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Dental caries from the past to the future: is it possible to reduce caries prevalence?

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ABSTRACT

Dental caries is a significant oral health issue encountered globally. Unlike bone tissue, dental tissue lacks the capacity for self-renewal, leading to the permanence of pathological changes in teeth. Dental caries is primarily the result of acid production by microorganisms that metabolise sugary foods, which demineralises tooth enamel. If left untreated, caries can progress beyond the enamel and damage the dentin and pulp tissue. The development and spread of dental caries is influenced by an individual's dietary habits, oral hygiene practices and various socio-economic factors. Throughout history, dental decay has consistently posed a major health issue across both ancient and contemporary communities. The incidence of dental caries has been influenced by factors such as dietary preferences, oral hygiene routines, and shifts in societal lifestyles. In particular, increased consumption of fermentable carbohydrates significantly increases the risk of caries formation. Conversely, preventive measures such as fluoride applications and a balanced diet can substantially reduce the incidence of caries. Other factors impacting the risk of caries include the chemical composition of saliva, the individual's general health and various medical conditions. Fluoride applications, healthy eating habits and regular dental visits stand out as effective methods for preventing dental caries. Therefore, the success of dental caries prevention strategies depends on raising health awareness at the individual level and strengthening public health policies. This multifaceted approach will help to create healthier oral conditions for future generations.

Keywords: Dental caries, dental anthropology, diet, dental anatomy, caries prevalence

INTRODUCTION

Bone tissue undergoes a continuous process of renewal, giving it a dynamic structure capable of self-regeneration. In contrast, dental tissues lack this regenerative capacity. Pathological conditions in bone are often characterised by an increase or decrease in bone mass, whereas pathological processes in teeth typically manifest as tissue loss. Dental caries has been identified as one of the most common infectious dental diseases leading to tissue loss in dental tissues.[1]

Dental plaque is a biofilm layer formed by microorganisms that adhere to and accumulate on the tooth surface. These microorganisms induce demineralization of the hard tissues of the teeth through the acidic products generated during the breakdown of carbohydrates in the teeth, leading to the formation of caries.[1,2]

The increase in acidity and decrease in pH in the oral environment results in damage to dental minerals and the initiation of dental caries. It can be said that dental caries develops as a consequence of the acid-base imbalance that occurs throughout the day. In particular, bacteria such as *Streptococcus mutans, Streptococcus sanguis, Actinomyces viscosus, Actinomyces naeslundi and Lactobacillus acidophilus* are among the microorganisms that cause dental caries.[3-8]

Caries usually begins in the enamel layer, leading to loss of substance and disruption of enamel integrity. If left untreated, caries progresses to the dentin and then to the pulp tissue. Dental caries occurs in the enamel, cementum and dentin layers and is classified according to its location on the tooth surface, including types such as fissure caries, proximal caries, facial and lingual smooth surface caries and root caries.[9,10]

The teeth most commonly affected by caries are, in order, molars, premolars, incisors and canines, with first molars being particularly affected. More caries are observed in the maxillary teeth than in the mandibular teeth, which is attributed to the less effective action of saliva in the maxilla. When examining the localisation of caries,

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the most common sites are the fissures on the occlusal surfaces and the lateral surfaces of the crowns.[10]

A strong correlation exists between dietary choices and the incidence of dental caries. The nature and quantity of carbohydrates consumed significantly impact the rate of dental caries within a population. Diets rich in carbohydrates and deficient in proteins are likely to contribute to a higher prevalence of dental decay.[1]

Dental caries has been a common chronic disease throughout history. Archaeological finds indicate the presence of caries in the teeth of prehistoric dinosaurs, reptiles and primitive mammals. A study of the teeth of an extinct species of mammal, *Microsyops latidens*, has revealed some of the oldest caries cavities ever discovered. The fruit-based diet of these mammals supports the conclusion that dental caries is directly related to dietary habits.[11]

Anthropological studies confirm the presence of dental caries in ancient societies. However, as civilisation has progressed, dental caries has become more prevalent in human life. Changes in dietary habits and the foods consumed are important factors influencing this process. Agriculture and industrialisation are among the factors that influence dietary patterns and thus the development of dental caries.[12]

