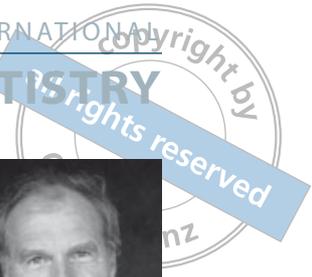


Lutz Laurisch



Strategies for caries risk diagnostics

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Prior to performing preventive measures, a specific caries risk diagnosis is necessary. Individual risk factors and personal habits influence the exposure to caries-producing bacteria and thus affect the caries incidence. The general etiologic parameters and necessary therapeutic foci are weighted differently

depending on the patient's age. This determines the selection of treatment as well as the frequency of the recommended preventive measures. (*Quintessence Int* 2014;45:619–627; doi: 10.3290/j.qi.a31958; Originally published in *Quintessenz* 2008;59(12)1291–1299.)

Key words: individual caries risk, professional care, saliva test, *Streptococcus mutans*, sugar intake

Scientific and pharmacologic innovations today offer a wide spectrum of preventive methods of treatment. Preventive therapy depends heavily on the individual caries risk.^{1,2} Prevention does not treat caries itself, but the risk of developing caries. Because of its multifactorial origin it is clear that comprehensive preventive diagnostics are necessary. Caries risk assessment is based on the following etiologic factors:^{1,3,4}

- Clinical examination: previous caries experience and plaque colonization (morphologic vulnerabilities, hygienic deficiencies)
- Subclinical findings: microbiologic and functional saliva parameters
- Nutrition: frequency of sugar intake per day (nutrition care, cariogenic potential, cariogenic effectiveness)

By analysis of individual caries risk factors, success of preventive measures, and the patient's compliance, the caries risk can be estimated.

The anamnesis chart, published by Laurisch in 1988² and later modified, determines single parameters and allows a comprehensive view of risk factors (Fig 1). These factors were modified in the "cariogram" by Bratthall⁵⁻⁷ by using software-based graphical analysis, which shows the various factors in a pie chart. The following factors are considered (Fig 2):

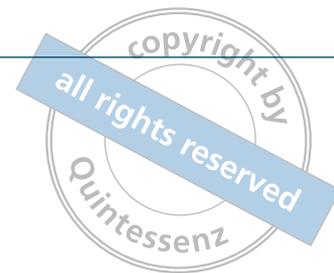
- Diet: the frequency of sugar intake and food consistency (this area is colored dark blue in the cariogram)
- Bacteria: quantity and quality of plaque (amount of *Streptococcus mutans/Lactobacillus* ["Sm/Lb"]) (this area is colored red)
- Susceptibility: resistance of teeth against acids (fluoridation) and saliva quality (secretion rate, buffer capacity, saliva pH value) (this area is colored light blue)
- Circumstances: past caries and general health condition (this area is colored yellow).

Considering all these aspects, the software calculates the likelihood of avoiding new caries lesions in the future (this area is colored green; Fig 2).⁸

This cariogram can be downloaded from the Malmö University website (currently free of charge).⁹

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Assessment form to evaluate individual caries risk

Name: _____ First name: _____ Date of birth _____
 Date of test: _____

Clinical Findings

1. Type of dentition: Primary dentition Mixed dentition Permanent dentition

2. Oral hygiene:
 API.....
 SBI.....
 PBI.....

3. Subsurface lesions:

Clinical caries risk: low medium high

Subclinical Findings

Streptococcus mutans	CRT Class	0	1	2	3
Lactobacilli	CRT Class	0	1	2	3
pH value	< pH 7	≥ pH 7			
Buffer capacity	< 4.5	4.5–5.5	> 5.5		
Salivary flow rate	< 0.7 mL	< 1 mL	≥ 7 mL		

Subclinical caries risk: low medium high

Nutritional analysis

a) An unbalanced diet with preference for sucrose and starch products:
 Yes/No Comments: _____

b) Irregular food intake:
 Yes/No Comments: _____

c) Consumption of sugar-containing products:
 Yes/No Comments: _____

d) Consumption of sugary drinks:
 Yes/No Comments: _____

e) Estimated sugar impulses per day between meals:
 0–2 (low) 3–4 (medium) ≥ 5 (high)

Nutrition conditional caries risk: low medium high

Individual caries risk

Based on the findings

Individual caries risk: low medium high

Fig 1 Assessment form for evaluation of individual caries risk.

