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Silver Diamine Fluoride in Pediatric Dentistry: Current Evidence, Clinical Applications, Safety and Global Public-Health Perspectives

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ABSTRACT

Dental caries remains one of the most prevalent chronic diseases of childhood and disproportionately affects children with limited access to conventional dental care. Silver diamine fluoride (SDF) has emerged as a minimally invasive option for arresting active carious lesions and, in selected settings, supporting prevention. This narrative review critically synthesizes contemporary evidence on SDF in pediatric dentistry, with emphasis on biological mechanisms, clinical effectiveness, indications, application protocols, safety, parental acceptance, comparative effectiveness, economic implications, and global public-health relevance. A structured narrative search prioritized systematic reviews, randomized and pragmatic clinical trials, prospective studies, pharmacokinetic investigations, economic evaluations, and international guidance published primarily from 2014 through September 2026. The strongest evidence supports 38% SDF for arresting cavitated dentinal lesions in primary teeth without pulpal involvement, with repeated application generally providing more sustained control than a single application. Advantages include rapid delivery, absence of drilling and injectable local anesthesia, low equipment requirements, and suitability for very young children, patients with behavioral or medical challenges, and community-based programs. Permanent black staining of carious tissue remains the principal limitation and materially affects caregiver acceptance, especially for anterior teeth. Available pharmacokinetic evidence is reassuring when small quantities are professionally applied. SDF should be integrated into comprehensive, risk-based caries management rather than used as a universal substitute for restorative care.

KEYWORDS: silver diamine fluoride; pediatric dentistry; dental caries; early childhood caries; minimally invasive dentistry; caries arrest.

1. INTRODUCTION

Dental caries remains a major global public-health problem despite being largely preventable. The World Health Organization (WHO) estimates that oral diseases affect approximately 3.5 billion people worldwide and that untreated caries of the primary dentition affects about 514 million children aged 1-9 years. The global average prevalence of untreated caries in deciduous teeth is approximately 43%, with more than three-quarters of cases occurring in middle-income countries. These figures are clinically important because they represent not only a large volume of untreated lesions but also a persistent distributional problem: the burden is concentrated among populations that often face barriers to prevention, early diagnosis, restorative care, and continuity of dental follow-up.[1]

Early childhood caries (ECC) is particularly consequential. Disease may progress quickly in very young children, and extensive treatment can be complicated by limited cooperation, dental fear, neurodevelopmental or medical complexity, limited availability of pediatric dental services, and the logistical burden of multiple appointments. In severe cases, conventional operative treatment may require pharmacological behavior guidance, procedural sedation, or general anesthesia. These approaches are sometimes necessary and appropriate, but they consume substantial

resources and are not equally accessible across healthcare systems. The clinical challenge is therefore not simply to restore cavitated teeth; it is to control a chronic biofilm-mediated disease while minimizing procedural burden and preserving future treatment options.

Silver diamine fluoride (SDF) occupies a distinctive position within this therapeutic framework. Contemporary 38% solutions combine a high concentration of ionic silver with fluoride in an alkaline, ammonia-stabilized preparation. The intervention can be placed directly on carious tissue without complete excavation, rotary instrumentation, or local anesthetic injection. Its primary purpose is biological control of the lesion rather than replacement of lost anatomy. This distinction is central: SDF may arrest disease, but it does not recreate contact areas, cuspal form, occlusal morphology, or esthetics. Accordingly, its appropriate role is best understood within minimally invasive, risk-based caries management.[2–6]

During the last decade, evidence and guidance on SDF have expanded considerably. The American Academy of Pediatric Dentistry (AAPD) supports 38% SDF for arrest of cavitated carious lesions in children and adolescents, including individuals with special health care needs, and emphasizes use within an ongoing caries-management plan.[3,4] The AAPD's broader policy on minimally invasive dentistry places SDF among interventions that can arrest disease while preserving tooth tissue and potentially delaying entry into the restorative cycle.[5] The American Dental Association (ADA) has also incorporated 38% SDF into evidence-based guidance for nonrestorative management of carious lesions.[6] In 2026, WHO issued a global guideline on environmentally friendly and less invasive oral healthcare that specifically recommends twice-yearly 38% SDF as a non-invasive treatment option for cavitated carious lesions without pulpal involvement in primary teeth; WHO also suggests twice-yearly 38% SDF as a population-level preventive intervention, although with lower certainty of evidence for prevention.[2]

At the same time, important controversies persist. Caries-arrest rates vary across trials; study protocols are heterogeneous; certainty of evidence is not uniformly high; outcomes are influenced by lesion site, oral hygiene, dietary exposure, baseline disease activity, application frequency, and follow-up. The permanent dark staining of carious tissue remains the most visible disadvantage and a major determinant of caregiver acceptance. Evidence for permanent teeth, while increasing, is less mature than evidence for primary dentinal lesions. Regulatory status also varies internationally; for example, caries arrest in the United States is an off-label use even though SDF is widely incorporated into clinical practice and professional guidance. These factors require a nuanced interpretation that distinguishes biological plausibility, clinical effectiveness, evidence certainty, patient preference, and health-system feasibility.

The objective of this narrative review is to synthesize and critically interpret current evidence on SDF in pediatric dentistry, integrating epidemiology, mechanisms of action, clinical effectiveness, indications and contraindications, application protocols, safety and toxicology, parental acceptance, comparison with alternative caries-arrest strategies, cost-effectiveness, and global public-health relevance. Particular emphasis is placed on literature from the last 10-12 years and on the implications of the 2026 WHO guidance for contemporary pediatric practice.

2. MATERIALS AND METHODS

This review used a structured narrative approach designed to identify the most clinically informative contemporary evidence rather than to perform an exhaustive systematic review or meta-analysis. Literature searches were completed through 29 September 2026. The principal evidence window was January 2014 to September 2026, with older material considered only when required for historical or mechanistic context. The review prioritized evidence directly relevant to children and adolescents and, where possible, distinguished findings from primary and permanent dentitions.

Electronic searches focused on PubMed/MEDLINE and the Cochrane Library. Targeted searches were also undertaken for guidance and policy documents from WHO, AAPD, and ADA. Reference lists of major systematic reviews, guidelines, and influential trials were used for backward citation tracking. Core search concepts included combinations of "silver diamine fluoride", "silver diammine fluoride", "SDF", "pediatric dentistry", "paediatric dentistry", "early childhood caries", "primary teeth", "permanent molars", "caries arrest", "randomized clinical trial", "systematic review", "safety", "pharmacokinetics", "parental acceptance", "staining", "cost-effectiveness", and "public health". The detailed search framework is provided in Supplementary File 1.