HISTORICAL CHANGES IN THE PREVALENCE OF DENTAL CARIES

Dental caries has been one of the most persistent health problems in human history since the first human-like beings appeared. Spanning a broad time frame from prehistoric times to modern societies, dental caries has maintained its status as one of the most prevalent diseases in human history. The frequency of dental caries in ancient societies provides valuable insights into the oral hygiene practices, dietary habits and economic structures of those communities or individuals.[13-16]

Primitive societies tend to have a low prevalence of dental caries, largely due to their protein-rich diets and the consumption of hard foods that promote chewing and mechanical cleaning. [12] In the Paleolithic and Mesolithic periods, hunter-gatherer societies had rare cases of dental caries, but the transition to agriculture in the Neolithic period brought significant dietary changes, leading to an increase in the incidence of dental caries.[17-24]

The introduction of agriculture and the tools used to grind and prepare food made food softer and stickier, which prolonged its presence on teeth and increased the risk of caries.

Bernal et al.[26] have proposed that the consumption of carbohydrates, fats and proteins is closely related to the frequency of dental caries and that this relationship can be utulized to determine the economic activities of societies.[1,25]

Studies from the Middle Palaeolithic show a 0% rate of dental caries in Neanderthals, rising to 1% in the Upper Palaeolithic. With dietary changes in the Neolithic period, there was an increase in the prevalence of dental caries, which was higher in societies that transitioned to agriculture earlier. During the Chalcolithic period, which followed the Neolithic and the subsequent Metal Age, dental caries rates generally varied between 3-5%, reaching around 10% in advanced agricultural societies.[23,27,28]

Archaeological studies have revealed that the prevalence of dental caries remained low in European countries until the 19th century. However, between 1850 and 1960, an increase in dental caries rates was observed, in parallel with the increase in sugar cane imports from the Americas. This trend is associated with the availability of sugar in the early 20th century in developed and affluent countries. In England in the early 20th century, the rejection of volunteers for military service because of poor oral health was a warning sign for public health experts. Around the same time, the discovery by the dentist Frederic McKay of the effectiveness of fluoride in preventing dental decay led to the introduction of water fluoridation. After the 1970s, the dental caries epidemic declined significantly in Europe and other developed countries. However, there has been a continuing increase in the prevalence of dental caries in developing countries.[23,29]

THE CONTEMPORARY PROBLEM OF DENTAL CARIES

The 2016 World Health Organization (WHO) Global Burden of Disease Study highlights that dental caries remains one of the most prevalent health problems today. The study found that approximately 2.4 billion people worldwide have dental caries in their permanent teeth, and that 480 million children have dental caries in their primary teeth. The Global Oral Health Status The report, published in 2022, updated the number of caries cases in children to 514 million.[30-32] The global average prevalence of caries in primary teeth was estimated to be 43%, with 134 of the 194 WHO Member States having a prevalence of over 40% in primary teeth. In upper-middle-income countries, this rate reached 46%, while in high-income countries it fell to 38%. The highest number of caries cases was recorded in lower-middle-income countries (244 million cases) and the lowest in high-income countries (45 million cases). The majority (75%) of untreated primary caries was found in middle-income countries, where health systems and resources were often inadequate. The global average prevalence of permanent

dental decay was 29%, representing over 2 billion cases. The highest numbers of caries cases were found in lower-middle-income countries (816 million cases) and upper-middle-income countries (690 million cases). Middle-income countries accounted for 75% of untreated dental caries in permanent teeth.[31,33]

From 1990 to 2019, there was a 2.6% reduction in instances of dental caries, although the absolute number of cases rose by around 640 million. This escalation primarily stems from demographic expansions in low- and lower-middle-income nations. In contrast, upper-middle and high-income countries have seen a decline in cases, which may be attributed to heightened oral hygiene awareness and the adoption of preventive dental health strategies in these regions.[33]

RISK FACTORS FOR DENTAL CARIES

Risk factors encompass environmental, behavioral, and biological components that influence the likelihood of disease development.[34] Identifying these factors is crucial in preventing dental caries, a largely preventable disease. Early recognition of these risk factors, before clinical symptoms manifest, is essential in minimizing the risk of subsequent episodes of the disease.[35]

Caries risk, which indicates the likelihood of an individual developing a carious lesion in a given period of time, serves as a marker for predicting the future occurrence of the disease. The risk of developing dental caries is closely linked to an individual's lifestyle, dietary habits and behavioural factors.[36]

