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IMPROVING PREVENTION AND TREATMENT STRATEGIES FOR THE IMPACT OF SUGARY BEVERAGES AND ULTRA-PROCESSED FOODS ON HARD DENTAL TISSUES IN CHILDREN

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Abstract
The increasing consumption of sugary beverages and ultra-processed foods among children has emerged as a major public health concern worldwide, particularly due to its detrimental effects on oral health. Hard dental tissues, including enamel and dentin, are especially vulnerable during childhood, when mineralization processes are still ongoing. Excessive intake of free sugars, acidic additives, and refined carbohydrates contributes to the development of dental caries, enamel erosion, hypomineralization, and increased tooth sensitivity. This article provides a comprehensive analysis of the mechanisms by which sugary drinks and ultra-processed foods affect hard dental tissues in children and explores contemporary approaches to improving prevention and treatment strategies. Emphasis is placed on dietary modification, early risk assessment, fluoride-based and biomimetic remineralization therapies, minimally invasive restorative techniques, and interdisciplinary preventive programs. Strengthening these strategies is essential to reduce the burden of dental diseases and improve long-term oral health outcomes in the pediatric population.

Keywords: Children, sugary beverages, ultra-processed foods, dental enamel, dental caries, prevention, remineralization.

Introduction

In recent decades, dietary patterns among children have undergone profound changes, characterized by a sharp increase in the consumption of sugary beverages and ultra-processed foods. These products are widely accessible, heavily marketed, and often preferred due to their palatability, low cost, and convenience. However, their excessive intake has been strongly associated with a wide range of systemic and oral health problems. Among these, damage to hard dental tissues represents one of the earliest and most prevalent consequences [1.5].

Hard dental tissues, primarily enamel and dentin, serve as the structural foundation of teeth and play a critical role in protecting the dental pulp and maintaining masticatory function. During childhood, enamel maturation is not fully complete, rendering teeth particularly susceptible to chemical, microbial, and mechanical insults. The frequent exposure of teeth to fermentable carbohydrates and acidic substances disrupts the balance between demineralization and remineralization, favoring pathological processes[1.2.4].

Dental caries remains the most common chronic disease of childhood globally. Numerous epidemiological studies have demonstrated a direct relationship between sugar intake frequency and

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caries prevalence. Sugary beverages, including carbonated soft drinks, fruit juices with added sugars, energy drinks, and sweetened dairy products, contribute not only to high sugar exposure but also to acid erosion due to their low pH. Ultra-processed foods, defined as industrial formulations containing refined ingredients, additives, and preservatives, further exacerbate this risk by promoting prolonged oral retention and biofilm formation[3.5.

Given the scale of this problem, improving preventive and therapeutic strategies aimed at protecting hard dental tissues in children has become a priority in pediatric dentistry. This article aims to synthesize current evidence on the harmful effects of sugary beverages and ultra-processed foods on dental hard tissues and to propose integrated approaches for prevention and treatment optimization.

Mechanisms of Damage to Hard Dental Tissues

The destructive impact of sugary beverages and ultra-processed foods on hard dental tissues is multifactorial and involves biochemical, microbiological, and physical mechanisms. One of the primary factors is the presence of free sugars, particularly sucrose, glucose, and fructose. These carbohydrates serve as substrates for cariogenic bacteria such as Streptococcus mutans and Lactobacillus species. Through metabolic fermentation, these microorganisms produce organic acids that lower the pH of dental plaque, leading to enamel demineralization[1.3].

Repeated acid challenges prevent adequate remineralization, especially when saliva flow and buffering capacity are insufficient. In children, salivary defense mechanisms may be compromised by dehydration, mouth breathing, or systemic conditions, further increasing vulnerability. Moreover, ultra-processed foods often have a sticky consistency, which promotes prolonged contact with tooth surfaces and enhances plaque accumulation.

Another significant mechanism is dental erosion caused by acidic beverages. Many sugary drinks have a pH well below the critical threshold for enamel dissolution. Citric and phosphoric acids, commonly used as flavoring agents, chelate calcium ions and directly dissolve the mineral structure of enamel. Unlike caries, erosion can occur independently of bacterial activity and leads to surface softening, increased roughness, and progressive enamel loss[6.7].

Ultra-processed foods also contribute indirectly to enamel defects by displacing nutrient-rich foods from the diet. Insufficient intake of calcium, phosphate, vitamin D, and protein during critical periods of tooth development can impair enamel mineralization, resulting in hypoplasia or hypomineralization. These structural defects significantly increase the risk of caries and hypersensitivity.

Dietary Patterns and Risk Factors

Understanding dietary patterns is essential for effective prevention. Children who consume sugary beverages daily or multiple times per day exhibit a markedly higher prevalence of caries and erosion compared to those with limited intake. The timing and frequency of consumption are more critical than the total amount of sugar consumed. Frequent snacking and sipping maintain a consistently low oral pH, preventing enamel recovery.