Priority was given to systematic reviews and meta-analyses, randomized and cluster-randomized trials, prospective cohorts, pharmacokinetic studies, economic evaluations, and evidence-based professional guidance. Pediatric studies were preferred. Adult evidence was considered only when it contributed directly to pharmacology, regulation, guideline interpretation, or public-health implementation. Purely laboratory studies were not used to infer clinical effectiveness, although mechanistic evidence was considered through a dedicated review of SDF biology.[7]

Because this article is a narrative review, no pooled effect estimate was calculated and no PRISMA flow diagram was generated. Evidence was interpreted according to study design, sample size, duration of

follow-up, consistency across studies, relevance to pediatric clinical practice, and methodological limitations reported by the original investigators or systematic reviewers. Particular attention was given to the difference between a consistent clinical signal of benefit and the formal certainty of comparative evidence. This distinction is important because several favorable individual trials coexist with systematic reviews that downgrade certainty because of risk of bias, heterogeneity, clustering of multiple lesions within participants, and variability in outcome definitions.[8–12]

3. RESULTS AND DISCUSSION

3.1 Epidemiological and Clinical Rationale

The scale of untreated childhood caries creates a treatment need that cannot realistically be met by conventional restorative dentistry alone. WHO's 2022 global report documented approximately 514 million children with untreated caries in deciduous teeth and highlighted marked socioeconomic inequalities in oral disease and access to care.[1] These inequalities are clinically relevant because the children with the greatest burden are often those least able to obtain repeated restorative appointments, specialist pediatric care, or hospital-based treatment.

SDF addresses a specific gap in this landscape: rapid control of active lesions when conventional operative treatment is either unnecessary, impractical, delayed, or disproportionately burdensome. Its value is therefore not determined solely by a comparison of lesion-level arrest percentages. Operational properties matter. SDF requires no electricity, rotary equipment, restorative matrix system, or injectable anesthesia; a small quantity can be applied quickly with simple isolation. These characteristics make it suitable for very young children, patients with limited cooperation, individuals with special health care needs, and community settings where conventional dental infrastructure is limited.[3–5,13]

The intervention also fits a contemporary chronic-disease model. Caries management is increasingly organized around risk assessment, biofilm and dietary control, fluoride exposure, lesion activity, surveillance, and selective intervention. Within this framework, a successful outcome is not always synonymous with immediate replacement of missing tooth structure. A cavitated primary tooth that becomes hard, asymptomatic, cleansable, and stable until exfoliation may represent a satisfactory outcome in an appropriately selected child. Conversely, an arrested lesion with major structural loss may still require a restoration or preformed crown to re-establish contact, function, or cleansability. SDF thus separates biological disease control from structural rehabilitation, allowing these objectives to be addressed at different times when clinically appropriate.

This staged model may also reduce treatment urgency. Claims-based evidence from the United States found that children who received SDF and subsequently underwent sedation or general anesthesia experienced a longer interval before the first sedation or general-anesthesia encounter than comparable children without documented SDF use.[14] Such observational evidence cannot prove that SDF prevents anesthesia or establish equivalence to definitive treatment, but it illustrates an important health-services role: SDF can function as a disease-control bridge while a child matures behaviorally, awaits specialist care, or moves through a complex treatment pathway.

3.2 Composition and Mechanisms of Action

SDF is an alkaline silver-fluoride complex stabilized by ammonia. Commercial 38% preparations contain approximately 24-29% silver and about 5-6% fluoride by weight/volume, yielding a fluoride concentration close to 44,800 ppm. The very high fluoride concentration is only one component of activity; the distinctive clinical effect depends on interaction among silver ions, fluoride, tooth mineral, dentinal collagen, and the caries-associated biofilm.[7]

Silver has broad antimicrobial activity. Experimental work summarized by Zhao and colleagues indicates that SDF can damage bacterial cell membranes, interfere with metabolic enzymes, inhibit DNA replication, and suppress cariogenic biofilm growth. Effects have been described against Streptococcus mutans and other organisms associated with caries. However, the lesion should not be considered permanently sterilized. The oral microbiome remains dynamic, and dietary sugar exposure, plaque stagnation, salivary conditions, and fluoride availability continue to influence future disease activity. SDF should therefore be viewed as a lesion-directed modifier of a pathogenic environment rather than a substitute for comprehensive risk-factor control.[7]

Fluoride contributes through well-established effects on demineralization and remineralization. SDF-treated dentin can develop mineral-rich surface layers and deposits that act as fluoride reservoirs during subsequent acid challenges. Silver-containing precipitates may reduce dentinal permeability and contribute to the characteristic hardening of arrested lesions. Laboratory studies also suggest increased microhardness and reduced mineral loss after treatment, providing a tissue-level correlate for the clinical shift from soft, active dentin to hard or firm, inactive tissue.[7]

The organic component of dentin is also relevant. During caries progression, the demineralized collagen matrix is degraded by bacterial enzymes and host-derived proteases, including matrix metalloproteinases and cysteine cathepsins. SDF has demonstrated inhibitory effects on proteolytic degradation in experimental models. Preservation of collagen may therefore complement mineral precipitation and antimicrobial activity. The resulting lesion is not simply "disinfected"; rather, several biological and physicochemical processes

converge to slow demineralization, reduce biofilm activity, preserve organic matrix, and favor hardening.[7]

These mechanisms help explain why lesion activity rather than color alone should determine treatment success. Black discoloration is a visible consequence of silver chemistry, but the clinically meaningful endpoint is conversion of an active lesion to a hard or firm, non-progressing state without symptoms or signs of pulpal disease. This distinction is important in follow-up because color change can occur even when a lesion requires reapplication or subsequent restorative treatment.

3.3 Current Evidence on Clinical Effectiveness

Evidence is strongest for cavitated dentinal lesions in the primary dentition. Early systematic reviews identified a consistent caries-arrest signal across pediatric studies, although treatment protocols varied in concentration, frequency, lesion type, and follow-up duration.[8] Subsequent randomized trials provided more detailed information about dose and frequency.

Fung et al. compared 12% and 38% SDF applied annually or semiannually over 30 months in preschool children. Higher concentration and more frequent application were associated with more favorable arrest outcomes; the semiannual 38% regimen produced the highest arrest proportion among the tested groups.[15] This study is clinically influential because it supports two recurring features of modern guidance: preference for 38% SDF and the expectation that repeated application is often necessary.

Milgrom et al. conducted a randomized placebo-controlled trial in preschool children and demonstrated a marked short-term advantage of 38% SDF for caries arrest compared with placebo, while also examining microbiological outcomes.[16] The trial showed that meaningful lesion activity change can occur rapidly after application. It also reinforced that SDF can be delivered in young children with minimal procedural complexity.

Mabangkhru et al. compared semiannual 38% SDF with 5% sodium fluoride varnish in children aged 1-3 years with high caries risk. At 12 months, SDF achieved greater arrest of active dentinal lesions than fluoride varnish.[17] This difference is conceptually important. Fluoride varnish remains a central preventive strategy and is appropriate for non-cavitated lesions, but established cavitated dentinal caries represents a different clinical target. SDF's silver component and very high fluoride concentration provide a lesion-arrest mechanism that is not equivalent to routine preventive varnish.

