

respect to rights, obligations, benefits to society, values, fairness, or specific virtues. Honesty, compassion, and loyalty are often involved in ethical standards of conduct.

One's individual ethics can conflict with others' ethics, whether these others are patients, professionals, or peers. In addition, an individual's ethics can conflict with those of a profession. Behaving ethically demands that one has an ability to balance the various interests involved. Thus, ethics is more subjective than law and not as clear-cut in deciding what to do. It's possible to take various actions and still behave ethically because of the facts and circumstances that exist and are relevant to the ethical decision-making process.

As with law, ethics can be developed from numerous sources and often reflects the influence of more than 1 source. These sources can be guidance from institutions, professional societies, how one was raised, culture, or religion. A code of ethics for a profession sets the parameters of the social contract with the public that profession serves and allows the profession to be self-governing and able to maintain the public's trust.

## DISCUSSION

It's possible to act within the law but not ethically, just as one can act ethically but be outside the scope of the law. Everyone must balance law and ethics. For a professional, this requires the ability

to consider the short-term and long-term consequences for that person and his or her patients, profession, and society itself. Ethical standards are considered more fundamental than laws because laws may not be ethical. If a law is unethical, individuals should act to change it or engage in conscientious violation or civil disobedience until it is changed.

### Clinical Significance

Law defines what you must do to avoid penalties such as fines or imprisonment. Ethics defines what you must do to ensure that there is the most desirable outcome for yourself, your patients, and your profession. Unethical behavior is punished by patients and the public losing trust in the professional and the profession. Professionals such as dentists need to understand the difference between law and ethics and act accordingly.

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# PREVENTIVE DENTISTRY

## Preventing caries through oral microbiome manipulation



### BACKGROUND

Caries is a non-communicable disease (NCD) that shares risk factors with many other NCDs, especially overweight and diabetes. Despite decades of decline in the number of cases of caries, this disease remains a public health concern worldwide. It cannot be eradicated, but the current efforts to prevent caries and manage patients' oral health to avoid caries are inadequate to significantly reduce the problem. The instability of the oral microbiome appears to play a significant role in the development of caries, with dysbiosis linked to both bacterial acid production and other biological and non-biological factors that can influence caries development. Some of the factors involved are beyond the control of dental professionals, but others can be managed. Some commonly used preventive technologies were reviewed for their ability to affect the composition of the oral microbiome so that a symbiotic homeostasis can be maintained or restored. All of

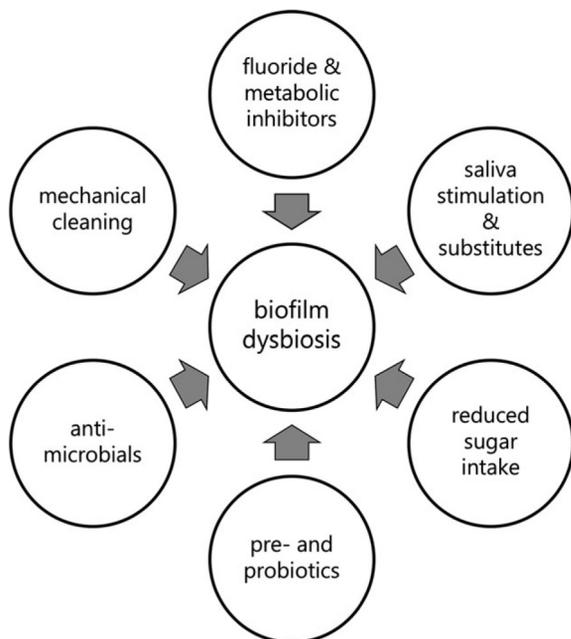
these methods should be available to the general dental practitioner.

### CLINICAL METHODS TO INTERFERE WITH DYSBIOSIS

The most important methods for interfering with dysbiosis related to a patient's lifestyle are reduction in sugar intake and regular oral hygiene (Figure 2). In addition, several biological approaches can be used to restore or maintain a healthy oral microbiome, including using metabolic inhibitors, pH-increasing supplements, salivary enhancement techniques, antibacterial agents, and prebiotics and probiotics to alter the biofilm.

