean DS than the lowest risk group. The total group of individuals showed a mean DS value of 1.32 ± 2.18, (ANOVA *P* value 0.003).

For root surfaces, the mean decayed filled root surfaces (DFRS) increment over 5 years in relation to baseline Cariogram predictions is presented in Fig. 3. The highest risk group showed a mean DFRS increment of 4.59, while in the lowest risk group the corresponding value was 0.65. For the total study group, the mean DFRS increment was 2.53 ± 3.98 (ANOVA *P* value 0.001).

Regarding the mean ‘decayed root surfaces’ (DRS) at the 5th year, the highest risk group had nearly 8 times higher mean DRS than the lowest risk group (Fig. 4). Mean DRS for the total group at the 5th year was 1.04 ± 2.09 (ANOVA *P* value 0.005).

Figures 5 and 6 express the percentage of individuals with or without ‘new decayed and/or filled surfaces’ (DFS) over 5 years and the percentage of individuals with or without ‘decayed surfaces’ (DS) at the 5th year, according

to the Cariogram groups 5 years earlier. Eighty-four percent of the individuals in the lowest risk group had no new caries lesions at the 5th year, while in the highest risk group 18% had no new caries lesions. When looking at DFS over 5 years, the corresponding values were 48.4% and 12.8%.

The mean DFS and DFRS increments for each score of the caries-related factors evaluated are given in Table 3 as well as the mean DS and mean DRS at the 5th year. For example, one of the factors, the lowest score of mutans streptococci counts, showed a mean DFS increment of 2.22 ± 3.81 and mean DFRS increment of 0.65 ± 1.07. The highest mutans score displayed a mean DFS increment of 9.31 ± 9.80 and mean DFRS increment of 4.84 ± 5.55.

Ninety-five percent of the elderly reported that they used fluoride toothpaste. The 5% who did not had a mean DFRS increment twice as high as the individuals using fluoride toothpaste.

Data for DF increment as a percentage of the number of tooth surfaces at risk (DFS% increment) showed that where the program predicted 0–20% (high risk), 21–40%, 41–60%, and 61–100% (low/rather low risk) ‘chance of avoiding caries’, the mean DFS% over 5 years were 8.16, 2.84, 5.03, and 1.05, respectively. The corresponding values for the number of root surfaces that had become decayed or had been filled during the 5-year period as a

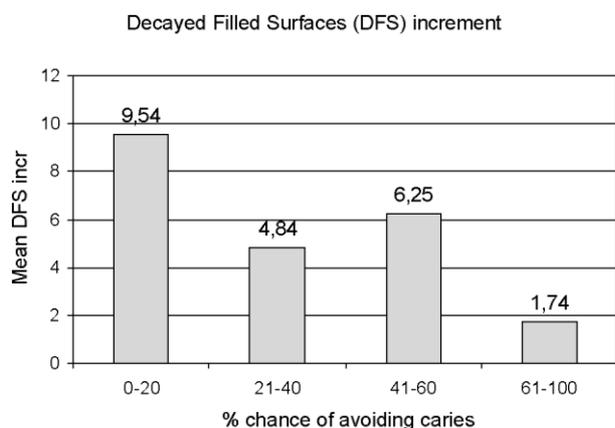


Fig. 1. Mean decayed filled surfaces (DFS) increment over 5 years in relation to baseline Cariogram predictions, ‘% chance of avoiding caries’. 0–20% indicates high risk for caries, etc.

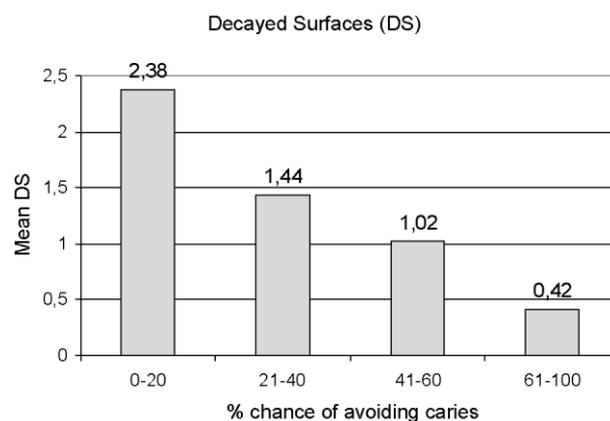


Fig. 2. Mean ‘decayed surfaces’ (DS) at the 5th year in the predicted groups according to the caries risk assessments made by the Cariogram 5 years earlier.