A large non-inferiority trial by Gao et al. enrolled more than 1,000 young children and compared semiannual 38% SDF with sequential silver nitrate followed by sodium fluoride varnish. The two silver-fluoride strategies produced similar long-term arrest outcomes.[18] The study supports the principle that combined antimicrobial silver and fluoride-mediated mineral effects can be delivered through more than one protocol, while also illustrating why pooled evidence is heterogeneous: formulations and application sequences are not identical across trials.

Systematic reviews published between 2022 and 2024 broadly support SDF for caries arrest in children. Zaffarano et al. concluded that SDF is effective for cavitated caries in primary molars, while emphasizing variation among studies.[9] Muntean et al. included 16 randomized trials involving children from approximately 18 months to 13 years and characterized SDF as a practical non-invasive intervention requiring continued monitoring.[10] Vishwanathaiah et al. included 15 studies and nearly 7,900 children and adolescents; most studies favored SDF, but many were judged to have substantial risk of bias.[11]

The 2024 Cochrane review provides the most cautious synthesis. Worthington et al. included 29 randomized trials involving more than 13,000 participants and concluded that SDF may improve caries arrest in the primary dentition compared with placebo or no treatment, while certainty for many other comparisons remained low or very low.[12] The review could not establish with high confidence that one SDF regimen was superior to another across all outcomes, nor could it consistently rank SDF against every alternative intervention. These conclusions do not negate the favorable trial evidence; rather, they highlight methodological limitations such as heterogeneity of lesion definitions, varied application schedules, risk of bias, incomplete reporting of staining and adverse effects, and statistical dependence when multiple surfaces within the same child are analyzed as independent units.

The distinction between clinical utility and certainty of evidence is therefore essential. A clinician can reasonably conclude that 38% SDF is useful for arresting many cavitated primary-tooth lesions while also recognizing that the exact magnitude of effect and comparative superiority vary across settings. WHO's 2026 guideline reflects this balance: it provides a strong recommendation, supported by moderate-certainty evidence, for twice-yearly 38% SDF in cavitated primary-tooth lesions without pulpal involvement, while acknowledging that evidence on optimal concentration and frequency remains limited.[2]

Pragmatic school-based evidence extends the discussion beyond specialty dental clinics. The CariedAway program used cluster-randomized designs to compare an SDF-based caries-control strategy with more resource-intensive approaches in New York City schools. The 2023 report supported SDF as a feasible school-based strategy for caries arrest and prevention.[19] A four-year

analysis published in 2025 found no statistically significant difference in total surface-level failure between SDF and atraumatic restorative treatment (ART), while participant-level failure was lower in the SDF group for the reported comparison.[20] These studies are valuable because they examine effectiveness under real-world conditions and demonstrate that simple non-operative care can be integrated into school delivery at scale.

Evidence in permanent teeth is less mature but evolving. A 2026 randomized controlled trial in 165 children aged 6-12 years compared 38% SDF plus potassium iodide with 5% fluoride varnish for early carious lesions in first permanent molars. After six months, a larger proportion of teeth in the SDF group showed regression to ICDAS 0 than in the fluoride-varnish group, and eruption stage did not significantly alter the observed effect.[21] The trial is encouraging for partially erupted molars, where moisture control can complicate sealant or restorative placement, but longer follow-up and independent replication are required before evidence for permanent teeth can be regarded as equivalent to that for cavitated primary teeth.

Taken together, the evidence supports three practical conclusions. First, the best-established pediatric indication is cavitated dentinal caries in primary teeth without pulpal involvement. Second, 38% SDF and repeated application are the most consistently supported strategy. Third, success depends on continuing disease management: SDF is not a one-time substitute for dietary counseling, fluoride exposure, plaque control, surveillance, and definitive treatment when structure or pulpal status requires it.

Table 1: Principal contemporary evidence on sdf in pediatric dentistry.

Study	Design / population	Intervention / comparator	Key finding	Critical interpretation
Gao et al., 2016	Systematic review of pediatric clinical trials	SDF protocols across trials	Consistent signal of caries arrest	Early synthesis; substantial heterogeneity in protocols and outcomes
Fung et al., 2018	30-month randomized trial in preschool children	12% vs 38% SDF; annual vs semiannual	Higher concentration and semiannual application produced more favorable arrest	Supports 38% and repeated application; setting-specific effect sizes
Milgrom et al., 2018	Randomized placebo-controlled preschool trial	38% SDF vs placebo	Marked short-term improvement in lesion arrest	Strong proof-of-concept; short primary endpoint
Mabangkhru et al., 2020	RCT; children aged 1-3 years with high caries risk	Semiannual 38% SDF vs 5% NaF varnish	SDF achieved greater dentin-caries arrest at 12 months	Directly relevant to very young high-risk children
Gao et al., 2020	Large randomized non-inferiority trial	38% SDF vs AgNO3 followed by NaF varnish	Similar long-term arrest between silver-fluoride approaches	Shows efficacy can be delivered through different silver/fluoride protocols
Worthington et al., 2024	Cochrane review; 29 RCTs, >13,000 participants	SDF vs no treatment and alternative therapies	Possible benefit for primary-tooth caries arrest; many comparisons low/very-low certainty	Most rigorous caution regarding heterogeneity, bias, and clustering
Ruff et al., 2023/2025	Cluster-randomized pragmatic school program	SDF-based strategy vs ART / sealant strategy	SDF effective for school-based caries control; long-term surface-level performance broadly comparable to ART	High external relevance for community delivery
Andrade et al., 2026	Randomized trial; children aged 6-12 years	38% SDF + KI vs 5% fluoride varnish on early first-permanent-molar lesions	Greater six-month regression/arrest in SDF group	Promising permanent-tooth evidence; longer follow-up needed

3.4 Clinical Applications in Pediatric Dentistry

Appropriate case selection is the foundation of successful SDF use. The intervention is most valuable when a lesion is active and accessible, the tooth has no evidence of irreversible pulpal disease, and biological stabilization offers a meaningful advantage over immediate conventional treatment. Typical candidates include very young children with ECC; children with multiple active

lesions; patients with limited tolerance for rotary instrumentation or local anesthetic injection; children with special health care needs; patients awaiting definitive treatment; and children living in settings where timely restorative access is limited.[3–5]

SDF can also be useful when a tooth is technically difficult to restore at a particular visit. Examples include partially erupted molars with poor moisture control, very young children in an initial acclimatization phase, or families who require time to decide among restorative, crown, sedation, or general-anesthesia options. In these contexts, SDF can reduce biological activity while a definitive plan is organized. Its use should be documented as an intentional disease-control step rather than an indefinite postponement of necessary treatment.

