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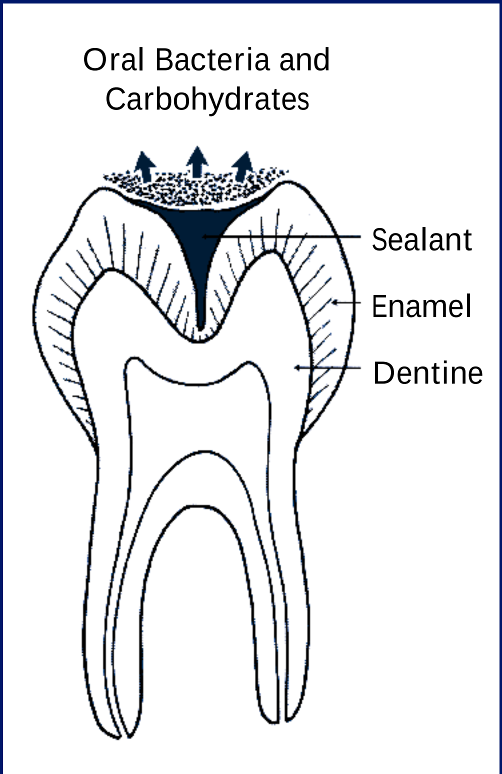

CARIES PREVENTIVE STRATEGIES

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CARIES PREVENTIVE STRATEGIES

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FOREWORD

Most dental practitioners recognise the need for strategies to help their patients prevent dental caries (tooth decay), and there are a number of options available. However, there has been much debate about which of these provide the best benefit and which are most applicable in practice to the care of individual children and adults.

To address these questions, the European Academy of Paediatric Dentistry held a scientific conference in March 1992 entitled “Efficacy of Caries Preventive Strategies”. Experts in the science of dental caries (cariology), many of them paediatric dentists, were invited to consider which strategies are the most effective in preventing caries.

They looked at the impact of fluoride, which has for a long time been recognised as an effective weapon against decay; the role of diet; how bacteria in the mouth behave as part of the decay process; and how sealants covering certain tooth surfaces can be used to protect the teeth.

This concise monograph summarises the findings of the conference of the European Academy of Paediatric Dentistry. The full report of the conference was published in Caries Research, Volume 27, supplement 1 (1993), which is the journal of the European Organisation for Caries Research (ORCA). Caries preventive strategies based on the the syposium are being implemented in dental health programmes and have proven to be effective.

Recent publications and symposia on nutrition and dental caries (see further reading section) are in line with the findings of this scientific conference on the effectiveness of caries preventive strategies.

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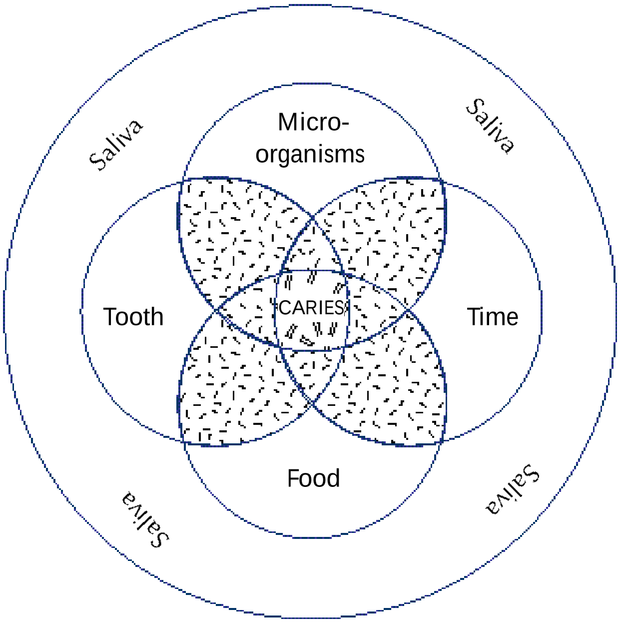
INTRODUCTION

Dental caries (decay) is caused by the dissolution (demineralisation) of tooth enamel by acid in the mouth (see Figure 1). The acid is produced by the fermentation of carbohydrate foods (fermentable carbohydrates) by bacteria in the mouth. For caries to result, these acid attacks must be repeated over time.

Even so, decay is not an inevitable consequence. After an acid challenge, saliva gradually neutralises the acid and returns calcium and phosphate back to the tooth enamel to start the repair process (remineralisation).

FIGURE 1.
Factors involved in the caries process



Furthermore, some teeth are more susceptible to decay than others; they differ within the same mouth and from person to person.

Decay therefore occurs only when demineralisation, over a period of time, exceeds remineralisation (see The caries process box).

Because of the complexity of the caries process there are a number of different approaches to preventing caries. Broadly, these are aimed at maximising the protective factors and remineralisation while minimising the factors which lead to demineralisation.

One of the most widely known methods of protecting against decay employs fluoride. Fluoride helps control decay by enhancing remineralisation and altering the structure of the tooth so that the surface is less soluble. It also reduces bacterial metabolism, especially glycolysis, thus reducing acid production and hence demineralisation.

Fluoride can be supplied to the tooth in two ways. When fluoride is ingested, for example, with drinking water, it enters our bodies; this is described as a systemic application of fluoride. When fluoride is applied directly to the tooth surface, for example, in toothpaste, this is described as a topical application. Both systemic and topical applications of fluoride need to be considered as ways of preventing caries.

As carbohydrate is required for an acid attack, diet is another aspect of the caries process which needs to be addressed when considering approaches to prevention.

A number of different methods have been used to assess the potential of individual foods to promote dental caries. These include measuring cariogenicity in animals, that is, the amount of caries produced by a food. Less directly, the acidogenicity can be measured to gauge the capacity of a food to produce acid in the plaque. Neither method can be relied on to predict conclusively the extent to which a food can contribute to caries in humans, but extensive studies using both methods are accepted as providing a good indication of the potential cariogenicity of various foods.

Without bacteria there would be no decay. Other strategies for caries prevention therefore look at ways in which the bacteria most closely implicated in the caries process can be reduced. Fluoride is especially effective in preventing caries on the smooth tooth surfaces (front, back and sides) but has less effect on the biting surfaces of back teeth. Using sealants to stop bacteria and food from getting to these vulnerable tooth surfaces is another proven caries preventive approach.

After the strengths and weaknesses of these different approaches are considered individually in this booklet, the effectiveness of combining them in caries prevention programmes is discussed.

The caries process

Dental caries is one of the most prevalent diseases in the Western world. It is not life-threatening but nevertheless has considerable economic significance. It is a disease which usually begins in childhood and, once established, causes irreversible damage to teeth, with resultant pain and discomfort. If caries is not arrested, the tooth will eventually be destroyed. Many factors are involved.

- Dental caries is a pathological process which results from localised destruction of the tooth structure. The initial phase involves demineralisation of the tooth enamel by organic acids. This results in the release of enamel ions such as calcium, phosphate, carbonate, magnesium, hydroxyl, fluoride, sodium and some other microelements.
- Acid-producing bacteria are essential to the process. Germ-free rats do not develop caries, even when fed a cariogenic diet. In principle, all bacteria able to turn sugars into acids are cariogenic, but a group of related bacteria called mutans streptococci, which are very strong acid producers, increase the caries risk considerably.
- The demineralising acids result from the fermentation of common dietary carbohydrates by bacteria that accumulate in dental plaque on the teeth and in fissures.
- The following food and drink characteristics contribute to the cariogenic process: the frequency of intake of sucrose and/or other fermentable carbohydrates, the quantity of acid that can be produced from a food/drink at the tooth surface, the amount of time that a food/drink is retained on the tooth surface, and the capacity to induce the formation of dental plaque.
- Saliva has several protective functions, the most important one being to resist changes in acidity at the tooth surface. A number of salivary components help protect against oral microbiological activity, and calcium, phosphorus and other components help remineralise the dental tissue.
- Caries will occur only when these three factors are all present: a susceptible tooth, bacteria and fermentable carbohydrate. Furthermore, there must be sufficient time for demineralisation to occur, and the time or the potential for remineralisation must likewise be insufficient.

