Dental caries

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Dental caries, otherwise known as tooth decay, is one of the most prevalent chronic diseases of people worldwide; individuals are susceptible to this disease throughout their lifetime. Dental caries forms through a complex interaction over time between acid-producing bacteria and fermentable carbohydrate, and many host factors including teeth and saliva. The disease develops in both the crowns and roots of teeth, and it can arise in early childhood as an aggressive tooth decay that affects the primary teeth of infants and toddlers. Risk for caries includes physical, biological, environmental, behavioural, and lifestyle-related factors such as high numbers of cariogenic bacteria, inadequate salivary flow, insufficient fluoride exposure, poor oral hygiene, inappropriate methods of feeding infants, and poverty. The approach to primary prevention should be based on common risk factors. Secondary prevention and treatment should focus on management of the caries process over time for individual patients, with a minimally invasive, tissue-preserving approach.

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Dental caries is one of the most common preventable childhood diseases; people are susceptible to the disease throughout their lifetime.[1–4] It is the primary cause of oral pain and tooth loss.[3–5] It can be arrested and potentially reversed in its early stages, but is often not self-limiting and without proper care, caries can progress until the tooth is destroyed.[4] Therefore, physicians and other health-care providers should be familiar with dental caries and its causes. The aim of this Seminar is to enhance physicians' knowledge of the dental caries process and its management; to encourage physicians to incorporate relevant aspects of caries prevention and control into their daily practice, and to educate physicians about when to refer patients to a dentist.

Definition

Dental caries is the localised destruction of susceptible dental hard tissues by acidic by-products from bacterial fermentation of dietary carbohydrates.[4,6] The signs of the carious demineralisation are seen on the hard dental tissues, but the disease process is initiated within the bacterial biofilm (dental plaque) that covers a tooth surface. Moreover, the very early changes in the enamel are not detected with traditional clinical and radiographic methods. Dental caries is a multifactorial disease that starts with microbiological shifts within the complex biofilm and is affected by salivary flow and composition, exposure to fluoride, consumption of dietary sugars, and by preventive behaviours (cleaning teeth). The disease is initially reversible and can be halted at any stage, even when some dentine or enamel is destroyed (cavitation), provided that enough biofilm can be removed. Dental caries is a chronic disease that progresses slowly in most people. The disease can be seen in both the crown (coronal caries) and root (root caries) portions of primary and permanent teeth, and on smooth as well as pitted and fissured surfaces. It can affect enamel, the outer covering of the crown; cementum, the outermost layer of the root; and dentine, the tissue beneath both enamel and cementum. Caries in primary teeth of preschool children is commonly referred to as early childhood caries.

The terms dental caries or caries can be used to identify both the caries process and the carious lesion (cavitated or non-cavitated) that is formed as a result of that process.[7–9] In daily practice, dental practitioners, other health-care providers, and patients often refer to an established caries lesion as a cavity in the tooth. The cavity, or decayed surface, is the sequela of the disease process and is a sign of fairly advanced disease.[10] Dental caries is a continuum of disease states of increasing severity and tooth destruction that ranges from sub-clinical sub-surface changes at the molecular level to lesions with dentinal involvement, either with an intact surface or obvious cavitation[8,9,11,12] (figure 1). Assessment of the presence or absence of dental caries is dependent on the diagnostic cutoff points selected; this decision greatly affects practitioners' treatment decisions. Carious lesions are the outcome of events that progress over time.[7]

Search strategy and inclusion criteria

Sources of information for this Seminar were: (1) systematic reviews of dental caries (cariology), including the Cochrane Library, Centre for Reviews and Dissemination, University of York (restoration longevity), and the NIH Consensus Development Conference on Diagnosis and Management of Dental Caries Throughout Life; (2) formally constructed and peer reviewed consensus development papers and statements published in the Proceedings from the International Consensus Workshop on Caries Clinical Trials; (3) summaries of peer-reviewed reviews, such as proceedings of the 50th Anniversary Congress of the European Organisation for Caries Research, Cariology in the 21st Century and a specialist review on caries diagnostic literature; (4) MEDLINE database through PubMed to identify papers containing the term dental caries and associated definitions, epidemiological considerations, aetiological agents, pathogenic factors, and risk factors; and (5) as additional sources, comprehensive textbooks on dental caries.