Contraindications and situations requiring alternative management are equally important. SDF is inappropriate as sole therapy for teeth with spontaneous or persistent pain compatible with irreversible pulpitis, clinical or radiographic signs of pulpal necrosis or periapical pathology, abscess or sinus tract, or other findings indicating the need for pulp therapy or extraction. Direct application to exposed pulp should be avoided. Known hypersensitivity to silver compounds is a contraindication. Active ulcerative gingivitis, stomatitis, or mucosal lesions in areas where inadvertent contact is likely warrant caution or postponement. Inability of the patient or caregiver to accept expected dark staining after informed discussion is also a valid reason to choose another strategy.[2–4]

Structural considerations influence whether SDF can function as an interim or potentially definitive approach. A lesion may become arrested yet remain anatomically compromised. Loss of marginal ridge, food impaction, poor cleansability, or risk of fracture may justify subsequent glass-ionomer restoration, stainless-steel crown, or another restorative solution. In primary teeth approaching exfoliation, by contrast, successful arrest with maintained comfort and function may be sufficient until natural tooth loss. The decision should therefore be tooth-specific, child-specific, and time-sensitive.

A pragmatic clinical protocol begins with diagnosis and caries-risk assessment. When radiographs are clinically indicated and feasible, they can help estimate lesion depth and exclude pathology. The parent or legal guardian should be told that SDF is intended to arrest disease rather than reconstruct anatomy, that multiple applications may be required, and that treated carious tissue usually becomes permanently black. Showing representative photographs can improve the quality of consent because verbal descriptions alone may underestimate the visual effect.[3,4,22–24]

Complete caries excavation is not necessary. Gross debris can be removed to improve access, followed by simple isolation with cotton rolls or gauze. Petroleum jelly or another barrier may be used to protect lips and adjacent skin when appropriate. The lesion is gently dried, a minimal quantity of 38% SDF is transferred to a micro-applicator, and excess material is removed before placement. The solution is applied directly to the affected surface while avoiding unnecessary contact with gingiva and mucosa. AAPD chairside guidance supports maintaining application contact for approximately one minute when feasible; in an uncooperative child, a shorter application may still be preferable to abandoning treatment, provided the clinician recognizes the evidence base is strongest for standard application.[3,4]

The total amount should remain small. SDF is a high-concentration topical agent, and professional application should emphasize precise delivery rather than saturation of the oral cavity. After application, the material can be allowed to dry; no complex curing or instrumentation is required. Normal toothbrushing with fluoridated toothpaste and the child's broader preventive program should continue. SDF should not displace age-appropriate preventive measures.

Follow-up is necessary because a dark lesion is not automatically an arrested lesion. Successful arrest is primarily assessed by hardness or firmness on gentle tactile examination, absence of progression, lack of symptoms, and stable pulpal status. An early review within several weeks can be useful in high-risk or uncertain cases; subsequent recall should be determined by disease activity and overall caries risk. Persistent softness, progression, or new symptoms should trigger reassessment of diagnosis and management.

Repeated application is often required. The frequency used most consistently in trials and recent guidance is twice yearly. WHO explicitly recommends 38% SDF twice yearly for cavitated primary-tooth lesions without pulp involvement.[2] Fung et al. demonstrated a dose-frequency relationship favoring 38% and semiannual use over lower concentration and less frequent application.[15] This does not mean that every arrested lesion must be painted indefinitely. Rather, reapplication should be guided by lesion activity, caries risk, anticipated tooth retention, and the feasibility of definitive restoration.

SDF can be integrated with restorative treatment. A common staged approach is application of SDF followed by glass-ionomer restoration, often referred to as silver-modified atraumatic restorative treatment (SMART). The concept is attractive because it combines biological control with restoration of contour and cleansability. However, the evidence base for SMART is smaller than that for SDF alone or established restorative options, and terminology is not standardized across studies. Clinicians should avoid implying that the addition of SDF automatically improves restoration survival. Its most defensible role is to integrate lesion arrest with a restorative material when structural rehabilitation is

needed and patient circumstances favor a minimally invasive approach.

SDF also has a behavioral advantage that is difficult to capture in lesion-level outcomes. Treatment is brief, avoids noise and vibration, and often avoids local anesthetic injection. For anxious or sensory-sensitive children, these features may permit a positive first dental experience and create time for gradual behavior guidance. Such benefits are clinically meaningful, but they should not be used to deny indicated restorative or surgical care. A child whose tooth becomes symptomatic, structurally non-restorable, or pulpal-involved has moved beyond the scope of SDF-only management.

Table 2: Clinical decision framework for pediatric sdf use.

Clinical domain	Favors SDF use	Requires caution / alternative management
Lesion status	Active cavitated dentinal lesion accessible for topical treatment	Non-carious defects, inaccessible lesions, or uncertainty about diagnosis
Pulpal status	No spontaneous pain, swelling, sinus tract, or radiographic signs of pathology	Irreversible pulpitis, necrosis, abscess, sinus tract, pathological mobility, pulpal exposure
Patient factors	Young age, limited cooperation, special health care needs, dental anxiety, delayed access to definitive care	Known silver hypersensitivity; active mucosal ulceration at application site
Treatment objective	Rapid disease control, interim stabilization, reduction of procedural burden	Need for immediate restoration of contact, occlusion, strength, or esthetics
Aesthetic context	Posterior lesions; caregivers accept expected black staining	Anterior lesions or family declines permanent discoloration
Follow-up	Reliable recall with monitoring and reapplication if indicated	No realistic follow-up and high risk of missed pulpal progression

3.5 Safety and Toxicology

The high nominal concentrations of silver and fluoride in 38% SDF generate understandable concern about systemic exposure, particularly in small children. Toxicological interpretation should consider actual dose rather than product concentration alone. Clinically, SDF is applied in very small volumes to limited tooth surfaces, and most of the material remains bound locally or is removed during drying and salivary clearance.

Ellenikiotis et al. evaluated serum silver and fluoride after professional 38% SDF application in 55 healthy children aged 3-13 years. Serum fluoride showed no concerning temporal pattern. Population pharmacokinetic modeling suggested that smaller children could have higher peak silver concentrations and longer modeled silver half-life than larger children, but the investigators concluded that intermittent professional application posed little risk of toxicity under the studied conditions.[25] This study is important because it provides pediatric pharmacokinetic data rather than extrapolating entirely from adults.

A subsequent quasi-experimental pharmacokinetic study by Lim et al. assessed silver and fluoride disposition in healthy children using urine and hair measurements after SDF treatment.[26] Although sample sizes in pharmacokinetic research remain modest, the available pediatric evidence has not identified a clinically important systemic toxicity signal from recommended intermittent topical use. The limited size of these studies nevertheless supports conservative technique: use the smallest effective amount, avoid unnecessary repeat dosing, document treated surfaces, and exercise additional judgment in very small or medically complex children.