Particularly, sugar consumption is a significant risk factor for dental caries. It is well-documented that high sugar intake correlates with increased caries activity, and that reducing sugar consumption can significantly decrease both the incidence and severity of dental caries.[37]

Other important factors influencing caries risk include an individual's socio-economic status, dietary habits, oral hygiene habits, fluoride intake, salivary flow rate, salivary pH and buffering capacity, general health status and genetic predisposition. The detailed study of these factors play a critical role in the development of strategic approaches to the prevention and management of dental caries.[38]

EFFECTS OF DIETARY HABITS AND DIET ON CARIES RISK

The effect of fermentable carbohydrates on the pH of oral plaque was first documented by Stephan and Miller in 1943.[39] The frequent consumption of carbohydrates was thought to create an acidic environment in plaque, which favours the proliferation of cariogenic bacteria and contributes to the development of dental caries.[40]

Extensive research has documented a linear relationship between sugar consumption and dental caries.[41] However, starchy foods and fresh fruit have been observed to have less cariogenic properties. Foods that require intensive chewing stimulate salivary secretion and therefore have a lower cariogenic potential. For example, fibrous and hard fruits such as apples and carrots act as natural toothbrushes, cleaning the tooth surfaces during chewing. The use of sugar alcohols and artificial sweeteners such as xylitol, saccharin and aspartame instead of fermentable carbohydrates can reduce the risk of caries.[42] A diet rich in protein and vegetables and the consumption of dairy products has the potential to lower the risk of dental caries.[37]

Liquid foods move quickly through the mouth and have minimal contact with tooth surfaces. However, holding beverages in the mouth for extended periods and frequent consumption can increase the risk of dental caries. In particular, hard candies and lollipops left in the mouth for a long time can prolong the demineralization process due to the slow release of sugar.[43]

SOCIOECONOMIC AND DEMOGRAPHIC FACTORS RELATED TO CARIES

Oral and dental health directly influences an individual's quality of life and overall health, and cannot be viewed in isolation from general health. Extensive research indicates that socioeconomic status is a key determinant in both the oral and general health outcomes of individuals.[44]

Research shows that individuals with lower socioeconomic levels have a higher prevalence of dental caries. Lower levels of education and cultural background can lead to a lack of knowledge about oral health, resulting in poor brushing habits and the continuation of unhealthy dietary patterns. Economic constraints make it difficult to access preventive and curative dental health services, increasing the risk of dental caries.[45-47]

A study conducted in Ankara in 1972 on 5684 children aged 6-14 years found that the prevalence of dental caries was 43.1% in children from urban areas with high socio-economic status, but 50.5% in rural areas.[48]

Epidemiological studies suggest that age is associated with the prevalence of dental caries. Individuals may be more susceptible to caries development at certain stages of their lives. In particular, the period between the ages of 1-2 years, when *Mutans streptococci* are transmitted from mother to child, the completion of the primary dentition and the eruption of the first molars during the mixed dentition phase are periods when the risk of caries increases.

In both childhood and adulthood, females have been observed to have higher DMFT (Decayed, Missing, Filled Teeth) index scores than males.

Earlier eruption of large molars in girls compared to boys and a relatively higher frequency of eating in women are among the factors that can increase the risk of caries. Hormonal changes during female-specific periods such as menstruation, pregnancy and menopause can lead to changes in saliva flow rate and composition, increasing the risk of caries.[49]

THE ROLE OF SALIVA COMPOSITION IN CARIES FORMATION

Saliva plays a crucial role in preserving the health of both soft and hard tissues within the oral cavity, and is considered a vital factor in the development of dental caries. The functions of saliva, such as its flow rate, antimicrobial properties, buffering capacity and ability to remove food from tooth surfaces, play an important role in preventing the development of caries. [50,51]

Scientific studies have shown that people with dental decay have a faster and more intense production of acid in their saliva than people without dental decay. These findings strongly support the effectiveness of the buffering capacity of saliva in preventing dental decay.