In 1990, Axelsson¹⁰ published a list of risk factors that can trigger the diagnoses “no caries risk” or “high caries risk” (Table 1). It can be seen that the evaluation of individual caries risk is possible using only a combination of clinical (plaque, DMFT, initial caries, nutrition)

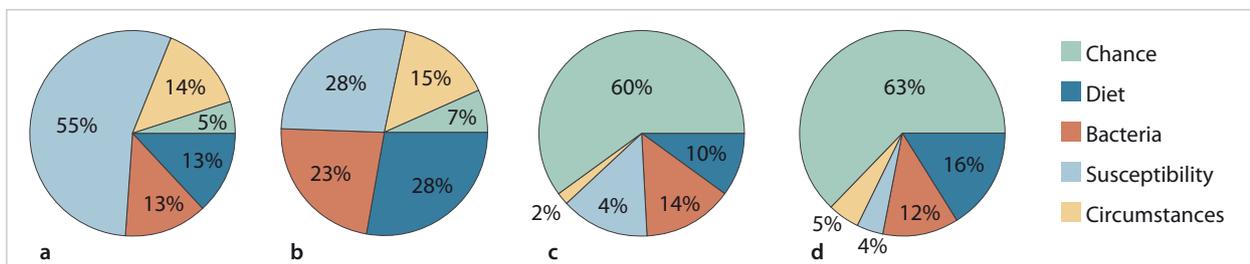
and subclinical (*Sm/Lb* and functional saliva) parameters.

König⁴ illustrates the interrelations by evaluating four risk factors regarding their importance for caries risk and erosion (Fig 3). This diagnosis consists of

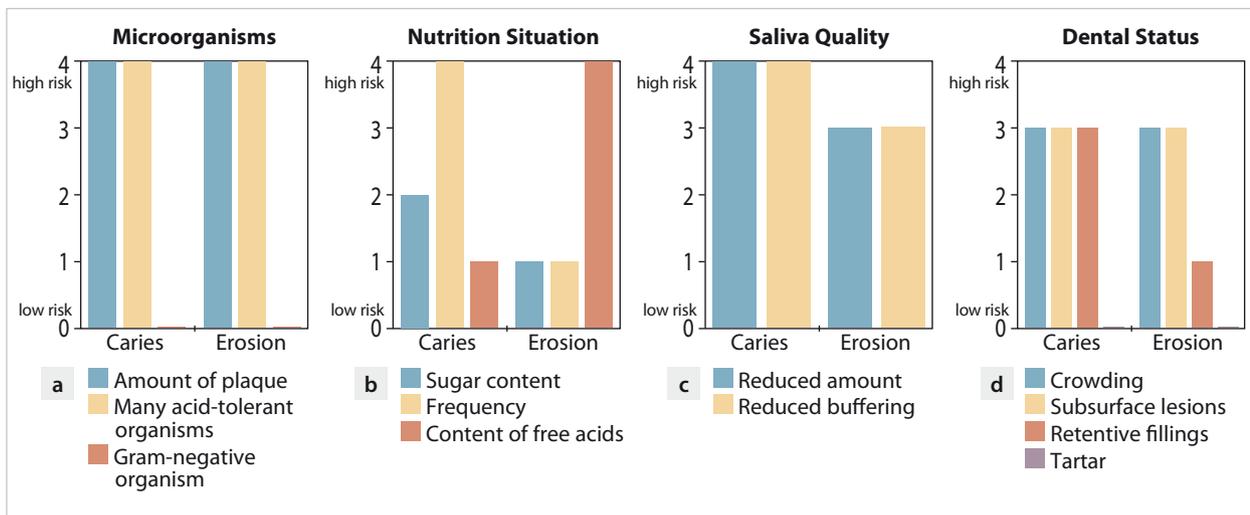


No caries risk	High caries risk
<i>S mutans</i> negative	<i>S mutans</i> values > 500,000 mL/min
Very little plaque	A lot of plaque
Good oral hygiene habits	Poor oral hygiene habits
Low <i>Lactobacillus</i> values	<i>Lactobacillus</i> values > 100,000 mL/min
Very low DMFS/DMFT index	Very high DMFT value (buccal and lingual)
No active initial caries	Large amount of initial caries
Sufficient saliva secretion	Saliva secretion rate < 1 mL/min
Good buffer capacity pH ≥ 5.5	Buffer capacity ≤ pH 4
Low consumption of sticky sugar-containing products	High consumption of sticky sugar-containing products

DMFS, decayed, missing, or filled surfaces; DMFT, decayed, missing, or filled teeth.