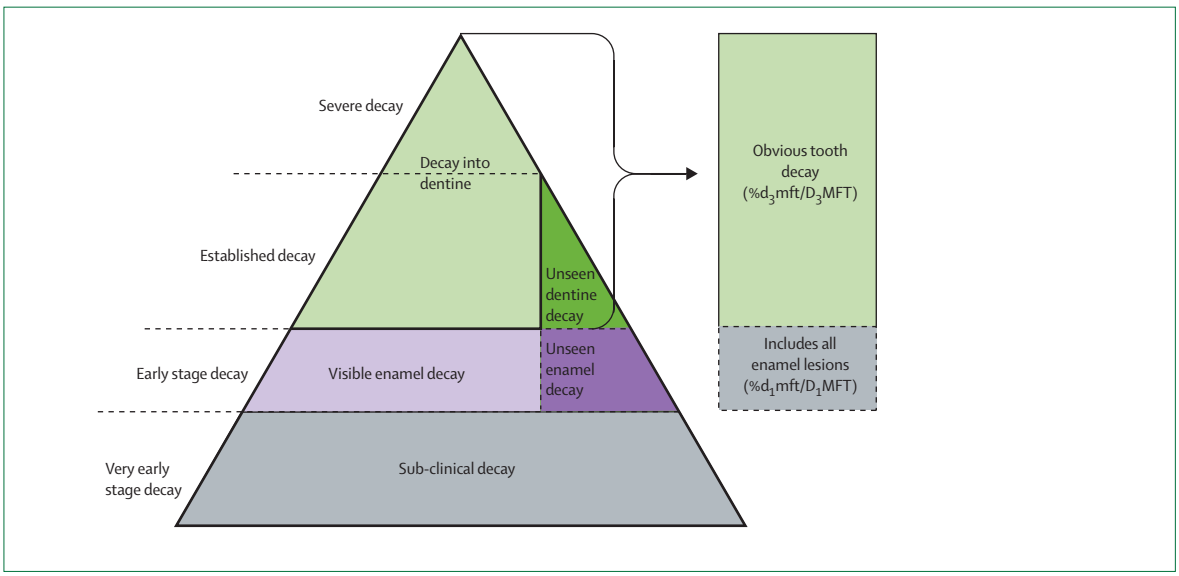

Figure 1: **Diagram of the iceberg metaphor for dental caries identifying the stages of caries scored at different diagnostic thresholds**
Adapted from Pitts, 2004[33] with permission of the author and publisher. The dmf (primary teeth) and DMF (permanent teeth) index is used to quantify caries experience, which is the sum of decayed, missing, and filled teeth. The subscript relates to the diagnostic cut-off used. d_1/D_1 refers to enamel or dentine caries, whereas d_3/D_3 refers to dentine caries only.

Pathogenesis

Dental caries results from interactions over time between bacteria that produce acid, a substrate that the bacteria can metabolise, and many host factors that include teeth and saliva. Dental caries results from an ecological imbalance in the physiological equilibrium between tooth minerals and oral microbial biofilms.[13,14] Bacteria live on teeth in microcolonies that are encapsulated in an organic matrix of polysaccharides, proteins, and DNA secreted by the cells, which provides protection from desiccation, host defences and predators and provides enhanced resistance to antimicrobial agents.[4,14] Teeth offer non-shedding surfaces for microbial colonisation and large numbers of bacteria and their by-products accumulate in a biofilm on tooth surfaces in health and disease.[6,14]

The mechanisms of the caries process are similar for all types of caries. Endogenous[13–15] bacteria (largely mutans streptococci [*Streptococcus mutans* and *Streptococcus sobrinus*] and *Lactobacillus* spp) in the biofilm produce weak organic acids as a by-product of metabolism of fermentable carbohydrates. This acid causes local pH values to fall below a critical value resulting in demineralisation of tooth tissues.[2,12,15] If the diffusion of calcium, phosphate, and carbonate out of the tooth is allowed to continue, cavitation will eventually take place.[12,16] Demineralisation can be reversed in its early stages through uptake of calcium, phosphate, and fluoride. Fluoride acts as a catalyst for the diffusion of calcium and phosphate into the tooth, which remineralises the crystalline structures in the lesion. The rebuilt crystalline surfaces, composed of fluoridated hydroxyapatite and fluorapatite, are much more resistant to acid attack than is the original structure. Bacterial enzymes can also be involved in the development of caries.[11]

Whether dental caries progresses, stops, or reverses is dependent on a balance between demineralisation and remineralisation. The process of demineralisation and remineralisation takes place frequently during the day in most people. Over time this process will lead to either cavitation within the tooth or repair and reversal of the lesion, or maintenance of the status quo.[12] Remineralisation is frequent, especially when the biofilm pH is restored by saliva, which acts as a buffer. The remineralised areas have a higher concentration of fluoride and less microporous enamel structure than the original tooth structure because of the acquisition of calcium and phosphates from saliva (figure 2).