METHODS OF PREVENTING DECAY

Systemic administration of fluoride in water

More than 100 studies have been carried out worldwide to find out the effect of fluoride in water on rates of tooth decay. They have shown that water fluoridation at the optimal level of 1 part per million (1 ppm) has led to a significant reduction in caries. For example, in 86 studies of permanent teeth, 65 studies showed a caries reduction of 50% or more.

Some studies in which caries levels were measured in the same community before and after the water supply was artificially fluoridated show slightly higher than average rates of reduction. One explanation for this finding is that the underlying caries rate was in decline over the period of the study.

This variable can be overcome by carrying out simultaneous studies in different communities, one with and the other without fluoridated water. Sixty-five studies of this type have been carried out, and Figure 2 illustrates the percentage caries reduction observed in the studies in both primary and permanent teeth.

FIGURE 2.

The effectiveness of artificial water fluoridation on caries reduction in 32 studies of primary teeth and 33 studies of permanent teeth

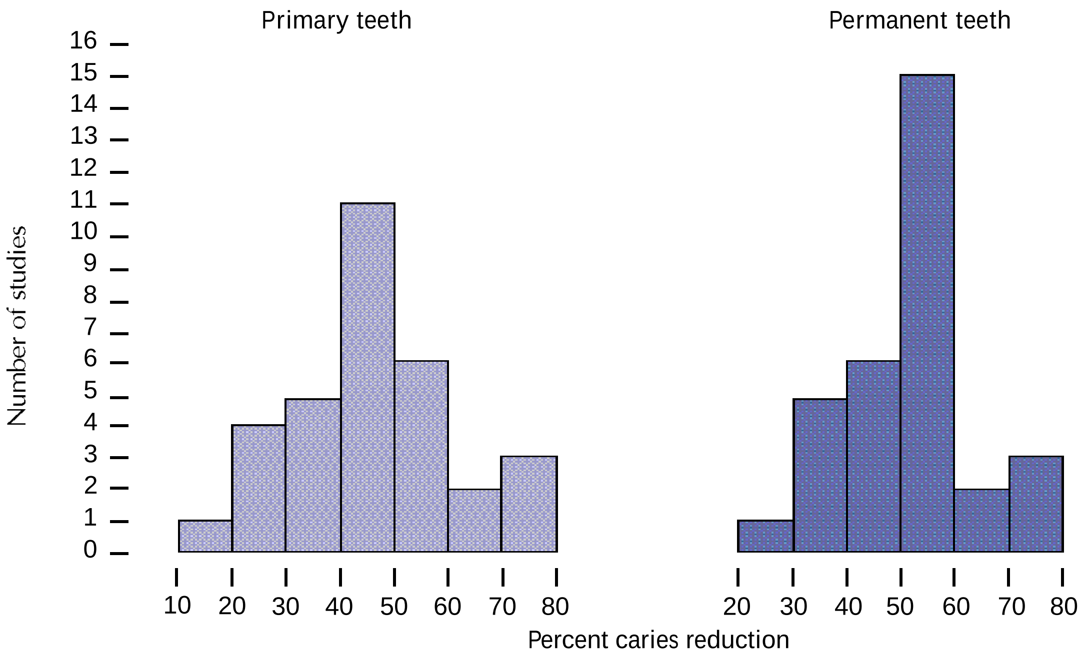
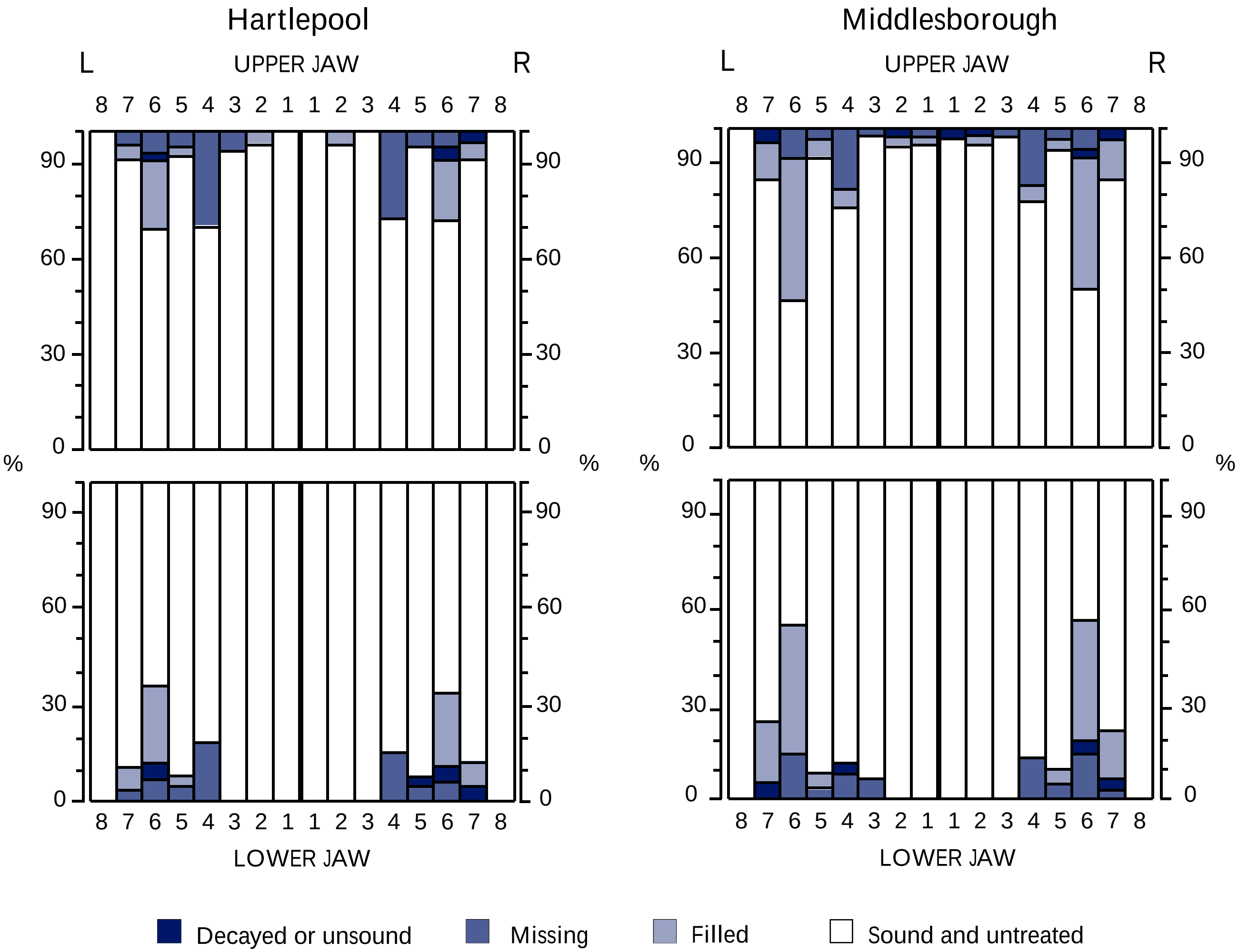


FIGURE 3.

The percentage of decayed, missing and filled teeth in 15- to 16-year-old children in Hartlepool (natural fluoride content in water of 1.0–1.3 ppm) and Middlesborough (0.2 ppm fluoride in water). The information is given for each tooth position in the mouth. The teeth are numbered from 1 to 8, starting from the centre of the mouth.



Source: Murray JJ, Efficacy of Preventive Agents for Dental Caries, Caries Research 1993;27(Suppl.1); 2-8 © Karger.

Studies carried out in the North of England compared the amount of decay with varying concentrations of fluoride in the water in different areas. The results clearly show that residents in the area with the highest concentration of fluoride in the water had less decay than those in the areas with less fluoride in the water (Figure 3). These studies also show that those who are continuously resident in a high-fluoride area benefit more than do those whose residence is interrupted. Not surprisingly, when water fluoridation ceases, an increase in caries levels results. A return to prefluoridation levels of caries occurs within 5 years.

Fluoridation of salt, milk and beverages

Other ways of providing systemic fluoride are in salt, milk and other drinks.

Studies in several countries have shown caries reductions of up to 50% with salt fluoridation. It has been repeatedly shown that salt fluoridation can be just as effective as water fluoridation.

