Episode 86 – Dental Caries: Part 1 June 9, 2023

Overview

Dental caries is the most common noncommunicable disease and a major public health concern. Dental caries affects individuals of all ages worldwide. The World Health Organization (WHO) Global Oral Health Status Report (2022) estimated more than one third of the global population lives with untreated dental caries. Untreated dental caries in permanent teeth is the most prevalent condition among all oral diseases (i.e., severe periodontitis, tooth loss, oral cancers), affecting over two billion people worldwide. Untreated caries in primary teeth is the single most common chronic childhood disease, affecting 514 million children globally. [1] [2]

Dental caries was the most prevalent condition included in the 2015 Global Burden of Disease study, ranking first for decay of permanent teeth (2.3 billion people) and 12th for primary teeth (560 million children). [3]

Almost half of the world's population is affected by dental caries, making it the most prevalent of all health conditions. High levels of dental caries occur in middle-income countries, where sugar consumption is high. [1] [3]

Prevalence in Canada

Based on the 2019 Global Burden of Disease study, the prevalence of untreated caries of primary teeth in Canadian children 1-9 years was 39% and prevalence of untreated caries of permanent teeth in individuals 5+ years was 25%. [4]

Negative impacts

Dental caries develops when oral bacteria metabolize sugars to produce acid that demineralizes hard tissues of teeth. Early stages are often asymptomatic. Advanced dental caries can lead to pain, infections, abscesses, sepsis, and tooth loss. [3]

Severe dental caries and tooth loss negatively impact systemic health, esthetics, function, self-esteem, and quality of life. Repeated episodes of pain as well as chewing and sleeping difficulties reduce quality of life and productivity. For example, dental caries is a major cause of productivity losses at work. [1] [3] [5]

Negative impacts from untreated caries are also common among children and adolescents, frequently causing acute infection, dental pain, and discomfort. Untreated caries affects children's ability to eat, leading to poor nutrition, growth, and weight gain. It also impacts ability to speak, learn, and sleep, as well as appearance and self-

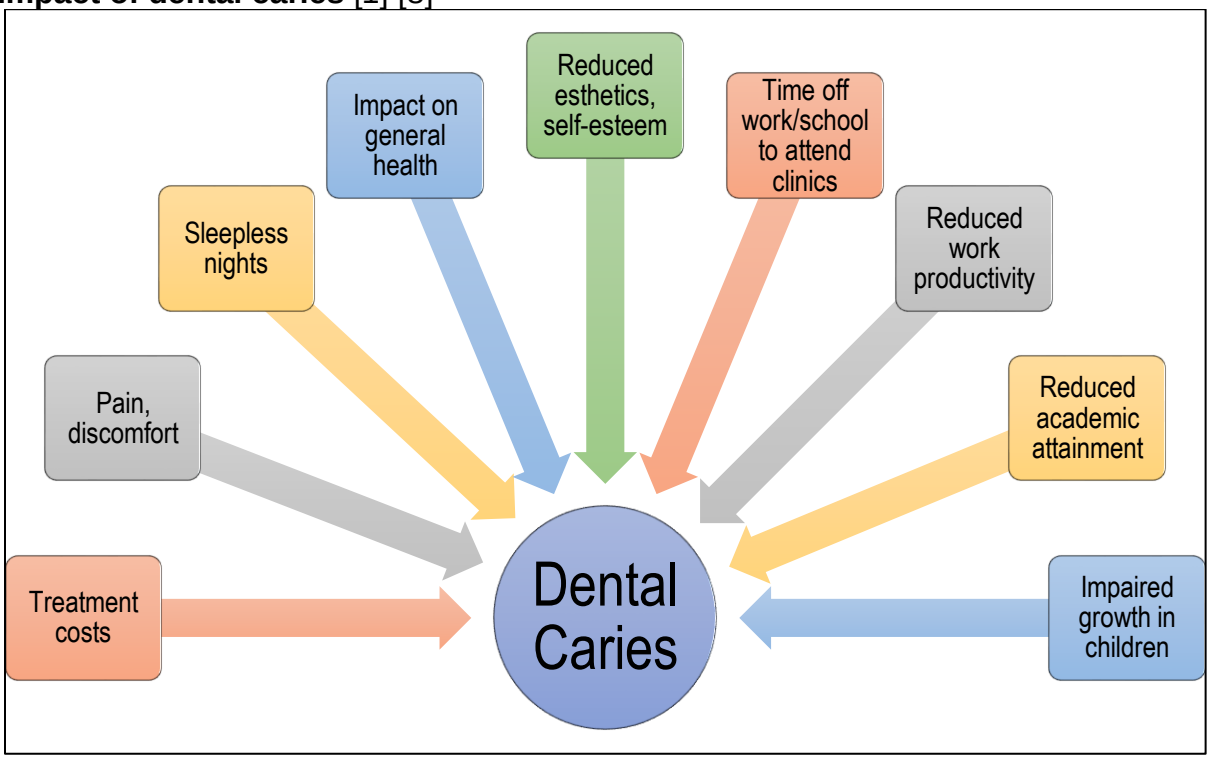
esteem. Tooth pain can affect school attendance, leading to poorer academic performance. These negative impacts disproportionally affect those from more disadvantaged backgrounds. [1] [6]