Caries lesions develop where oral biofilms are allowed to mature and remain on teeth for long periods. If a cavity is allowed to develop, the site provides an ecological niche in which plaque organisms gradually adapt to a reduced pH.[13] Formation of a cavitated lesion protects the biofilm, and unless the patient is able to cleanse this area, the carious process will continue (figure 2).[8] Dental caries in enamel is typically first seen as white spot lesions, which are small areas of subsurface demineralisation beneath the dental plaque. Root-surface caries is similar to enamel caries, but unlike enamel caries, the surface can become softened, and bacteria penetrate further into the tissue at an earlier stage of lesion development.[4,8] Recession of the gingival margin, resulting from poor oral hygiene and loss of periodontal attachment with age, leads to exposure of the juncture of the crown with the

root surface. This area retains dental plaque and is prone to developing carious lesions.[4]

Early childhood caries is an aggressive presentation of dental caries that affects the primary teeth of infants and toddlers, and typically develops in anterior tooth surfaces and can also affect maxillary or mandibular primary molars. It begins with white spot lesions in upper primary incisors along the margin of the gingiva. If the disease continues, caries can progress and lead to complete destruction of the crown. In the moderate stage, cavitation takes place, and caries begins to spread to the upper molars. In severe cases, the caries process destroys the upper teeth and spreads to the lower molars.[17,18]

Risk factors

A person's risk of caries can vary with time since many risk factors are changeable. Physical and biological risk factors for enamel or root caries include inadequate salivary flow and composition, high numbers of cariogenic bacteria, insufficient fluoride exposure, gingival recession, immunological components, need for special health care, and genetic factors.[4,19–23] Caries is related to one's lifestyle, and behavioural factors under a person's control are clearly implicated. These factors include poor oral hygiene; poor dietary habits—ie, frequent consumption of refined carbohydrates; frequent use of oral medications that contain sugar; and inappropriate methods of feeding infants.[4,19,20,24,25] Other factors related to caries risk include poverty, deprivation, or social status; number of years in education; dental insurance coverage; use of dental sealants; use of orthodontic appliances; and poorly designed or ill-fitting partial dentures.[5,18–20,26] Also, children with a history or evidence of caries or whose primary caregiver or siblings have severe caries should be regarded as at increased risk for the disease.[4,20] Although evidence of a link between low birthweight and dental caries is inconclusive, clinicians are advised to regard such children as at risk for dental caries.[27]

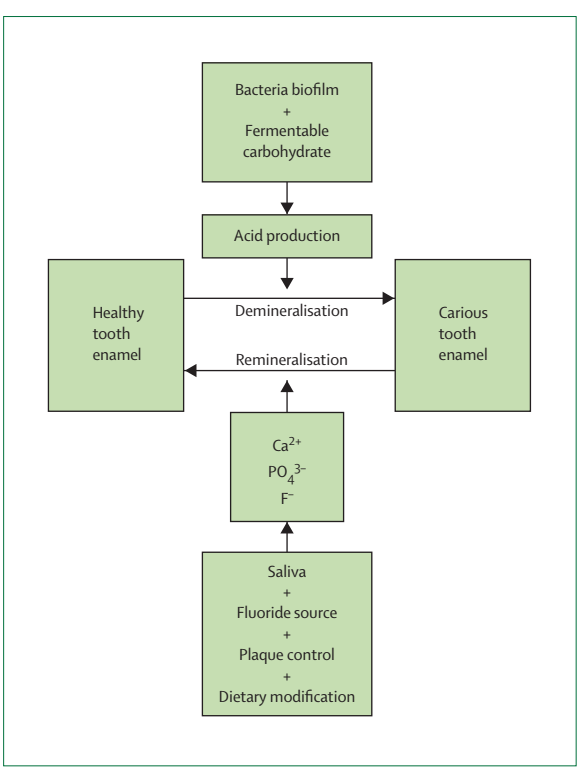

Figure 2: **Diagram of the caries process as regular flux of demineralisation (destruction) and remineralisation (repair)**
Adapted from Kidd and Joyston-Bechal, 1997[49] with permission of the authors and the publisher.