Milk has also been considered as a way of delivering fluoride. The fairly small scale studies carried out so far suggest that daily consumption of fluoridated milk from birth might be as effective as water fluoridation. However, there may be some practical problems involved, and a clear picture will not emerge until the large-scale studies, which are currently underway, have been completed.

Fluoride in tea can help reduce caries, too. One study has shown that as the number of cups of tea drunk per day goes up, the amount of decay falls proportionally. Fluoride in carbonated drinks and orange juice can minimise the effects of the acid attack caused by those drinks, and fluoridated mineral water can also have a protective effect. This is more likely to help at the individual rather than the community level.

Fluoride drops and tablets

Fluoride drops and tablets are another way of preventing caries. They not only can help protect the primary and permanent teeth of children and adolescents, but also can provide protection for adults with root caries (caused when gums recede with age, enabling caries to develop at the exposed root of the tooth). Although fluoride is ingested from supplements, the effect is mainly at the tooth surface; that is, it is topical rather than systemic.

Studies using fluoride supplements yield extremely varied results, probably because of the practical difficulties of getting children, via their parents or teachers, to take regular doses. In some cases, using drops or tablets has reduced caries by as much as 80%, in others by as little as 20%. Prenatal fluoride supplementation has not shown any significant benefit.

Developing teeth of young children, exposed to high levels of fluoride, can become mottled, a condition known as fluorosis. These levels of fluoride intake are nevertheless well below those which might pose a toxic hazard. Fluorosis is commonly seen where high levels of fluoride are naturally present in drinking water.

To avoid possible fluorosis, the level of fluoride in drinking water should be taken into account when establishing whether to recommend fluoride drops or tablets. Supplements (0.5 mg fluoride per day) should be prescribed only from the age of 3 years.

When fluoride tablets are used, they should be allowed to dissolve slowly in the mouth and be moved about inside the mouth to spread the fluoride around for maximum benefit. The effects also last longer when supplements are taken at bedtime. Saliva flow decreases during sleep, which slows down the rate at which the fluoride will be washed away, thus maximising the topical effect.

The general conclusion is that although supplements can be beneficial at the individual level, for community-based programmes they are likely to be less effective than water- or salt-based sources.

Topical applications of fluoride

Toothpaste

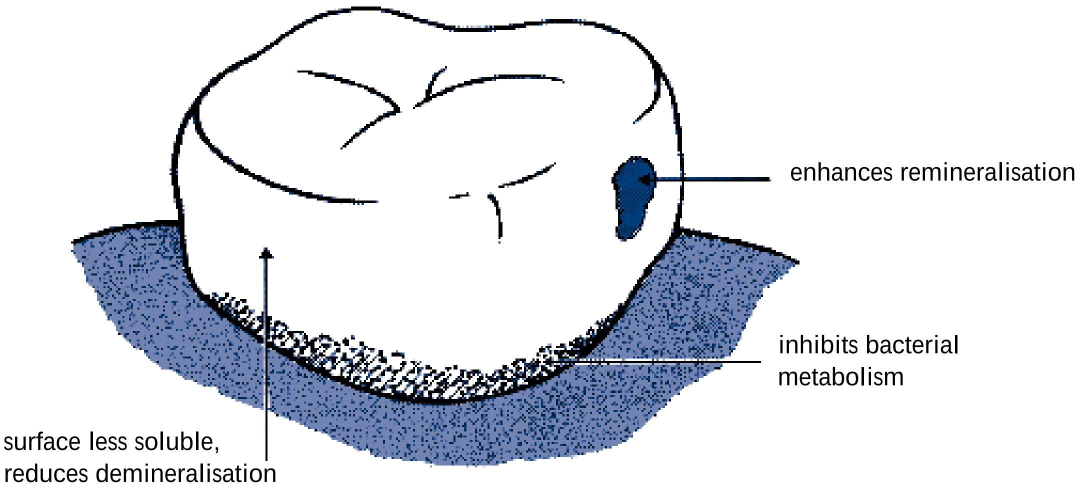
Water fluoridation and fluoride supplements have been shown to reduce caries (see Figure 4). However, a significant decline in caries has also been seen in developed countries where these preventive methods are not in use or are inadequately applied, even where sugar consumption has remained high. In this circumstance, it is widely accepted that the reason for the decline in caries is the use of fluoridated toothpaste.

Oral hygiene on its own is not a very effective preventive measure. In Japan, where oral hygiene is promoted extensively in schools but fluoride is not widely used, no substantial caries reduction has resulted, likely owing to the absence of fluoride.

Oral hygiene is becoming more and more socially desirable, and as a result, sales of toothbrushes and toothpaste are increasing. Fluoridated toothpastes are considered to be one of the most important and effective routes to caries prevention. The removal of bacteria by brushing also reduces the risk of periodontal disease, an advantage that other fluoride applications do not have.

There is now evidence that very young children swallow a sizable portion of the toothpaste used. Hence children under the age of 6 years should be supervised when brushing their teeth with a fluoride toothpaste. Only a pea-sized amount (5 mm) should be used.

FIGURE 4.
The effects of fluoride on the tooth



Fluoride gels

Fluoride gels, which have replaced an older method of "paint-on" fluoride solutions, are mostly used in dental practices, but can be self-administered. Studies show that gels professionally applied twice a year can reduce caries by around 25%. People with severe caries need gel applications four times a year.

Again, to prevent overuse of fluoride, gels are not recommended in those areas where water is already fluoridated except in those patients at moderate or high risk of developing caries. Dentists, hygienists and auxiliaries need to be made aware of the hazards of ingesting the gels, with special care taken for patients under 6 years old. Table 1 summarises the recommended frequency of gel applications according to the level of caries and water fluoridation status.

To limit the risks of ingestion, self-applied gels have a lower fluoride concentration than professionally applied gels. Nevertheless, they are not used extensively, probably because other applications are easier and cheaper. Their main use is for two high-risk groups: those undergoing orthodontic treatment and those suffering reduced salivary flow as a result of radiation therapy to the head and neck.

Fluoride mouthrinses

Fluoride mouthrinses can reduce caries by 20–50%. Studies have shown that the combined use of fluoride toothpaste and mouthrinses has a greater effect than either agent used alone.

School-based programmes are found predominantly in Scandinavia and North America: between 3 and 12 million children in the United States regularly participate in such programmes, as do 90% of children aged 6–12 in Sweden, 40% in Finland and 20% in Iceland. Despite its effectiveness, the cost-benefit ratio of using mouthrinses in school programmes has been questioned except in areas with moderate or high caries levels. Mouthrinsing is not recommended for preschool children because of the risk of swallowing the entire rinse.

TABLE 1

Recommended application frequency to age 16 for professionally applied topical fluoride gels

Water fluoride status	Caries status		
	Caries free	Active	Rampant
Deficient	Twice a year	Twice a year	Four times a year
Optimal	0	Twice a year	Four times a year

Fluoride varnishes

Varnishes are usually applied with small brushes or syringes; the process is easy and takes about 5 minutes. Varnishes are usually applied twice a year, or four times a year for those at very high risk of caries. They are widely accepted in Europe and their use is increasing elsewhere. However, they are not approved for use in the United States.

Varnishes give high caries reductions ranging from 50% to 70%, and even higher on certain tooth surfaces. Varnishes are safe, despite their high fluoride concentrations, and although the relative cost is high when the varnish is applied by the dentist, the cost decreases when the application is by a dental auxiliary.

Slow-release fluoride

The objective of slow-release systems is to release a constant supply of fluoride from a device placed in the mouth over a period of at least 1 year. The latest evidence suggests that frequent applications of fluoride at fairly low concentrations are effective even for those with high caries. Trials in the United Kingdom and the United States suggest that these devices could be very useful, especially for caries-prone groups, low-socio-economic groups, ethnic minorities and handicapped individuals.