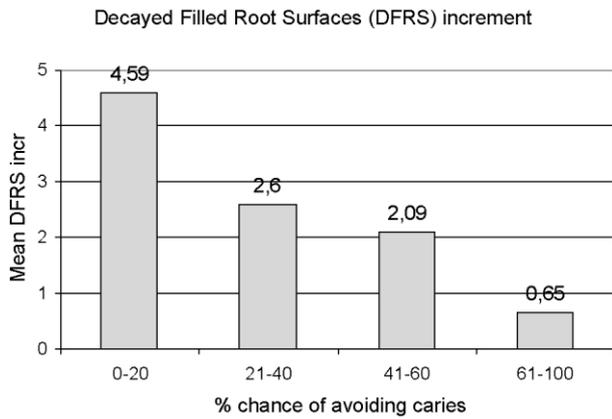


Fig. 3. Mean decayed filled root surfaces (DFRS) increment over 5 years in relation to baseline Cariogram predictions.

percentage of the number of root surfaces at risk (DFRS% increment) were 8.97, 3.67, 3.64, and 0.94.

Discussion

Studies on caries risk assessment in elderly individuals are clearly more complex than studies of younger individuals. This is in part due to the presence of earlier dental work that may fracture or even help to induce new lesions due to insufficient quality. There are also clear problems in keeping the study group together for several years, more difficult as age increases. Elderly Swedes, i.e. those who were at school before the 1960s, had no access to school fluoride rinsing, tablet programs or effective fluoride toothpastes. This resulted in numerous cavities and fillings and, consequently, high DMFT values. A large randomized epidemiological study in Sweden in 1993

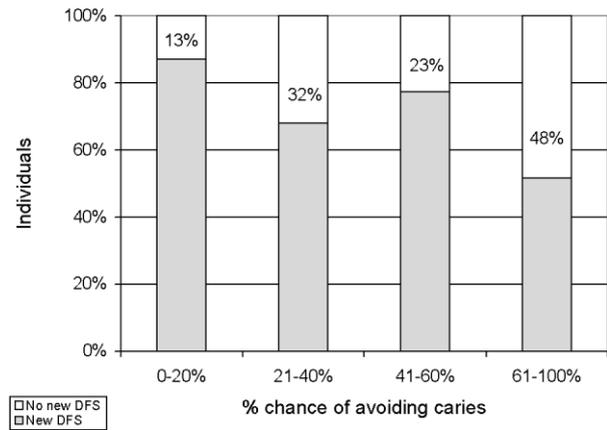


Fig. 5. The percentage of individuals with or without 'new decayed and/or filled surfaces' (DFS) over 5 years in relation to baseline Cariogram predictions.

revealed DMFT values between 21.4 and 24.4 for 50 and 70-year-olds, respectively (26). These values are similar to the results in the present study. It can readily be understood that with such already high baseline values, where most teeth are already filled, decayed, or extracted, major changes in DMFT cannot be expected. Nevertheless, the number of new lesions (secondary caries and root surface lesions) can vary to a larger extent.

