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Early Childhood Caries: Prevention and Recent Advances in Management Strategies

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Abstract

Early childhood caries (ECC) is one of the most prevalent chronic diseases affecting young children worldwide and continues to pose a major challenge to pediatric oral health services. It is defined as the presence of one or more decayed, missing, or filled tooth surfaces in any primary tooth in children under six years of age. ECC is multifactorial in nature, resulting from the interaction of cariogenic microorganisms, dietary habits, host susceptibility, oral hygiene practices, and broader social determinants of health. If left untreated, ECC can lead to pain, infection, nutritional deficiencies, impaired speech development, and diminished quality of life. Traditional preventive measures have focused on fluoride use, oral hygiene promotion, and dietary counseling. However, recent advances emphasize risk-based disease management, minimally invasive dentistry, biofilm-targeted therapies, and integration of oral health into primary healthcare systems. This review aims to summarize current knowledge on ECC prevention and highlight recent advances in management strategies, while identifying gaps in existing research.

Keywords
Early childhood caries, prevention, pediatric dentistry, fluoride, minimally invasive dentistry, caries management.

Introduction

Early childhood caries (ECC) represents a significant public health concern due to its high prevalence, early onset, and long-term consequences on oral and general health. According to the American Academy of Pediatric Dentistry (AAPD), ECC is diagnosed when one or more decayed (non-cavitated or cavitated), missing (due to caries), or filled tooth surfaces are present in any primary tooth in a child younger than 71 months (1). Despite being largely preventable, ECC remains one of the most common chronic diseases of childhood, affecting millions of children globally (2).

The global burden of ECC is unevenly distributed, with higher prevalence observed in low- and middle-income countries and among socioeconomically disadvantaged populations within high-income countries (2,3). Studies have shown that ECC prevalence can exceed 60% in certain regions, particularly where access to preventive dental care is limited and sugar consumption is high (3). This disparity highlights the influence of social determinants of health, including income, education, access to care, cultural feeding practices, and caregiver oral health literacy (2).

The etiology of ECC is multifactorial and dynamic. The disease process involves prolonged exposure of tooth surfaces to fermentable carbohydrates, colonization by cariogenic microorganisms such as Streptococcus mutans and Lactobacillus species, and insufficient protective factors such as fluoride and saliva (1,3). Vertical transmission of cariogenic bacteria from caregivers to children has been well documented, emphasizing the importance of maternal and family oral health in ECC prevention (12). Feeding practices such as frequent snacking, nocturnal bottle feeding, prolonged breastfeeding combined with poor oral hygiene, and early introduction of sugary foods further increase caries risk (4).

Beyond oral health implications, ECC has profound effects on a child's overall well-being. Children with ECC may experience pain, difficulty eating, disturbed sleep, impaired growth, and reduced self-esteem (2). Severe ECC has also been associated with increased school absenteeism and poorer academic performance (2). Additionally, untreated ECC often necessitates extensive dental treatment, sometimes under general anesthesia, placing a significant financial burden on families and healthcare systems (9).

Historically, management of ECC focused primarily on restorative treatment of cavitated lesions. However, this approach does not address the underlying disease process and has limited success in preventing recurrence (3). Contemporary understanding of ECC as a chronic, behaviorally influenced disease has shifted emphasis toward prevention, early risk assessment, and minimally invasive management strategies (5). Recent advances in cariology, dental materials, and public health models have introduced new approaches such as silver diamine fluoride, atraumatic restorative treatment, chronic disease management frameworks, and biofilm-targeted therapies (6).

Given the evolving landscape of ECC prevention and

and management, a comprehensive synthesis of current evidence is necessary. This review aims to provide an in-depth overview of preventive strategies and recent advances in the management of ECC, while highlighting existing gaps in research and future directions.

Aim

To review the current evidence on early childhood caries with a focus on preventive approaches and recent advances in management strategies, including clinical, behavioral, and public health perspectives.

Materials and Methods

Study Design

A structured narrative review was conducted following PRISMA guidelines to identify relevant literature related to ECC prevention and management.