Socioeconomic factors also play a role. Ultra-processed foods are often more affordable and accessible in low-income communities, where oral health literacy may be limited. Aggressive

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marketing targeting children further reinforces unhealthy preferences. Parental knowledge, attitudes, and behaviors strongly influence children's dietary choices and oral hygiene practices.

Table 1 summarizes the main dietary risk factors associated with hard dental tissue damage in children.

Table 1. Major dietary risk factors affecting hard dental tissues in children

Risk factor	Mechanism of action	Dental outcome
Frequent sugary beverage intake	Acid production, low pH exposure	Enamel demineralization, erosion
Ultra-processed sticky foods	Prolonged plaque retention	Increased caries risk
High snacking frequency	Reduced remineralization time	Progressive enamel loss
Low intake of protective nutrients	Impaired enamel formation	Hypoplasia, hypomineralization

Preventive Strategies

Improving prevention requires a comprehensive, multi-level approach involving individual, family, community, and healthcare systems. Dietary counseling is a cornerstone of prevention. Educating parents and children about the harmful effects of sugary beverages and ultra-processed foods and promoting healthier alternatives, such as water, milk without added sugars, fruits, and whole foods, can significantly reduce risk.

Behavioral interventions should focus on reducing consumption frequency rather than complete elimination, which may be unrealistic. Encouraging consumption during meals rather than between meals helps minimize acid exposure. Label literacy programs can empower parents to identify hidden sugars and make informed choices.

Fluoride remains a highly effective preventive agent. Community water fluoridation, fluoride toothpaste, and professionally applied fluoride varnishes strengthen enamel by enhancing remineralization and inhibiting bacterial metabolism. In recent years, biomimetic materials containing calcium phosphates, casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), and nano-hydroxyapatite have gained attention for their ability to repair early enamel lesions.

Saliva stimulation strategies, such as sugar-free chewing gum containing xylitol, can further support remineralization and reduce cariogenic bacteria. Regular dental check-ups enable early detection of initial lesions, allowing non-invasive management.

When preventive measures are insufficient and hard dental tissues are already affected, treatment strategies must prioritize tissue preservation. The modern paradigm of pediatric dentistry emphasizes minimally invasive approaches. Early carious lesions can often be managed through remineralization therapy without operative intervention.

For enamel erosion and hypersensitivity, desensitizing agents and protective sealants may be applied to reduce pain and prevent further loss. In cases where restorative treatment is necessary, adhesive materials with fluoride release and bioactive properties are preferred. These materials not only restore function but also contribute to ongoing remineralization.

Children with enamel defects or high caries risk require individualized treatment plans. Interdisciplinary collaboration with pediatricians and nutritionists can address underlying dietary and systemic factors. Table 2 outlines key preventive and therapeutic measures aimed at improving outcomes.

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Table 2. Prevention and treatment strategies for protecting hard dental tissues in children

Strategy	Target	Expected outcome
Dietary modification	Sugar and acid exposure	Reduced demineralization
Fluoride therapy	Enamel strengthening	Increased caries resistance
Biomimetic remineralization	Early enamel lesions	Enamel repair
Minimally invasive restorations	Structural defects	Tissue preservation
Parental education programs	Behavior change	Long-term oral health improvement

Discussion

The evidence clearly indicates that the widespread consumption of sugary beverages and ultra-processed foods plays a central role in the deterioration of hard dental tissues in children. Addressing this issue requires more than isolated clinical interventions. A shift toward preventive, education-based, and minimally invasive care is essential.

One of the major challenges is ensuring adherence to preventive recommendations. Behavioral change is complex and influenced by cultural, economic, and social factors. Therefore, public health policies aimed at regulating marketing, improving food labeling, and reducing sugar content in commercially available products can significantly support individual-level efforts.

From a clinical perspective, early diagnosis and risk-based management are crucial. Advances in diagnostic technologies, such as laser fluorescence and digital imaging, allow clinicians to identify early changes in enamel structure. Integrating these tools into routine pediatric dental care can improve outcomes and reduce the need for invasive treatments.

Conclusion

Sugary beverages and ultra-processed foods pose a significant threat to the integrity of hard dental tissues in children. Their frequent consumption disrupts the delicate balance of demineralization and remineralization, leading to caries, erosion, and structural defects. Improving prevention and treatment strategies requires a comprehensive approach that combines dietary modification, fluoride and biomimetic therapies, minimally invasive clinical interventions, and sustained educational efforts.

By strengthening preventive programs and optimizing treatment protocols, it is possible to significantly reduce the burden of dental diseases in children and promote healthier oral development. Continued research and interdisciplinary collaboration are essential to adapt these strategies to diverse populations and evolving dietary trends.

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