The present study is the first where the Cariogram has been applied on an elderly Swedish population for caries risk assessment. A few important findings are worthwhile discussing. First, comparing the overall risk profile of the elderly with a similar assessment made for children (14) the study clearly illustrated a much higher risk among the elderly. For example, in a study of 10–11-year-olds, nearly 50% of the children were assigned to the 'best' Cariogram group (lowest risk), while among the elderly only 2% belonged to this group. Among the children, the highest risk group consisted of 3.6%, but in the elderly 26.4%

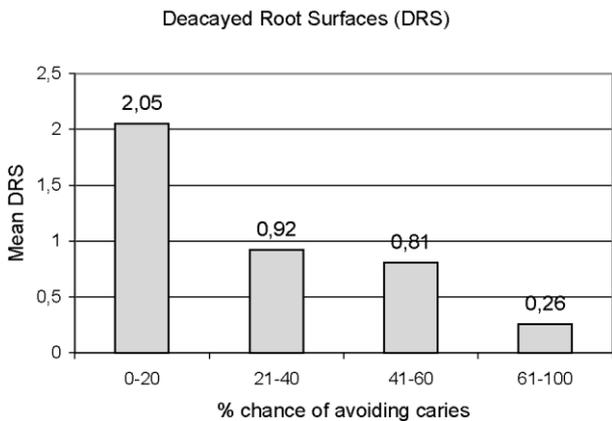


Fig. 4. Mean 'decayed root surfaces' (DRS) at the 5th year in the predicted groups according to Cariogram risk assessment 5 years earlier.

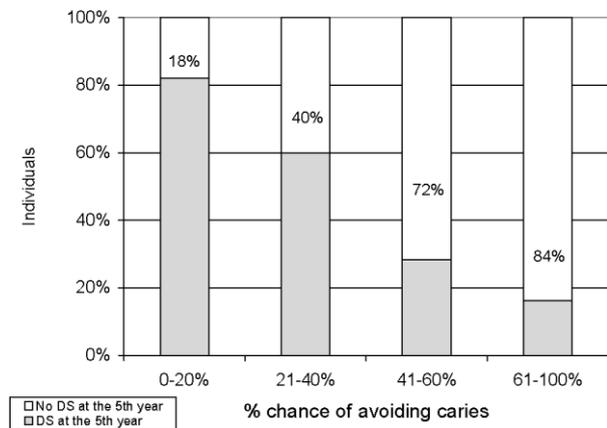


Fig. 6. The percentage of individuals with or without 'decayed surfaces' (DS) at the 5th year in the predicted groups according to Cariogram risk assessment 5 years earlier.

Table 3. Comparison of some caries-related factors as estimated at baseline versus mean caries increment, DFS ± s (standard deviation), as well as mean caries increment for root surfaces DFRS ± s over 5 years and mean decayed surfaces DS ± s along with mean decayed root surfaces DRS ± s at the 5th year