#### Sugar Reduction

Excessive intake of fermentable carbohydrates is the main driver of caries-related dysbiosis. Commensal bacteria metabolize



**Figure 2.** Examples of preventive strategies to influence biofilm dysbiosis. (Courtesy of Twetman S: Prevention of dental caries as a non-communicable disease. *Eur J Oral Sci* 126(Suppl 1):15-25, 2018.)

carbohydrates and produce acids even with a low-sugar diet, but the pH is rapidly restored by the oral physiological mechanisms. Frequent and high-quantity consumption of sugars tips the balance in favor of the bacteria, leading to caries. The World Health Organization (WHO) has based their recommendation for a limited intake of free sugars to less than 10% of total energy intake on a systematic review of 54 studies on sugar and caries risk. Daily intake with this limit would be less than 50 g per day, depending on the type of sugar. Data from ecological studies suggest that free sugars should be less than 5% of total energy intake. With this limit, the development of caries lesions would be highly unlikely, even if no fluoride were used.

The effect of a limited-sugar diet on the oral microbiome over time is unknown. No randomized controlled trials indicate that sugar reduction has a clinical efficacy on caries in children and adults. Some indirect evidence does support reducing the intake of free sugar to minimize caries.

Starch has also been identified as a significant dietary stress factor for oral biofilms because it is retained in the mouth. The metabolism of cooked and processed starch particles can produce a prolonged acidic challenge in fissures and interdental sites.

Dental personnel and medical care providers need to deliver the same message about limiting sugar intake because healthy eating and sugar reduction are important preventive measures not just for caries but also for overweight and diabetes. In developed countries, total sugar consumption should be reduced by an average of one-third across all age groups. Although no single

method works to reduce sugar intake, the best evidence supports the use of motivational interviewing and face-to-face counseling. Structured motivational interviews are especially successful for family settings where the goal is to prevent childhood caries.

### Oral Hygiene

Systemic changes can result from behavioral factors as well as host factors. These include age, smoking, and poor oral hygiene practices. To maintain a healthy biofilm requires regular, gentle mechanical disruption, especially where plaque is readily retained. After oral hygiene, the oral biofilm is altered for some time, with daily hygiene used to help maintain the healthy balance. Mechanical plaque measures without fluoride are not, however, effective in preventing and managing dental caries.

### Fluoride and Xylitol

The low pH that results from acid production of bacteria contributes to the imbalance in the oral microbiota. Fluoride-containing deposits in the oral biofilm can help to control the caries process, however. Fluoride can alter the balance between demineralization and remineralization but also inhibits acid production and the enzyme enolase, which catalyzes the breakdown of disaccharides to lactic acid. Fluoride also interferes with sugar transport through the cell wall. With higher fluoride concentrations, larger calcium fluoride-like reservoirs are formed. Using high-concentration fluoride toothpastes, rinses, and varnishes can significantly elevate and sustain levels of fluoride in both the saliva and the dental biofilm. Keeping the pH of the biofilm at more than 5.5 has been modeled to indicate that the metabolic activity of the biofilm will be reduced, but clinical studies verifying this effect are lacking.

Xylitol can also reduce acid production from oral biofilms. However, the exact effect on the total composition of the oral microbiota requires further evaluation.

### Salivary Enhancement

The secretion of saliva is important in preventing dysbiosis and maintaining oral health. Saliva cleanses the oral cavity and acts as a pH buffer, but also contains numerous physiological substances that contribute to the stability of the oral biofilm. When salivary function is impaired, which can result from aging, medication, medical conditions, chemotherapy, or radiotherapy, dysbiosis and overgrowth of candida species can occur.