A cross-sectional study by Quadros et al. (2020) assessed for dental caries presence and severity in 363 adolescents of low socioeconomic status. Clinical findings were compared with school academic performance. Dental caries was significantly related to poorer academic performance, with severity (visible pulp, abscess, fistula) more strongly related to lower academic performance. The study emphasizes caries prevention and treatment remain vitally important for overall health and wellness. [7]

Dental caries is an expensive disease to treat, consuming 5-10% of healthcare budgets in industrialized countries. In many high-income countries, extraction of carious teeth under general anaesthesia is the main reason for hospitalization of young children. [1] [3]

Globally in 2010, it was estimated $298 billion (USD) was spent on direct costs associated with dental caries and $144 billion (USD) on indirect costs. [3]

Impact of dental caries [1] [8]



Dental caries as a noncommunicable disease

Dental caries is regarded as a preventable noncommunicable disease (NCD). It shares several behavioural, socioeconomic, and lifestyle factors with other NCDs (e.g., obesity, diabetes). Caries prevention has traditionally relied on fluoride exposure, diet control, thorough oral hygiene, and antibacterial measures. Prevention of dental caries as an NCD does not disqualify these methods, but brings them into a new context. [9]

For many decades, dental caries was described as an infectious transmissible disease caused by pathogenic bacteria, primarily *Streptococcus mutans.* It was believed these bacteria were infectious agents and infants acquired this pathogen from their mothers only after the eruption of primary teeth. As with other infectious diseases, efforts focused on limiting or eliminating *S. mutans* (e.g., via antimicrobials and hard tissue removal, up to sound dentin), and preventing transmission. However, trying to eradicate specific bacteria from dental biofilm is futile, as pathogens are endogenous to the oral cavity and remain as members of the oral microbiota, regardless of attempts to eliminate them. [10] [11]

The concept that caries is a transmittable infectious disease would require caries prevention by vaccination or antibiotics, approaches to control classical infectious diseases to kill a specific pathogen. Koch's key postulates state the presence of an organism leads to disease, and the absence of that organism prevents disease development. There are no specific 'pathogens' that fulfil Koch's postulate and are diagnostic for the disease. Species commonly indicated as caries 'pathogens', such as *S. mutans*, are frequently present in caries-free individuals. [9] [10] [12] [13]

Furthermore, DNA- and RNA-based studies discovered a diverse ecosystem where *S. mutans* account for <1% of the total bacterial community isolated from caries lesions. This supports the concept that multiple microorganisms act collectively, probably synergistically, to initiate and develop a carious lesion, replacing the 'one pathogen, one disease' paradigm of dental caries. [10] [14]

Dental caries results from a change in the oral microbiota composition, where certain acid-tolerant and acidogenic bacteria become more prevalent. The main driver of this dysbiotic shift is frequent sugar consumption and is the primary factor in lowering oral pH. Cariogenic species metabolize free sugars and create acidic by-products, creating a low pH environment that favours acid-tolerant and acidogenic bacteria, rather than commensal (beneficial) bacteria that prefer a near-neutral environment. Similarly, impaired salivary flow reduces buffering capacity, and inadequate oral hygiene allows biofilm accumulation driving similar shifts. If the acidic environment is sustained, the tooth structure is demineralized and dental caries develops. [10]

The pathogenesis of dental caries demonstrates the disease is not an infection in the traditional sense, in that it is not caused by the introduction of a pathogen that would not normally be present in a healthy individual. Rather, disease development is driven by change in the oral environment owing to behaviours, physiological characteristics, and genetic susceptibilities of the individual, demonstrating caries better fits the description of an NCD. [10]

As an NCD, dental caries shares characteristics with other NCDs (e.g., cardiovascular diseases, chronic respiratory diseases, cancer, diabetes) including long duration, slow progression, not transmissible from person-to-person (in the traditional sense), strongly related to modifiable behavioural risk factors, and disproportionally affecting disadvantaged populations. [11]

Given the high prevalence of dental caries, and its consequences on health and quality of life, recognizing caries as a NCD is required to target effective management. This understanding of dental caries supports prevention through modifying risk factors (behaviours) and management based on an interdisciplinary approach.

