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Strategies to Encourage Recall and Prevent Relapse after Full Mouth Rehabilitation under General Anesthesia in Children

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Abstract

Background: Dental caries are preventable. Dentists utilize many prevention strategies in the office and provide at-home education to families. However, once a child develops Early Childhood Caries (ECC), especially in more severe cases, they may need general anesthesia (GA) to complete treatment. While this is an effective way to achieve full mouth dental rehabilitation (FMDR), this burdens the healthcare systems and families and does not come without risk to the patient. Patients with high caries experience remain at high risk of caries relapse after FMDR under GA, sometimes necessitating additional FMDR under GA. While there has been a significant amount of research on dental caries and prevention strategies, there has yet to be a comprehensive preventive program for children with a high risk of developing dental caries that has been shown to work consistently.

Objectives: This literature review compiles research on preventing the relapse of dental caries to identify the causes of caries recurrence in children after FMDR under GA.

Methods: A systematic review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework and four databases: CINAHL, Dentistry & Oral Sciences Source, Embase, and PubMed.

Results: The search resulted in 430 articles, which, after applying the PRISMA framework, thirty of those articles were found to be relevant to the identifying factors that relate to high caries relapse rates after children have FMDR under GA. The articles were reviewed, and the common demographic, physical, behavioral, and socioeconomic themes were determined.

Conclusions/implications: The relapse rate of dental caries after children have FMDR under GA is high. There has been a significant amount of research regarding the high caries recurrence that children experience, with many articles having similar themes but with no overly successful

prevention programs. Caries prevention programs are not one-size-fits-all and must be individualized to the patient and their family.

Strategies to Encourage Recall and Prevent Relapse after Full Mouth Rehabilitation under General Anesthesia

Introduction

Dental caries, the disease process many know as cavities, is most commonly caused by the bacterium *Streptococcus mutans*, and under conditions of a poor diet, which can include frequent snacking of carbohydrate and sugar-rich foods and poor oral hygiene, can cause damage and degradation of teeth resulting in the need to restore or remove teeth (Y. Li & Tanner, 2015). Dental caries is the most common chronic disease of childhood; dental caries is five times more than asthma and seven times more prevalent than hay fever in American children (Health & Services, 2000). Even more concerning, it is children's number one unmet health need in the United States (Newacheck et al., 2000). One case that brought the access to care issue in the United States into the spotlight in 2007 was Deamonte Driver, a Maryland child with untreated dental caries that ultimately led to his death. If that is not alarming enough, dental caries is a global problem, affecting more than 621 million children worldwide (Kassebaum et al., 2015). Deamonte Driver's death spurred federal reforms in Maryland and across the United States to increase access to oral healthcare for all children, but his death was entirely preventable; we must continue to be proactive with providing oral healthcare to children and preventing dental caries rather than being reactive to tragic cases like Deamonte's (Tinanoff et al., 2019).

Twenty-three percent of children ages two to five have experience with dental caries; that percentage rises to 56 percent in children ages six to eight. Pediatric caries are classified as Early Childhood Caries (ECC) when a child under the age of six has "one or more decayed, missing, or filled tooth surface in any primary tooth" (American Academy of Pediatric Dentistry, 2021). Some children with ECC cannot cooperate for treatment in the traditional dental setting, which

may utilize basic behavior guidance techniques and sedation with nitrous oxide, known to some as “laughing gas.” Advanced behavior guidance techniques used to complete dental treatment, known as full mouth dental rehabilitation (FMDR), include general anesthesia (GA). The American Academy of Pediatric Dentistry (AAPD) has outlined indications for GA, which include:

> “Those who cannot cooperate due to a lack of psychological or emotional maturity and/or mental, physical, or medical disability; for whom local anesthesia is ineffective because of acute infection, anatomic variations, or allergy; who are extremely uncooperative, fearful or anxious; who are pre-communicative or non-communicative; requiring significant surgical procedures that can be combined with dental procedures to reduce the number of anesthetic exposures; for whom the use of general anesthesia may protect for the developing psyche and/or reduce medical risk; and requiring immediate, comprehensive, oral/dental care (American Academy of Pediatric Dentistry, 2020)

Treating dental caries under GA is an effective treatment modality; it allows dentists to manage patients who would otherwise not be able to complete treatment and significantly improve their quality of life (Ludovichetti et al., 2022).

Once a child is at high risk for dental caries, as determined by the AAPD caries-risk assessment, they have an increasingly difficult time decreasing their risk significantly—the most reliable indicator of future caries experience is past caries experience (Berry et al., 2017). Dental caries is a preventable disease process; however, it burdens many children and causes emotional harm to children worldwide and financial hardship for their families, sometimes requiring multiple GA appointments for FMDR. Studies have been conducted to evaluate how many children have a relapse of dental caries after FMDR under GA and need subsequent FMDR

under GA; upwards of thirty-nine percent of children who had S-ECC, a classification of ECC, and were treated relapsed in the first 12 months (Berkowitz et al., 2011).

Dentists spend much of their time focusing on prevention but have struggled for decades with what works to prevent these severe cases. To minimize the negative impact of ECC, the dental profession must harness the best preventive strategy to prevent ECC, especially the severe cases that necessitate FMDR under GA. After decades of research, it is clear there is no one-size-fits-all children answer. This literature review seeks to compile a comprehensive overview of what has shown the most success in preventing relapse of dental caries after FMDR. The goal is to understand how to prevent relapse in children who have had FMDR under GA with dentists and families partnering to prevent as many as possible. This will be done by identifying effective prevention strategies for children at high risk for dental caries who have had FMDR under GA and categorizing them to allow practicing pediatric dentists to implement them effectively.