In practice it's difficult to stimulate saliva secretion, although some evidence indicates that topical measures such as increasing water consumption and regular use of chewing gums and salivary substitutes may increase salivary secretion in patients with residual secretory capacity. The inclusion of enzymes and moisturizers in oral care products can alleviate subjectively perceived symptoms related to dry mouth and support the stability of the

biofilm. The effects in a patient with active caries are as yet unproved.

### Antibacterial Agents

Disrupting the microbiome by prescribing broad-spectrum antibacterial agents may cause secondary infections, recolonization by opportunistic bacteria, and other negative effects. Chlorhexidine (CHX) is the gold standard of antibacterial agents used to control plaque accumulation and selectively kill pathogens by chemical means. Evidence indicates that CHX in rinses, gels, and varnishes can positively affect gingivitis. Its role in preventing and controlling crown and root caries remains undetermined.

It has been recommended that any antibacterial agents in oral care products only be present in sublethal concentrations, which should slow down bacterial growth and sugar metabolism while inhibiting the formation of a biofilm that supports bacterial growth. Bacteriocidal concentrations are only advocated for short-term use and as an adjunct to mechanical plaque control.

An alternative that has been proposed is the selective killing of *Streptococcus mutans* with the goal of re-establishing a balanced oral microbiota to protect from caries over an extended period of time. Although preliminary studies indicate that antimicrobial peptides in mouth rinses can reduce *S mutans* counts in plaque and saliva and have little impact on total biofilm, the clinical effect of such targeted strategies remains limited.

Use of 38% silver diamine fluoride (SDF) has been successful in arresting or preventing caries in children, adolescents, and root caries-prone older adults. This topically applied solution allows silver ions to act directly against bacteria in lesions. Studies are needed to substantiate the findings, but SDF treatment may offer minimal risk of unintended systemic effects on the oral microbiome.

### Prebiotics and Probiotics

Prebiotics are dietary fibers and oligosaccharides that promote the growth and presence of beneficial bacterial. In contrast, probiotics are live microorganisms that confer a positive health effect on the individual who uses them. Prebiotics other than arginine are currently seldom used in dental practice. Arginine occurs naturally in low concentrations in saliva and promotes the growth of health-related bacteria in the oral biofilm and dental plaque. Adding arginine to fluoride toothpaste can increase the activity of the arginine deaminase system (ADS), raise the biofilm pH, and shift plaque microbial profiles to one similar to what is seen in caries-free persons. The combination of arginine and fluoride produces synergistic effects on

early coronal and root caries compared to placebo or fluoride alone.

Breastfeeding is a source of complex prebiotic oligosaccharides and may protect the infant against caries. Systematic reviews have found that breastfeeding over the course of the child's first year of life can protect against early childhood caries. Breastfed infants are 4 times less affected by caries than bottle-fed infants, although extending breastfeeding beyond the first year of life is associated with a higher risk of caries than is seen in bottle-fed infants.

Probiotic bacteria are especially useful for young children and are administered as drops, tablets, or lozenges. Various direct effects in the oral biofilm as well as systemic immunomodulating effects have been reported. Among the findings are a selective reduction in oral mutans streptococci counts and a shift of the oral microbiota to increased levels of health-related non-mutans streptococci. Further investigations are needed to document the impact of probiotic supplements on microbial diversity and composition. The best and most consistent findings are seen in toddlers and preschool children, who represent an age where the ability to influence the composition of the biofilm is most pronounced. Probiotic therapy to maintain oral health is the most advanced of the emerging concepts seen in clinical caries trials.

### Clinical Significance

Dental caries may not be amenable to eradication, but the later forms of carious disease can be prevented. The caries process tends to be slow enough that various preventative approaches can be used successfully. The most important target behaviors are a reduction in sugar intake, good oral hygiene, reductions in plaque metabolism, and enhanced salivary function. Biofilm engineering early in life may support the development of a balanced microbiome and also offers promise to prevent carious disease.

Twetman S: Prevention of dental caries as a non-communicable disease. *Eur J Oral Sci* 126(Suppl 1):15-25, 2018

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