Figs 2a to 2d Pie charts displaying factors collected for the cariogram. (a and b) Examples of low caries risk (small green area). The same overall risk can be obtained by different proportions of the individual risk factors. (c and d) There are various possibilities which result in a good chance of conditions remaining healthy.



Figs 3a to 3d Risk determination according to König.⁴The risk is divided from 0 (low risk) to 4 (high risk). Plaque quantity and contained microorganisms are evaluated (*S mutans* and *Lactobacillus*) regarding caries and erosion.

Fig 3a It can be seen that impact of acid creators is high.

Fig 3b The risk classification is dependent of the nutrition situation. The frequency of sugar intake, the content of sugar, as well as the content of free acids is taken into account. It can be seen that the frequency of sugar consumption is a significantly higher risk factor (4) than sugar content (2), whereas the content of free acids is a high risk factor regarding erosion (4).

Fig 3c Saliva quality. Reduced quantity and reduced buffer capacity result in a higher risk factor for caries and erosion.

Fig 3d The correlation between risk and dental findings. Recent white spot lesions as well as retentive fillings and crowding are risk factors for caries.



Fig 4 Caries Risk Test to detect *S mutans* and *Lactobacillus* (Ivoclar Vivadent).

clinical and subclinical parameters. The determination of individual caries risk assumes knowledge of

- clinical parameters
- subclinical parameters
- patient's nutritional situation.

OVERVIEW

Recent evidence allows an even more detailed evaluation. The key to interpreting the collected caries risk data is the patient's age. At the age of 2 to 6 years, the detection of *S mutans* significantly affects the caries incidence rate. During this period, the presence of *S mutans* almost certainly predicts the occurrence of caries in the next 3 years.

Later, sensitivity to the presence of *S mutans* decreases, and additional subclinical parameters take effect. The absence of *S mutans* enables prediction of the absence of caries.

Although there are many bacteria harbored in the mouth and in the plaque that are able to produce acid, *S mutans* is still the main pathogenic organism, and plays a significant role in the prediction of health or disease of teeth.

As also outlined by Bratthall⁵⁻⁷ and König,⁴ the subclinical parameters converge into an overall risk assessment. Based on the fact that caries is unlikely when both *S mutans* and *Lactobacillus* are absent, the sub-

clinical bacteria parameters are relevant for older patients in terms of health forecast. For elderly patients, medication and general condition influence salivary secretion rate (normally 1 mL/min). This reduction corresponds to decreased buffer capacity, loss of antibacterial saliva parameters, and a decreased clearance rate. This results in increased growth of acid-producing bacteria.

Comprehensive diagnostics of subclinical parameters is a precondition for the choice of preventive treatment measures.^{3,11,12}

A comprehensive preventive treatment concept which is orientated on individual etiologic parameters alters the balance between pathologic and protective factors, which results in risk minimization and reduced substrate for cariogenic bacteria.¹³

Subclinically, this is reflected in a reduction in cariogenic bacteria, providing an identifiable parameter. In this way the success of the performed preventive treatments as well as the compliance of the patient can be verified.

Therefore, understanding of the subclinical parameters is important for the evaluation of the oral health condition or diseases of the patient. For determination of the number of caries-relevant *S mutans* and *Lactobacilli*, the Caries Risk Test (CRT; Ivoclar Vivadent) can be used. This test has a high sensitivity and specificity in providing evidence of these bacteria (Fig 4).^{14,15}

If the necks of the teeth are exposed due to the age of the patient or periodontal disease, the subclinical functional saliva parameters gain a higher weight: exposed tooth root cement demineralizes not at a pH value of 5.5 as for tooth enamel, but at a pH value of 6.7,¹⁶ which is very close to the normal pH value of 7.0. With insufficient secretion rate or salivary buffer capacity, each intake of sour food will inevitably lead to a demineralization of root surface – bacterial activity is not even necessary.