Background and Literature Review

GA is not without risks; many people would think the experience of having a child undergo GA for dental treatment would motivate behavior change in parents. However, this was not observed in a study by M. S. Amin et al., as parents only partially complied with oral hygiene, diet modifications, and other instructions post-GA for FMDR (M. S. Amin et al., 2010). While general anesthesia has not been found to change the behaviors of parents or decrease children's risk of developing dental caries significantly across the board, it may still be the most reasonable way for children to get dental work completed if they experience S-ECC and are not able to cooperate in the traditional dental setting (El Batawi, 2014). The proposed literature review seeks to form a comprehensive review of how to lessen the prevalence of caries relapse after FMDR under GA and what steps dental professionals and families can take to diminish that relapse.

When a child receives GA for FMDR, their medical insurance covers the costs of anesthesia and hospital or surgery center fees, while their dental insurance covers the dental treatment. If a patient does not have insurance, these fees may be out-of-pocket expenses for the parents, but that is often cost-prohibitive, as it can cost thousands of dollars. Higher relapse rates are associated with not attending follow-up appointments; 24% of patients who attended a recall within 12 months of the FMDR under GA appointment had caries, whereas 53% of those who attended a recall 13-24 months after their FMDR under GA appointment has caries (M. S. Amin et al., 2010). Patients who were followed up more than six months after FMDR under GA had higher caries-risk after Caries-Risk Assessment (CRA) than those who presented for three-month (44%)and six-month recalls (70%)post-FMDR (Berry et al., 2017). Since more frequent recalls are beneficial in preventing relapse after FMDR, cost analysis of prevention compared with treatment costs should be evaluated.

The cost of early childhood caries has burdened healthcare systems (Schroth et al., 2016). FMDR accounted for nearly 31% of cases in a day of pediatric surgeries for children 12-59 months in Canada, estimating that hospital fees for dental cases exceed $21 million (Schroth et al., 2016). Further alarming, this shockingly large number accounts for only the children with the most severe cases who necessitate FMDR under GA—these numbers did not account for children who receive treatment in a traditional dental office setting or the adults with caries experience who receive treatment in a dental office or under GA (Schroth et al., 2016). While this study looked at Canada, the impact is seen worldwide; the cost burden is one of the many reasons that the relapse of dental caries after FMDR under GA needs to be decreased.

Some relapse of dental caries may be due to the dentist rendering more conservative dental treatment under GA. Treatment rendered can be due to guardian preference, but there is a significant amount of research that dentists should follow to prevent relapse for their high-risk patients. A restoration's survival time depends on the restoration modality chosen; Stainless Steel Crowns (SSCs) and amalgam restorations have higher long-term success rates than composites (M. Amin et al., 2016). Second primary molars that did not receive treatment under GA and their time to new treatment were assessed; SSCs had "overwhelming success." Therefore, practitioners should strongly consider SSCs "for almost any pattern of caries on a second molar" in children at high risk for dental caries, especially under GA, as SSCs are the most cost-effective treatment for the child, with a high success rate (Azadani et al., 2020).

While research is conflicting, many have found a correlation between poor compliance with dentist-recommended home care and diet modifications and future caries relapse, sometimes necessitating children to undergo subsequent GA for FMDR (El Batawi, 2014). It is critical to decrease caries risk, caries experience, and relapse after FMDR, as children with dental disease can experience pain, swelling, and infection (Tinanoff et al., 2019). This

preventable disease accounts for over fifty-one million hours of school lost annually, and when in school, if children have untreated dental caries, it can cause them to have difficulty learning (American Academy of Pediatric Dentistry, 2019). Dental pain negatively impacts one's quality of life, which comes at a high emotional and monetary cost. Dental caries have negative emotional and economic impacts and affect children's orofacial function, which is restored in less than three months after FMDR (Collado et al., 2017). Managing the caries risk of patients with ECC must be approached from multiple sides as it is a multi-factorial disease process—there is not a uniform plan to put in place for all children nor a "miraculous solve-it-all approach" (Oubenyahya & Bouhabba, 2019).

Many effective preventive strategies require a combination of education and compliance at home. One study sought to determine how susceptible children were to caries after treatment under general anesthesia. Interventions included oral hygiene instruction to parents, which was brushing twice daily with fluoridated toothpaste and flossing. After the FMDR appointment, the ECC group returned for a one-week visit, and oral hygiene instruction (OHI) was reinforced (Almeida et al., 2000). Focusing OHI on the primary caregiver is critical to increasing compliance (El Batawi, 2014).

Behavioral interventions also show promise in reducing relapse of dental caries after FMDR; the importance of providing significant support with home care, diet modifications, and behavioral interventions to families with high-risk children to prevent caries development post-GA (M. S. Amin et al., 2010). More novel approaches for preventing future relapse, such as motivational interviewing techniques, focus more on the dental caries disease process and less on the treatment being the end product (Berkowitz et al., 2011). Motivational interviewing is a technique used to harness people's intrinsic motivation to illicit change in behaviors by utilizing reflective listening and guiding people to be self-aware.

Motivational interviewing techniques involve phone calls before patients' appointments and have improved recall attendance rates (Cardenas et al., 2022). One of the critical characteristics of motivational interviewing that makes it relevant in today's pediatric dentistry practice is that one does not have to be a pediatric dentist to be successful at motivational interviewing—these techniques can be taught to any dental team member (Cardenas et al., 2022). Motivational interviewing training allows dental assistants and dental hygienists to communicate effectively; it empowers them to teach patients and their families to take control and lead the changes they wish to make in their oral health (Cardenas et al., 2022).