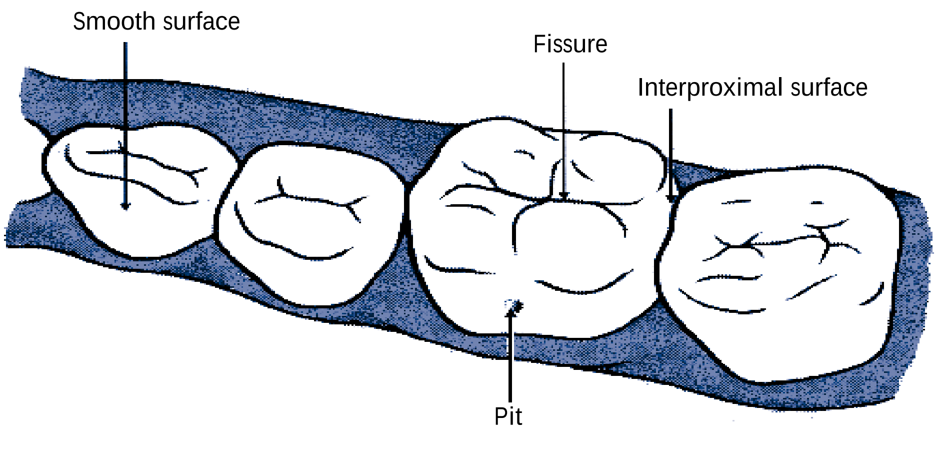
Diet

Sucrose

It is well known that oral bacteria can metabolise sucrose and other sugars, resulting in acid production at the tooth surface, which may lead to caries (see Figure 5). Research shows that refined starches also have cariogenic potential, although sucrose appears to play the dominant role.

In Britain, sucrose still accounts for 83% of sugars consumption, giving a higher per capita consumption of sucrose than in the United States (although the consumption of all sugars is higher in the United States). Elsewhere in Europe sucrose remains the predominant sugar in the diet. In the United States, however, high-fructose corn syrup has replaced sucrose in many processed foods and soft drinks. In consequence, sucrose intake in the United States has dropped and now

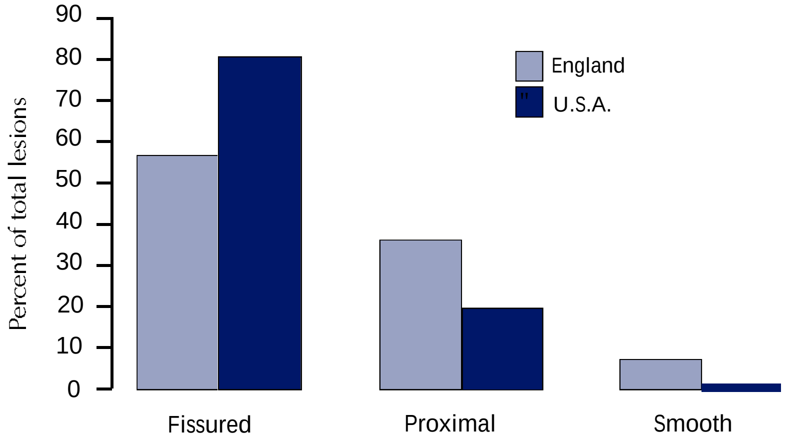
FIGURE 5.
Nomenclature of different tooth surfaces



How the decline in caries has affected different tooth surfaces

In addition to the overall decline in caries, another trend has been the way in which caries affects different tooth surfaces. Where a typical Western diet is eaten, pit and fissure lesions constitute the majority of lesions in children while smooth surface caries has declined. Figure 6 shows the distribution of caries increments by fissured, proximal, and smooth surfaces for children in diet studies in Newcastle, England, and Michigan, United States.

FIGURE 6.



accounts for 47% of total sugars consumption, even though the overall intake of all sugars during the period 1961–1988 remained fairly stable.

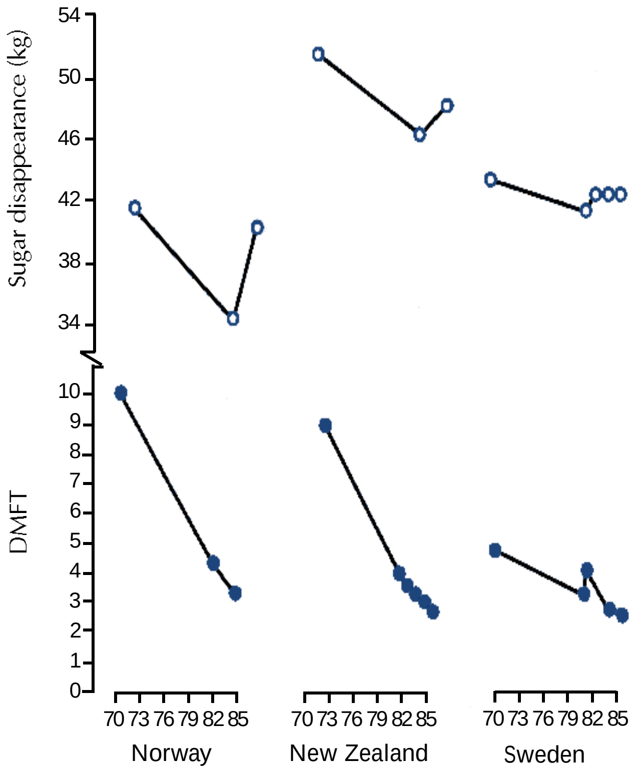
Data from two recent surveys suggest that British children experience more caries on the proximal and smooth surfaces and fewer on the fissure surfaces than children in the United States. This difference in the sites affected by caries might be explained by the higher sucrose consumption of British children, because other data indicate that dietary sucrose is implicated in smooth surface caries in animal tests. However, it is difficult to disentangle other factors such as fluoride, which has a larger protective effect on smooth surfaces. Water fluoridation is much more extensive in the United States than in Britain.

Over the years many researchers have shown a relationship between levels of sugar consumption and caries. However, recent evidence suggests that this relationship is less clear-cut today in many economically developed countries. Sugar consumption in these countries is 40–60 kg per person per year, but caries has declined (see Figures 7, 8 and 9).

The same studies show that in the present-day child population for whom caries has been substantially controlled (for example, by fluorides and by regular dental care), consumption of sugars is not a major risk factor for caries, except for those who are highly susceptible.

FIGURE 7.

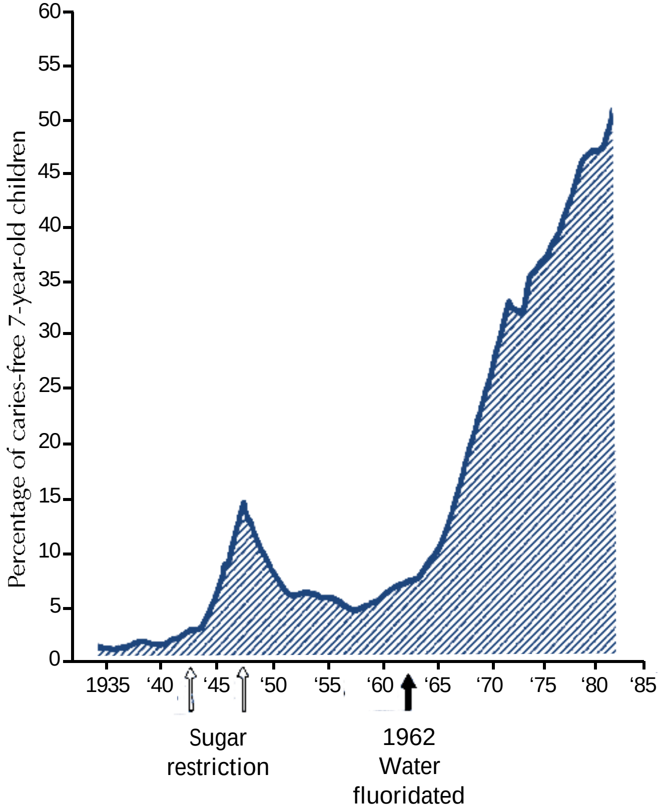
Per capita sugar disappearance and average number of decayed, missing and filled teeth (DMFT) in 12-year-old children in Norway, New Zealand and Sweden between 1970 and 1985



Adapted with permission from: König KG, Changes in the Prevalence of Dental Caries: How much can be atributed to changes in diet, Caries Research 1990;24 (Supp. 1);16-18 ©Karger

FIGURE 8.