Caries risk determination and preventive therapy for 0–4-year-old children

Healthy teeth at the age of 2 years gives no indication of caries risk. Surveys by Tenovuo et al,¹⁷ Kristofferson



Figs 5a and 5b Testing can be performed (a) with a plaque smear test, or (b) by taking saliva with a wooden stick.



Fig 5c Evidence of *S mutans* in the saliva by use of CRT (Caries Risk Test; Ivoclar Vivadent).



Fig 5d Chlorhexidine-containing gel and chlorhexidine/thymol-containing varnish (Ivoclar Vivadent).

et al,¹⁸ Köhler et al,³ and later the results of Thenisch et al¹⁹ show that only the number of *S mutans* bacteria gives a reliable indication of future caries development. The verification of *S mutans* in saliva doubles the caries risk. The verification of *S mutans* in the plaque means an increase by a factor of four. If the child also has high sugar consumption, this means an appropriate increase in caries risk with an increase in sensitivity.²⁰

Tenovuo et al^{17,21} reported that having *S mutans* at the age of 2 means a positive forecast value of 92% of getting caries in the following 2 to 4 years. Obtaining *S mutans* later on (age 3 or 4 years) means a decrease of caries prevalence and a loss of forecast accuracy. Powell,²² in a review of the literature, reported that the amount of *S mutans* in saliva is the best predictor of caries risk for milk teeth. These facts lead to the conclusion that currently caries-free teeth of 2-year-old children need extra attention if *S mutans* is present. Testing can be either with a plaque smear test or by direct contact test using a wooden scoop to gently collect the

patient's saliva (Figs 5a and 5b). Plaque or saliva is put onto the agars, which are incubated for 2 days. Figure 5c shows the CRT after 2 days of incubation: colonies of *S mutans* in high numbers are clearly visible.

If a premature colonization of the child's oral cavity with *S mutans* is confirmed, the following preventive measures are indicated:

- professional cleaning of occlusal surface and interproximal space (if possible)
- application of chlorhexidine/thymol-containing varnish onto the occlusal surface (eg, Cervitec, Ivoclar Vivadent; the Cervitec varnish should be spread on three times within 2 weeks) (Fig 5d)
- nutrition care (avoidance of sugar-containing food and beverages), substitution of sugary snacks with sugar-free sweets (eg, xylitol- or sorbitol-containing snacks)
- consider topical fluoride application
- controlled prophylaxis sessions within the next 6 to 8 weeks, at intervals of 14 days.



Fig 6a Protection of the occlusal surface with glass-ionomer cement (taken in 2000). This is distributed onto the dried occlusal surface with a small pellet and covered with Vaseline (or cocoa butter) thereafter. It is indicated in cases where composite sealing is not yet possible.



Fig 6b Replacement of glass-ionomer cement with composite sealer in the year 2003. The existing glass-ionomer cement will be removed with ultrasonic scalers. Thereafter, the primary teeth will be sealed. Note that the primary tooth enamel has no enamel prism, therefore a longer etch is necessary.

Table 2 Examples of harmful and protective etiologic factors	
Harmful factors	Protective factors
High sugar consumption	Low sugar consumption
High microbial colonization	Low microbial colonization
Poor oral hygiene	Good oral hygiene
Low fluoride supply	Sufficient fluoride supply
Less chewing-intensive nutrition	Chewing-intensive nutrition
Low saliva (< 1 mL/min)	Lots of saliva (> 1 mL/min)
Low buffer capacity (< pH 5)	Good buffer capacity (> pH 5)
Inadequate restorations	Adequate restorations
Lots of retention niches (tooth position)	Few retention niches (tooth position)
Unfavorable occlusal surface	Favorable occlusal surface

The following domestic measures are necessary:

- brushing teeth for 12 weeks once a week with 0.2% chlorhexidine (age group from 10 months)²³
- cleaning of occlusal surfaces of primary molars with chlorhexidine in order to minimize the colonization risk of the child’s oral cavity because occlusal surfaces are niches for *S mutans*²⁴
- interproximal cleaning with floss²⁵

