

# Assessment of Caries Risk in Elderly Patients Using the Cariogram Model

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## ABSTRACT

For several decades, Swedish researchers, clinicians and educators have recognized risk assessment as an important part of routine management of dental caries. Innovative caries risk assessment models, such as the Cariogram software program, have been developed to systematize the evaluation of various risk factors for caries and to develop targeted prevention interventions based on caries risk. The benefits derived from these models in terms of improving the health of high-risk groups such as older adults have not been well studied. The purpose of this article is to demonstrate the application of the Cariogram software in the management of dental care for 3 elderly patients.

**MeSH Key Words:** computer simulation; dental caries/etiology; dental caries/susceptibility; models, biological

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The number and proportion of elderly people in the world continue to grow. Today, approximately 600 million people in the world (corresponding to approximately 9% of the total population) are 60 years of age or older. It is estimated that this number will more than double by 2025, reaching 2 billion by 2050.<sup>1</sup> In response to this changing demographic, the World Health Organization (WHO) recently issued a document entitled *Active Ageing: A Policy Framework*,<sup>2</sup> which outlines essential approaches toward healthy aging. To ensure that people enjoy longevity and sustain health-related quality of life with age, the framework emphasizes the importance of minimizing risk factors that contribute to chronic disease and functional decline and maximizing protective factors against such problems.

Oral health is an identified component of “active aging” and is included in the WHO policy proposals. Fringe factors are associated with enhanced risk for oral disease. Older people today retain more teeth than did earlier generations, often maintaining a so-called “functional dentition,” defined as the presence of at

least 20 natural teeth,<sup>1</sup> many of which may be heavily restored with fillings, crowns and bridges. Elevated incidence and severity of oral disease in the aging population are often attributed to the increased number of teeth and tooth surfaces available where disease processes can occur.<sup>3</sup> In addition, gingival recession and bone loss associated with periodontal changes result in increased exposure of the root surface.<sup>4</sup> High prevalence rates of coronal dental caries and root surface caries are found among old-age populations worldwide,<sup>1</sup> and severe dental caries and periodontal disease represent the major reasons for tooth extractions.

Dental caries, which is known to be linked to social and behavioural factors, is described as a major public health problem among older people.<sup>1</sup> The topics of dental caries profile and prevention have been the subject of much scrutiny, research and development over the past 60 years. However, very little work has been done on the assessment of caries risk among elderly people.

Caries risk assessment is an important part of modern dentistry since caries are endemic

**Table 1** Caries-related factors according to the cariogram

Factor	Information to be collected	Cariogram score
Caries experience	DMFT, DMFS, new caries experience	0: No caries, no fillings 1: Better than normal for the age group 2: Normal for the age group 3: Worse than normal for the age group
Related general diseases	Medical history, medications	0: Healthy 1: Presence of a general disease that can indirectly influence the caries process 2: Continuous medication or bedridden
Diet content	Diet history (or <i>Lactobacillus</i> test): quality of diet	0: Very low fermentable carbohydrate 1: Low fermentable carbohydrate 2: High fermentable carbohydrate 3: Very high fermentable carbohydrate intake
Diet frequency	Questionnaire results: quantity of dietary intake	0: Maximum 3 meals/day 1: Maximum 5 meals/day 2: Maximum 7 meals/day 3: More than 7 meals/day
Amount of plaque	Silness-Löe plaque index <sup>11</sup>	PI 0: <5% plaque adhering surfaces PI 1: 5%–20% plaque adhering surfaces PI 2: 21%–50% plaque adhering surfaces PI 3: >50% plaque adhering surfaces
<i>Streptococcus mutans</i>	Dentocult SM Strip mutans test (or similar test) <sup>a</sup>	0: <i>S. mutans</i> < 104/mL saliva 1: <i>S. mutans</i> < 106/mL saliva 2: <i>S. mutans</i> < 107/mL saliva 3: <i>S. mutans</i> > 107/mL saliva
Fluoride program	Fluoride exposure	0: Maximum fluoride exposure 1: Additional fluoride measures (other than toothpaste), but infrequent application 2: Fluoride toothpaste only 3: Avoidance of fluorides (i.e., no fluoride exposure)
Saliva secretion rate	Secretion rate on stimulated saliva test; the examiner's own clinical and personal score for the individual patient. For scoring 0–3, please read the manual.	0: Normal saliva secretion 1: Low, 0.9–1.1 mL/min 2: Low, 0.5–0.9 mL/min 3: Very low, <0.5 mL/min
Saliva buffering capacity	Dentobuff (or similar) test	0: Adequate, saliva pH > 6.0 1: Reduced, saliva pH 4.5–5.5 2: Low, saliva pH < 4.0
Clinical judgement	Opinion of dental examiner; the examiner's own clinical and personal score for the individual patient. For scoring 0–3, please read the manual.	0: More positive 1: Normal setting 2: Worse 3: Very high caries risk