After the 72nd session of the WHO World Health Assembly in May 2019, the World Dental Federation (FDI), and the International Association for Dental Research (IADR) signed a joint statement for dental caries to be included among NCDs. According to the WHO, NCDs are those with a long duration (i.e., chronic diseases). NCDs usually have multiple associated factors that can explain their onset, including genetic, physiological, environmental, and behavioural determinants. [11]

Terminology

Dental caries is a biofilm-mediated, diet modulated, multifactorial, noncommunicable, dynamic disease resulting in net mineral loss of dental hard tissues. It is determined by biological, behavioural, psychosocial, and environmental factors. A caries lesion develops as a result of this process.[1] [15]

The disease is caused by dietary sugars that are broken down by microorganisms in the biofilm on a tooth surface, which produces acids that demineralize tooth enamel over time. The demineralization and remineralization process is dynamic. Dental caries can be reversed in early stages. However, when factors promoting demineralization exceed those favouring remineralization, dental caries progresses into dentin. [16]

Caries lesion is the clinical sign of caries. Caries lesions can be categorized according to their:

- Anatomical location on the tooth (coronal or root/cementum surface);
- Severity (noncavitated, cavitated);
- Penetration depth into the tissue (enamel, dentin, pulp); and
- Activity status (active, inactive). [15]

Noncavitated carious lesion is a surface that appears macroscopically intact and without clinical evidence of cavitation. Sometimes referred to as incipient, initial, early, or white-spot lesions (although these lesions can be brown). Noncavitated lesions have the potential to reverse by chemical interventions, or arrest by chemical or mechanical interventions. [17]

Cavitated lesion is a carious lesion with a surface that is not macroscopically intact and with a distinct discontinuity or break in surface integrity, usually determined by visual or tactile means. Cavitated lesions are less likely to reverse or arrest without chemical or mechanical interventions. [17]

[1] This definition of dental caries was developed by the 2019 consensus report from the joint workshop of the European Organization for Caries Research (ORCA) and the International Association for Dental Research (IADR) Cariology Research Group.

Initial caries lesion is a frequently used term for noncavitated caries lesion. Although the term implies an early-stage lesion, the lesion could have been present for a lifetime. The term refers to stage of severity and does not inform about lesion activity. [15]

White-spot lesion (white spot) is a popular term for noncavitated lesions in the past. The term refers only to the colour of the lesion, does not reflect lesion activity, and may be confused with other types of pathology (e.g., dental fluorosis, molar incisor hypomineralization). [15]

Primary caries is a caries lesion on a previously sound tooth surface. [15]

Secondary caries (recurrent caries) is a caries lesion that developed adjacent to a restoration. [15]

Residual caries is demineralized carious tissue left in place before a restoration was placed. [15]

Rampant caries is a historic term used to describe multiple caries lesions in the same person, often used in association with early childhood caries or radiation caries. [15]

Early childhood caries (ECC) is the early onset of caries in young children with often fast progression, which can result in complete destruction of the primary dentition. An epidemiological definition of ECC is the presence of one or more decayed (noncavitated or cavitated lesions), missing (due to caries), or filled surfaces in any primary tooth of a child under age six. Due to frequent consumption of carbohydrates, especially sugars, and inadequate oral hygiene in small children, ECC demonstrates an atypical pattern of caries attack, especially on smooth surfaces of maxillary anterior teeth. Children with ECC have a much higher risk of continued disease burden in their later life. [1] [15]

Caries lesion detection is identifying signs of dental caries. Caries lesions can be detected clinically at various thresholds and stages (e.g., noncavitated, micro-cavitated, cavitated). Caries lesions can also be detected by supplementary detection tools, such as radiography and optical and electrical methods. [15]

Visual detection is the identification of a lesion visually and should be carried out on clean and dry teeth. [15] [18]

Tactile assessment is the atraumatic tactile evaluation of the surface integrity and texture of a caries lesion using a manual dental instrument. Tactile methods using an explorer or ball-tipped dental probe provide adjunctive information on evidence of enamel roughness and softening of dentin. It should not be confused with the historical practice of lesion detection by ‘catching’ the probe. This is no longer recommended due to concerns about the potential, when the probe is used under force, for iatrogenic damage to the enamel surface and promoting the progression of caries. [15] [18]

Radiographic detection is identifying a radiolucency interpreted as a caries lesion on a dental radiograph. Radiographs (e.g., bitewings) can detect lesions on contacting

approximal surfaces. However, this method has varying sensitivity and specificity, depending on the stage of the lesion. [15] [18]