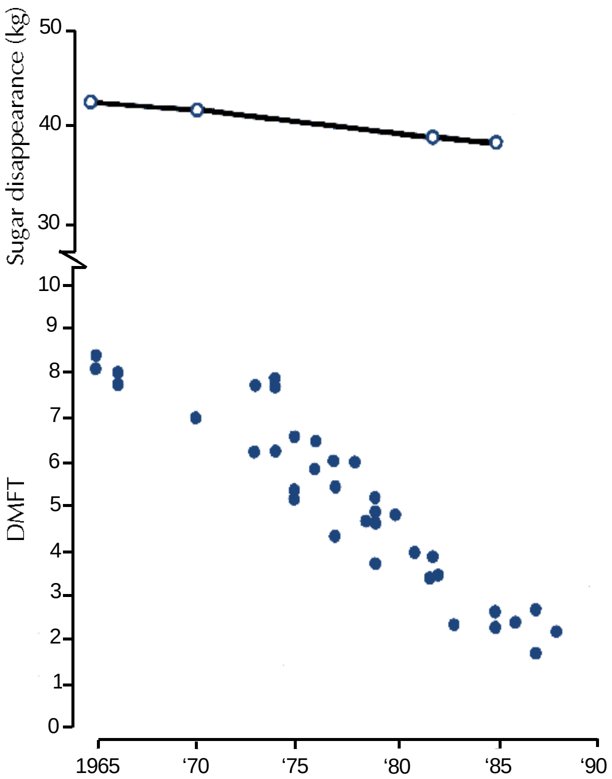
Percentages of caries-free 7-year-old schoolchildren in Basel, Switzerland, between 1933 and 1982



Wartime sugar restriction (to half of normal levels) resulted in only a minor increase in the percentage of caries-free children, whereas fluoride in the form of water fluoridation and fluoride toothpaste greatly improved dental health after the war.

FIGURE 9.

The average number of decayed, missing and filled teeth (DMFT) of 12-year-old Dutch children between 1965 and 1988, and per capita sugar disappearance per year in the Netherlands in 1961, 1970, 1982 and 1985, corrected for import andexport of sugar products



Intrinsic and extrinsic sugars

The Committee on Medical Aspects of Food Policy (COMA), which advises the United Kingdom's Ministry of Health, considered the role of dietary sugars in human diseases. The panel classified sugars into two major groups:

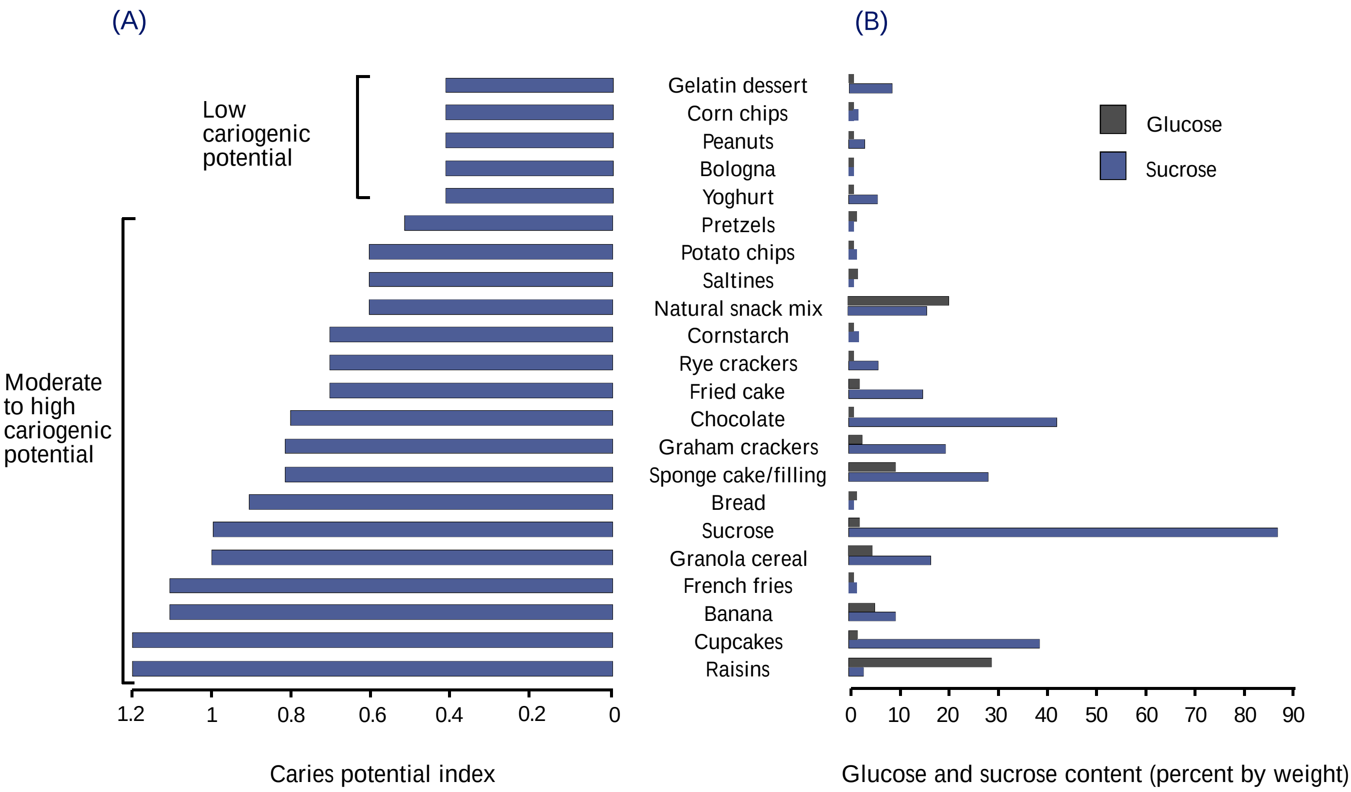
- Intrinsic sugars are those present naturally within the cellular structure of food, that is, mainly in fruits and vegetables.
- Extrinsic sugars are those "which are free in food or added to it". This group is further divided into milk sugars (lactose) and non-milk extrinsic sugars, that is, fruit juices, honey and added sugars.

The COMA panel concluded that nonmilk extrinsic sugars are more cariogenic than other sugars and that their consumption should therefore be reduced and replaced by fruits, vegetables and starchy foods. How valid is this advice given that both starches and fruits can be fermented to acid by oral bacteria and may therefore be potentially cariogenic?

The surveys in Britain and the United States noted above show that variations in sugars consumption (amount or frequency) in a relatively homogeneous child population in which caries is controlled is only weakly correlated with caries incidence. Experiments have shown that there is no quantitative relationship between the concentration of sucrose in a food and either the level of acidity it produces in plaque or the amount of caries produced in tests on animals (Figure 10). For example, in one experiment no significant difference was shown in levels of caries in rats fed breakfast cereals containing between 8% and 60% sucrose.

FIGURE 10.

Index of the potential of foods to cause caries in rats (A) compared with the sugar (sucrose and glucose) content of those foods (B)



Human studies have shown little difference in acidogenic potential among sucrose, fructose and glucose, although lactose is less acidogenic. Similarly, in animal feeding trials, the cariogenicity of sucrose, fructose and glucose differs only slightly, but lactose is markedly less cariogenic.

These and other studies bring into question the distinction between intrinsic and non-milk extrinsic sugars. The distinction also ignores eating patterns. In normal diets, fruit is not eaten frequently and so is not a great contributor to caries, but surveys show that where fruit is eaten frequently an increase in caries can result. A study of South African farm workers showed that those working on fruit farms growing apples and grapes had substantially higher caries scores than did those working on grain farms. The diets of the two groups differed only in the amount of fruit consumed.

Laboratory studies of animals also show that the consumption of apples, bananas and grapes can give rise to appreciable levels of caries. Thus, although it is not now possible to detect the contribution to caries made by fresh fruits as normally consumed in human diets, they may be harmful if eaten frequently between meals.

COMA's advice to replace non-milk extrinsic sugars for dental reasons with fruit, vegetables and starchy foods is not useful if these foods are eaten just as frequently as the foods which have been substituted. The conclusion, therefore, is that the COMApanel missed an opportunity to reinforce advice to modify dietary patterns to reduce the frequency with which sugars, intrinsic or extrinsic, are present around plaque-covered teeth.