On completion of this therapy, after 4 to 6 weeks another occlusal surface smear test should be performed to verify the success of the preventive measures. Finally, it is recommended to seal the occlusal surface with flowable glass ionomer cement (Fig 6).²⁶

Caries risk determination and preventive therapy for adults

Axelsson¹⁰ defined the parameters of high caries risk. However, it should be noted that his description of caries risk is not valid for all areas of the mouth and should be considered an overview. Microbiotopes can occur, for example in occlusal surfaces that are food and plaque retentive, or in the case of morphologic discrepancies or teeth malposition, especially in the posterior regions. The increase in such microbiotopes is supported by decreased oral hygiene. Even if a general caries risk does not exist, it can arise according to the alteration of these various parameters. Oral microbiotopes typically occur at retentive areas such as inadequate tooth fillings or

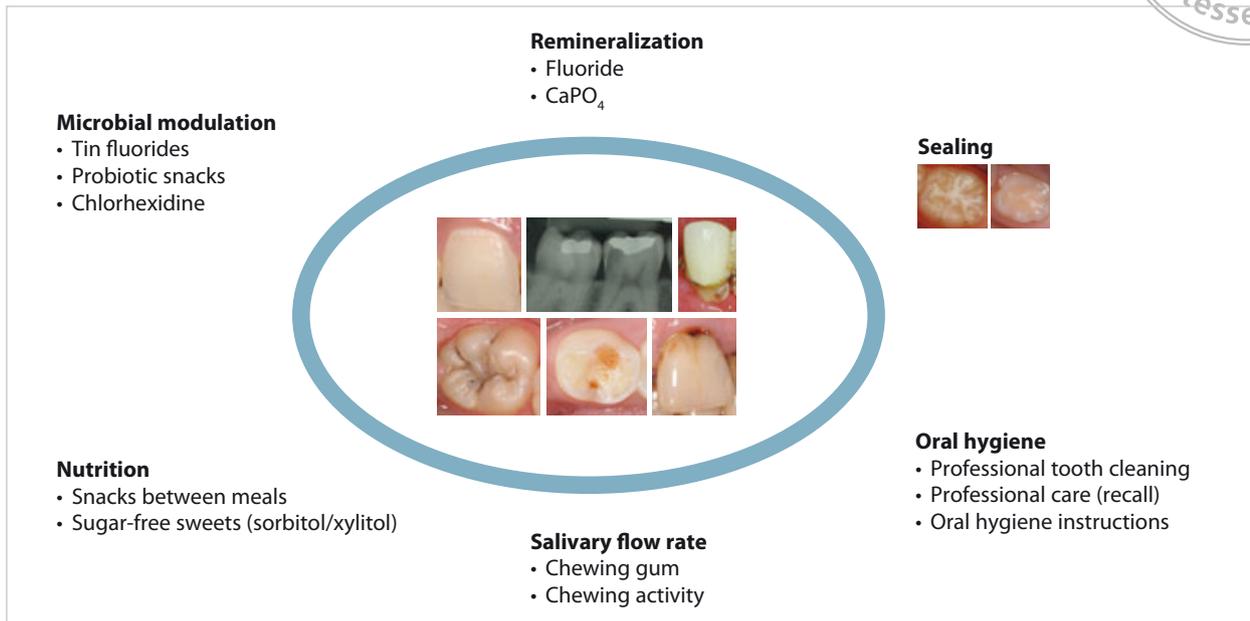


Fig 7 Elements of caries prevention.



Fig 8 (left) Plaque colonization of prosthesis at a fixing element.

Fig 9 (right) Application of chlorhexidine-containing varnish into the outer part of a telescopic crown in order to reduce microbial colonization at the crown margin.

dental crowns, interproximal areas, crowded regions, or morphologically deeply rutted teeth. This means that besides the determination of the general caries risk, the control and elimination of microbiotopes is a major task of our preventive efforts. The general therapeutic approach is to identify factors that damage the teeth. The therapy then is to eliminate harmful parameters and strengthen protective ones (Table 2). This delivers optimal therapeutic possibilities:²⁶

- Fluoride: amine fluoride, tin fluorides, CaPO₄, high-dose fluoride preparations such as Elmex Gelée (Gaba) and Duraphat toothpaste or varnish (Colgate-Palmolive), fluoride-containing mouth rinses.
- Sealing of ecological niches for cariogenic bacteria: flowable composites or sealing materials (fissures, marginal gaps). Fissure sealing can also be indicated for elderly patients.