Factor	Mean DS at the 5th year	Mean DFS increment	Mean DRS at the 5th year	Mean DFRS increment	No. of elderly	Percentage of group
Diet, content (here based on lactobacillus count)						
≤10 <sup>3</sup> CFU/ml	0.94 ± 1.80	3.52 ± 5.05	0.66 ± 1.56	1.57 ± 2.39	77	52
10 <sup>4</sup> CFU/ml	1.33 ± 2.45	8.12 ± 9.95	1.15 ± 2.45	2.79 ± 4.59	33	22
10 <sup>5</sup> CFU/ml	2.06 ± 2.50	8.94 ± 14.32	1.74 ± 2.61	4.38 ± 5.53	34	23
≥10 <sup>6</sup> CFU/ml	2.50 ± 2.65	6.00 ± 4.32	1.50 ± 1.73	3.25 ± 2.36	4	3
ANOVA <i>P</i> value	0.037	0.014	0.085	0.006		
Diet, frequency						
Maximum 3 meals per day	1.14 ± 2.21	3.43 ± 4.50	1.00 ± 2.15	1.79 ± 2.61	14	9
4-5 meals per day	1.42 ± 2.20	5.75 ± 8.55	1.11 ± 1.96	2.34 ± 3.34	64	43
6-7 meals per day	1.13 ± 1.87	5.58 ± 7.72	0.83 ± 1.86	2.55 ± 4.33	53	36
>7 meals per day	1.71 ± 3.02	9.12 ± 16.94	1.47 ± 3.08	3.82 ± 5.70	17	11
ANOVA <i>P</i> value	0.767	0.384	0.725	0.492		
Plaque amount						
<5% surfaces with plaque	2.33 ± 3.20	0.28 ± 0.89	2.33 ± 3.20	3.50 ± 5.50	6	4
5-20% surfaces with plaque	0.53 ± 0.84	4.00 ± 8.54	0.42 ± 0.84	1.89 ± 3.03	19	13
>20-50% surfaces with plaque	1.14 ± 1.83	6.59 ± 11.43	0.80 ± 1.80	2.21 ± 2.95	56	38
>50% surfaces with plaque	1.61 ± 2.54	5.84 ± 7.87	1.30 ± 2.37	2.90 ± 4.77	67	45
ANOVA <i>P</i> value	0.146	0.774	0.125	0.628		
Mutans streptococci						
<20,000 CFU/ml	0.43 ± 0.95	2.22 ± 3.81	0.26 ± 0.69	0.65 ± 1.07	23	16
20,000-100,000 CFU/ml	0.63 ± 1.50	3.19 ± 4.66	0.53 ± 1.50	1.41 ± 2.34	32	22
>100,000-1 million CFU/ml	1.33 ± 2.34	6.85 ± 11.46	0.97 ± 2.18	2.62 ± 3.86	61	41
>1 million CFU/ml	2.66 ± 2.50	9.31 ± 9.80	2.25 ± 2.58	4.84 ± 5.55	32	22
ANOVA <i>P</i> value	<0.001	0.009	0.001	<0.001		
Saliva secretion						
>1.1 ml/min	1.20 ± 2.18	5.13 ± 8.92	0.91 ± 2.07	2.20 ± 3.42	116	78
>0.9-1.1 ml/min	1.00 ± 1.32	6.71 ± 10.18	0.82 ± 1.33	1.47 ± 2.18	17	11
0.5-0.9 ml/min	2.15 ± 2.41	10.69 ± 11.54	2.00 ± 2.52	6.46 ± 7.32	13	9
<0.5 ml/min	6.00 ± 0.00	9.50 ± 4.95	4.50 ± 2.12	5.50 ± 3.53	2	1
ANOVA <i>P</i> value	0.007	0.202	0.029	0.001		
Saliva buffering capacity						
pH ≥6.0	1.00 ± 1.96	3.81 ± 5.47	0.77 ± 2.00	1.79 ± 2.92	43	29
pH 4.5-5.5	1.06 ± 1.84	3.73 ± 3.92	0.64 ± 1.52	1.94 ± 2.46	33	22
pH ≤4.0	1.64 ± 2.42	8.06 ± 12.11	1.39 ± 2.32	3.25 ± 4.90	72	49
ANOVA <i>P</i> value	0.233	0.020	0.136	0.101		

were allocated to this group. Overall, one could say that caries risk, as assessed by the Cariogram, was twice as high for the elderly (median value 'chance of avoiding caries' 44% for the elderly and 80% for the children).

Second, although very few elderly have a low caries risk, the individuals could be assigned fairly evenly to 4 risk groups. The outcome was evaluated using two criteria: (i) the caries increment over the 5 years and (ii) the caries situation at the 5th year appointment. Whatever way, the risk groups reflected the real outcome in terms of new lesions, filled or not. Individual factors such as mutans streptococci and diet content (lactobacillus class) also showed significant correlations.

What are the reasons for the generally higher caries risk among the elderly? Some factors have been identified, for example medical problems (8), reduced saliva secretion rate, which is often the side effect to medication (27, 28). Steele et al. (29) mention frequent sugar intake, poor hygiene, and partial dentures as factors associated with large increases in risk. Ravald (30) points out that the same main factors as for coronal caries, i.e. cariogenic microorganisms, diet, saliva, and fluoride exposure, are important in root caries development. Salonen et al. (31), in a large epidemiological survey, demonstrated higher proportions of subjects with high levels of mutans streptococci among dentate individuals wearing some kind of removable dentures.