Intense sweeteners and sugar substitutes

Given the role of sugars in the causation of caries, one possible strategy is to replace these sugars with sweeteners with lower levels of acidogenic ingredients. Two main types have been developed: intense sweeteners and sugar substitutes. These are not metabolised by oral bacteria and thus do not give rise to dentally significant amounts of acid.

Intense sweeteners are much sweeter than sugar, provide very little energy and are used in small amounts in drinks and other foods, generally in weight control or diabetic products. Examples are saccharin, cyclamate, aspartame and acesulfame-K.

The use of intense sweeteners is limited because they provide sweetness but not bulk or any of the variety of other functional properties possessed by sucrose and other sugars which are technologically useful in the manufacture of sugar-containing foods. Sugar substitutes have therefore been developed to provide various aspects of sugar functionality as well as low cariogenicity. Examples are sorbitol, xylitol, Palatinit® and Lycasin®. Sugar substitutes are derived from carbohydrates and are partially absorbed and metabolised, providing some energy to the body.

Sweeteners and sugar substitutes do not support plaque growth and can reduce the total cariogenic load of an individual consumer's diet when used to replace fermentable carbohydrate. In addition, they stimulate salivary flow, which in the absence of significant acid production can lead to remineralisation of enamel. There is also evidence that saccharin, aspartame and xylitol have properties which might contribute to the active reduction of caries by an antibacterial effect (discussed below). The low cariogenicity of sweeteners and sugar substitutes has been demonstrated in clinical trials, although so far the impact on dental caries in populations is not readily discernible.

In Switzerland the label "safe for teeth" is allowed for those products which do not promote an acid response. These products are mainly consumed by children. Figure 11 shows the extent to which this market has grown.

Control of oral bacteria

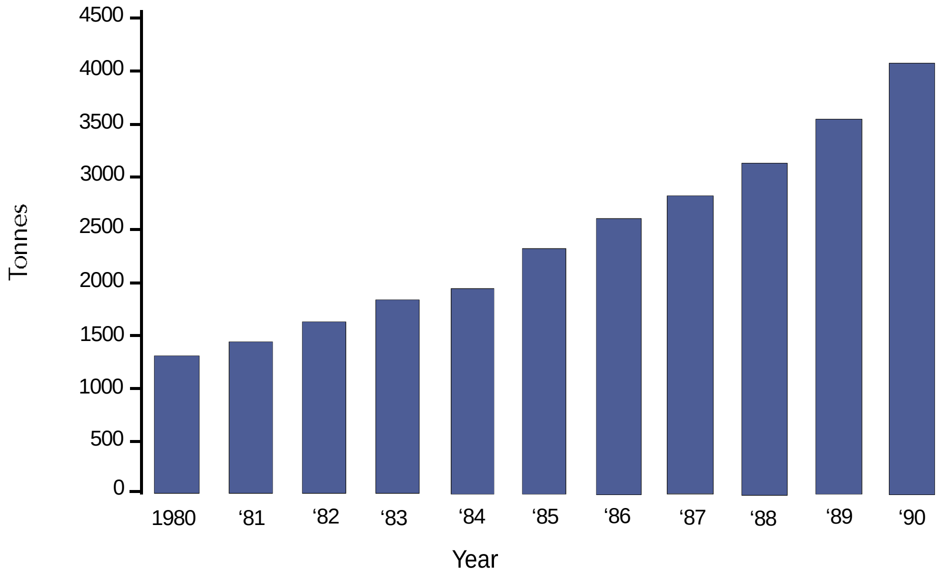
Antibacterial agents

Numerous clinical studies have found that certain bacteria are closely associated with caries. Mutans streptococci and lactobacilli are generally implicated, although their exact impact on the caries process remains unclear.

Antibacterial agents have been successfully developed to control plaque and reduce the bacteria associated with caries. For example, chlorhexidine has been found to reduce caries by 78% in students in a short-term study. In another study with teenagers, a 56% reduction in caries over 3 years was achieved.

FIGURE 11.

Sales figures for confectionery products sweetened with sugar substitutes in Switzerland, 1980-1990



Antibacterial agents are also of benefit in preventing the principal route of transmission of caries-inducing bacteria to children – from the mother. They are useful too for handicapped children for whom conventional control measures are inappropriate.

Although professionally applied antibacterial agents are effective, it is not feasible to provide such high levels of clinical involvement on a population level. In addition, chlorhexidine is generally reserved for short-term use because of the possibility of local side effects. Other antibacterial agents are now being successfully formulated into toothpastes and mouthwashes for routine, unsupervised use.

Sweeteners and sugar substitutes

The role of sugar substitutes in preventing caries has already been discussed. As well as acting as non-acidogenic substitutes for fermentable carbohydrates and not contributing to plaque formation, some may play an active role in caries prevention. For example, aspartame, saccharin and xylitol may actively inhibit bacterial growth.

Xylitol has been shown to have an antibacterial effect on mutans streptococci. It was found that habitual xylitol gum users had lower levels of mutans streptococci and fewer caries lesions over a 6-year period, compared with those who ate a conventional diet. However, because there was no control group using unsweetened gum, it is not clear whether the caries reduction was due specifically to xylitol or due simply to salivary stimulation.

Vaccination

Research has been carried out to develop a vaccine to create an immune response to caries-inducing bacteria. In primates, reductions in caries have ranged from 50% to 60%. There have been no clinical trials in humans of an anticaries vaccine.

During the period when these vaccines were being developed, the incidence of caries fell dramatically, thereby diminishing the need for a vaccine. It is also questionable whether a vaccine is justified for a disease which is not life-threatening.

During these animal studies it was also found that antibodies against mutans streptococci could be applied topically or via foods for successful caries prevention. Further research is needed to determine whether this could form the basis of an alternative strategy for preventing caries.

Use of fissure sealants

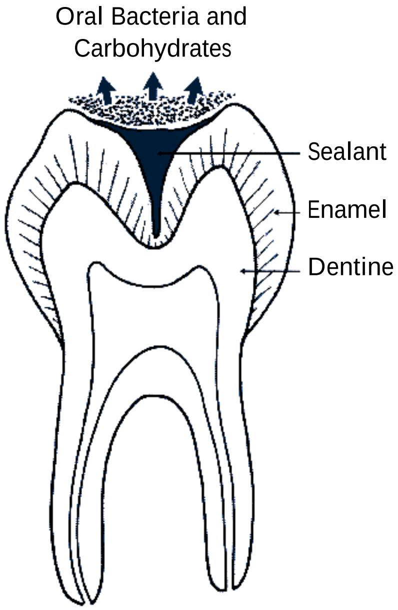
Although the incidence of caries has declined greatly in the smooth surfaces of teeth (see Figure 6), the incidence in the pits and fissures has not declined as much, with the result that the greatest proportion of caries is now in pits and fissures. This may be partly due to the fact that fluoride tends to strengthen smooth surfaces but has less effect on pit and fissure caries. It is also easier for pits and fissures to harbour plaque and food debris. Since the 1960s, many trials have shown the effectiveness of using sealants on pit and fissure surfaces to create a physical barrier between the tooth and the cariogenic agents which attack it (Figure 12).

The first generation of sealants, no longer marketed, was activated by ultraviolet light. The second generation of sealants is activated by a chemical mix, and the third and latest generation is activated by visible light.

The effectiveness of fissure sealants is primarily determined by the length of time they remain attached to the tooth surface. Sealant retention depends not only on the type of sealant but also on the position of the teeth in the mouth, the clinical skill of the operator, the age of the child being treated and other factors. Extensive tests have been carried out on first- and second-generation sealants to determine their retentiveness for periods of up to 15 years. Retentiveness of third-generation sealants has been tested for only up to

FIGURE 12.

Fissure sealants prevent the entry of both cariogenic bacteria and fermen-table carbohydrate into the vulnerable deep fissures, thereby protecting teeth from acid attack



5 years, owing to their more recent introduction. Second- and third-generation sealants remain effective over long periods of time, with two-thirds remaining in place after 5–7 years.