Colonisation by mutans streptococci, and other cariogenic bacteria at a young age could be a key risk factor for caries development.[16,28] However, the role of mutans streptococci as the main cause of caries has not been proven. Because of the complexity of the oral microflora, which contains several hundred species of bacteria and millions of cells growing on a single tooth surface, no single bacterial species can predict caries development in a particular person. Moreover, the present knowledge of this complex disease does not allow for accurate prediction of caries activity in any one person or tooth.[29] However, evidence that consideration of risk factors such as the presence of mutans streptococci or lactobacilli; low socioeconomic status; previous caries experience; amount of fluoride exposure and salivary flow; and the dentist's judgment can lead to beneficial outcomes. The major reservoir from which infants acquire mutans streptococci, a widely studied cariogenic bacterial species, is the primary care giver, usually the mother.[16,28] Evidence suggests that mutans streptococci can colonise the mouth of pre-dentate infants and are acquired by both vertical and horizontal transmission from human reservoirs.[28] The report of the 2001 US National Institutes of Health Consensus Development Conference on Diagnosis and Management of Dental Caries Throughout Life contains additional information on caries risk.[30] Figure 3 summarises the factors implicated in the caries process.[31]

Epidemiology

Comparisons of the global frequency and distribution of dental caries are complicated by diagnostic criteria that differ from study to study,[4,7,32,33] but a fall in the prevalence and severity of caries in permanent teeth has been seen in many developed countries over recent decades.[3,34–39] Also, the rate of progression of the disease slows down with increased age.[40] The disease is mainly found in specific teeth and tooth types in both primary and permanent teeth.[22,36] The caries decline in permanent teeth has been greater on interproximal and smooth surfaces than on fissured or occlusal surfaces.[36] Coronal caries in children's permanent teeth is predominately a disease of the pits and fissures.[3,22] In early childhood caries lesions develop in smooth surfaces, which are usually at low risk of caries.[17] In some population groups,