<sup>a</sup> Dentocult (Orion Diagnostica, Espoo, Finland)

and potentially both preventable and curable. Therefore, early identification of relevant factors affecting older people and that may increase the risk of caries is important. It is well known that dental caries is a multifactorial disease, the extent of which is affected by the patient's general health and diet, by the amount and type of bacteria present in the oral cavity, and by salivary factors and exposure to fluoride. Information on lifestyle, living conditions and general health, along with traditional oral data, are useful for determining the impact of risk factors for dental caries among older people.<sup>5</sup> Higher morbidity associated with chronic disease, the use of medications with xerostomic side effects, frequent carbohydrate intake, and heavy restoration of the dentition are additional risk factors that challenge older people. Moreover, frailty and the physical and mental decline associated with aging have a significant impact on personal oral hygiene practices.<sup>6</sup>

Elderly people and their caregivers should be informed that the need for caries preventive measures increases with age. Because of the heterogeneity of the elderly population and the broad spectrum of factors that affect this chronic disease, those at risk can benefit from individually designed preventive programs. Recent dental research in the area of risk assessment has examined new and advanced methods for the diagnosis and early prediction of caries.<sup>7</sup>

### Caries Risk Assessment — A Swedish Model

Over the past few decades, Swedish researchers have been developing and applying new concepts for caries risk assessment. The pioneering work of Bo Krasse and his team at the Dental School in Göteborg laid the foundation for the development of a comprehensive model of the caries risk profile for use in the management of dental caries.<sup>8</sup> Building on this work, Douglas Bratthall and coworkers at the Dental School in Malmö have attempted to make the practical application of risk assessment more accessible by developing a computer-based caries risk assessment model.<sup>9,10</sup> Relevant information regarding the patient is collected, scored according to a standardized protocol and then entered into a computerized program called Cariogram.<sup>9</sup> The program's algorithm evaluates the data and summarizes the results as a pie chart, which illustrates graphically "the chance to avoid caries in the future" (as a green sector). This way of illustrating the interaction of factors contributing to the development of caries systematizes the clinician's task of evaluating and analyzing the individual components of caries risk. It also serves as a useful pedagogic tool for the clinician when discussing caries risk with patients.

### Estimating Caries Risk

Factors considered in the estimation of the caries risk include both "attack factors" (e.g., dental plaque, presence of specific microorganisms and influences of diet) and "defence factors" (e.g., the salivary protective system and

exposure to fluoride). Past caries experience and related general diseases are also important when assessing risk. Table 1 itemizes the list of caries-related risk factors included in Cariogram. Scores are assigned on the basis of both objective and subjective criteria. A clinical and radiographic examination is performed, and the decayed, missing, filled teeth (DMFT) and plaque index (PI) are determined. The patient is interviewed about general and oral health, medications and dietary habits. Stimulated saliva is measured (mL/min). Salivary pH provides a measure of buffering capacity. The numbers of *Streptococcus mutans* and *Lactobacillus* spp. in saliva are determined with selective agar media available as chairside test kits. The bacterial load is expressed as colony-forming units per millilitre saliva. The "clinical judgement" factor gives the examiner an opportunity to provide evaluative input that may not be captured by indicators in the Cariogram program (e.g., socioeconomic status, cognitive challenges) but that may contribute to increased risk for disease.