Local effects are much more common than systemic adverse events. Permanent black staining of demineralized or cavitated carious tissue is expected and represents the principal adverse effect from a patient-centered perspective. Transient gingival or mucosal staining can occur after accidental contact and usually resolves as superficial epithelial layers desquamate. Temporary local irritation and unpleasant or metallic taste have been reported. Serious adverse reactions appear uncommon in clinical studies and professional guidance when SDF is used appropriately.[3,4,11,12]

Pulpal safety depends heavily on case selection. SDF is not a pulp-capping material for direct placement on exposed vital pulp, nor should it be used to mask symptoms of irreversible disease. Deep lesions require careful assessment of pain history, clinical signs, radiographic findings when available, and restorability. The absence of spontaneous pain, swelling, sinus tract, pathologic mobility, and periapical or furcation pathology supports non-operative management in appropriate cases, but diagnostic uncertainty should prompt closer monitoring or definitive treatment rather than repeated SDF without reassessment.[2–4]

Fluorosis is not considered a clinically meaningful risk from properly dosed professional SDF application because the exposure is intermittent and localized rather than chronic systemic ingestion during enamel formation. Nonetheless, fluoride and silver exposure should be minimized according to good clinical practice. Large-scale public-health programs should use

standardized dose limits, training, documentation, and referral protocols rather than treating SDF as a casual topical product.

Safety assessment also includes occupational and environmental handling. SDF can permanently stain clothing, work surfaces, and porous materials. Eye protection, controlled dispensing, and protective barriers are practical requirements. These issues are minor compared with toxicity concerns but become operationally important when programs are delivered in schools or community settings by multiple trained providers.

3.6 Parental Acceptance, Esthetics, and Shared Decision-Making

The permanent darkening of carious tissue is the principal barrier to SDF acceptance. This effect is not a cosmetic side issue; it can determine whether a clinically effective therapy is acceptable to a child and family. The ethical response is not to minimize staining but to incorporate it explicitly into shared decision-making.

A systematic review and meta-analysis by Sabbagh et al. found that parental acceptance was strongly related to tooth location and child cooperation. Posterior staining was more acceptable than anterior staining, and acceptance increased when conventional dental treatment was expected to be difficult for the child.[22] This pattern has been replicated in later regional studies.

Timms et al. compared caregiver attitudes in secondary-care settings in the United Kingdom and United States. Approximately seven in ten parents in both samples reported willingness to accept SDF on posterior primary teeth, whereas acceptance was lower for anterior teeth.[23] Italian data reported by Cappiello et al. showed an even larger anterior-posterior contrast: most parents considered posterior staining acceptable or somewhat acceptable, while acceptance of anterior staining was substantially lower. Importantly, willingness increased when the alternative involved greater treatment difficulty, sedation, or general anesthesia.[24]

These findings show that acceptance is contextual rather than fixed. A parent may reasonably decline SDF on an anterior primary incisor when a conventional esthetic restoration can be performed easily, yet accept staining on the same tooth if the alternative is hospital general anesthesia in a very young or medically complex child. Consent should therefore present SDF beside realistic alternatives, not as an abstract choice between a black tooth and a white tooth.

Clinical communication can improve decision quality. Families should understand that sound tooth structure does not ordinarily undergo the same permanent black discoloration as active carious tissue; the darkening is concentrated in the diseased area. Photographs of typical posterior and anterior outcomes are helpful. The discussion should distinguish temporary gingival staining from permanent tooth staining and should explain that successful arrest does not necessarily restore normal appearance or shape.

Several strategies have been proposed to reduce staining. Potassium iodide (KI) is applied after SDF with the aim of precipitating free silver ions and reducing visible darkening. A 2020 systematic review found some evidence of short-term stain reduction but concluded that evidence for a durable clinically important benefit was insufficient.[27] A 2024 systematic review evaluated restorative masking, chemical agents including KI and glutathione, and nano-silver approaches. Although several strategies improved color outcomes in laboratory or limited clinical studies, the literature remained dominated by in vitro work, and robust long-term clinical evidence was insufficient to promise reliable stain prevention.[28]

For this reason, clinicians should not present KI as a guaranteed solution to the esthetic disadvantage of SDF. When appearance is a high priority, restorative masking or an alternative treatment may be more predictable. Informed consent remains essential even when an adjunct intended to reduce staining is used.

3.7 Comparison with Alternative Caries-Arrest and Minimally Invasive Strategies

SDF should be compared with alternatives according to the clinical objective being pursued. Preventing new lesions, arresting an existing cavitated lesion, restoring anatomy, sealing caries from the biofilm, and maintaining tooth function are related but distinct goals. Apparent disagreements about whether SDF is "better" than another approach often reflect comparisons of interventions designed to achieve different endpoints.

Five-percent sodium fluoride varnish is a well-established preventive intervention and remains highly relevant for children at caries risk. WHO recommends twice-yearly 5% sodium fluoride varnish as a population-wide preventive intervention and as a non-invasive treatment for initial non-cavitated lesions.[2] For established cavitated dentinal caries, however, SDF often produces higher arrest rates in direct pediatric comparisons, as shown in the Mabangkhru trial.[17] The practical implication is not that SDF replaces fluoride varnish; rather, varnish is primarily preventive and remineralizing, while SDF has a distinct role in arresting active cavitated lesions.

Atraumatic restorative treatment (ART) removes softened carious tissue with hand instruments and restores the cavity, usually with high-viscosity glass ionomer cement. ART therefore provides an anatomical result that SDF alone cannot. It also requires more chair time, material handling, and patient tolerance. The 2025 CariedAway analysis found broadly comparable long-term caries-control performance between SDF and ART

at the surface level, with a participant-level advantage for SDF in the reported outcome.[20] The choice between them should be based on lesion morphology, need to restore contact or function, cooperation, equipment, follow-up, and caregiver preference rather than assuming one modality is universally superior.

The Hall technique uses a preformed metal crown to seal caries in a primary molar without conventional caries removal or tooth preparation. It provides robust mechanical protection and restores tooth form, but it requires appropriate occlusion, sufficient remaining tooth structure, crown placement, and acceptance of a metallic restoration. SDF is faster and requires less material, making it attractive for stabilization and field delivery. The two approaches can be complementary: SDF may be used to control disease before definitive crown placement, while a Hall crown may be preferred when long-term structural protection of a primary molar is the central objective.[5]

Conventional adhesive restorations remain appropriate when anatomy, contact, esthetics, or function must be restored. SDF should not become a rationale for avoiding restorative care in teeth with significant structural needs. Conversely, conventional restoration should not be considered obligatory solely because a cavity exists if the tooth is asymptomatic, stable, cleansable, close to exfoliation, and managed within a monitored caries-control plan. The modern approach is to match intervention intensity to disease activity, tissue requirements, child factors, and time horizon.[5,6]

Preformed metal crowns, selective caries removal, interim therapeutic restorations, sealants, resin infiltration, and SMART each occupy additional positions on the minimally invasive spectrum. SDF is most distinctive where the priority is rapid biological arrest with minimal child burden. The trade-off is lack of structural reconstruction and the esthetic consequence of staining. Table 3 summarizes the practical contrasts among commonly used approaches.