Additionally, children who have existing medical conditions such as autism, cardiac defects, genetic conditions, or other special health care needs should have more aggressive treatment when receiving FMDR under GA as they were more likely than children without additional medical conditions to require further GA treatment within four years (Guidry et al., 2017). The high relapse rate of dental caries could be due to many medications ASA II and above patients are on, as polypharmacy can impact reduced salivary flow, and these patients have more cariogenic diets and exhibit poor post-operative care (Amin et al., 2015).

Even with preventive measures increased for children with ECC, children still present at high risk of dental caries years later—even into adulthood. The fact that high-risk children inevitably become high-risk adults highlights the need to develop better preventive therapies to diminish caries risk in children with ECC (EzEldeen et al., 2015). A multi-modal approach to preventing dental caries after FMDR under GA is critical to minimizing caries risk in children with ECC, thereby preventing relapse and possibly subsequent FMDR under GA. Current studies have yet to find an effective, multi-modal way to prevent relapse of dental caries after FMDR under GA for children at high risk for dental caries. Therefore, this systematic literature review

aims to find practical and sustainable methods for guardians and dental health professionals to prevent the relapse of dental caries under GA.

Methods

A systematic literature review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, outlined in Figure 1. With assistance from the University of Nebraska Medical Center (UNMC) librarian, the following databases were identified for use in the systematic review: CINAHL, Dentistry & Oral Sciences Source, Embase, and PubMed. Articles available in English in full-text and published after 2000 were included. The key terms included in the searches for information regarding relapse and recall after full-mouth dental rehabilitation after general anesthesia were used to gather helpful qualitative and quantitative results. The key terms were discussed with the UNMC librarian, and are outlined in Table 1.

Table 1 Databases and Key Terms
Databases: CINAHL, Dentistry & Oral Sciences Source, Embase, and PubMed
Key Terms: (“dental infection” OR “dental abscess” or “facial swelling” OR caries OR “dental caries” OR “dental decay” OR decay OR “decayed teeth” OR “tooth decay” OR “high caries-risk” OR ECC) AND (treatment OR FMDR OR “full mouth rehabilitation” OR “oral rehab*”) AND (“general anesthes*” OR “general anaesthes*” OR “GA”) AND (recurrence OR relapse OR new OR “re-treatment” OR repeat)

AND (prevention OR “caries-risk assessment” OR (“motivational interviewing” OR MI) OR intervention OR “multi-modal intervention” OR “intervention techniques” OR “behavioral intervention” OR therapy)

Many interventions could be helpful in the reduction of dental caries recurrence after GA, which is why it is crucial to include articles that mention prevention, caries-risk assessment, motivational interviewing, or behavioral intervention. Duplicate articles were removed using Excel’s duplicate values function, and a single reviewer reviewed all articles to confirm they met the inclusion criteria. Inclusion and exclusion criteria are outlined in Table 2. Only articles that included follow-up results of dental caries recurrence after full mouth rehabilitation under general anesthesia were included. Articles were excluded that included follow-up only related to the quality-of-life changes after full mouth rehabilitation under general anesthesia or changes in the behavior of parents or children. Articles that were limited to children with special health care needs were excluded as there are many contributing factors included in the care of these children. Exclusion criteria were study protocols, which do not include results, articles with limited samples, or case reports. These inclusion and exclusion criteria will narrow the research scope and ensure it applies to the systematic literature review. The inclusion and exclusion criteria follow the PRISMA guide and are shown in Figure 2. After reading the articles, a single reviewer assigned common themes relating to social determinants of health. The common themes were demographic, physical, behavioral, and socioeconomic, as indicated in Table 3. The research objective is to compile sustainable and effective methods to prevent the relapse of dental caries after FMDR under GA.

Table 2

Inclusion and Exclusion Criteria		
Criteria	Inclusion	Exclusion
Publication Date	• Published after 2000	• Published before 2000
Language	• English language available	• No English available
Results/Outcomes	• Pediatric patients (under the age of 19) • Patients who have received care under GA • Reported recurrence of dental caries • Received follow-up after treatment under GA	• Adult population • Patients had treatment in the office or using moderate sedation • Children with special healthcare needs • Did not include follow-up after GA • Not related to caries recurrence • Concerns quality of life (QOL) • Related to behavior change
Publication Type	• Full-text available • Peer-reviewed journals • Articles included results that were qualitative or quantitative	• Case report • Full-text not available • Abstract only • Retracted articles • No results included in articles

Application of Public Health Competencies

Foundational Competencies:

MPHF7: Assessing a population's needs, assets, and capacities that affect communities' health

MPHF13: Proposing strategies to identify stakeholders and build coalitions and partnerships for influencing public health outcomes

Concentration Competencies:

HRSAMPH1: Demonstrating the skills to analyze and resolve organizational issues through a multidisciplinary systems-based approach

HRAAMPH4: Summarize the legal, political, social, and economic issues that impact the structure, financing, and delivery of health services within health systems in the US

Dental caries affects 56 percent of children ages six to eight in the United States, creating a significant need for dental treatment under general anesthesia—many times repeat FMDR under GA (American Academy of Pediatric Dentistry, 2022). This significant need, at times, can burden the community or population. Therefore, assessing this issue of high rates of early childhood caries and utilization of full mouth rehabilitation under general anesthesia is critical (MPHF7). This issue must be addressed by partnering with stakeholders in the community and with the families. This comprehensive review of literature works to propose reasonable solutions to the issue of caries relapse after FMDR under GA (MPHF13)