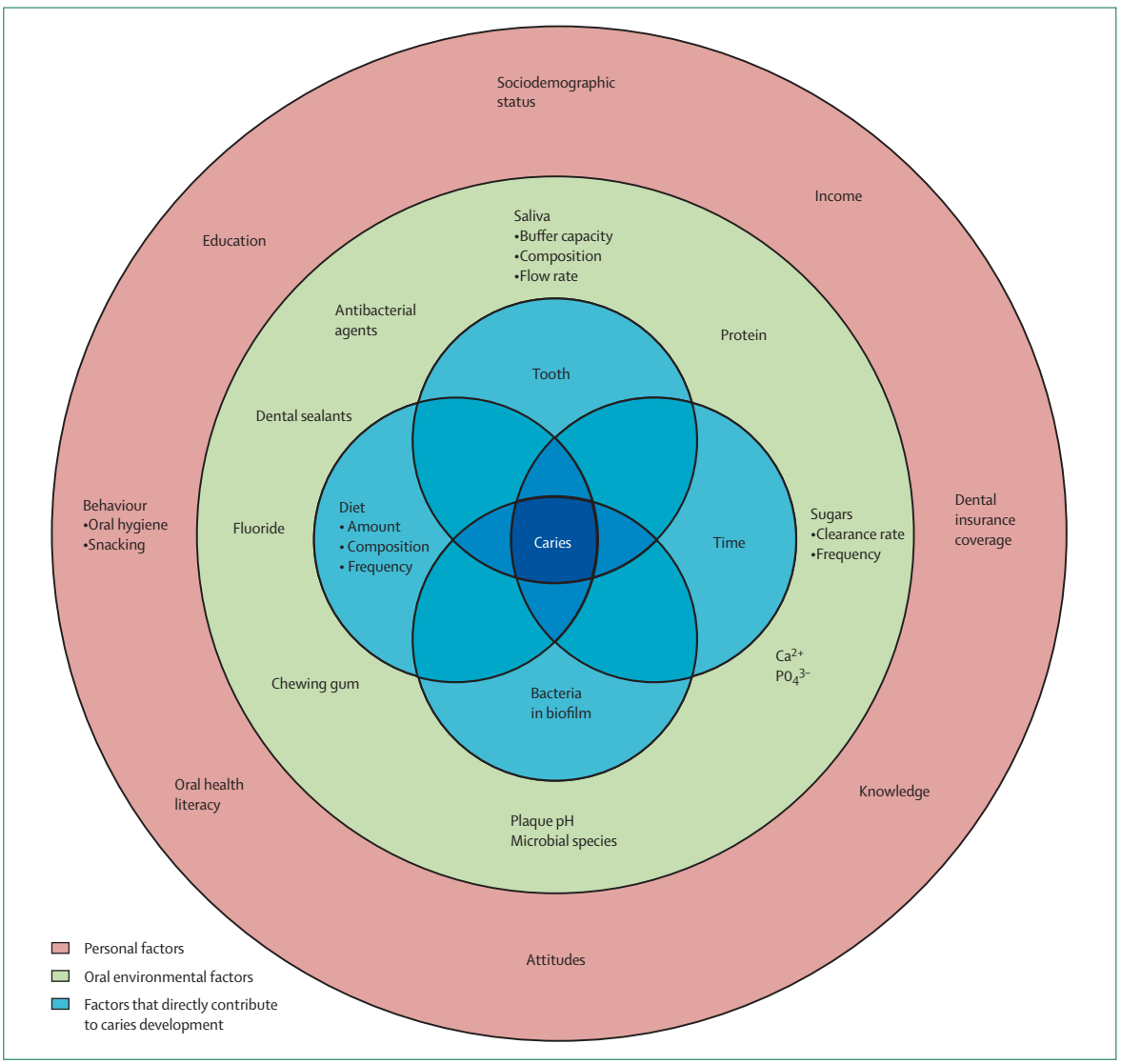

Figure 3: **Illustration of the factors involved in caries development**
Adapted from Fejerskov and Manji, 1990[31] with permission of the authors and the publisher.

caries prevalence and severity in primary teeth might have stabilised or increased slightly.[3,41,42]

Despite the widespread decline in caries prevalence and severity in permanent teeth in high-income countries over the past few decades, disparities remain and many children and adults still develop caries.[18,20,42,43] In the USA, caries is the most common chronic disease of childhood, and is five times more common than asthma.[3] Dental caries is increasing in frequency among elderly people in the USA and elsewhere as more people are retaining more teeth throughout their lifespan.[22] Older adults might have similar or higher levels of new caries formation than have children.[44,45] Studies show that nursing home residents are more likely to have root caries than do elderly people who live in their own homes.[5] Other population groups at high risk for dental caries include people living in poverty; people with poor education or low socioeconomic status; ethnic minority groups; individuals with developmental disabilities; recent immigrants; individuals with HIV or AIDS; elderly people who are frail; and people with several risky lifestyle factors.[3,20,42,43,46–49]

The effect of dental caries on the overall quality of health and wellbeing has not been well studied. This disease and its sequelae can cause significant pain and are expensive to treat. The burden of dental caries lasts a lifetime because once the tooth structure is destroyed it will usually need restoration and additional maintenance throughout life. In developing countries, where the prevalence of dental caries is low and the disease clusters on occlusal surfaces of a few teeth, the costs of treatment are higher than can be met by the funds available for

essential public health programmes.[50] Consequently, 90% of these lesions remain untreated.[50] In the USA, Canada, and the UK, for example, there is evidence that early childhood caries greatly affects the quality of life of children.[39,51,52] In Aboriginal children in Western Australia, dental caries is the fifth and sixth most common disease causing hospitalisation in preschool children (aged 1–4 years) and primary school children (aged 5–12 years), respectively.[53]

As retention of teeth in populations in the USA and Europe increases, dental caries has become a burden for ageing adults. In Canada, Locker[54] reported that one third of adults aged 50 years or older reported problems with eating, communication, and social interaction and 18·7% worried a great deal about their oral health. Almost a third were dissatisfied with some aspect of their oral health status. Adults in France also reported high needs for dental care.[55] In a cohort study of adults from New Zealand, those who grew up in families with low socioeconomic status had worse cardiovascular health and a higher burden of periodontal disease and dental caries, than did adults who were living in families with middle or high socioeconomic status during their childhood.[56]

Diagnosis

International consensus[57] recommends that caries diagnosis, (ie, comprehensive assessment of all patient information by a dentist) is differentiated from lesion detection, (use of objective method to detect disease) and lesion assessment (characterising and monitoring of a lesion once detected). Caries diagnosis, whether in the dental office, during a field survey, or as part of a clinical research project, is done by the visual examination of tooth surfaces, perhaps with the use of a dental probe.[32,58–60]

Although this method of examination is well established and universally taught, clinicians and patients do not generally recognise that this method is imperfect. A comprehensive review[60] provides estimates of sensitivity of lesion detection of 39–59% in both the enamel and dentine of occlusal surfaces, dependent on study methodology. Specificity was high (about 95% or greater), but no one overall estimate was provided. Thus, examiners could miss half the lesions present on occlusal surfaces, although they are unlikely to misclassify any healthy occlusal surfaces as decayed using this method. The use of the dental probe (or explorer) has been controversial for many years. Practice in the USA has long been to use a sharp explorer tip to provide tactile feedback (ie, evidence of softness) as an adjunct to visual signs of disease, whereas in Europe this practice is believed to add little to diagnostic yield and might induce iatrogenic damage to the enamel surface and promote caries initiation or progression.[59] However, clinicians in many countries, including in Europe, still use dental probes for diagnosis.