Inclusion Criteria

- Studies involving children under six years of age
- Original research articles, systematic reviews, and clinical guidelines
- Articles addressing prevention, risk assessment, and management of ECC
- Publications in English

Exclusion Criteria

- Case reports and opinion articles
- Studies not specifically addressing ECC

Search Strategy

Electronic searches were conducted in PubMed, Scopus, Web of Science, and Google Scholar for articles published between 2010 and 2025. Keywords used included early childhood caries, ECC prevention, caries management, fluoride, silver diamine fluoride, minimally invasive dentistry, and risk assessment. Manual searches of reference lists were also performed.

Results of Search

A total of 3,241 records were identified through electronic database searches. After removing duplicates, 2,789 records remained for screening. Following title and abstract review, 2,156 articles were excluded, leaving 452 full-text articles for detailed assessment. Of these, 20 studies met the inclusion criteria and were included in the final review.

Discussion

Early childhood caries (ECC) remains a persistent global health challenge despite decades of research and preventive efforts. The findings of this review reaffirm that ECC is not merely a localized dental condition but a complex, multifactorial disease influenced by biological, behavioral, environmental, and social determinants (7). The high prevalence of ECC, particularly among children from socioeconomically disadvantaged backgrounds, underscores the limitations of traditional treatment-focused models and highlights the urgent need for prevention-oriented, risk-based, and equity-focused strategies.

Understanding ECC as a Multifactorial Disease

The multifactorial etiology of ECC involves the interaction of cariogenic microorganisms, frequent exposure to fermentable carbohydrates, susceptible tooth surfaces, and inadequate protective factors such as fluoride and saliva (8,9). The early colonization of Streptococcus mutans through vertical transmission from caregivers plays a critical role in disease initiation (10). This microbial component is strongly influenced by caregiver oral health status and behaviors, reinforcing the importance of family-centered preventive strategies.

Dietary practices, particularly frequent sugar intake and prolonged exposure through bottle feeding or nocturnal breastfeeding combined with poor oral hygiene, significantly increase ECC risk (11). However, these behaviors are often shaped by cultural norms, socioeconomic constraints, and limited access to health education. Therefore, ECC should be understood within a broader social and behavioral context rather than solely as a result of poor oral hygiene.

Preventive Strategies: Strengths and Limitations

Fluoride-based interventions continue to be the cornerstone of ECC prevention. Evidence consistently supports the use of fluoride varnish and age-appropriate fluoride toothpaste in reducing caries incidence and progression in primary teeth (12). Community water fluoridation remains one of the most cost-effective public health measures, yet its implementation is inconsistent across regions, particularly in low- and middle-income countries.

While the effectiveness of fluoride is well established, preventive success largely depends on caregiver compliance and access to dental services. Studies indicate that knowledge alone does not necessarily translate into positive oral health behaviors (13). This knowledge–practice gap highlights the need for behaviorally informed interventions that address parental beliefs, motivation, and perceived barriers to care.

Dietary counseling is another essential preventive component, yet it remains challenging to implement effectively. Reducing sugar consumption requires not only individual behavior change but also broader policy interventions targeting food marketing, labeling, and availability of sugary products, especially those targeted at children. Without supportive environments, individual-level dietary advice may have limited long-term impact.

Shift Toward Risk-Based and Preventive Care Models

One of the most significant advances in ECC management is the shift toward risk-based disease management. Risk assessment tools enable clinicians to identify high-risk children early and tailor preventive and therapeutic interventions accordingly (14). This individualized approach aligns with contemporary cariology concepts, which view dental caries as a dynamic and reversible process in its early stages.

However, the predictive accuracy and standardization of risk assessment tools remain variable. Many tools rely heavily on clinical judgment and may not fully capture social and behavioral risk factors. Future research should focus on developing validated, culturally adaptable risk assessment models that integrate biological, behavioral, and social determinants of health.