Tests have been carried out to study the effects of adding fluoride to sealants. The fluoride has little lasting effect on salivary fluoride levels, so the only benefit would occur if fluoride is absorbed into the enamel directly underlying the sealant. Since sealant materials do not fully penetrate the pits and fissures, this is unlikely to be the case. Thus, there is currently little evidence to support the incorporation of fluoride into sealants.

The Karlstad prevention programme

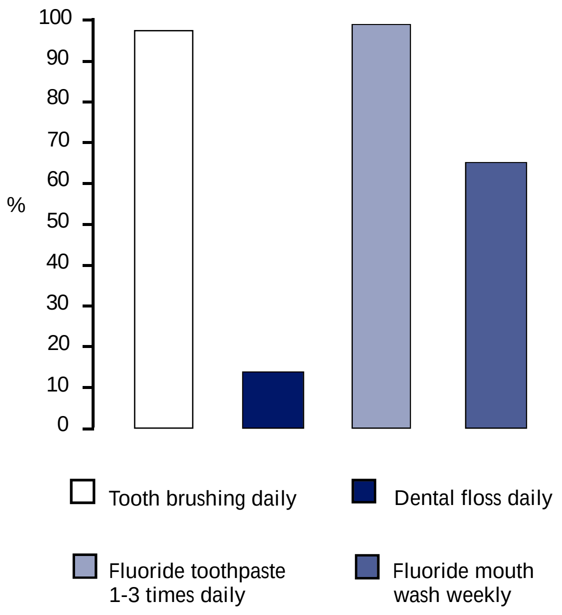
Twenty years ago caries levels in Sweden were among the highest in the world. Within Sweden, levels were highest in the county of Värmland and lowest in the county of Uppsala, the latter of which had naturally fluoridated water. Since artificial fluoridation is not permitted in Sweden, a number of other initiatives were introduced in 1971 as part of the "Karlstad studies" to evaluate the separate and combined effects of different plaque control programmes.

The studies found that there were two basic principles of successful cost effective programmes:

- The higher the risk of developing dental disease for most of the population, the more effective will be a population strategy centred on one single preventive measure.
- With a lower caries incidence, further significant reduction at the lowest cost will be achieved only by carefully assessing at-risk individuals, teeth and surfaces, and by tailoring preventive measures accordingly (see the Advice to the caries prone box).

Well-supervised fluoride mouthrinsing programmes carried out once a week or fortnight at school resulted in caries reductions of between 30% and 50%. At the time the programme started, daily toothbrushing and use of fluoride toothpaste by Swedish schoolchildren was virtually nonexistent. The improvement in oral health practices since then can be seen in Figure 13. By 1980, caries occurrence had dropped so much that no further reduction was achieved from mouthrinsing once a week. The programme was therefore discontinued and replaced by individual prevention programmes.

FIGURE 13.
The frequency of oral hygiene practices in Swedish schoolchildren



The current programme emphasises primary prevention:

- antenatal care
- child welfare centre programmes for the early establishment of good daily oral hygiene and dietary habits for 6-month-old, 18-month-old and 3-year-old children
- professional mechanical tooth cleaning and use of fluoride varnish at needs-related intervals in 3–5-year-old children

The programme has produced extremely positive results. For example, from 1979 to 1991 the percentage of caries-free 5-year-old children increased from 27% to 72% in Värmland, and from 43% to 76% in Uppsala. The average caries reduction for all age groups was 75–90% for all tooth surfaces (Figure 14), and the time spent at the dentist fell from 1.7 to 1.1 hours per year. See also Figure 15.

Findings of the Karlstad prevention programme

- Daily national average sugar consumption in Sweden remained unchanged from 1960 to 1990, but consumption of sweets, soft drinks, marmalade and cakes increased significantly. Caries reduction therefore could not be attributed to reduced consumption of sweet foods. This has been mirrored in several countries.
- The key risk surfaces should be targeted for optimal caries prevention, with plaque control by self-care, by professional mechanical tooth cleaning and by topical fluoride (toothpaste, and varnish if needed).
- Chemical plaque control should normally be reserved for caries-prone individuals.
- Pregnant women with high mutans streptococci values should receive high-quality mechanical plaque control and chemical plaque control with chlorhexidine.

FIGURE 14.

Percentages of caries-free 5-year-old children in 1979 and in 1991 in the counties of Värmland, Uppsala and Halland and in all of Sweden

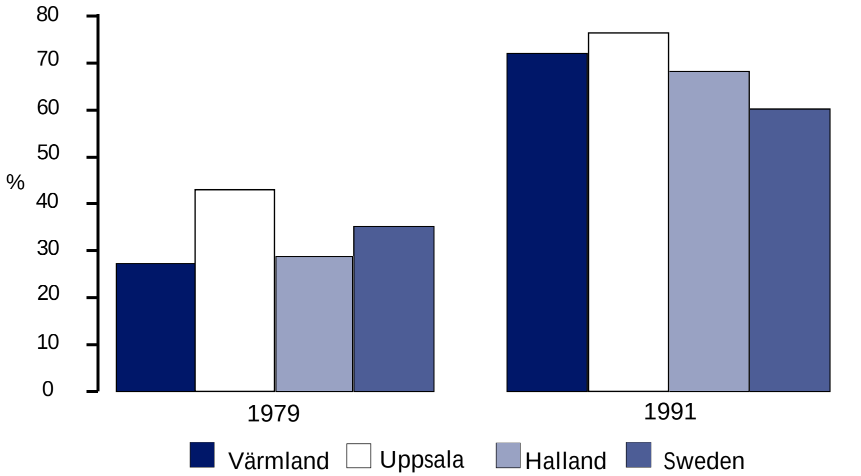
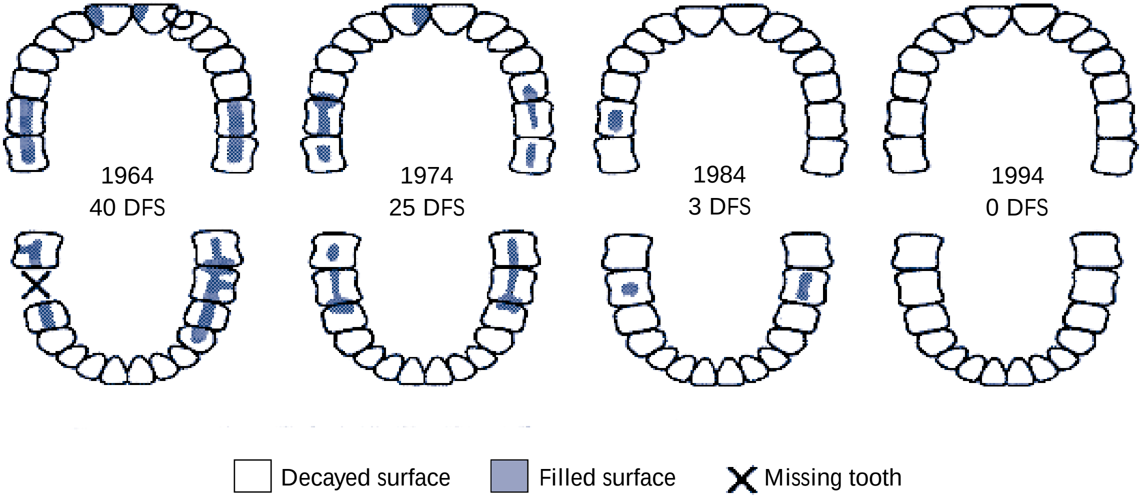


FIGURE 15.

Changes in the level of caries in 12-year-old children in the county of Värmland, Sweden, in 1964, 1974, 1984 and prospectively in 1994. DFS denotes the average number of decayed or filled tooth surfaces per child.