Detection of lesions on contacting approximal surfaces (ie, the sides of adjacent teeth that are touching each other) of posterior teeth is also a challenge, and the inadequacy of clinical visual and tactile methods is the reason that use of ionising radiation for bitewing radiographs is still sanctioned. However, the same systematic review[60] of high quality studies showed that, for approximal surfaces, radiographs had an overall sensitivity of 50% and a specificity of 87%. Thus, using conventional clinical and radiographic methods, the dentist will detect only about half the lesions present and, could misclassify sizeable numbers of sound surfaces as decayed. Radiographs are not very helpful for anything but advanced dentinal lesions on occlusal surfaces (sensitivity 39%, specificity 91%).[60] The consequence of diagnostic errors depends on the treatment strategy used.

The international trend in caries management is to move away from the surgical model (to excise and replace diseased tooth tissue) towards a preventive approach aiming to control the initiation and progression of the disease process over a person's lifetime.[1] Therefore, a major challenge for the clinician is to detect lesions at an early stage, before surgical intervention is needed. The epidemiological examiner has to capture information about need of preventive treatment rather than just the number of fillings required; and the clinical researcher has to assess the effectiveness of products and strategies aiming to control the caries process and prevent disease progression to advanced stage disease that needs restoration. Another major challenge is to detect caries activity at the lesion stage. Unfortunately, despite claims that some new clinical criteria systems are reliable, we contend that additional studies are needed before clinicians in general practice can reliably assess caries activity. In view of the range of dental caries and the various stages of caries that can be detected and differentiated from one another (figure 1), clarity is needed in discussion and reporting of these stages of decay to ensure that patient care, dental-care policies and evidence-based practices are in agreement. Some controversy exists as to the effect of the different diagnostic cutoff points and to the feasibility of epidemiological data collection that includes lesions in the enamel, although results of studies and practices in some countries show that both are desirable.[61] Seemingly trivial changes in diagnostic criteria can produce sizeable differences in the amount of disease recorded.[62] Figure 4 shows the caries process as recorded by classic epidemiology and the inappropriateness of using the term caries free when reporting the results of surveys that only record dentine lesions seen clinically, in view of the proportion judged caries free who could have undetected disease. Rather than claim such groups are free of disease, many authorities are now using terms such as no obvious decay.

Treatment

Over a long period from the turn of the 20th century dentists have thought of tooth restoration as a cure for dental caries. The focus on restoration and retention of teeth was an advance on the previous treatment method

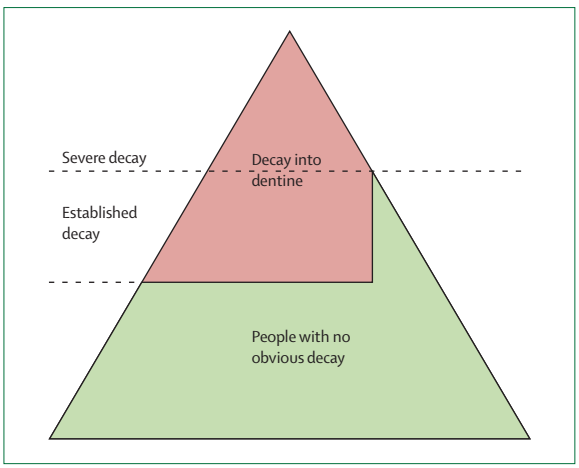

Figure 4: **Diagram of the caries process captured by classical epidemiological survey criteria**
The top right section of the area labelled "People with no obvious decay" corresponds to unseen dentine decay, as shown in figure 1.

of tooth extraction, and became widely used at a time when there was little knowledge of caries prevention, caries formed quickly, and progression rates were high, but there were few dental practitioners.