Caries activity reflects the mineral balance, in terms of net mineral loss, net mineral gain, or stasis over time. Active caries implies caries initiation and progression. Inactive caries implies caries arrest and regression. [15]

Caries lesion severity assessment is staging net mineral loss from small lesions to advanced destruction involving the dental pulp. Examples of classification methods include:

- Clinical staging into noncavitated, microcavitated, and cavitated lesions;
- Clinical and radiographic staging into initial, moderate, and extensive lesions; and
- Clinical staging from noncavitated lesions to pulpal sepsis. [15]

Sound enamel/dentin is tooth structure without clinically detectable alterations of the natural translucency, colour, or texture. [15]

Demineralization is the loss of tooth mineral due to acids. In dental caries, this process is biofilm-mediated, while in erosion,[2] the acid comes from other sources. [15]

Remineralization is the net gain of mineral in previously demineralized tissue. It does not imply the lesion has regained its original mineral content. [15]

Cariogenic describes substrates or microorganisms capable of promoting caries. [15]

Cariogenicity is the potential of substrates or microorganisms to promote caries. [15]

Cariostatic describes substances or procedures capable of arresting caries. [15]

Risk factors

There are multiple risk factors for dental caries development, including sugar consumption, inadequate oral hygiene, low fluoride exposure, and age.

Sugar

Consumption of free sugars in food and beverages is the most important risk factor for dental caries and is one of the common risks for other noncommunicable diseases (e.g., diabetes, obesity). In many countries the primary source of free sugars are sugars-sweetened beverages, including fruit-based and milk-based sweetened drinks and 100% fruit juices, as well as candy, cakes, cookies, sweetened cereals, sweet desserts, sucrose, honey, syrups, and preserves. [3] [19]

High sugar consumption is directly related to higher caries activity, and restricting sugar intake decreases dental caries incidence and severity. In addition to decreasing sugar intake, oral self-care can significantly reduce dental caries development and slow progression. [1]

[2] Refer to Episode 82 for information on dental erosion.

Sugar is cheap and almost universally available worldwide. In high- and middle-income countries, sugar consumption far exceeds WHO recommendations. In many low-income countries, consumption is steadily rising. The very high level of free sugars found in commercial foods for infants and young children is a cause for concern. [1]

Liu et al. (2020) estimated Canadians consumed an average of 57 g/day of added sugars, 67 g/day of free sugars, and 106 g/day of total sugars (~26 teaspoons of sugar/day). The foods with the highest added and free sugar content were desserts, sweets, breakfast cereals, baked products, beverages, and snacks. Desserts, sweets, and beverages were the main contributors of sugar in the Canadian diet. The findings demonstrated the majority of Canadians consumed more added and free sugars than recommended. [20]

In 2015, the WHO released guidelines for adults and children to reduce daily intake of free sugars to less than 10% of daily total energy intake, and ideally to less than 5% or roughly 25 grams (6 teaspoons) per day to achieve additional health benefits. Evidence indicates keeping intake of free sugars to less than 10% of total energy intake reduces the risk of overweight, obesity, and dental caries. [21]

WHO defines free sugars as all monosaccharides (e.g., glucose, fructose) and disaccharides (e.g., sucrose or table sugar) added to foods by the manufacturer, cook, or consumer, and sugars naturally present in honey, syrups, fruit juices, and fruit juice concentrates. Free sugars provide little or no nutritional value. [21]

An updated systematic review by Moores et al. (2022) included data published between 2011 and 2020 to examine the relationship between the amount of sugar consumed and levels of dental caries. Overall, eleven of fifteen studies on children and six of eight studies on adults showed at least one positive association between sugar intake and caries levels. Amalgamating data from the new update with those from the original review showed a positive association between the amount of sugar consumed and caries levels. Restricting free sugar intake to <10% of energy showed a lower caries incidence with moderate-quality evidence. These findings strengthen the original evidence upon which the WHO based its guidelines on sugar intake for adults and children. [22]

Many sugars consumed today are “hidden” in processed foods. For example, one tablespoon of ketchup contains approximately four grams (~one teaspoon) of free sugars. One can of sugar-sweetened soda contains up to 40 grams (~ten teaspoons) of free sugars. [21]

Sugar comes in many forms, such as white sugar, brown sugar, molasses, honey, maple syrup, and corn syrup. Sugars are often added to processed foods to improve flavour, colour, texture, and shelf-life and may be listed on food labels as glucose, fructose, dextrose, maltose, or sucrose. [23]

Research by Public Health Ontario and University of Waterloo showed 66% of 40,000 packaged food products in Canada contain at least one added sugar. The most

common added sugar term was "sugar," identified in 54% of all food products analyzed. The next five most frequently appearing terms (dextrose, glucose, glucose-fructose, corn syrup, maltodextrin) were found in 45% of food products, collectively. Other added sugars included fruit juice concentrate, honey, molasses, syrup, lactose, fructose, cane juice, malt, barley malt, high-fructose corn syrup, caramel, agave, sucrose, date paste, maltose, carob, treacle, ethyl maltol, corn sweetener, and nectar. (Refer to table on page 9 for more hidden sources of sugar.)