In developing the Cariogram program, the impact of various factors on the disease process was determined through review and evaluation of a large number of scientific publications.<sup>10</sup> The data have been synthesized and weighted according to their theoretical impact. The result is a prediction of the future development of disease expressed as the "chance to avoid new cavities in the future."<sup>10</sup> The program generates an individualized "preliminary interpretation and proposed measure," which includes therapeutic strategies for prevention and risk reduction. Using the Cariogram program, the examiner is also able to estimate the impact of changes to various risk factors. For example, the addition of a fluoride program will have a positive impact on the "chance to avoid new cavities in the future." The impact of changes can be demonstrated to the patient by modifying his or her Cariogram profile and generating an updated pie chart. This is one strength of the Cariogram program. Another strength is the ease with which a risk assessment can be repeated. For all high-risk cases, it is important to follow up on actions taken, and it is recommended that the caries risk evaluation be repeated after 6 months.

Although caries risk assessment models have been used in Sweden for some time, their specific benefit for improving the health of high-risk groups such as older adults has not been well studied. Therefore, more research is required to evaluate the program in elderly populations, especially in those over 80 years of age.

The following clinical case provides an example of an older individual with substantial caries risk. Using the Cariogram program, both the assessment and predicted outcomes of targeted prevention interventions are demonstrated. Two more case reports are included at the end of this article on p. 463a.

### Patient 1

A 72-year-old man presents with severe xerostomia (no resting or stimulated saliva) secondary to surgery and radiotherapy for parotid gland malignancy. He takes no medications. He has good oral hygiene, brushing twice a day with fluoride toothpaste. He eats 2 main meals and 3 or 4 snacks a day. He has undergone major restorations in the dentition and has a full maxillary fixed dental bridge and crowns and fillings in the lower arch (Figs. 1a to 1c).

Caries-related factors for this patient are assessed (Table 2), and according to the Cariogram software (Fig. 1d), there is less than a 1% chance to avoid new cavities in the future, an extremely high risk for caries. This

situation is primarily the result of the patient's very low salivary secretion rate. The preliminary interpretation and proposed measures indicate that urgent actions are needed (Box 1). Because of the high caries risk, diet modification and a special fluoride program are recommended. A fluoride program might include daily 5-minute applications of fluoride gel with custom trays or fluoride mouth-rinsing, as well as clinical application of a fluoride varnish. The recommendation for chlorhexidine gel treatment must be carried out with caution because of the potential side effects in patients with severe dry mouth.



Figure 1a: Frontal view.



Figure 1b: Occlusal view of the maxilla.



Figure 1c: Occlusal view of the mandible.

Table 2 Caries-related factors according to the cariogram for patient 1

Factor	Patient data	Score
Caries experience	DMFT: 13 + 13 + 2 = 28 (more than normal)	3
Related general diseases	Xerostomia	2
Diet content (carbohydrates)	<i>Lactobacillus</i> count 10 <sup>5</sup> /mL (high quantity of fermentable carbohydrate)	2
Diet frequency	Maximum 7 times/day (high frequency)	2
Amount of plaque	18%	1
<i>Streptococcus mutans</i>	12 × 10 <sup>6</sup> /mL saliva (high)	3
Fluoride program	Fluoride toothpaste	2
Saliva secretion rate	0.05 mL/min stimulated (very low)	3
Saliva buffering capacity	pH 2.3 (low)	2
Clinical judgement	Normal setting	1

### Concluding Remarks

Because people are living longer and retaining more natural teeth than was the case for previous generations, oral health care providers must remain attentive to caries risk factors and the effective management of caries throughout the lifespan. As demonstrated by the cases presented here, the Cariogram software program highlights both relevant caries-related factors and practical thera-

peutic interventions for selected elderly patients. The Cariogram model has been evaluated in scientific studies of both children and adults, including elderly persons. It is a useful pedagogic tool for dentists, dental hygienists and dental assistants in discussions with patients about their caries risk. Today, the Cariogram program is used in several dental schools in Sweden. Given the oral health challenges facing people who live in institutions, expansion to