Nano-silver fluoride has been investigated as an alternative intended to preserve antimicrobial activity while reducing discoloration. A randomized trial in preschool children comparing nano-silver fluoride with 38% SDF reported improvement in oral-health-related quality of life in both groups.[29] However, formulations, regulatory status, and long-term evidence for nano-silver fluoride remain less mature. It should therefore be regarded as an emerging technology rather than an established replacement for 38% SDF.

Table 3: Practical comparison of sdf with alternative strategies.

Approach	Primary objective	Caries removal	Restores anatomy	Local anesthesia commonly required	Aesthetic / visible trade-off	Community-delivery suitability
38% SDF	Arrest active lesions	No	No	No	Black staining of carious tissue	Very high
5% NaF varnish	Prevention / remineralization	No	No	No	Minimal	Very high
ART	Arrest + restore	Selective hand excavation	Yes	Usually no	Tooth-colored GIC but restoration wear possible	High
Hall technique	Seal caries + protect primary molar	No	Yes	Usually no	Metal crown	Moderate
SMART	Biological arrest + restoration	Variable / minimal	Yes	Usually no	SDF staining may remain beneath restoration	Moderate-high
Conventional adhesive restoration	Remove/contain disease + restore form	Selective or conventional depending on case	Yes	Sometimes	Generally esthetic	Lower in field settings

Abbreviations: ART, atraumatic restorative treatment; GIC, glass ionomer cement; KI, potassium iodide; NaF, sodium fluoride; SDF, silver diamine fluoride; SMART, silver-modified atraumatic restorative treatment.

3.8 Patient-Centered Outcomes and Quality of Life

Lesion arrest is an important clinical endpoint, but pediatric dentistry must also consider pain, sleep, eating, family burden, treatment fear, and the child's experience of care. Untreated ECC can affect nutrition, sleep, school or childcare participation, and family well-being. A rapid non-invasive intervention that controls active disease

may therefore generate benefits not captured by a binary lesion-hardness measure.

Duangthip et al. prospectively evaluated oral-health-related quality of life in preschool children receiving SDF in a kindergarten-based program and found improvement over six months.[30] More recent randomized work comparing SDF and nano-silver fluoride similarly examined quality-of-life outcomes rather than focusing exclusively on lesion activity.[29] These studies support inclusion of patient-reported and family-reported outcomes in future SDF trials.

The behavioral experience is also relevant. SDF avoids rotary noise, vibration, prolonged mouth opening, and injectable local anesthesia in many applications. This can be advantageous for children with dental anxiety, sensory sensitivities, neurodevelopmental conditions, or previous traumatic dental experiences. For some patients, an SDF visit can function as a low-burden entry point into a longer-term dental relationship.

However, patient-centered care also means respecting esthetic values. An intervention that efficiently arrests disease but creates an appearance a child or caregiver finds unacceptable is not automatically patient-centered. The clinician should balance biological benefit, procedural burden, anticipated longevity of the tooth, esthetic visibility, and the child's and family's preferences.

3.9 Cost-Effectiveness and Resource Use

SDF has intuitive economic advantages: low material use, short appointments, minimal capital equipment, and potential to avoid or delay restorations, sedation, and hospital-based care. Yet cost-effectiveness is context dependent. It is influenced by baseline caries activity, treatment setting, reimbursement, lesion distribution, follow-up adherence, and the cost of alternatives.

A 2025 scoping review identified a limited but generally favorable body of economic evaluations for SDF in preschool children. Across included studies, SDF was commonly characterized as cost-effective for prevention or control of ECC, particularly in public-health contexts.[31] The authors also emphasized heterogeneity in analytic methods and health-system assumptions, limiting direct transfer of a single cost figure across countries.

Tan et al. used a decision-analytic model and demonstrated that the economic value of SDF changes with disease activity. SDF was particularly attractive in children with high caries activity, whereas direct restorations could become comparatively favorable in lower-activity scenarios under specific assumptions.[32] This finding is important because it argues against an overly simplistic narrative that the least expensive procedure is always the most cost-effective. Cost-effectiveness depends on downstream outcomes and on which treatment pathway is most likely to succeed for a specific risk profile.

Avoidance or deferral of sedation and general anesthesia may add health-system value. The retrospective cohort study by Meyer et al. found a longer interval to first sedation or general anesthesia among children who had received SDF.[14] Although causal interpretation is limited by the observational design and by the fact that all included children eventually had a sedation or anesthesia claim, the study suggests that SDF can alter timing and resource use in severe disease pathways.

At population level, the economic argument is strongest when the alternative is no timely care or a high-cost operative pathway. In well-resourced settings with excellent preventive coverage and easy access to definitive restorations, SDF may still be valuable, but its economic advantage may be narrower and patient preference may carry greater weight.

3.10 Public-Health and Global Perspectives

SDF is unusually well aligned with public-health delivery because the technology required is modest. It can be applied in schools, community clinics, mobile units, long-term care facilities, and remote settings without electricity or aerosol-generating instrumentation. These characteristics are particularly relevant in regions where the principal barrier to care is not diagnostic uncertainty but a shortage of restorative infrastructure or trained dental personnel.[13]

International policy has historically varied substantially. Gao et al. documented differences in product availability, regulation, and professional guidance across countries and regions.[13] Some health systems incorporated SDF into community programs years before others, while regulatory labeling did not always match common dental use. In the United States, for example, SDF has FDA clearance for dentin sensitivity, while caries arrest is an off-label use supported by professional guidance. Such differences can affect procurement, reimbursement, delegation, and informed-consent wording even when the biological treatment is the same.

The 2026 WHO guideline changes the international context. WHO recommends 38% SDF twice yearly as a non-invasive treatment option for cavitated carious lesions without pulpal involvement in primary teeth and on root surfaces of permanent teeth. It also suggests twice-yearly 38% SDF as a population-wide preventive intervention in both primary and permanent teeth, but assigns lower certainty to the preventive recommendation.[2] The guideline evaluates not only effectiveness but also cost-effectiveness, toxicity, environmental impact, equity, feasibility, and acceptability. This multidimensional framework is particularly appropriate for SDF because its public-health value derives as much from simplicity and reach as from lesion-level efficacy.

Task sharing is another important implication. Because SDF application is technically simple, appropriately trained allied dental personnel or other health workers may be able to deliver it where permitted by local law and under defined diagnostic and supervisory structures. AAPD policy supports delegation to qualified personnel when consistent with dental-practice acts and when a dentist has completed appropriate examination and caries-risk assessment.[4] Public-health programs should therefore distinguish between simple application and clinical decision-making: the former may be delegated, whereas diagnosis of pulpal status, case selection, treatment planning, and referral pathways remain essential professional responsibilities.