Added sugars were highest in the expected food products such as candy, sweet bakery products, and soda. But also, the majority of products frequently marketed as 'healthy' options (e.g., yogurt, juice, breakfast cereals, snack and granola bars) also listed added sugars in their ingredients. In addition, almost half of all infant formulas and baby food studied listed added sugars as part of their ingredients. The findings underscore the prevalence of added sugar in the Canadian food supply as well as the difficulty identifying added sugar content, which requires a detailed understanding of the many ways in which added sugar is reported as an ingredient. It highlights the difficulty for consumers to identify added sugars using nutrition labels. [24]

Early exposure to sweet tastes predicts similar food preferences and eating behaviour in later life. A prospective study by Bernabé et al. (2020) found introducing sugar-sweetened beverages during the first year of life can put children in a trajectory of high levels of dental caries. The findings support current recommendations to avoid sugars for very young children. [25]

In a large review by Huang et al. (2023) of 73 meta-analyses, which included 8,601 studies, high consumption of added sugar was associated with significantly higher risks of 45 negative health outcomes, including diabetes, gout, obesity, hypertension, myocardial infarction, stroke,[3] cancer, asthma, dental caries, depression, and early death. The authors concluded high dietary sugar consumption is more harmful than beneficial for health. Reducing the consumption of free sugars or added sugars to below 25 g/day (~six teaspoons/day) and limiting the consumption of sugar sweetened beverages to less than one serving/week (~200-355 ml/week) are recommended to reduce the adverse effect of sugars on health. [26]

According to research by Burgette et al. (2023), more than two thirds (72%) of mothers indicated grandparents gave their grandchildren large amounts of cariogenic foods and beverages (e.g., candy, baked goods, juice, soda) or did not limit their grandchildren's consumption of cariogenic foods and beverages. Only 51% of the mothers addressed the issue with grandparents. Factors influencing whether mothers had this conversation included:

- Frequency at which the grandparents and children interacted;
- Mothers' dependency on grandparents for childcare;
- Quantity of sugary foods and beverages provided by grandparents; and
- Strength of the relationship between mothers and their children's grandparents.

[3] Refer to Episodes 79, 80, and 81 for additional information on cardiovascular diseases.

Initiatives to decrease childhood caries should consider how to address interpersonal family relationships as part of successful sugar-reduction interventions. [27]

Liquid or chewable medications containing sugars, either prescription or over the counter, can contribute to the frequency and amount of sugar intake. This presents a challenge as people who are likely to be taking long-term medications in liquid format are likely to be at increased risk of dental caries, most notably children with chronic illnesses, individuals with special needs, or vulnerable older adults. [16]

Sources of hidden sugar in foods*			
Agave	Corn sweetener	Golden syrup	Panocha
Agave nectar	Corn syrup	Grape sugar	Powdered sugar
Agave syrup	Corn syrup solids	Granulated sugar	Rapadura
Barbados sugar	Crystalline fructose	High-fructose corn syrup	Raw sugar
Barley malt	Date paste	Honey	Refiner's syrup
Barley malt syrup	Date sugar	Icing sugar	Rice malt syrup
Beet sugar	Dehydrated cane juice	Invert sugar	Rice syrup
Blackstrap molasses	Demerara sugar	Lactose	Saccharose
Brown sugar	Dextrin	Malt	Sugar
Brown rice syrup	Dextrose	Malt syrup	Sorghum syrup
Buttered syrup	Ethyl maltol	Maltodextrin	Sucanat
Cane juice	Evaporated cane sugar	Maltol	Sucrose
Cane juice crystals	Florida crystals	Maltose	Sweet sorghum
Cane sugar	Fructose	Mannose	Syrup
Caramel	Fruit juice	Maple syrup	Table sugar
Carob	Fruit juice concentrate	Molasses	Tapioca syrup
Carob syrup	Fruit nectars	Muscovado	Treacle
Castor sugar	Galactose	Nectar	Turbinado sugar
Coconut palm sugar	Glucose	Palm sugar	White granulated sugar
Coconut sugar	Glucose syrup solids	Pancake syrup	Yellow sugar
Confectioner's sugar	Golden sugar	Panela	*Nonexhaustive list

Inadequate oral hygiene

Inadequate oral hygiene accelerates dental plaque accumulation and bacterial activity in dental plaque, which results in the development and progression of dental caries.

