

## CAUSES OF DENTAL CARIES, PREVENTION, AND MODERN TREATMENT METHODS

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**Abstract:** *This article analyzes the etiology and development of dental caries, traditional and modern preventive methods, and innovative treatment technologies. The microbiological, biochemical, and epidemiological factors contributing to caries formation are discussed. In addition, new-generation biotechnologies, microbiome modulation, nanocoatings, and artificial intelligence-based diagnostic systems in the prevention and treatment of caries are reviewed.*

**Annotatsiya:** *Ushbu maqola tish kariesining etiologiyasi va rivojlanishini, an'anaviy va zamonaviy oldini olish usullarini hamda innovatsion davolash texnologiyalarini tahlil qiladi. Karies hosil bo'lishiga hissa qo'shadigan mikrobiologik, biokimyoviy va epidemiologik omillar inson salomatligiga salbiy ta'sir etuvchi narkozlar muhokama qilinadi. Shuningdek, yangi avlod biotexnologiyalari, mikrobiomni modulyatsiya qilish, nanoqoplamalar va sun'iy intellekt asosidagi diagnostika tizimlar kariesni oldini olish va davolashda qo'llanilishi ko'rib chiqiladi.*

**Keywords:** *caries, microbiome, prevention, remineralization, nanocoating, AI diagnostics, innovative dentistry.*

### INTRODUCTION

Dental caries is the most widespread oral disease, affecting more than 90% of the world's population. Its development is influenced by microbiological factors, high sugar consumption, poor hygiene, genetics, and environmental conditions. Despite traditional treatment methods, the high global prevalence of caries necessitates the development of modern preventive and therapeutic technologies. Therefore, innovative strategies for combating caries have become a priority in contemporary dentistry.

#### Causes of Dental Caries

##### 1. Microbiological factors

The main causative agents of caries are *Streptococcus mutans*, *Lactobacillus*, and other cariogenic bacteria. These microorganisms ferment carbohydrates and produce organic acids, lowering the pH and initiating enamel demineralization followed by dentin destruction.

##### 2. Dietary factors

Rapidly fermentable sugars (sucrose, glucose, fructose) significantly increase caries risk. Frequent consumption of sweets maintains a consistently acidic environment that promotes bacterial growth.

##### 3. Poor oral hygiene

If dental plaque is not removed regularly, it becomes a dense biofilm that accelerates bacterial multiplication and carious processes.

#### 4. Biological properties of enamel

The mineral composition, hardness, and structural characteristics of enamel—often genetically determined—play a key role in susceptibility to caries. Conditions such as hypomineralization increase the rate of caries progression.

#### 5. Genetic and systemic factors

Reduced salivary flow, endocrine disorders, vitamin deficiencies, and weakened immunity can significantly contribute to caries development.

#### Preventive Measures

1. Proper oral hygiene Brushing twice daily with fluoride toothpaste. Using dental floss or interdental brushes.

Using antiseptic mouth rinses (chlorhexidine, fluoride rinses).

2. Healthy diet Reduced sugar intake. Use of safer sweeteners such as xylitol and erythritol. Increased consumption of fruits and vegetables to stimulate salivary flow.

3. Fluoride prophylaxis Fluoride strengthens the enamel and increases acid resistance. Fluoride gels, varnishes, and toothpaste have proven preventive value.

4. Professional dental care Professional cleaning every 6 months. Removal of plaque and calculus. Remineralization procedures when needed.

#### Modern and Innovative Treatment Strategies

1. Minimally invasive dentistry The principle of preserving healthy tooth structure is central. Icon infiltration allows early enamel lesions to be treated without drilling.

2. Laser-assisted treatment Laser systems remove carious tissue precisely and painlessly while providing antimicrobial effects and reducing tissue trauma.

3. Nano-hydroxyapatite coatings Nanoparticles penetrate enamel microdefects and restore natural mineral structure, increasing resistance to caries.

4. Bioactive peptides Amelogenin-mimicking peptides promote the formation of enamel-like crystal structures, reducing the need for restorative fillings.

5. Artificial intelligence-based diagnostics AI can identify early demineralization through imaging analysis. Portable scanners allow early detection at home.