SDF may also contribute to environmentally less intensive oral healthcare. WHO's 2026 guideline was developed partly in the context of transition away from mercury-containing restorative materials and toward preventive, minimally invasive, and mercury-free options.[2] SDF requires little material and no rotary removal of tooth tissue for its primary use. Nevertheless, claims of environmental superiority should remain evidence based; sustainability depends on the entire care pathway, including follow-up, subsequent restorations, transport, packaging, and waste handling.

A potential ethical risk is creation of a two-tier standard in which inexpensive arrest treatment is disproportionately offered to disadvantaged children while more comprehensive options remain available to affluent families. Equity does not mean providing the cheapest treatment to the poorest patient. It means offering SDF when it is clinically appropriate and advantageous, with informed choice and access to definitive treatment when needed. Community programs should therefore include prevention, recall, reapplication, referral, and restorative or surgical pathways rather than treating SDF as an endpoint imposed by scarcity.

The greatest public-health opportunity may be in settings where many children currently receive no treatment for active caries. In such populations, the comparison is not between SDF and an ideal restoration delivered immediately; it is often between SDF and continued untreated disease. This changes the value proposition substantially and explains why WHO's framework emphasizes feasibility and equity alongside clinical effect.

3.11 Regulatory Differences and Implementation Considerations

Implementation requires attention to regulatory status, professional scope, procurement, documentation, and reimbursement. SDF is not uniformly labeled for caries arrest in all jurisdictions, even where professional organizations recommend or permit its use. Clinicians should therefore distinguish evidence-based practice from product labeling and comply with national or regional rules governing off-label use, consent, and delegation.

Standardized documentation improves safety and continuity. A clinical record should identify the tooth and surface treated, concentration used, number of applications, caregiver consent including discussion of staining, pulpal assessment, and planned follow-up. Photographic documentation can be useful in high-risk lesions because changes in color, surface integrity, and plaque stagnation can be compared over time. In community programs, simple standardized forms are particularly valuable when different providers perform application and follow-up.

Supply-chain quality also matters. Because the literature and major guidelines primarily concern 38% SDF formulations, substitution with unvalidated silver-fluoride products should not be assumed to provide equivalent efficacy or safety. Product concentration, storage conditions, expiration, dispensing system, and regulatory authorization should be verified. This issue is likely to become more relevant as new silver-based and nano-silver products enter the market.

Training should emphasize diagnostic boundaries as much as application technique. The technical act of painting SDF is easy; the clinical challenge is deciding which lesion is suitable, when reapplication is justified, when restoration is needed, and when pulpal therapy or extraction is indicated. A high-quality implementation program should therefore include calibration in lesion activity, pulp diagnosis, informed consent, adverse-event management, and referral.

3.12 Critical Appraisal and Areas of Controversy

The SDF literature illustrates why evidence should not be reduced to a single arrest percentage. Study populations differ in age, disease burden, fluoride exposure, oral hygiene, lesion site, and access to follow-up. Some trials evaluate surfaces, others teeth or children. Definitions of arrest vary, commonly relying on hardness, visual-tactile criteria, color, or composite measures. Multiple lesions within one child create statistical clustering that is not handled consistently. These methodological differences contribute to the broad range of reported outcomes and to the lower certainty assigned by Cochrane for several comparisons.[12]

Blinding is intrinsically difficult because successful SDF treatment produces visible dark staining. Examiners may therefore infer treatment allocation, and parents cannot be fully blinded in many designs. This limitation does not invalidate the observed biological effect but increases risk of performance and detection bias. Future trials should use independent outcome assessment when feasible and objective standardized criteria for lesion activity.

Another controversy concerns prevention. SDF may reduce incidence of new lesions or provide a protective effect on adjacent surfaces, but evidence for population-wide prevention is less certain than evidence for arrest of cavitated primary lesions. WHO's 2026 recommendation appropriately reflects this distinction: treatment of cavitated primary lesions receives a stronger evidentiary footing than population-level preventive use.[2] Clinicians should avoid extrapolating an arrest indication into a claim that SDF alone is sufficient preventive care.

The role of SDF in permanent teeth is also evolving. The 2026 trial in first permanent molars is promising, particularly for partially erupted teeth, but longer-term data are required because permanent teeth must function for decades.[21] A six-month regression of early occlusal lesions is clinically encouraging but cannot answer questions about multi-year stability, need for sealants, recurrent activity, or eventual restoration.

Aesthetics remain a genuine therapeutic trade-off rather than a minor adverse effect. Strategies to reduce staining are attractive, but the evidence for durable color mitigation is weaker than the evidence for caries arrest itself.[27,28] Attempts to improve appearance should not compromise arrest efficacy or create false expectations. In many anterior lesions, an esthetic restorative approach may be preferred if it can be delivered safely and predictably.

Finally, SDF's simplicity creates a paradox. Because application is easy, it can be overused without adequate diagnosis or follow-up. The intervention is most valuable when embedded in a structured plan. Unmonitored repeated application to a tooth with evolving pulpal disease is not minimally invasive dentistry; it is delayed diagnosis. Conversely, automatic operative treatment of every cavitated lesion may expose children to avoidable procedural burden. The quality of care lies in selecting the right level of intervention at the right time.

3.13 Future Directions

Future research should prioritize standardized outcomes. Trials should define lesion activity using reproducible criteria, distinguish primary from permanent teeth, report patient-level and lesion-level outcomes, and account statistically for clustering of multiple surfaces within children. Consistent reporting of application concentration, quantity, contact time, isolation, reapplication schedule, and co-interventions would substantially improve comparability.

Long-term comparative effectiveness is another priority. Clinically meaningful questions include how often arrested lesions ultimately require restoration, how many remain stable until exfoliation, whether SDF changes pulpal outcomes, and how it compares over several years with Hall crowns, selective caries removal, ART, SMART, or conventional restoration. Economic analyses should be linked to these long-term outcomes rather than to procedure cost alone.

Permanent dentition requires dedicated study. Partially erupted first molars are an attractive indication because moisture control can be difficult and early lesion activity may be high, but the acceptable threshold for uncertainty is different in a tooth expected to function for decades. Trials should evaluate SDF alone, SDF plus KI, fluoride varnish, sealants, resin infiltration, and staged combinations with sufficiently long follow-up.[21]

Aesthetic modification deserves clinically focused research. Laboratory colorimetry is useful for screening approaches, but families need evidence on visible appearance after months and years. Studies of KI, glutathione, restorative masking, and nano-silver formulations should measure both color outcomes and caries-control efficacy.[27,28] An adjunct that reduces staining but weakens arrest would not necessarily improve patient care.

Additional pediatric pharmacokinetic data would strengthen safety assessment in very young, low-body-weight, and medically complex children. Existing studies are reassuring but relatively small.[25,26] Large community programs also offer opportunities for pharmacovigilance and standardized adverse-event reporting.