In children, poor oral hygiene has been found to be the main cause of ECC. Infants and toddlers who had heavy plaque accumulation were at higher risk of developing dental caries and having severe ECC. Similarly, preschool children who had a significantly higher plaque index score developed more dental caries than those with lower plaque scores. [28]

A cross-sectional study by Manchanda et al. (2023) found poor oral hygiene was a risk factor associated with the presence of noncavitated lesions in preschool children, while poor oral hygiene and poor parental oral health knowledge and attitude were associated with the presence of cavitated lesions. This may be explained as parents with less knowledge about caries causation and prevention are potentially less attentive about

their child's oral health and oral hygiene, resulting in decreased oral health. The findings highlight the importance of effective toothbrushing and enhancing parental oral health knowledge to support health behaviour change to help prevent the development of noncavitated and cavitated carious lesions. [29]

A ten-year longitudinal study by Edman et al. (2021) investigated the prevalence of dental caries in an elderly population.[4] The study revealed no increase in the prevalence of dental caries, indicating good oral health can be preserved among elderly people as long as adequate preventive routines are maintained. The strongest risk for dental caries lesions was among participants with inadequate oral hygiene routines (toothbrushing once a day or less and seldom using interproximal devices) and in need of help in daily living, emphasizing the importance of oral hygiene and collaboration between oral healthcare services and community-based healthcare. [30]

Lack of optimum fluoride

Fluoride, a naturally occurring mineral, helps prevent dental caries and can even reverse the earliest stages of tooth damage. Dental caries risk increases if there is a lack of or low fluoride exposure, for example from drinking water, professional applications, or toothpaste. [31]

Affordability of fluoride toothpaste

Affordability of fluoride toothpaste has been identified as a barrier for widespread use, particularly for individuals and families with low income. Gkekas et al. (2022) assessed fluoride toothpaste affordability in 78 countries. Results showed fluoride toothpaste was highly affordable in high-income countries, relatively affordable in middle-income countries, and highly unaffordable in low-income countries. A person living on the lowest-paid unskilled government worker income in a high-income country would have to work about 4.5 hours to purchase an annual supply of fluoride toothpaste. A person in the same income category living in a low-income country would need to work an average of 3.6 days to buy the same amount of toothpaste. For most low-income countries surveyed, the required expense was a catastrophic expenditure. [1] [32]

Age

Everyone is at risk of dental caries, but children and adolescents are most at risk. Primary teeth are prone to dental caries as soon as they erupt, with a peak prevalence around age six. Caries prevalence in permanent teeth typically shows steep increases after eruption and reaches the highest levels in late adolescence and early adulthood, with a third peak in older age, due to the appearance of root caries. [1] [8] [33]

In older adults,[5] polypharmacy leading to xerostomia is a significant risk factor for dental caries, as well as sugared oral nutritional supplements. Ten percent of adults 75-84 years of age are affected by secondary coronal caries, likely related to the prevalence of restorations in the older population. The majority of dental caries occurs in adults because the disease is cumulative. [31] [34]

[4] Refer to Episode 55 for additional information on seniors and oral health.
[5] Refer to Episode 55 for additional information on aging and oral health.

Enamel defects
Enamel defects may increase susceptibility to dental caries risk. For example, research studies have confirmed enamel hypoplasia and molar incisor hypomineralization increase the risk of dental caries. Also, children and adolescents with cystic fibrosis[6] are thought to be at increased risk for dental caries due to factors related to CF, such as enamel defects and other factors. [8] [35] [36] [37]

Xerostomia
Certain medications, some medical conditions (e.g., Sjögren's syndrome), radiation to the head or neck, or certain chemotherapy drugs can increase dental caries risk by reducing saliva production. [31]

Xerostomia has been associated with >500 medications, including antidepressants, antihistamines, antihypertensives, anxiolytics, diuretics, and decongestants.[7] [38]

Sjögren's syndrome[8] is a relatively common chronic, systemic, autoimmune, inflammatory disorder affecting various exocrine glands, including salivary glands. Saliva can be thick, ropey, and mucinous, or absent. [39]

Radiation-associated caries[9] can start within three months of completing radiation therapy to the head or neck.[10] High risk of developing caries is due to the combination of permanent reduced saliva flow, high sugar consumption, and high level of cariogenic flora. Also, high-sugar containing food supplements are often prescribed to aid calorie intake. [40]