In addition, research has shown that a low buffering capacity of saliva reduces the neutralisation of acids in plaque, which negatively affects the remineralization of early enamel lesions and increases the risk of caries formation.[52]

GENERAL MEDICAL FACTORS INFLUENCING CARIES FORMATION

Long-term and regular use of medicines containing sugars such as glucose, fructose or sucrose can increase the prevalence of dental caries. Classes of drugs such as antidepressants, antihistamines, anxiolytics and antipsychotics can reduce the rate of salivation, increasing the risk of caries.[49]

Autoimmune diseases and metabolic disorders also have a significant impact on the development of caries. For example, Sjögren's syndrome leads to reduced saliva production due to inflammation of the salivary glands and can disrupt the pH balance of the oral cavity, facilitating caries formation. Uncontrolled diabetes, due to high blood glucose levels, can cause changes in the composition of saliva, increasing the risk of caries.[53]

Cancer treatments, especially chemotherapy, can affect the mineralization of dental enamel, increasing the prevalence of dental caries. In addition, physical or mental disabilities can affect oral hygiene and thus increase the risk of dental caries.

Neurological conditions, such as Parkinson's disease, can make it difficult for individuals to maintain adequate oral care, potentially triggering the formation of caries. Similarly, individuals with developmental disabilities, including those on the autism spectrum, may face challenges with dental care, which can increase the risk of caries.[49]

DENTAL ANATOMY AND ITS RELATIONSHIP TO CARIES

Dental caries can start in different anatomical areas of the teeth, and there exists a set of classifications developed specific to these starting points. The spread of caries can vary depending on the anatomical characteristics of the site.[9]

Occlusal Caries: Pit and Fissure Caries

Pits and fissures on the occlusal surfaces of teeth can create a favourable environment for caries formation due to factors such as plaque accumulation and microbial colonization. The difficulty of toothbrushes to reach these narrow and deep structures can lead to inadequate oral hygiene. While the pronounced pits and fissures in younger individuals may increase the risk of caries in this age group, the erosion of tooth surfaces with age may lead to the flattening of pits and fissures, potentially reducing the risk of caries in shallow fissures. [54,55]

Smooth Surface Caries

Smooth surface caries, which affect buccal, lingual and interproximal surfaces, can provide a suitable environment for plaque accumulation and microbial colonization. These caries are more prevalent in areas that are difficult to clean, facilitating caries formation.[56]

Root Surface Caries

The increased longevity of humans and the longer presence of teeth in the oral environment may lead to an increased incidence of root surface caries. Particularly in the elderly, root surface exposure may become more susceptible to plaque accumulation due to gingival recession. The low inorganic content and relatively thin structure of cementum indicate that if left untreated, caries can progress rapidly to the dentin. This emphasises the importance of caries treatment and early intervention.[57]

PREVENTION OF DENTAL CARIES AND REDUCING ITS PREVALENCE IN FUTURE GENERATIONS FLUORIDE APPLICATIONS

Dental caries prevention is a multifaceted approach that involves various strategies to reduce the prevalence and incidence of caries. Effective prevention strategies include fluoride applications, dietary adjustments, and the expansion of preventive dentistry practices. Each of these components plays a crucial role in maintaining

dental health and preventing the development of caries. Below are detailed descriptions of these preventive measures.[37]

Fluoride is an essential mineral that plays a crucial role in maintaining dental health and preventing caries. When present in trace amounts, fluoride can increase the resistance of dental materials and create a protective barrier during the demineralization process, thereby reducing caries activity.[58]

Both systemic and topical applications of fluoride are considered to be among the most effective methods of preventing dental caries. Fluoridation of public water supplies is a strategy supported by numerous studies to reduce the prevalence of dental caries. International health authorities, such as the WHO, recommend an optimal fluoride concentration of 1.5 ppm in drinking water. However, high doses and prolonged exposure to fluoride can have adverse effects on the skeletal system, teeth, and other organs. Historically, systemic applications of fluoride, such as the fluoridation of public water, milk, and salt, have been widely used. However, since the second half of the 20th century, topical applications such as fluoridated toothpastes and mouthrinses have emerged as effective alternatives. Professional applications, including fluoride gels, solutions, and varnishes, have been developed and research has shown that there are no significant differences in effectiveness between these methods.[59-63]

There are numerous studies in the literature supporting the effectiveness of fluoride applications in preventing dental caries. In particular, topical fluoride varnishes have been highlighted as an effective method of caries prevention. A study by Ashkenazi et al.[59] highlighted the advantages of topical fluoride applications over systemic methods in terms of time and efficacy. Similarly, a study by Beltrán-Aguilar and colleagues in 2000 found that locally applied fluoride varnishes are an effective method of caries prevention.[64]