Considering the overall high risk and the many factors that make up the risk, is it feasible to identify caries 'risk groups' among elderly people? For several years a discussion has been going on regarding strategies for young individuals—should one take the population strategy or the risk group strategy? Risk intervention programs of some researchers have been successful (32, 33), while others have failed (34). If the question is seen as an 'either/or' problem, then a population-based strategy would probably lead to fewer cavities in total. However, few if any argue for such an either/or approach. How much additional analyses of individual risk factors among elderly, followed by targeted actions, can reduce the risk further needs to be explored.

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## References

- Fure S, Zickert I. Incidence of tooth loss and dental caries in 60-, 70- and 80-year-old Swedish individuals. *Community Dent Oral Epidemiol* 1997;25:137–42.
- Glantz PO, Nilner K, Jendresen MD, Sundberg H. Quality of fixed prosthodontics after 15 years. *Acta Odontol Scand* 1993;51:247–52.
- Deligeorgi V, Mjor IA, Wilson NH. An overview of reasons for the placement and replacement of restorations. *Prim Dent Care* 2001;8:5–11.
- Mandel ID. The role of saliva in maintaining oral homeostasis. *J Am Dent Assoc* 1989;119:298–304.
- Persson RE, Izutsu KT, Treulove EL, Persson R. Differences in salivary flow rates in elderly subjects using xerostomatoc medications. *Oral Surg Oral Med Oral Pathol* 1991;72:42–6.
- Tenovou J. Oral defense factors in the elderly. *Endod Dent Traumatol* 1992;8:93–8.
- Nederfors T, Isaksson R, Mornstad H, Dahlof C. Prevalence of perceived symptoms of dry mouth in an adult Swedish population: relation to age, sex and pharmacotherapy. *Community Dent Oral Epidemiol* 1997;25:211–6.
- Ettlinger RL. The unique oral health needs of an aging population [Review]. *Dent Clin North Am* 1997;41:633–49.
- Wyatt CC, MacEntee MI. Dental caries in chronically disabled elders. *Spec Care Dentist* 1997;17:196–202.
- Powell LV. Caries prediction: a review of the literature. *Community Dent Oral Epidemiol* 1998;26:361–71.
- Zero D, Fontana M, Lennon A. Clinical applications and outcomes of using indicators of risk in caries management. *J Dent Educ* 2001;65:1126–32.
- Hänsel Petersson G, Carlsson P, Bratthall B. Caries risk assessment: a comparison between the computer program 'Cariogram', dental students and dental instructors. *Eur J Dent Educ* 1998;2:184–90.
- Hänsel Petersson G, Bratthall D. Caries risk assessment: a comparison between the computer program 'Cariogram', dental hygienists and dentists. *Swed Dent J* 2000;24:129–37.
- Hänsel Petersson G, Twetman S, Bratthall D. Evaluation of a computer program for caries risk assessment in schoolchildren. *Caries Res* 2002;36:327–40.
- Fure S, Zickert I. Prevalence of root surface caries in 55, 65, and 75-year-old Swedish individuals. *Community Dent Oral Epidemiol* 1990;18:100–5.
- Fure S, Zickert I. Five-year incidence of coronal and root caries in 60-, 70- and 80-year-old Swedish individuals. *Caries Res* 1997;31:249–58.
- Abrams RA, Ayers CS, Weinstein LB. Salivary testing to reduce sugar consumption in school children. *Clin Prev Dent* 1989;4:12–7.
- Crossner CG. Variation in human oral lactobacilli following a change in sugar intake. *Scand J Dent Res* 1984;3:204–10.
- Fure S. Five-year incidence of caries, salivary and microbial conditions in 60-, 70- and 80-year-old Swedish individuals. *Caries Res* 1998;32:166–74.
- World Health Organization Oral Health Surveys: Basic methods, ed. 3. Geneva: WHO; 1987.
- Banting DW, Ellen RP, Fillery ED. Prevalence of root surface caries among institutionalised older persons. *Community Dent Oral Epidemiol* 1980;8:84–8.
- Bratthall D, Hänsel Petersson G, Stjernswärd JR. *Cariogram-handboken* (in Swedish). Stockholm: Förlagshuset Gothia AB; 1997.
- Bratthall D, Stjernswärd RJ, Hänsel Petersson G. Assessment of caries risk in the clinic: a modern approach. In: Wilson NHF, Roulet JF, Fuzzi M, editors. *Advances in operative dentistry*. Chicago, Ill: Quintesse Publishing Co; 2001. p. 61–72.
- Gold OG, Jordan HV, van Houte J. A selective medium for *Streptococcus mutans*. *Arch Oral Biol* 1973;18:1357–64.
- Ericsson Y. Clinical investigation of the salivary buffering action. *Acta Odontol Scand* 1959;17:131–65.
- Hugoson A, Koch G, Bergendal T, Hallonsten AL, Slotte C, Thorstensson B, Thorstensson H. Oral health of individuals aged 3–80 years in Jönköping, Sweden, in 1973, 1983 and 1993. *Swed Dent J* 1995;19:243–60.
- Thomson WM, Chalmers JM, Spencer AJ, Slade GD. Medication and dry mouth: findings from a cohort study of older people. *J Public Health Dent* 2000;60:12–20.
- Joshi A, Papas AS, Giunta J. Root caries incidence and associated factors in middle-aged and older adults. *Gerodontology* 1993;10:83–9.