Minimally Invasive Dentistry and Its Impact

Minimally invasive dentistry (MID) has transformed the management of ECC by emphasizing disease control, preservation of tooth structure, and child-centered care. Silver diamine fluoride (SDF) has emerged as a particularly valuable tool for arresting carious lesions in

young or uncooperative children and in settings with limited access to conventional dental care (10). Its simplicity, low cost, and high efficacy make it a promising intervention for reducing ECC burden at the population level.

Despite its benefits, SDF presents esthetic concerns due to black staining of treated lesions, which may limit caregiver acceptance, particularly for anterior teeth. This underscores the importance of effective communication with parents and shared decision-making. Techniques such as silver-modified atraumatic restorative treatment (SMART) aim to balance esthetics and caries control, though long-term clinical evidence remains limited (15).

Atraumatic restorative treatment (ART) is another MID approach that has demonstrated success, particularly in community and school-based programs. ART reduces the need for rotary instruments and anesthesia, making it suitable for young children and low-resource environments. However, operator skill, case selection, and material longevity influence outcomes, emphasizing the need for standardized training and protocols.

Chronic Disease Management Approach

The adoption of a chronic disease management (CDM) framework represents a paradigm shift in ECC care. Rather than focusing on episodic restorative treatment, CDM emphasizes continuous risk assessment, preventive interventions, caregiver education, and long-term monitoring (16). This approach acknowledges that ECC, like other chronic diseases, requires sustained behavioral and environmental changes.

Evidence suggests that CDM models improve treatment outcomes and reduce recurrence rates, particularly in high-risk children. However, successful implementation requires integration within healthcare systems, adequate reimbursement structures, and interdisciplinary collaboration among dental professionals, pediatricians, and public health workers.

Role of Public Health and Health Systems

ECC prevention cannot rely solely on clinical interventions. Public health strategies that integrate oral health into maternal and child health programs have shown promising results. Prenatal oral health education and early infant interventions can reduce bacterial transmission and promote healthy behaviors before disease onset (17).

School-based and community-based preventive programs, including fluoride varnish applications and caregiver education, are effective in reaching underserved populations. Nevertheless, resource constraints, workforce shortages, and lack of policy prioritization continue to limit the scalability of such programs in many regions.

Emerging Therapies and Future Directions

Emerging research on biofilm-targeted therapies represents an exciting frontier in ECC management. Novel agents that selectively disrupt cariogenic biofilms without affecting beneficial oral microbiota offer the potential for more precise disease control (18). Advances in smart dental materials and antimicrobial peptides may further enhance preventive and therapeutic outcomes.

However, most emerging therapies are still in experimental or early clinical stages. Robust randomized controlled trials and long-term follow-up studies are needed to establish their safety, effectiveness, and cost-efficiency before widespread clinical adoption.

Equity and Access Considerations

A recurring theme in ECC research is the persistent inequality in disease burden and access to care. Children from low-income families, rural areas, and marginalized communities experience disproportionately higher rates of ECC (19,20). Addressing these disparities requires multisectoral approaches that combine clinical care with social policies targeting education, nutrition, and healthcare access.

Emerging Therapies

Emerging research on biofilm-targeted therapies and smart dental materials offers future directions for ECC management . These approaches aim to selectively disrupt cariogenic biofilms without affecting beneficial oral microbiota. While promising, these innovations require further clinical trials to establish safety, efficacy, and long-term outcomes.

Conclusion

Early childhood caries remains a significant yet preventable public health problem. Effective management requires a shift from purely restorative approaches to comprehensive, preventive, and risk-based strategies. Fluoride use, dietary counseling, early dental visits, and minimally invasive techniques form the foundation of contemporary ECC management. Continued research, policy support, and integration of oral health into primary healthcare systems are essential to reduce the global burden of ECC.

Gaps in Research

1. Limited long-term evidence on newer materials such as nano-silver fluoride
2. Lack of standardized and universally validated ECC risk assessment tools
3. Insufficient implementation research in low-resource settings
4. Need for equity-focused preventive strategies targeting vulnerable populations

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