6. Microbiome modulation technologies Probiotic dentistry restores microbial balance.

Bacteriophage therapy selectively targets cariogenic bacteria. Artificial microbiome implants (future technology) release beneficial bacteria to stabilize oral flora.

7. Smart polymer coatings These materials release minerals when pH drops, offering automatic protection and repair.

8. Stem-cell-based regenerative dentistry Mesenchymal cells derived from pulp tissue can regenerate dentin, offering a future alternative to traditional fillings.

#### ADDITIONAL SECTION: THE USE OF NITROUS OXIDE (“LAUGHING GAS”) IN PEDIATRIC DENTISTRY — RISKS AND SAFER ALTERNATIVES

##### Nitrous Oxide in Pediatric Dentistry

Nitrous oxide (N<sub>2</sub>O), commonly known as “laughing gas,” is widely used for conscious sedation in children due to its rapid onset, anxiolytic effect, and relatively short recovery period. However, recent clinical studies show that its repeated or prolonged use may have harmful consequences.

### Potential Harmful Effects of Nitrous Oxide in Children

1. Vitamin B12 Inactivation Nitrous oxide inactivates vitamin B12 by oxidizing the cobalt atom within the molecule. This can lead to: impaired DNA synthesis, megaloblastic anemia, neurological complications in vitamin B12-deficient children.

Children with undiagnosed B12 deficiency are at particular risk.

2. Neurological Side Effects Prolonged or repeated exposure may cause: peripheral neuropathy, gait disturbances, numbness or tingling (paresthesia), in severe cases, spinal cord myelopathy.

3. Respiratory and airway risks In very young children or those with respiratory issues, nitrous oxide can: suppress normal breathing patterns, cause diffusion hypoxia if oxygen administration is insufficient after the procedure.

4. Behavioral and emotional side effects Some children may experience: agitation, nausea or vomiting, unpleasant hallucinations (rare).

5. Environmental and occupational hazards Chronic leakage of N<sub>2</sub>O in dental offices can expose healthcare workers to long-term health risks, including reproductive and neurological effects. These concerns have encouraged clinicians to reduce unnecessary exposure and explore safer alternatives. Safer Alternatives to Nitrous Oxide for Pediatric Sedation

While the choice of sedative must always be made by qualified medical professionals, the following agents are widely accepted in pediatric dentistry as alternatives to nitrous oxide Midazolam (oral, intranasal, or IV) Provides anxiolysis and mild sedation. Rapid onset and predictable duration. Common for mild to moderate sedation.

Advantages:

Good for short procedures; child remains responsive

2. Ketamine (oral or IM, specialist use)

Produces dissociative sedation with preserved airway reflexes.

Useful for highly anxious or uncooperative children. Advantages:

Strong analgesic effect; minimal respiratory depression.

3. Dexmedetomidine (intranasal or IV)

Newer sedative with strong calming effects.

Maintains respiratory function better than many alternatives.

Advantages:

Effective for children who cannot tolerate nitrous oxide.

4. Propofol (IV, for deep sedation/general anesthesia)

Used in hospital or specialized settings under anesthesiologist supervision. Advantages:

Rapid onset and recovery; strong sedative effect.

Summary

Based on this article, it can be concluded that dental caries is a multifactorial process, and its development is significantly influenced by the microbiological composition of the oral cavity, frequent consumption of sugary products, insufficient oral hygiene, individual characteristics of enamel, and overall health of the body. Preventing caries is most effective through regular oral hygiene, healthy nutrition, preventive dental check-ups, fluoride

strengthening, and modern minimally invasive approaches. In addition, the rapid development of nanomaterials, microbiome modulation, digital diagnostics, and bioactive technologies is taking caries prevention to a new level. The use of laughing gas (nitrous oxide) in pediatric dentistry carries certain risk factors, which in some cases may negatively affect the nervous system, metabolic processes, and respiratory function.

Therefore, it is important to apply safer sedation methods considering the child's age, health, and individual condition, as well as to use non-pharmacological behavior management strategies. Overall, combining scientifically-based preventive measures against caries with judicious use of safe sedation methods for children represents the most effective, safe, and optimal approach in modern dental practice.

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