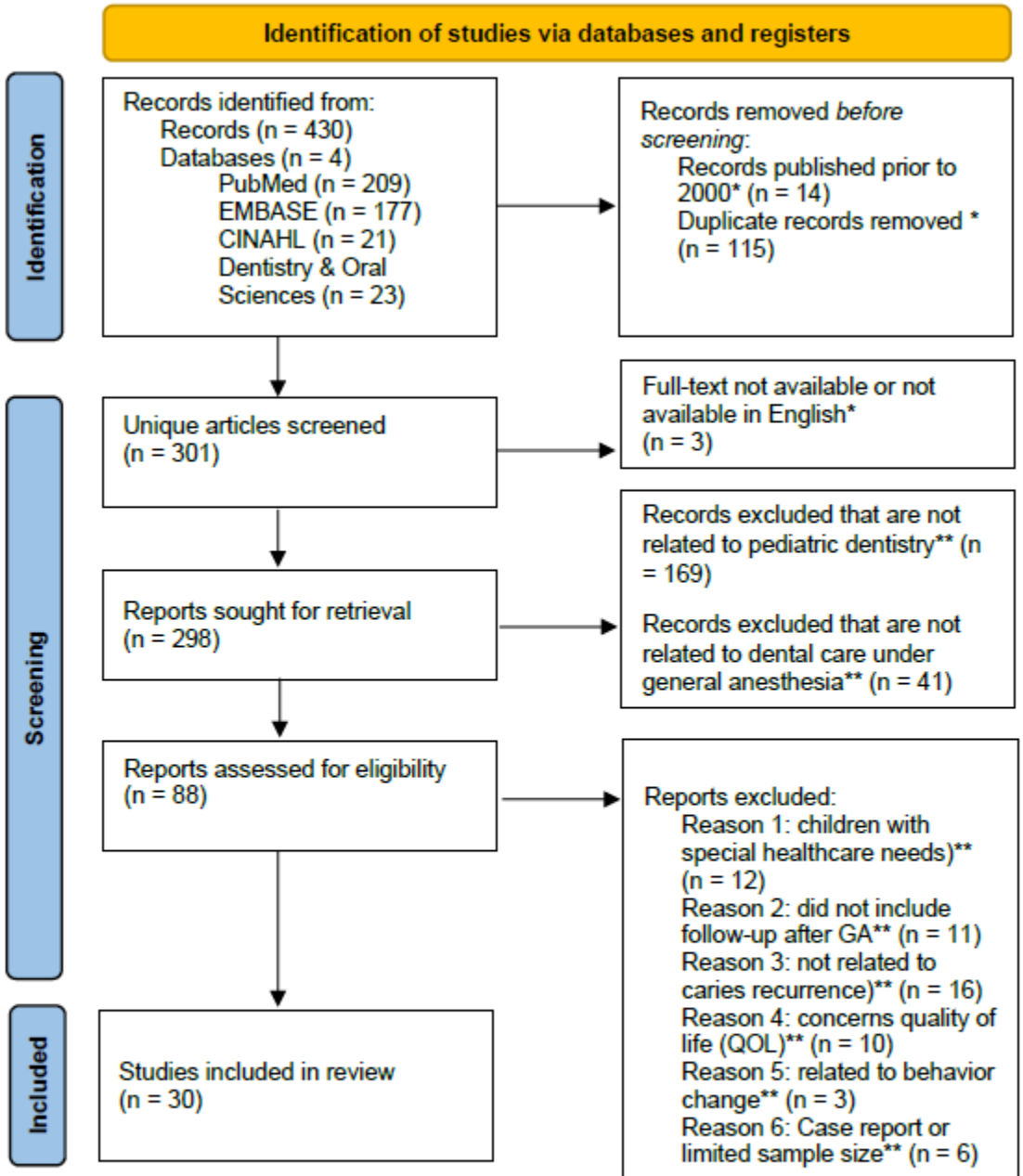
After compiling these articles, they were analyzed to understand better how to approach them from a multidisciplinary perspective. As understood from the culmination of these articles, dentistry as a profession has struggled to get a handle on successfully preventing caries relapse in

high caries-risk children after FMDR under GA. Public health professionals must be involved in the conversation to successfully reduce the number of children necessitating FMDR under GA, especially those requiring multiple visits over their lifetime (HRSAMPH1). Additionally, it is not reasonable to come up with realistic solutions to reducing caries relapse in high caries-risk children who have undergone FMDR under GA without taking the legal, political, social, and economic issues that impact how dental care is delivered, paid for, and utilized by children in the United States into consideration. Dental caries costs families, health systems, and government-funded insurance a significant amount of money as it is the most common chronic disease of childhood (HRAAMPH4). Reducing dental caries would be a public health victory, especially to the threshold that children necessitate FMDR under GA (Health & Services, 2000).

Results

Searches of PubMed, EMBASE, CINAHL, and Dentistry & Oral Sciences were done utilizing the key terms in Table 1, yielding 430 results. After removing duplicate articles, those published after 2000, those without full-text available, or those not available in English were removed, and 298 were reviewed using the inclusion and exclusion criteria in Table 2. Thirty articles were included after the screening. The resulting studies evaluated relapse rates of dental caries observed after children had FMDR under GA, different factors that affected these patients, and the children's caries risk. The common themes are outlined in Table 3, and articles are described thematically in Table 4.

Figure 1. PRISMA used to show which articles were included.



*Indicates records excluded using automation tools

**Indicates records excluded by a human.

Table 3. Common themes as they relate to domains.

	Individual-level	Family-level	Health system-level	Socioecological-level
Barriers	X	X	X	X
Behavior change of pt or family	X	X		
Economics		X	X	X
Education	X	X	X	
High caries-risk for life	X		X	
Overall Health	X			
Re-treatment of teeth	X		X	
Recall importance		X	X	
Will need future treatment	X	X		

Table 4. Articles chosen with common themes.