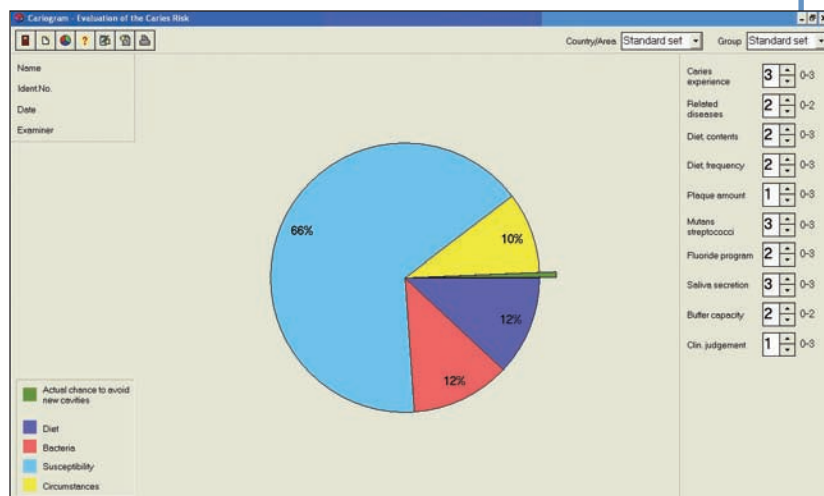


Figure 1d: Cariogram for patient 1.<sup>12</sup>

**Box 1:** Preliminary interpretation and proposed measures for patient 1, according to the Cariogram software

The cariogram indicates a very high risk for caries, and urgent actions are needed. The situation is seriously affected by the fact that there is a very low saliva secretion rate. Consider all parameters where score 2 or 3 have been added in the boxes - which of them can most easily be changed to the better? Examples of actions in this case are:

\* The Diet situation with respect to both content of fermentable carbohydrates and frequency of eating is a clear problem - a much better "dietary discipline" is needed.

\* The Bacterial situation with respect to counts of Mutans streptococci is one of the problems. For an effective reduction of the Mutans streptococci, a Chlorhexidine gel treatment session is recommended.

\* Due to the high caries risk, a reinforced Fluoride program in addition to the fluoride tooth-paste is encouraged.

\* The low saliva secretion rate is a major problem. Try to figure out the reasons behind the reduced rate and investigate if there are possibilities to improve the situation. If use of medicines for general disease is etiological factor, discuss with patient's physician if alternatives are available which do not affect saliva secretion. If saliva secretion cannot be improved, even more intensive efforts for other parameters must be installed.

\* The buffer capacity is reduced. Try to figure out the reasons behind. Buffer capacity is partly related to saliva secretion rate. Consider possibilities to improve the situation. Smoking is one factor negatively affecting buffer capacity.

In deciding which etiological factors to try to reduce, it is important to understand WHY the particular unfavourable factors are present. Such an approach may make it easier to assess if it is possible to improve the factor or not. For this High Risk case, it is important to follow up on actions taken, to make sure they have been effectively installed. It is recommended to repeat the caries risk evaluation after about half a year.

the long-term care setting seems particularly promising. The Cariogram program complements the current trend toward computerized record-keeping and management of clinical data, which is especially helpful in the management of a multifactorial disease such as caries. Future studies examining the application of the Cariogram program to special high-risk groups such as elderly patients is warranted. ✦

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## Patient 2

A 65-year-old woman brushes her teeth twice a day with fluoride toothpaste and has adequate oral hygiene. Her typical dietary intake consists of 2 main meals and 3 snacks daily. She is taking thyroxine. Her salivary *S. mutans* count is high, which may indicate high carbohydrate intake through a “hidden” source, such as throat pastilles, not captured by the dietary history. She has previously undergone dental restoration and has a fixed bridge in the upper jaw (Figs. 2a to 2c).

Caries-related factors for this patient are assessed (Table 3) for input into the Cariogram program, which calculates a 17% chance to avoid new cavities in the

future (Fig. 2d) (i.e., a high risk for caries). The preliminary interpretation and proposed measures generated by the program indicate that numerous urgent actions are needed (Box 2). Specifically, the patient should decrease the content and frequency of fermentable carbohydrate, especially if there is a “hidden” source of carbohydrate intake, such as throat pastilles. To address the high caries risk, the patient should perform daily fluoride rinsing (morning and evening), which is known to have a good preventive effect. Repeated clinical application of chlorhexidine gel treatment in custom trays could be considered to reduce the high counts of *S. mutans*.



Figure 2a: Frontal view.



Figure 2b: Occlusal view of the maxilla.



Figure 2c: Occlusal view of the mandible.