Patient-reported outcomes should become routine. Future trials should measure pain, child distress, caregiver satisfaction, oral-health-related quality of life, acceptance of staining, school absence, and avoidance or delay of sedation and general anesthesia. These outcomes are particularly important because SDF's principal advantages are procedural and access-related as well as biological.[14,29,30]

Implementation science may ultimately determine population impact. Research is needed on training models, task sharing, recall adherence, integration with primary medical care, school-based delivery, reimbursement, referral pathways, and strategies that avoid creating a lower standard of care for disadvantaged populations. The 2026 WHO guideline provides a framework for this work by explicitly linking clinical effectiveness with equity, sustainability, safety, and feasibility.[2]

4. CONCLUSION

Silver diamine fluoride has become an important component of contemporary pediatric caries management because it can control active disease with exceptionally low procedural burden. The strongest evidence supports 38% SDF for cavitated dentinal lesions in primary teeth without pulpal involvement. Repeated, commonly semiannual, application is better supported than a one-time strategy, and 2026 WHO guidance now recommends twice-yearly 38% SDF for this indication.[2]

Its major clinical advantages are rapid application, avoidance of drilling and injectable local anesthesia in many cases, low equipment requirements, relatively low cost, and suitability for very young children, patients with behavioral or medical challenges, and community-based programs. These benefits are offset by permanent black staining of carious tissue, the absence of anatomical reconstruction, the need for surveillance and reapplication, and uncertainty in several comparative outcomes. Evidence for permanent teeth is promising but less mature than for primary dentition.[12,21]

SDF should therefore be neither idealized as a universal replacement for restorative dentistry nor dismissed because it does not restore tooth form. Its appropriate role is as a disease-control tool within individualized, prevention-oriented care. When case selection, informed consent, follow-up, and access to definitive treatment are preserved, SDF can reduce treatment burden and extend effective caries management to children who might otherwise remain untreated. Its greatest contribution to global pediatric oral health may lie in combining biological effectiveness with operational simplicity while maintaining shared decision-making and clinical accountability.

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Conflict of Interest

The authors declare no conflicts of interest related to this manuscript.

Ethical Approval

Ethics committee approval and informed consent were not required because this article is a narrative review based exclusively on previously published literature and publicly available guidelines and contains no individual patient data.

Data Availability

No original dataset was generated or analyzed. All information discussed in this narrative review is derived from cited published sources and public guidance documents.

Generative AI Disclosure

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Silver Diamine Fluoride in Pediatric Dentistry: Current Evidence, Clinical Applications, Safety, and Global Public-Health Perspectives

Supplementary File 1: Structured Narrative Search Strategy and Evidence-Selection Framework

S1. Review Scope

The narrative review was designed to synthesize clinically important evidence on 38% silver diamine fluoride in pediatric dentistry, with emphasis on evidence published from January 2014 through 29 September 2026. Older sources were eligible only when necessary to explain foundational mechanisms or historical context. The search was structured and reproducible at the level of concepts and sources but was not intended to meet PRISMA requirements for an exhaustive systematic review.

S2. Sources Searched

- PubMed/MEDLINE
- Cochrane Library
- World Health Organization oral-health guidance and publications
- American Academy of Pediatric Dentistry policy, guideline, and chairside resources
- American Dental Association evidence-based guidance and oral-health topic resources
- Backward citation tracking from key systematic reviews, randomized trials, and guideline documents

S3. Core Search Concepts

SUPPLEMENTARY TABLE S1. REPRESENTATIVE SEARCH CONCEPTS

Search domain	Representative query / concept string
Core SDF / pediatric caries	("silver diamine fluoride" OR "silver diammine fluoride" OR SDF) AND (child* OR pediatric* OR paediatric* OR preschool* OR "primary teeth" OR "primary dentition" OR adolescent*) AND (caries OR "dental caries" OR "caries arrest")
Effectiveness / evidence synthesis	("silver diamine fluoride" OR SDF) AND (random* OR trial OR "systematic review" OR meta-analysis OR Cochrane)
Safety / toxicology	("silver diamine fluoride" OR SDF) AND (safety OR toxicity OR toxicology OR pharmacokinetic* OR fluoride OR silver OR adverse)
Acceptance / staining	("silver diamine fluoride" OR SDF) AND (parent* OR caregiver* OR accept* OR stain* OR discolor* OR aesthetic* OR esthetic*)
Economic / public health	("silver diamine fluoride" OR SDF) AND (cost-effect* OR economic* OR public health OR school* OR community OR access OR equity)
Comparators	("silver diamine fluoride" OR SDF) AND (fluoride varnish OR atraumatic restorative treatment OR ART OR Hall OR SMART OR glass ionomer OR restoration)

S4. Evidence Prioritization

- Highest priority: international guidelines and evidence-based clinical-practice guidelines; Cochrane reviews and high-quality systematic reviews/meta-analyses.
- Next priority: randomized controlled trials, cluster-randomized pragmatic trials, and prospective comparative studies in children.
- Targeted priority: pediatric pharmacokinetic or safety studies, caregiver-acceptance studies, economic evaluations, and implementation research when directly relevant to the review questions.
- Mechanistic evidence: used to explain antimicrobial, remineralizing, and collagen-protective pathways but not to estimate clinical effectiveness.
- Adult-only studies: generally excluded unless necessary for regulation, pharmacology, or a global guideline discussion.

S5. Eligibility Framework

SUPPLEMENTARY TABLE S2: ELIGIBILITY FRAMEWORK.

Domain	Included	Generally excluded
Population	Children/adolescents; mixed populations if pediatric data relevant	Adult-only clinical effectiveness studies without pediatric applicability
Intervention	SDF, particularly 38% formulations; SDF+KI when relevant	Unvalidated silver products without direct relevance to SDF
Outcomes	Caries arrest/prevention, safety, pharmacokinetics, staining/acceptance, OHRQoL, cost, implementation	Purely surrogate laboratory outcomes when no clinical implication
Study design	Guidelines, systematic reviews, RCTs, pragmatic trials, cohorts, PK studies, economic evaluations	Opinion pieces as primary evidence; duplicate reports; conference abstracts without adequate data

Period	Primarily 2014-Sep 2026	Older literature unless needed for mechanism/history
Language	English-language sources or authoritative English versions	Sources that could not be reliably interpreted

S6. Critical Appraisal Approach

No formal risk-of-bias instrument was applied de novo because this is a narrative review. The interpretation nevertheless considered study design, sample size, follow-up duration, masking feasibility, clustering of multiple lesions within patients, consistency of lesion-activity definitions, comparator relevance, attrition, and risk-of-bias judgments reported by systematic reviewers. Where individual randomized trials appeared strongly favorable but systematic reviews rated the certainty of evidence as low or very low, the manuscript explicitly distinguishes the clinical signal from the certainty of comparative evidence.

S7. Search-Process Limitation

Because the objective was a clinically focused narrative synthesis rather than an exhaustive systematic review, no study-flow count, duplicate-removal count, or PRISMA diagram was generated. The supplementary search strategy is therefore intended to improve transparency and reproducibility without implying systematic-review methodology.

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