Title	**Authors**	**Barriers**	**Behavior change of pt or family**	**Economics**	**Education**	**High caries-risk for life**	**Overall Health**	**Re-treatment of teeth**	**Recall importance**	**Will need future treatment**
Future caries susceptibility in children with early childhood caries following treatment under general anesthesia	Almeida, A.G., Roseman, M.M., Sheff, M., Huntington, N., Hughes, C.V.					X				
Caries recurrence after treatment under general anaesthesia for early childhood caries: a retrospective cohort study	Amin, M.S., Nouri, R., ElSalhy, M., Shah, P., Azarpazhooh, A.					X			X	X
Change in parental oral health practices following a child's dental treatment under general anaesthesia	Amin, M.S. & Harrison, R.L.	X	X						X	
Early childhood caries: recurrence after comprehensive	Amin, M.S., Bedard, D., Gamble, J.					X			X	X

Title	Authors	Barriers	Behavior change of pt or family	Economics	Education	High caries-risk for life	Overall Health	Re-treatment of teeth	Recall importance	Will need future treatment
dental treatment under general anaesthesia										
Primary Second Molar Treatment as a Predictor of Repeat General Anesthesia	Azadani, E.N., Casamassimo, P.S., Peng, J., Griffen, A., Amini, H., Kumar, A.							X		
A survival analysis of primary second molars in children treated under general anesthesia	Azadani, E.N., Peng, J., Kumar, A., Casamassimo, P.S., Griffen, A., Amini, H., Ni, A.							X		X
Outcomes two, three and four years after comprehensive care under general anaesthesia	Drummond, B.K., Davidson, L.E., Williams, S.M., Moffat, S.M., Ayers, K.M.					X		X		
Factors affecting clinical outcome following treatment of early childhood caries under general anaesthesia: a two-year follow-up	El Batawi, H.Y.		X		X					
Factors relating to failure rates of dental procedures in children following comprehensive dental treatments under general anesthesia: A 2-year retrospective study	Elkhodary, H.M., Bagher, S.M., Sabbagh, H.J., Almushayt, A., Almalik, M., Baghlaf, K., Alamoudi, N.							X		X
Recurrence of early childhood caries after comprehensive treatment with general anesthesia and follow-up	Foster, T., Perinpanayagam, H., Pfaffenbach, A., Certo, M.								X	X
A study of the provision of hospital based dental general anaesthetic services for children in the northwest of England: part 1--a comparison of service delivery between six hospitals	Goodwin, M., Sanders, C., Pretty, IA.								X	

Title	Authors	Barriers	Behavior change of pt or family	Economics	Education	High caries-risk for life	Overall Health	Re-treatment of teeth	Recall importance	Will need future treatment
Clinical outcomes for early childhood caries: influence of aggressive dental surgery	Graves, C.E., Berkowitz, R.J., Proskin, H.M., Chase, I., Weinstein, P., Billings, R.							X		
Recall rates and caries experience of patients undergoing general anesthesia for dental treatment	Jamieson, W.J., Vargas, K.								X	
Effects of dental general anaesthesia treatment on early childhood caries: a prospective cohort study in China	Jiang, H., Shen, L., Qin, D., He, S., Wang, J.							X		
Further dental treatment needs of children receiving exodontia under general anaesthesia at a teaching hospital in the UK	Kakaounaki, E., Tahmassebi, J.F., Fayle, S.A.				X					
Repeat general anaesthesia, a 6-year follow up	Kakaounaki, E., Tahmassebi, J.F., Fayle, S.A.								X	X
Dental plaque pH in predicting caries relapse after general anaesthesia - an exploratory study	Kalhan, T.A., Lin, Y.T., Kalhan, A.C., Lin, Y.J., Chou, C.C., Hsu, C.S.									X
Repeat paediatric dental general anaesthesia at Sheffield Children's NHS Foundation Trust: a service evaluation	Kirby, J., Walshaw, E.G., Yesudian, G., Deery, C.			X						
Changes in Candida spp., mutans streptococci and lactobacilli following treatment of early childhood caries: a 1-year follow-up	Klinke, T., Urban, M., Lück, C., Hannig, C., Kuhn, M., Krämer, N.		X							X
Incidence and risk factors of unplanned re-treatment following dental general anesthesia in children with severe early childhood caries	Li, J.-Y., He, S.-Y., Wang, P.-X., Dai, S.-S., Zhang, S.-Q., Li, Z.-Y., Guo, Q.-Y., Liu, F.							X		

Title	Authors	Barriers	Behavior change of pt or family	Economics	Education	High caries-risk for life	Overall Health	Re-treatment of teeth	Recall importance	Will need future treatment
Risk assessment models to predict caries recurrence after oral rehabilitation under general anaesthesia: a pilot study	Lin, Y.T., Kalhan, A.C., Lin, Y.J., Kalhan, T.A., Chou, C.C., Gao, X.L., Hsu, C.S.		X							X
A retrospective investigation of the oral health records of a cohort of preschool children who received extractions under general anaesthesia including cost analysis of treatment	McAuliffe, U., Kinirons, M., Woods, N., Harding, M.			X		X				
Outcomes assessment an intervention strategy to improve parental compliance to follow-up evaluations after treatment of early childhood caries using general anesthesia in a Medicaid population	Primosch, R.E., Balsewich, C.M., Thomas, C.W.	X								
Prevention in the context of caries-related extractions under general anaesthesia: an evaluation of the use of sealants and other preventive care by referring dentists	Raja, A., White, D.A., Kerr, S.E., Dietrich, T.							X		
Impact of Health Promotion Interventions on Early Childhood Caries Prevention in Children Aged 2-5 Years Receiving Dental Treatment Under General Anesthesia	Razeghi, S., Amiri, P., Mohebbi, S.Z., Kharazifard, M.J.		X		X					
A review of repeat general anesthesia for pediatric dental surgery in Alberta, Canada	Schroth, R.J., Smith W.F.							X		
Reasons for repeat dental treatment under general anesthesia for the healthy child	Sheller, B., Williams, B.J., Hays, K., Mancl, L.		X		X			X	X	X
Analysis of dental care of children receiving comprehensive care under	Tahmassebi, J.F., Achol, L.T., Fayle, S.A.							X		