In clinical practice, caries management by restorative treatment, despite its constraints and tendency to promote repeated restorations,[63] is still the favoured method in many countries. However, in some regions such as Scandinavia, more preventive approaches to care have been in place for many years.[64] The main flaws of restoration without a prevention approach are the short durability of restorations[65] and the propensity of new caries to form at the margins of restorations if the causes of the disease are not removed.[66]

Over the past three decades there has been a transition in many countries towards a largely preventive and preservative approach to caries management. Although caries rates vary greatly between individuals, groups, and countries and the dental workforce is sizeable, prevention and preservation of tooth tissue is desirable as the normal treatment for caries, since we know that caries progresses slowly in most people, that prevention is effective, and that excessive and premature tooth cutting can cause harm.[1,15,21,32,46,57,67] Prevention of early carious lesions by meticulous removal of the biofilm, as well as application of fluoride or placement of sealants, is successful in preserving tooth structure. When restorative intervention is needed, the use of modern micro-restorative techniques that use new adhesive materials can also preserve tooth structure.

Prevention

Discussions about improved methods for caries detection, assessment, and diagnosis for effective caries prevention should not be seen as an alternative to public health and health promotion strategies to reduce the burden of disease before a patient arrives at a dental practice with obvious disease. New clinical developments should work in conjunction with such public health approaches.

In dentistry, the promotion of evidence-based care and the production of clinical guidelines to support appropriate care for individual patients is now possible. In dental caries management, the focus has been around preventive caries management for children,[68] but caries is a disease process that needs to be managed over a person's lifetime.[32,69] The evidence is leading to an international trend in clinical practice, to move away from operative intervention towards prevention of caries.[1] The theory is that the caries process should be managed over time for individual patients and that the least invasive preservative dentistry should be provided.[67] This approach relies on accurate diagnosis of disease and lesions, disease prevention, just-in-time restoration, minimally invasive operative procedures, and prevention of recurrence.

It should be noted that there has been some controversy about the increased use of a high-risk individual approach for identification of people in need of caries prevention.[70] However, the distribution of caries is very skewed and although risk groups are increasingly targeted for prevention, appropriate and prudent surveillance and care should be provided for all patients since caries can occur and can progress in all risk groups. Risk classifications, are dynamic and vary from person to person, so should be periodically reviewed and updated.[69]

For self-administered care, fluoride toothpaste is the most powerful intervention for caries prevention because it has high clinical effectiveness and social acceptability.[71] A Cochrane review[71] of randomised or quasi-randomised controlled trials with blind outcome assessment, comparing fluoride toothpaste with placebo in children aged 16 years or more for at least 1 year, concluded that fluoride toothpastes are clearly effective in prevention of caries. This conclusion is supported by more than 50 years of research. Studies of other oral hygiene interventions alone are not as clear cut because many are confounded by the concurrent use of fluoride toothpaste. However, consensus supports the use of tooth brushing in combination with fluoride toothpaste, especially for occlusal surfaces at the time of tooth eruption.

Another Cochrane review[72] looked at the effectiveness of fluoride gels administered by professionals. Randomised or quasi-randomised controlled trials with blind outcome assessment compared fluoride gel with placebo or no treatment in children aged 16 years or younger for at least 1 year, and the reviewers concluded that fluoride gel showed clear evidence of a caries-inhibiting effect. However, little information exists about effects on primary teeth, adverse effects, or acceptability of treatment. Pit-and-fissure sealants were the subject of another Cochrane review[73] of randomised or quasi-randomised controlled trials of sealants used for caries prevention in children and adolescents aged less than 20 years. The reviewers recommended sealing of the occlusal surfaces with resin based sealants to prevent

caries of permanent molars. However, the reviewers recommended that the caries prevalence of both individuals and the local population should be taken into account. In practice, the benefit of sealants should be considered by individual dentists in accordance with treatment guidelines. In an additional review[74] fluoride varnishes gave promising results. The reviewers suggested a substantial effect of caries inhibition of fluoride varnish in both permanent and deciduous teeth.

Effective caries prevention programmes can use a range of interventions including community fluoridation of water or salt, school water fluoridation, school mouth-rinse programmes, provision of fluoride tablets at school, and school dental sealant programmes.

Additional interventions include those that focus on saliva. Lack of saliva results in catastrophic dental consequences with rapidly progressive caries that attack many sites. Saliva production can be reduced as a result of head and neck irradiation or as a consequence of other diseases (eg, Sjögrens syndrome) or medications. New theories are emerging aimed at the reduction of transmission of cariogenic organisms from caretaker to child to prevent early-childhood caries.