Decreased salivary flow causes reduced:
- Buffering capacity of saliva.
- Washing away of food, debris, and pathologic bacteria.
- Remineralization of enamel lesions. [41]

Caries experience of family and close contacts
Traditional microbial risk markers for ECC include acidogenic-aciduric bacterial species, namely *S. mutans* and *Lactobacillus*. *S. mutans* may be transmitted vertically from caregiver (e.g., mother, father, other caregivers) to the child through salivary contact, affected by frequency and amount of exposure. Horizontal transmission (e.g., between other family members, such as siblings, or children in daycare) also occurs. [42]

Mental health
Data from systematic reviews and meta-analysis suggest individuals with anxiety and depressive disorders present a greater risk of dental caries. The reasons may be multifactorial, including decreased interest in oral self-care, increased risk in smoking

[6] Refer to Episode 83 for discussion on cystic fibrosis and oral health.
[7] Refer to Episode 62 for additional information on drug-induced xerostomia.
[8] Refer to Episode 62 for additional information on Sjögren's syndrome.
[9] Refer to Episode 78 for discussion on radiation-associated caries.
[10] Refer to Episode for additional information on the effect of radiation therapy to the head and neck on the oral microbiome and oral innate immune response.

and sugary food and beverage consumption, and side effects of certain psychotropic medications that induce dry mouth. [43]

Cognitive impairment
Individuals with severe cognitive impairment, including dementia,[11] are at increased risk for dental caries because of decreased ability to engage in oral self-care. Educating the caregiver, as well as the client, is an important part of disease prevention and management. [44]

Socioeconomic status
Dental caries is associated with socioeconomic status, with high prevalence rates among poor and disadvantaged populations, which have lower access to prevention and care. [3]

Goldfeld et al. (2022) conducted a prospective population-based study that included the birth cohorts of four high-income countries (Australia, Canada, Netherlands, Sweden) to evaluate the extent of inequalities in dental caries in children. Low family income and low maternal education level in all four countries were related to a higher rate of dental caries among children. Fluoridated water was not available to all children in the four countries included in this study. The research highlights the need for public awareness and supportive policies to prevent dental caries in disadvantaged populations, such as low-income families, those with no access to water fluoridation, and a low level of maternal education. [45]

Food insecurity
Research by Bahanan et al. 2021 used data from 10,723 adults from the National Health and Nutrition Examination Survey (NHANES) to evaluate the association between food insecurity and dental caries. Food insecurity was found to be significantly associated with untreated dental caries and fewer teeth. A possible explanation is individuals with food insecurity are more likely to consume a poor-quality diet. Food insecurity was associated with untreated caries, demonstrating how social determinants of health affect oral health. These findings highlight the importance of assessing food insecurity as a risk factor for dental caries. [46]

E-cigarettes
E-cigarettes[12] may promote dental caries because of the sugars added to supplement flavourings. Also, propylene glycol and glycerine in e-cigarette aerosols are likely to adhere to the soft and hard tissues in the oral cavity. This interaction may facilitate bacterial adhesion leading to caries. A study by Kim et al. (2018) showed e-cigarette aerosols increased the adhesion of *S. mutans* to enamel and promoted biofilm formation. Moreover, enamel exposed to flavoured e-cigarette aerosols showed decreased hardness, compared with enamel exposed to unflavoured controls. [47] [48]