Title	Authors	Barriers	Behavior change of pt or family	Economics	Education	High caries-risk for life	Overall Health	Re-treatment of teeth	Recall importance	Will need future treatment
general anaesthesia at a teaching hospital in England										
Trends in repeat general anaesthesia for treatment of dental caries at a children's hospital in Toronto, Canada: a 10-year retrospective investigation	Vertullo, L., Barrett, E., Quinonez, C., Sidhu, N., Casas, M.								X	X
Clinical outcomes of dental treatment under general anesthesia and its effects on the caries activity and body growth of children: a 2-year retrospective study	Zhao, J., Yang, L., Lai, G., Wang, J.						X	X		

Summary of findings

In the thirty articles reviewed, common themes could be categorized under individual, family, health system, and socioecological levels. The recurring themes reinforced the successful systematic literature review, and statistically and clinically significant research exists. Throughout these themes, the opportunities for further research will be discussed.

Barriers

Barriers exist at all domain levels and studies discussed challenges with caries relapse after FMDR under GA at all levels (n=2). Many studies discussed the difficulty in follow-up for these high caries-risk patients who had FMDR under GA. Some barriers listed were distance to dental providers, lack of interest, the COVID-19 pandemic, and time (Aikaterini et al., 2023). Other barriers mentioned were uncooperative behavior of the patient, eating habits, family education, cost of treatment, and external issues such as access to care (M. S. Amin & Harrison, 2006). Many barriers Amin & Harrison discussed could be related to permissive parenting (M. S. Amin & Harrison, 2006). Additionally, many barriers are common in low-income populations and go back to oral health education (Primosch et al., 2001). It is difficult to determine how to mitigate health system and socioeconomic-level barriers; looking at barriers at an individual-level is more reasonable.

Behavior change of patient or family

The behavior changes in the child's home who receives FMDR under GA can also be seen in many articles with the education theme and can be categorized by individual and family-level domains (n=6). Many changes in families with children affected by dental caries were explained when the families returned to post-operative visits; many did not return, and even more did not comply with the post-operative instructions given (El Batawi, 2014). Changes

related to behaviors were reduced bacterial numbers, lower plaque indices, and mealtime duration (Lin et al., 2018). For caregivers whose children received FMDR under GA, motivation to quickly implement changes in oral hygiene and eating behaviors in their homes was noted, but these changes were complex to maintain long-term, emphasizing the need for constant reminders at frequent recall visits (Amin & Harrison, 2006; Klinke et al., 2014). The caregivers who received the educational intervention had increased knowledge of the importance, skill, and duration of toothbrushing; this intervention group showed significantly less development of recurrent caries than the control group (Razeghi et al., 2020). It is critical to address both the individual and family-level behavior changes to promote change.

Economics

While there are many articles about the exorbitant expense that FMDR under GA takes on families, health systems, and communities, many of those ended up being excluded from this literature review due to exclusion criteria (n=2). Therefore, economics can be characterized by family, health system, and socioecological level domains. However, it is essential to remember that restorative treatment, which is the bulk of what treatment is rendered during FMDR under GA, is up to eight times more expensive in similar populations than preventive treatment, which can often be completed in a clinical setting (McAuliffe et al., 2017).

Dental caries disproportionately affects people with low socioeconomic status, with 20 to 25 percent of children in poverty accounting for 80 percent of tooth decay (American Academy of Pediatric Dentistry, 2020). Because of this, it is not surprising that a disproportionate number of children who necessitate GA for FMDR are from areas of economic disadvantage status; however, dental caries does not discriminate based on socioeconomic status, and children of all economic classes can necessitate FMDR under GA (Kirby et al., 2020; McAuliffe et al., 2017). It

is challenging and outside the scope of healthcare professionals to address family-level economic challenges. However, dental professionals and public health professionals can work together to promote change in insurance coverage of dental procedures, encouraging preventive treatment, which will impact the health system and socioecological-level domains and, in turn, have an economic impact on families.

Education

Oral health education is critical to determine the best way to eventually determine the best solution to the high rates of relapse of dental caries (n=4). Oral health education should be given pre-operatively and directed appropriately at the patient and primary caregiver to decrease caries recurrence in children who receive FMD under GA, diminishing the need for additional GA (El Batawi, 2014). While few predictors were statistically significant, dental plaque pH was associated with caries relapse, indicating how critical appropriate oral hygiene instruction is to review (Kalhan et al., 2019). Oral hygiene intervention programs increased the number of mothers who knew how to brush their child's teeth appropriately and included brushing their teeth in their daily routine after the intervention; caregivers who complied with the preventive plan had less caries recurrence in their children than non-compliant caregivers (El Batawi, 2014; Razeghi et al., 2020; Sheller et al., 2003). Education can be looked at from an individual-level of the patient's oral hygiene and dietary instructions and from a family-level when brushing and diet instructions are directed at the parents. Additionally, it is critical to emphasize the importance of oral health education at a health system-level and make oral hygiene education common knowledge for everyone.