- The large decline in caries can be attributed in part to a change in toothbrushing habits. Swedish children now routinely brush their teeth using fluoride toothpaste.
- For an optimal effect in a population brushing with fluoride toothpaste one to three times a day, professional mechanical tooth cleaning should be directed towards surfaces inaccessible to toothbrushing; in caries-prone patients, professional mechanical tooth cleaning could be supplemented by varnishing key risk surfaces.
- School fluoride mouthrinsing programmes are very cost effective when there is no fluoridated drinking water, high caries, poor oral hygiene habits, no daily oral hygiene or no fluoride toothpastes.
- Selected caries-prone individuals should clean all tooth surfaces before meals and take fluoride tablets or fluoride chewing gum immediately after meals.
- Selected caries-prone individuals might also use an antibacterial mouthrinse, for example, chlorhexidine, twice a day for 3 weeks.
- Fissure sealants are recommended for caries-prone individuals and for at-risk fissures.
- Education is important; dental status is strongly related to educational levels.
- With such programmes, the percentage of caries-free Swedish 5-year-old children should reach 95% in the near future. By the year 2000, it is anticipated that 19-year-olds will have a maximum of only one decayed surface per individual and no approximal fillings (compared with 40 decayed or filled surfaces in 1964).

Advice to the caries prone

The role of carbohydrates in the caries process has been clearly demonstrated, and much past research on populations has supported a strategy of restricting sucrose intake. Within populations, however, a simple relationship between the consumption of sucrose and the development of dental caries cannot now be seen. Many people develop little dental decay even though they may consume large amounts of sugars on a frequent basis. The general message to "eat less sugar on fewer occasions" needs to be tailored depending on the target of the advice.

The use of fluorides, the practice of oral hygiene and a moderate reduction in dietary risk have proved effective for the majority of the population. In developed countries most caries occurs in a minority of the population (Figure 16). These caries-prone individuals are probably best identified by a high past decay experience, especially at smooth and proximal surfaces. Other factors can also be considered in making the assessment of caries risk, including high parental (especially maternal) decay experience, compromised salivary function, adverse dietary habits, increased levels of specific bacteria in the mouth, poor oral hygiene and inadequate use of fluoride. Many of those with a high caries experience live in less favourable social situations.

The behaviours that increase the risk of caries in the caries prone must be modified in a way that will effectively reduce the activity of the disease. Advice must take account of the life-style and social situation of the target group or individual. Diet and the use of preventive practices should be assessed to identify specific needs. It is difficult to change eating and drinking habits, so dietary advice, consistent with general advice on healthy eating, should concentrate primarily on controlling the frequency of exposure to fermentable carbohydrate. The ultimate goal is to control caries activity in the caries prone by combining all preventive therapies.

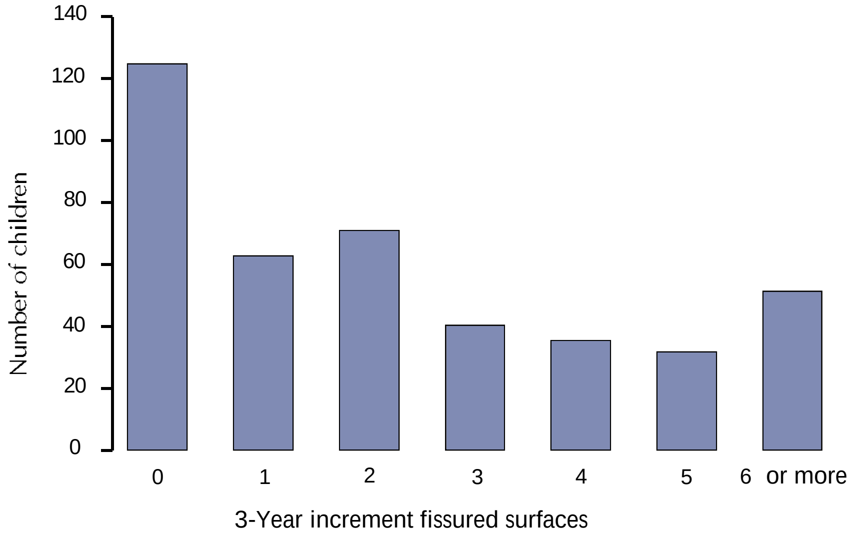
CARIES PREVENTION: WHOSE RESPONSIBILITY?

Caries prevention can be tackled at a number of levels, ranging from the community to the individual (Table 2). In European countries, where water fluoridation and other public health measures have not met with broad acceptance, much of the onus is placed on the individual. Dietary measures to protect against caries is also at the level of the individual. Table 2 demonstrates the central role of fluoride in caries prevention at all levels.

Dental professionals play a vital role in identifying specific needs in an individual. Routine examinations are important in monitoring dental health and provide the opportunity to apply control measures at an early stage where problems do arise.

FIGURE 16.

Increment in the number of decayed, filled or missing tooth surfaces containing fissures during a 3-year study in Michigan, United States



Each bar represents the number of children having the indicated numerical increase. Although the majority of children had an increment of between zero and two, a significant number had more than six new decayed, filled or missing fissured tooth surfaces.

SUMMARY

A number of different approaches can be used to prevent dental caries. Fluoride is considered to have played a significant role in the decline in caries in recent years.

Fluoride can be supplied in a number of ways. Water fluoridation and fluoride in toothpaste are very effective in preventing caries. Salt fluoridation can be as effective as water fluoridation, although few countries have adopted this approach.

Other vehicles for applying fluoride should also be considered, especially for at-risk groups. These include fluoride drops, tablets, gels, mouthrinses, varnishes and slow-release fluoride. There is also some potential for fluoridated milk.

Other methods of prevention include antibacterial agents, especially for handicapped children for whom conventional control measures are inappropriate, and fissure sealants. Fissure sealants offer good protection to the pits and fissures, the surfaces of the tooth where the decline in caries has been less marked.

TABLE 2

Dental disease preventive strategies in various target groups

Responsible for action	Target group	Operational during	Measure
Community	Population	Lifetime	Water fluoridation (C) Salt fluoridation (C)
School	Children	Childhood	Fluoride rinses (C) Fluoride supplements (C)
		Lifetime	Health education (C, P)
Dental professionals	Individual	Period after visits	Prophylaxis (C, P) Topical fluoride (C) Hygiene instruction (C, P) Fissure sealants (C)
Individual	Individual	Lifetime	Controlled diet (C) Oral hygiene (C, P) Use of therapeutic dentifrice (C, P)

C = Caries

P = Periodontal disease

Although a relationship between levels of sugar consumption and caries has been demonstrated in studies conducted in the prefluoride era, recent reports show that since the adoption of regular toothbrushing habits with fluoride pastes, these links are becoming weaker. Today consumption of sugars is not a major risk factor for many individuals, except for those who are regularly exposed to sugars and who have poor oral hygiene habits.

Furthermore, the distinction between intrinsic and non-milk extrinsic sugars is questionable. Fresh fruits may be potentially harmful if eaten frequently between meals. Dietary advice therefore should consider frequency of consumption of all carbohydrates and should be targeted at at-risk groups.

Sweeteners and sugar substitutes do not support acid formation in plaque and can, when used to replace fermentable carbohydrates, reduce the total cariogenic load of an individual consumer's diet.

Combining the use of fluoride with regular tooth-brushing and dietary advice primarily concentrating on controlling the frequency of exposure to fermentable carbohydrates has proved effective in caries prevention for the majority of the population.

GLOSSARY

Acidogenicity: Capacity of a food or drink, after metabolism (fermentation) of its carbohydrate by bacteria, to give rise to acid at the tooth surface.

Antibacterial agent: Chemical which can kill or stop the growth of bacteria.

Bacteria: Types of microscopic single-celled organisms.

Cariogenicity: Capacity of a food or drink to lead to caries in those who consume it.

Dental floss: Soft thread or tape used to clean debris and plaque from between teeth.

DMFS: Number of decayed, missing and filled surfaces on permanent teeth.

DMFT: Number of decayed, missing and filled permanent teeth.

Fermentable: Ability of a substance to be metabolised by bacteria.

Mutans streptococci: A group of species of bacteria which have been specifically implicated in the initiation of dental decay.

Plaque: The film of soft material which coats teeth. It contains a complex community of bacteria in a matrix of proteins derived from saliva as well as substances secreted by the bacteria.

Primary teeth: First or "milk" teeth.

Rampant caries: Development of 10 or more new carious lesions in the teeth of an individual over a period of a year.

Sugar disappearance: Sugar entering the food supply chain, taking account of imports and correcting for exports. This represents more than consumption levels, since not all the sugar that is refined will necessarily be consumed. Some will be lost through waste and some may be diverted to nonfood uses.

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