29. Steele JG, Sheiham A, Marcenes W, Fay N, Walls AW. Clinical and behavioural risk indicators for root caries in older people. *Gerodontology* 2001;18:95–101.
30. Ravald N. Root surface caries. *Curr Opin Periodontol* 1994;78–86.
31. Salonen L, Allander L, Bratthall D, Hellden L. Mutans streptococci, oral hygiene, and caries in an adult Swedish population. *J Dent Res* 1990;69:1469–75.
32. Axelsson P, Paulander J, Svärdröm G, Tollskog G, Nordensten. Integrated caries prevention: effect of a needs-related preventive program on dental caries in children. County of Värmland, Sweden: results after 12 years. *Caries Res* 1993;27:83–94.
33. Pienihäkkinen K, Jokela J. Clinical outcomes of risk-based caries prevention in preschool-aged children. *Community Dent Oral Epidemiol* 2002;30:143–50.
34. Hausen H, Karkkinen S, Seppä L. Application of the high-risk strategy to control dental caries. *Community Dent Oral Epidemiol* 2000;28:26–34.
35. Health Organization: Oral Health Country/Area Profile Programme. <http://www.whocollab.od.mah.se/index.html>, Oct 2002.

## Appendix

The Cariogram program calculates the caries risk according to a complex formula containing numerous 'if' conditions. Initially, all factors are given a certain weight in accordance with the chosen score. For example, in the basic settings, frequency of food/snack intake has been given a higher weight than diet content. Regarding the bacterial sector, the mutans streptococci have a higher weight than amount of plaque. If two factors in the same group, such as diet content and frequency of intakes, have high scores, an additional weight is given; similarly plaque amount and mutans streptococci. If high scores are obtained in several groups, a further risk weight is added. Heavy weight is given to 'non-use of fluoride'. The program can take the operator's 'clinical judgment' into consideration, but that possibility was not used in this

study. The weights are based on interpretation of data from numerous clinical studies from the literature, where various factors have been compared in respect of incidence of caries. Epidemiological studies have been considered as well as case reports. All papers presented in the special supplement entitled 'Dental Caries: Intervened – Interrupted – Interpreted' (*Eur J Oral Sci Suppl* 1996) have affected the final formula. The program contains about 5 million combinations of factors, and how the outcome in each combination will be can only be seen in the program. The full formula is too extensive to be presented here. It is possible, even likely, that another researcher (than Professor D. Bratthall) would have interpreted the data differently.

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