Prevention and control of dental caries can be promoted by clinicians other than dentists, if such clinicians are appropriately trained. Children can be examined by their primary care provider or paediatrician for signs of early carious demineralisation, which show as white areas around the gingival margin or brown-stained pits and fissures. Patients undergoing radiotherapy of the head and neck or who are on medication that lowers their salivary flow also should have regular dental examinations before and after such treatment. The detection of early signs of dental caries should complement preventive programmes in which biofilm on the affected tooth surfaces is frequently removed with a toothbrush, fluoride-toothpaste, and dental floss. Professional topical fluoride applications could be provided in medical offices, especially for infants and toddlers from high-risk population groups. Advice to restrict the consumption of sugary snacks and drinks should also be given to all patients as part of general dietary counselling. The detection of gross cavitated lesions and referral to an appropriate dental care professional for treatment should be thought of as a secondary preventive measure.

Future research directions

Prevention or control of dental caries cannot be achieved by reliance only on current methods and models of dental care. We need to consider the integrated roles of dental, medical, and other health-care providers and assess effective public health interventions and the introduction of oral health promotion activity linked to general health promotion. Most importantly, caregivers of children could play a major part in keeping children free of obvious dental caries.

Initiatives recently announced in Scotland,[75] and widely practised in Scandinavia, and some parts of the USA seek to improve oral health by use of a broad range of people from community and education settings, a mix of health-care professionals from visiting nurses to dental hygienists, in addition to dentists. Such interventions need to be carefully assessed to establish the health improvement that can be achieved. Primary care clinicians should be familiar with effective interventions for the youngest children before they need dental services. Additionally, dentists need to establish the best ways to provide preventive and clinically effective care. Medical providers can detect early signs of carious lesions and provide preventive care in their clinics and can also counsel their patients to restrict their consumption of sugary snacks and drinks.

A key concern is the implementation of high quality clinical research focused on useful topics that primary care clinicians regard as generalisable. In several countries, efforts are being mounted to try to support the ability of researchers and practitioners to conduct such studies. Future research should focus on better understanding of the determinants of caries activity—ie, how to tell if a caries lesion shows progression or regression, or has stopped. Knowledge of restorative care will continue to progress, but such an approach to care will not adequately resolve the worldwide caries problem. In the future,[76–78] when practitioners discover that their patients' risk of dental caries development has increased, new biomaterials that release remineralising fluorides or probiotic agents could be used for caries management and control. Dental practitioners will need to progress from the notion of surgical removal of tooth structure to a strategy that avoids operative intervention if possible, but relies on micro-removal of hard tissues or minimally invasive restorative care if needed.[67,79]

Physicians and other health-care providers will not concentrate on restorative dentistry in their practices. Rather, early detection of caries, by use of visual or other instruments that use advanced optics or other techniques, will be feasible in the future. In the USA, paediatric primary care providers who were given 2 h of training in infant oral health were equally able to detect cavitated lesions with similar accuracy to paediatric dentists.[80] Detection of early carious lesions, which is done by a few physicians in the USA,[81] is difficult, but is possible on the anterior maxillary teeth of infants and toddlers. We need to know more about how best to educate health-care providers to detect early signs of dental caries and how effective they could be in promotion of remineralisation of early carious lesions.[82]

Additionally, physicians and other health-care providers can play a part in advising patients about sound nutritional and dietary habits that could reduce the risk of developing dental caries. Frequent drinking or sipping of sugary drinks provides an abundant food supply for the caries-causing bacteria on tooth surfaces. Other

disease prevention approaches, which should be researched, include provision of instruction in sound oral hygiene practices; application of fluoride varnishes to teeth; and introduction of so-called good bacteria to replace the bad caries-causing bacteria in a child with high caries activity.[78]

Increased understanding of the complex biofilm that exists on tooth surfaces might hold the key to more effective control of dental caries. Another possibility the future could bring is genetic modification of the salivary glands to increase flow or secretion of protective proteins, which could change the ecology in the oral cavity and increase defensive mechanisms in the mouth.[83–85] Scientific advances should blur the demarcation between dental and medical practices—dental caries is a health problem that can be managed by a team of health-care providers including dentists and physicians.[85] For now, physicians should concentrate on use of existing methods to detect signs of early and advanced caries, and should provide advice on how to prevent and control the caries in their patients.

Conflict of interest statement

N Pitts is a director and consultant for Innovative Detection & Monitoring Systems plc. He is a cofounder of Innovative Detection & Monitoring Systems with the University of Dundee and owns equity in the company.

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