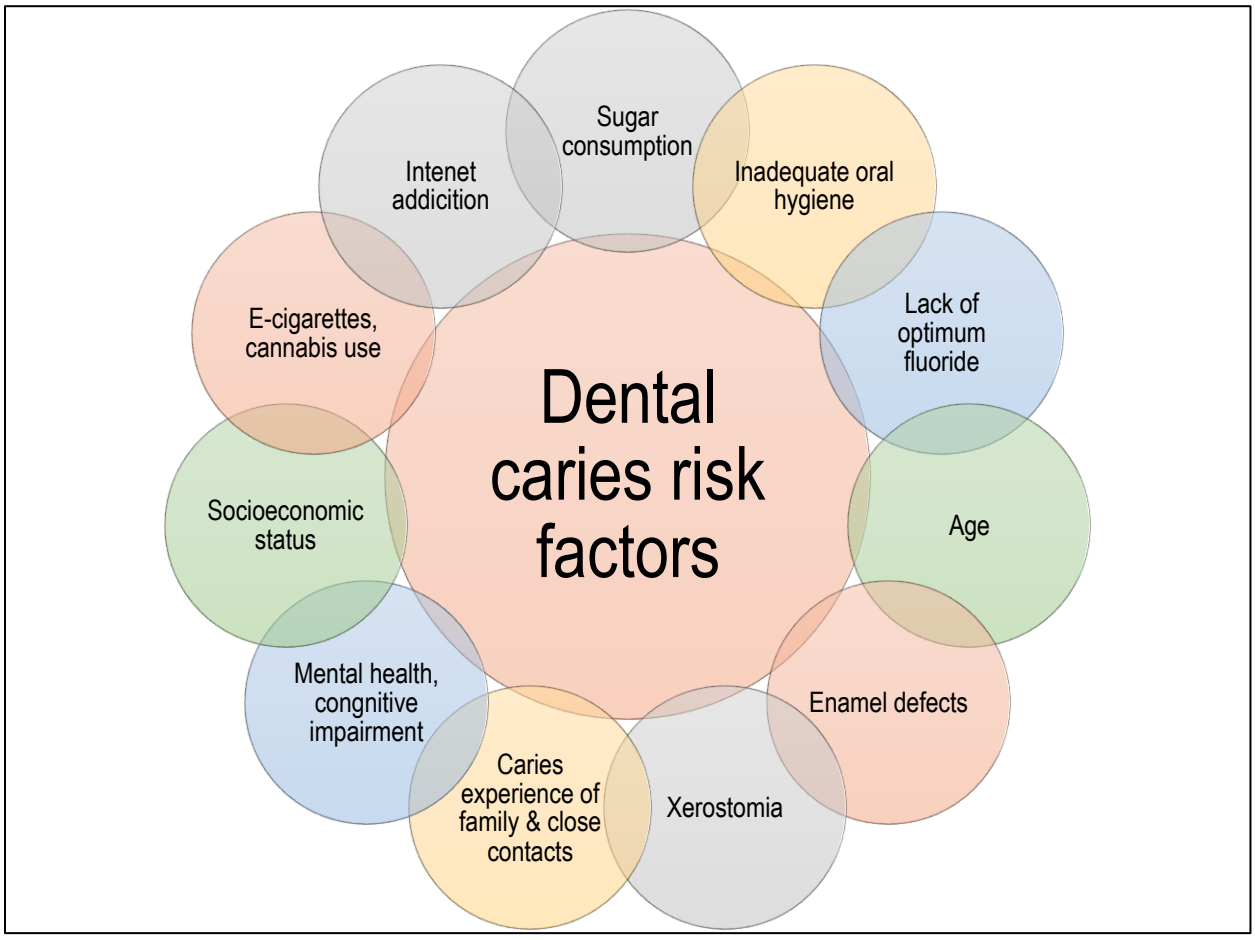
[11] Refer to Episode 29 for information on dementia and oral health.
[12] Refer to Episode 19 for more information on e-cigarettes and vaping.

Cannabis

Cannabis smoking[13] has been associated with poor oral health, and higher prevalence of dental caries and periodontal disease. Particularly when smoked, cannabis can cause xerostomia, lower salivary pH, and promote plaque and calculus formation, thus increasing the occurrence of caries. Individuals who use cannabis, especially if used on a regular or daily basis, tend to also have poorer oral health, as they tend to brush their teeth less frequently, visit their oral healthcare provider less often, have higher cariogenic diets, have xerostomia, and higher plaque scores than individuals not using cannabis, all of which increase the risk of caries. [49]

Internet addiction

A study of high schoolers in Japan found an indirect relationship between internet addiction and prevalence of caries through unhealthy lifestyle, such as short sleep duration, frequent consumption of soft drinks and sweet snacks, irregular mealtimes, and late-evening snacking. Also, the participants with internet addiction had poorer oral health behaviors, such as less frequent toothbrushing and not brushing teeth before bed. Previous studies reported adolescents with internet addiction tend to restrict their eating habits to accommodate their heavy internet use. Similarly, they may dedicate less time to oral self-care to spend more time online and neglect tooth brushing. [50]



[13] Refer to Episode 58 for discussion on cannabis and oral health.

Take home messages

Dental caries is a multifactorial chronic noncommunicable disease that affects people of all ages worldwide. Dental caries results from microbiome dysbiosis with the involvement of multiple cariogenic species, that have the cariogenic traits of acid production and acid tolerance. Sugar consumption plays an important role interacting with microbiome dysbiosis, determining the fate of caries development. Key drivers of dental caries include:

- Inadequate exposure to fluoride in the water supply and oral hygiene products (e.g., toothpaste).
- Availability and affordability of high sugar food, especially sweetened beverages.
- Aggressive marketing of food and beverages high in sugar, mainly targeting children.
- Poor access to oral healthcare services in the community.

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