High caries-risk for life

High-risk children are tagged as high risk for dental caries for life, reinforced by multiple articles in this literature review and many articles not included due to the exclusion criteria (n=5). Caries risk is focused on the individual child and thus falls solely under the individual-level domain. Children who have experienced dental caries remain at greater risk for dental caries later (Almeida et al., 2000). Despite preventive treatment, children remain at high risk for dental caries remain at high risk throughout their lives, into adolescence, which is a critical issue (Amin et al., 2010; Amin et al., 2015; Drummond et al., 2004; McAuliffe et al., 2017). Since caries risk is an individualized assessment, it is critical to review at each patient visit and prescribe treatment based upon that child's caries risk status.

Overall health

One of the exclusion criteria was that the patients included in the study were not solely special health care needs (SHCN) patients, as this population has many complex contributing factors (n=1). The higher ASA status of II and greater often correlates to higher caries risk and a higher rate of caries relapse after GA (M. Amin et al., 2015). This is due to many factors that will not be elaborated on due to the exclusion criteria of this literature review. However, the articles that concerned healthy patients without contributing health conditions also mentioned the overall health of children who received FMDR under GA, as oral health is closely related to overall health. Body mass index (BMI) is a measure that, if not in the healthy range, can indicate problems; patients with dental caries have been found to have both high and low BMIs (Zhao et al., 2022). Both low and high BMI can indicate insufficient chewing function to eat nutritious food, which can indicate oral pain from dental decay, confirmed by the fact that more children after FMDR under GA had normal BMI (Zhao et al., 2022). The individual health of each child is critical to assess for their safety and is the only factor that is relevant to that child, which is why the individual-level domain is the only one that applies to overall health.

Re-treatment of teeth

Due to the nature of the search, the most common theme amongst articles was the re-treatment of teeth (n=12). Primary tooth restoration procedures exhibit high success rates in high-risk children (Drummond et al., 2004). However, restoration failure was the primary reason for teeth requiring re-treatment, with most children requiring between three and four teeth to require re-treatment during subsequent FMDR under GA (Li et al., 2023; Schroth & Smith, 2007). While there may be a significant amount of pressure from guardians regarding esthetic restorations of composite or tooth-colored fillings over stainless steel crowns or silver crowns covering the entire tooth, full-coverage stainless steel crowns exhibit some of the highest success rates of restorations completed during FMDR under GA when compared to composite restorations (Azadani et al., 2020; Zhao et al., 2022). While stainless steel crowns can still have failures, which are commonly recurrent decay or open margins, non-full coverage restoration types resulted in higher rates of children necessitating repeat FMDR under GA (Azadani et al., 2020; Elkhodary et al., 2022). While not as successful as stainless steel crowns, but more esthetic, full-coverage strip crowns also exhibited high success rates (Tahmassebi et al., 2014). The number of crowns placed during FMDR under GA and surfaces at risk did not impact the relapse of dental caries (Graves et al., 2004).

Most healthy patients who received FMDR under GA are young; therefore, they may not have their six-year molars erupted. However, for those who do, there is a high incidence of caries found on their six-year molars two years after those teeth were deemed sound upon examination while receiving FMDR under GA (Raja et al., 2019). This supports preventive treatment, such as sealants on teeth that do not have dental caries at the time of treatment (Raja et al., 2019). While not everyone agrees with aggressive treatment of dental caries during FMDR under GA despite the research outlined in the articles in this literature review, most agree that preventive treatment

is critical (Sheller et al., 2003). The individual-level domain applies because treatment must be prescribed for the individual patient to minimize re-treatment of teeth after FMDR under GA. Additionally, the health system-level domain applies because dentists must be educated in the appropriate way to prescribe treatment based on the patient's caries risk status, age, and assessment of the individual tooth.

Recall importance

Many articles reinforced the importance of frequent recalls as a critical preventive approach (M. S. Amin et al., 2010) (n=9). The American Academy of Pediatric Dentistry recommends that all children visit the dentist by age one or within six months of the eruption of their first tooth (American Academy of Pediatric Dentistry, 2021). Promotion of the age-one dental visit was found to be a critical factor in reducing the risk of caries relapse; it is essential to involve families from an early age in regular attendance to dental appointments, instilling good oral health care habits (M. S. Amin & Harrison, 2006; Goodwin et al., 2015). This promotion needs to happen within families and in partnership with other healthcare providers in the community. Those patients whose families did not follow the recommendation of follow-up intervals were at higher risk of experiencing caries relapse after FMDR under GA (Foster et al., 2006; Jamieson & Vargas, 2007). Those patients who did not have appropriate follow-up had a four-times increased risk of relapse of dental caries (Kakaounaki et al., 2011). The more frequent the dental recalls were, the longer the time between FMDR under GA (Vertullo et al., 2021). Many articles in this literature review reinforced the importance of the age-one dental visit and active follow-up of patients who required FMDR under GA and cited lack of follow-up as a primary contributing factor to relapse of dental caries in this patient population (Sheller et al., 2003). It is critical to examine the family-level and health system-level domains as they both

need to be valued as important domains to increase knowledge of recall importance for these high-risk patients.

Who will need future treatment

Dental caries is a multi-factorial disease, so having one or even a few predictors of who will require subsequent treatment after FMDR under GA is impossible. However, there were common themes throughout the articles reviewed (n=11). Predictors are seen at an individual and family-level domains.