Table 3 Caries-related factors for patient 2

Factor	Patient data	Score
Caries experience	DMFT: 13 + 4 + 8 = 25 (more than normal)	3
Related general diseases	Healthy	0
Diet content (carbohydrates)	<i>Lactobacillus</i> count 10 <sup>5</sup> /mL saliva (high quantity of fermentable carbohydrate)	3
Diet frequency	Unreliable	2
Amount of plaque	15%	1
<i>Streptococcus mutans</i>	1.2 × 10 <sup>6</sup> /mL saliva (high)	3
Fluoride program	Fluoride toothpaste	2
Saliva secretion rate	2.4 mL/min stimulated (normal)	0
Saliva buffer capacity	pH 6.9 (good)	0
Clinical judgment	Normal setting	1

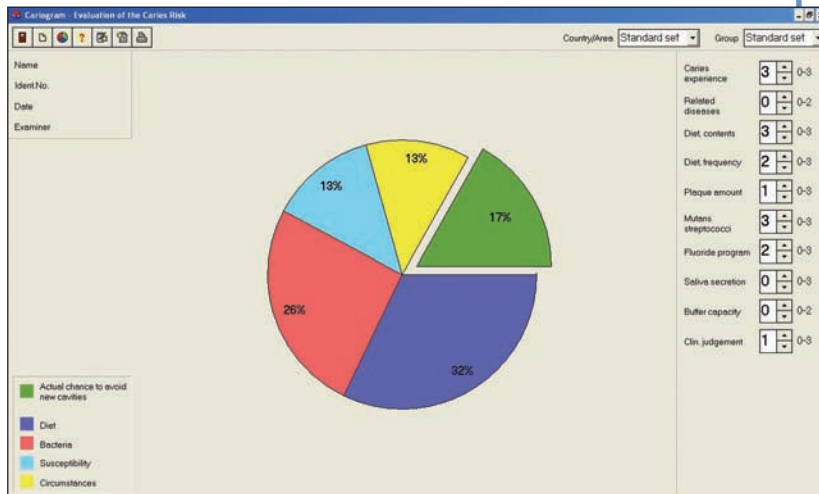


Figure 2d: Cariogram for patient 2.<sup>12</sup>

**Box 2:** Preliminary interpretation and proposed measures for patient 2, according to the Cariogram software

*The Cariogram indicates a very high risk for caries. Urgent actions are needed. Consider all parameters where score 2 or 3 have been added in the boxes – which of them can most easily be changed to the better?*

*Examples of actions in this case are:*

*\* The Diet situation with respect to both content of fermentable carbohydrates and frequency of eating is a clear problem - a much better "dietary discipline" is needed.*

*\* The Bacterial situation with respect to counts of mutans streptococci is one of the problems. For an effective reduction of the mutans streptococci, a chlorhexidine gel treatment session is recommended.*

*\* Due to the high caries risk, a reinforced fluoride program in addition to the fluoride toothpaste is encouraged. In deciding which etiological factors to try to reduce, it is important to understand WHY the particular unfavourable factors are present. Such an approach may make it easier to assess if it is possible to improve the factor or not. For this high risk case, it is important to follow up on actions taken, to make sure they have been effectively installed. It is recommended to repeat the caries risk evaluation after about half a year.*

### Patient 3

An 81-year-old woman who lives in a residence for senior citizens needs a lot of assistance with personal hygiene, including once-daily tooth-brushing. Most of her teeth are restored or decayed (Figs. 3a to 3c). Her diet consists of 5 meals a day in addition to multiple snacks (primarily sweet cookies). She takes several prescription medications, some of which have a known xerostomic effect: bromocriptine for Parkinson's disease, levodopa for urinary incontinence and the anticholinergic agent oxybutynin.

Caries-related factors for this patient are assessed (Table 4), and the Cariogram software estimates (Fig. 3d) a very high risk for caries, with only a 6% chance to avoid

new cavities in the future. The preliminary interpretation and proposed measures (Box 3) recommend reduction of the bacterial load, in terms of both the amount of plaque and the number of *S. mutans*. Frequent professional tooth cleaning, in combination with topical application of chlorhexidine or stannous fluoride gel, is recommended. If the recommended measures do not improve saliva secretion, sugar-free saliva-stimulating lozenges may be helpful for this patient. In deciding which etiological factors to address, it is important to understand why the particular unfavourable factors are present. An intensive fluoride program, similar to that recommended for patient 1, is indicated.