- Oral hygiene: special tooth care products, floss, sonic toothbrushes, professional tooth cleaning in the dental practice.
- Inducing salivary secretion: chewing gum, food that encourages chewing.
- Supporting buffer capacity: sodium bicarbonate-containing preparations.
- Nutrition: sugar substitution with sugar-free preparations, especially xylitol products, and sugar-free products and snacks.
- Microbial modulation: chlorhexidine products, tin fluorides, probiotic bacteria.

Figure 7 shows the currently available elements of caries prophylaxis.



Caries risk determination and preventive therapy for elderly patients

Often caries risk is evident if root caries is found. Somatic diseases occur with increasing general medication. As a side-effect many of these medicaments reduce salivary secretion (normal 1 mL/min), which often results in a decrease of sodium bicarbonate concentration. This causes a reduced buffer capacity (< pH 5). Acidic foods or beverages then more easily cause demineralization of the root area.²⁷

Of the huge number of risk factors, the following are the most important and easiest to determine:²⁸⁻³⁰

- high sugar consumption
- poor oral hygiene
- periodontal disease
- gingival recession.

Indicative values for risk factors are:

- age = 65 years
- Plaque Index > 50%
- decayed and filled surfaces (DFS) = 5 (root surfaces)
- *Lactobacilli* value: $\geq 100,000$ CFU/mL
- *S mutans* value: $\geq 500,000$ CFU/mL
- secretion rate ≤ 0.7 mL/min
- buffer capacity \leq pH 4.5
- nutrition ≥ 5 sugar impulses/day.

From the threshold values of the risk factors it can be seen that simple measurement of subclinical parameters (secretion rate, pH value, buffer capacity) can give an indication of the threat to root surfaces. Consecutive monitoring of these subclinical parameters allows timely detection of any change to the risk level.^{31,32} The general somatic health condition of the elderly is an important issue in professional preventive medical care.

In case of reduced saliva secretion the following factors are important: stimulation of salivary glands by consuming chewing-intensive food and sugar-free chewing gum. The most important elements of caries prevention are microorganism modulation (chlorhexidine/varnish) and high-dose fluoridation (eg, Duraphat tooth cream). The use of application foils strengthens the preventive effect by minimizing the salivary dilution.

Receiving dental prostheses always increases the amount of caries-relevant microorganisms (Fig 8). Professional application of antibacterial varnish (eg, Cervitec) helps to avoid secondary caries by reducing bacterial colonization of the crown margin. If telescopic crowns exist, antibacterial gel (eg, Cervitec Gel, Ivoclar Vivadent) can be placed directly in the outer telescopic part. This should be done before bedtime every 3 months for 1 week (Fig 9).¹¹

CONCLUSIONS

Depending on the patient's age, etiologic factors have a different weight when determining the individual caries risk. Caries risk determination always requires a comprehensive survey of all clinical and subclinical parameters that may cause caries, except for children under 4 years.

After performing preventive measures, the repetitive analysis of clinical and subclinical parameters allows objective control of the treatment results as well as evaluation of patient compliance. Subclinical parameters provide significant detailed information for the clinical evaluation of the patient's health condition.

The required tools for diagnostics are known and their availability is ubiquitous. Due to scientific developments in recent decades, highly efficient therapeutic measures can be used in caries prophylaxis.³³

As well as treatments for mineralization (fluorides) there are improved means for oral hygiene (sonic toothbrushes, interproximal brushes), sealing materials, sugar substitutes with inhibitory effects on bacterial metabolism (eg, xylitol), measures to increase the quantity and quality of saliva, means for microbial modulation (chlorhexidine, tin fluorides, probiotics) and, most importantly, subsequent preventive care in the dental practice. On the basis of determination of individual caries risk, comprehensive preventive care is achievable.

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