The type of treatment patients receive during their initial FMDR under GA and patients' age can predict what treatment they will likely need in the future. Patients who previously had extractions, leaving them without a full complement of primary dentition, were more likely to require additional treatment (Amin et al., 2015; Sheller et al., 2003). Patients who initially presented with pain and infection also had a higher chance of needing future treatment, likely due to the need for pulpal therapy or extractions for their initial treatment (Kakaounaki et al., 2011). Children whose maxillary incisors required treatment during their initial treatment were more likely to need future treatment, likely due to the progression of caries and the severity of dental caries when they presented initially (Sheller et al., 2003). Finally, the younger a patient was during their initial FMDR under GA, the more likely they were to need future treatment and more likely to necessitate GA to complete that treatment (Amin et al., 2010; Azadani et al., 2020; Elkhodary et al., 2022; Li et al., 2023). These factors all fall under the individual-level domain.

Oral hygiene is one of the primary indicators of patients needing future treatment. Oral hygiene and the plaque index, or amount of plaque present on teeth, was also an indicator of the likeliness of children needing re-treatment of teeth; children with high plaque indices and low resting plaque pH were found to have a higher incidence of needing subsequent treatment

(Elkhodary et al., 2022; Kalhan et al., 2019; Klinke et al., 2014). Children responsible for brushing their teeth independently also suffer from increased risk of future treatment; this may be because they are left alone to brush their teeth at inappropriate ages where they do not have the manual dexterity to adequately brush them (Sheller et al., 2003). Since children are not able to be solely responsible for their oral hygiene, this falls under individual and family-level domains.

The social situations children live in and parental compliance are factors that children and some caregivers have little control over. Behavior during dental appointments in a traditional dental setting predicts which patients may require future treatment; patients who cannot cooperate often require additional treatment (Sheller et al., 2003). Children living in complex social situations are more likely to require additional treatment (Sheller et al., 2003). Parental compliance with attending recalls and following prevention instructions is also crucial; patients who fail to attend follow-up appointments are at higher risk of needing future treatment (Foster et al., 2006; Kakaounaki et al., 2011; Sheller et al., 2003). Following dietary instructions is also critical to lowering the risk of future treatment; patients feeding from a bottle at the time of GA had an increased risk of needing future treatment, possibly due to their age or inappropriate diet practices (Sheller et al., 2003). While routinely visiting the dentist is critical, many instructions for the child's daily life at home must be followed; without proper compliance, it is challenging to reduce the child's risk of requiring additional future treatment. Since many of these factors are beyond the control of the pediatric patient, these fall under the family-level domain.

Articles that were peer-reviewed were desired. Papers that had been retracted or were case reports were not included. Filtering out studies that were case reports or had limited sample sizes and excluding editorials helped ensure that quality articles were used in the comprehensive literature review. The themes fall under individual, family, health system, and socioecological

levels, which can be used to determine prevention strategies for reducing dental caries after these high-risk children have FMDR under GA completed.

Discussion

The public health implications for developing a systematic methodology to reduce relapse of dental caries after FMDR under GA is critical to improving the oral health of our communities. Dental caries puts a significant burden on families, providers, and communities and deserves to be a top priority of public health professions as it is the most common chronic disease of childhood, can have lasting effects on children's lives, and creates a monetary burden for hospital systems, families, and state insurance funds (McAuliffe et al., 2017).

The strengths of this literature review are that there is a significant amount of evidence from multiple studies that conclude that children who are high caries-risk and have FMDR under GA are at high risk for having a relapse of dental caries, requiring them to have additional treatment possibly under GA additional times. Limitations of this systematic literature review are that not all populations have the same access to preventive resources, oral healthcare, and treatment. Therefore, applying interventions to reduce caries risk across populations is challenging. Because of this and the individualized nature of successful prevention, few randomized control trials are available with systematic prevention strategies in the systematic literature review. Additionally, because individual practitioners give oral health education and instructions in their own way, they vary from provider to provider. It is challenging to capture all providers' methodologies, so the changes must come from what is taught to new dental students and pediatric dentistry residents.

This comprehensive literature review identified the gaps in evidence. There have not been effective protocols in reducing dental caries in high-risk children who have undergone

FMDR under GA. While some standardized instructions exist, such as brushing for two minutes in the morning and at night, research should be done to formulate standardized instructions. These are critical opportunities for future research as GA procedures are expensive and not without risk to the child, even when healthy. Therefore, dentistry must develop well-researched protocols that are more systematic and reproducible in reducing caries relapse after FMDR under GA.

As the literature illustrates, dental caries is a multi-factorial disease process that is as complicated to solve as the patients it affects. What was conclusive from the literature review is that there is a high relapse rate of dental caries after FMDR under GA is completed, likely because the best indicator of future caries experience is past caries experience. Therefore, solving the disease process needs to be done on an individual patient level with the family, provider, and patient. Since little research shows definitive ways to prevent dental caries, it would be beneficial to conduct additional research. However, based on the literature review, it likely would come down to the individual patient and family and their level of compliance.

Ideally, we would be able to control for socioeconomic status, race, age, diet, oral hygiene, and education level of the guardian. However, it is not feasible to control that many external factors. Therefore, the best thing would be a randomized control trial in a diverse population with various interventions and providers to see the most effective preventive strategies or interventions. Dental caries is like any chronic disease process; it has external factors beyond a provider's control and sometimes insurmountable problems for families to solve without assistance that would take incredible resources.

It is critical to focus on the individual education of the patient and family as it relates to dental caries, encouraging good oral hygiene and dietary habits. Partnering with families and

other healthcare providers to facilitate establishing a dental home by their child's first birthday is crucial. After a dental home is established, regular dental recall appointments to reinforce oral hygiene education and diagnose dental caries early are essential, making an individualized plan for each patient and family. Finally, encouraging dentists to provide treatment with high long-term success rates while completing FMDR under GA is instrumental in not having to re-treat a tooth that has already undergone treatment. With these best practices and considerations, dentists can work alongside families to decrease caries relapse after FMDR under GA is completed and diminish dental caries one patient at a time.

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