Fluoridated toothpaste, containing fluoride concentrations ranging from 1000 to 1250 ppm, has been shown to play a significant role in preventing dental caries across children, adolescents, and adults. Additionally, there is evidence indicating that adopting the habit of brushing teeth twice daily from a young age can significantly reduce the development of caries.[65]

Dietary habits play a significant role in the prevention of dental caries. Consuming a balanced diet that includes adequate minerals and nutrients is essential for maintaining dental health. Foods high in fermentable sugars and carbohydrates increase the risk of caries, whereas a diet rich in proteins, vegetables, and dairy products can help reduce this risk. Limiting the intake of sugary foods and beverages, and ensuring regular consumption of foods that promote saliva production, such as fibrous fruits and vegetables, are important dietary strategies for caries prevention.[37]

REGULATION OF DIETARY HABITS

During the critical stages of tooth development, dietary habits play a significant role in the resistance of teeth to caries. Particularly in infancy, an adequate intake of minerals and essential nutrients supports dental robustness. In this context, the intake of nutrients such as calcium, phosphorus and vitamins A, D and C is essential for tooth development. The available literature indicates that deficiencies in vitamins A and D, as well as calcium and phosphorus imbalances, can adversely affect dental development.[66]

After the eruption of teeth, the influence of dietary habits and consumption patterns on dental caries becomes more pronounced. In particular, the intake of fermentable sugars can increase the risk of dental caries. The consumption of such sugars and starchy foods is increasing in modern diets. The frequency and timing of consumption of cariogenic foods are critical factors in caries risk. Studies have documented the relationship between the physical form of sugars, their frequency of consumption, their amount and their adhesiveness and dental caries.[37]

Anticariogenic diets are considered an effective strategy for reducing caries. Dairy products such as milk and yoghurt, which contain caries-preventive components such as calcium, phosphate, casein and lipids, contribute to the regulation of saliva and plaque acidity and the remineralization of early carious lesions.[67]

Limiting the consumption of sugary liquid foods, cooking methods, sequence of consumption and combinations may also influence the risk of caries. Therefore, attention to the cariogenic potential of foods consumed together and modifications in consumption or cooking methods are important.[37,68]

EXPANSION OF PREVENTIVE DENTISTRY PRACTICES

Dental caries is recognised as a significant public health problem worldwide. Particularly in countries where preventive dental care is not widely available, oral and dental health problems can lead to serious economic and social challenges.[69-71]

The main focus in tackling this problem is to address the mechanisms of caries formation and risk factors, and to improve the early stages of carious lesions through remineralization methods. The goal of this approach is to prevent caries and maintain oral and dental health throughout the population.[38]

Preventive dental services have become increasingly important, particularly since the 1930s, with practices aimed at maintaining oral and dental health in children. At the core of this strategy is the ability to maintain healthy hygiene and dietary habits acquired in childhood into adulthood, thereby preserving the overall oral health of individuals in the long term. Recently, this understanding has been extended to the wider community and has become more comprehensive.[69-71]

Widespread adoption and effective implementation of preventive dental practices are critical to improving community oral health and reducing common problems such as dental caries. Individual education, public awareness and active application of the principles of preventive dentistry are essential.[38]

CONCLUSION

Dental caries is influenced not only by individual health and hygiene practices, but also by broader social and economic factors. Fluoride application, regulation of dietary habits and expansion of preventive dental services are emerging as important tools in the fight against dental caries.

Effective management of dental caries requires an integrated approach at the individual, community and policy levels. This approach is based on instilling healthy oral and dental care habits from an early age, encouraging regular dental check-ups and taking specific measures for high-risk groups. It is also essential to understand the impact of diet and eating habits on caries, and to reduce the consumption of fermentable sugars and increase the intake of caries preventive foods. Raising public awareness and education levels is a critical factor in the success of these initiatives.

In conclusion, a multidisciplinary approach is essential for the effective prevention and treatment of dental caries. It is crucial for health professionals and policy-makers to collaboratively develop and implement comprehensive strategies to address this health issue. Such concerted efforts are pivotal in decreasing the prevalence of dental caries, thereby enhancing the overall oral and dental health of the community.

ETHICAL DECLARATIONS

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The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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