Figure 3a: Frontal view.



Figure 3b: Occlusal view of the maxilla.



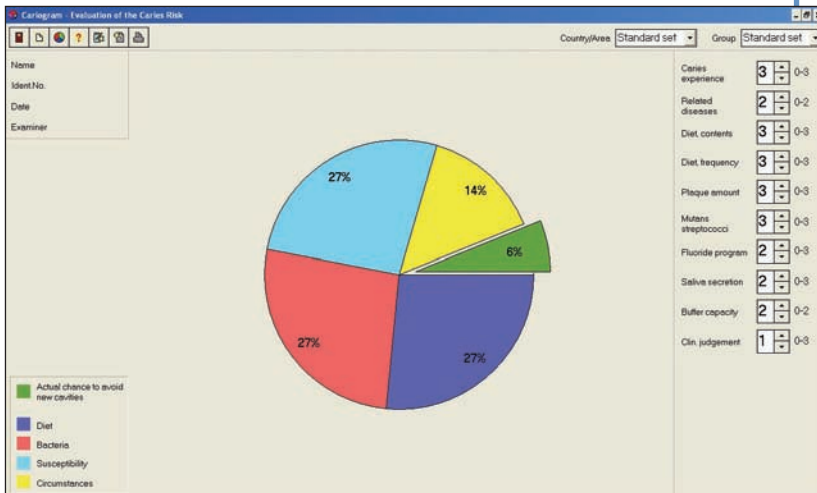
Figure 3c: Occlusal view of the mandible.

Table 4 Caries-related factors for patient 3

Factor	Patient data	Score
Caries experience	DMFT: 18 + 3 + 7 = 28 (more than normal)	3
Related general diseases	Parkinson's disease	2
Diet content (carbohydrates)	<i>Lactobacillus</i> count $2 \times 10^5$ /ml saliva (high quantity of fermentable carbohydrate)	3
Diet frequency	More than 7 times/day (high frequency)	3
Amount of plaque	75% (poor oral hygiene)	3
<i>Streptococcus mutans</i>	$6 \times 10^6$ /mL saliva (high)	3
Fluoride program	Fluoride toothpaste	2
Saliva secretion rate	1.2 mL/min stimulated, 0.05 mL/min resting* (very low)	2
Saliva buffering capacity	pH 3.5 (low)	2
Clinical judgement	Normal setting	1

\* The resting saliva rate is of great importance in elderly patients; this low rate yields a score of 2 for this patient





**Figure 3d:** Cariogram for patient 3.<sup>12</sup>

**Box 3:** Preliminary interpretation and proposed measures for patient 3, according to the Cariogram software

*The Cariogram indicates a very high risk for caries. Urgent actions are needed. Consider all parameters where score 2 or 3 have been added in the boxes - which of them can most easily be changed to the better?*

*Examples of actions in this case are:*

*\* The Diet situation with respect to both content of fermentable carbohydrates and frequency of eating is a clear problem - a much better "dietary discipline" is needed.*

*\* The Bacterial situation with respect to both plaque amount and mutans streptococci level has a heavy impact - both factors should be urgently controlled. Improved oral hygiene and repeated professional tooth cleaning is advised. For an effective reduction of the mutans streptococci, a chlorhexidine gel treatment session is recommended.*

*\* Due to the high caries risk, a reinforced Fluoride program in addition to the fluoride tooth-paste is encouraged.*

*\* The low saliva secretion rate is a major problem. Try to figure out the reasons behind the reduced rate and investigate if there are possibilities to improve the situation. If use of medicines for general disease is an etiological factor, discuss with patient's physician if alternatives are available, which do not affect saliva secretion. If saliva secretion cannot be improved, even more intensive efforts for other parameters must be installed.*

*\* The buffer capacity is reduced. Try to figure out the reasons behind. Buffer capacity is partly related to saliva secretion rate. Consider possibilities to improve the situation. Smoking is one factor negatively affecting buffer capacity. In deciding which etiological factors to try to reduce, it is important to understand WHY the particular unfavourable factors are present. Such an approach may make it easier to assess if it is possible to improve the factor or not. For this High Risk case, it is important to follow up on actions taken, to make sure they have been effectively installed. It is recommended to repeat the caries risk evaluation after about half a year.*