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Integrating silver diamine fluoride into school-based oral health programs: A pilot study

Carrie Godes [a], Lisa Westhoff [b], Tamarinda Barry Godín [c], Ryan Richard Ruff [c,*]

[a] Garfield County Public Health Department, Garfield County, CO, USA
[b] Aspen Community Health, Aspen, CO, USA
[c] Department of Epidemiology & Health Promotion, New York University, USA

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ABSTRACT

Objective: Current approaches to school-based caries prevention can increase access to oral healthcare, but are often limited by costs and other logistical challenges. Evidence from large pragmatic trials support the use of silver diamine fluoride (SDF) to prevent and control caries in school dental programs. In this pilot, we developed implementation strategies and integrated SDF into an existing school-based dental program, Smiles For Students (SFS).

Methods: This was a single-group observational pilot. Using a school-based SDF implementation toolkit, SFS clinicians received training in clinical protocols as well as ongoing interactive technical assistance to support SDF integration. SDF was then implemented into existing clinical workflows.

Results: Following training and implementation, the Smiles For Students program saw a 23 % increase in the number of patients served, a 53 % decrease in the per-child treatment time, a 45 % decrease in labor costs despite increased enrollment, and a 24 % decrease in supply costs. Qualitative feedback indicated strong support for simplified clinical protocols, reduction in cumbersome supplies and materials, and increased flexibility with space and resources.

Conclusions: In a pilot implementation project in which SDF was integrated into an existing school-based dental program serving 16 schools, multiple logistical and economic challenges were mitigated and program clinicians utilized both sealants and SDF to meet the needs of participating children.

What this study adds:

- School caries prevention is effective but faces logistical challenges to sustainability. Silver diamine fluoride can be used to increase the reach and impact of school-based dental programs.
- We conducted an implementation pilot to integrate SDF into an existing school-based dental program, demonstrating positive impacts on program processes including children served, treatment time, and program costs.

Implications for policy and practice:

- This project used an evidence-based minimally invasive intervention to prevent and control caries and successfully integrated it into an existing school-based dental program. The positive program impacts support the wide-scale adoption into established care practices and can contribute to sustainable school caries prevention.

1. Introduction

Dental caries is a pervasive noncommunicable disease, and is the most prevalent chronic condition in the world [1]. The World Health Organization estimates that over two billion people have caries in permanent dentition, and over 500 million children suffer from caries in primary teeth. Although dental caries has a multifactorial etiology [2], lack of access to preventive and therapeutic care is a consistent barrier to oral health equity. In the United States, low socio-economic status, lack of insurance, and those from minority, immigrant, or rural populations are associated with poor access to acceptable dental medicine [3].

Schools can serve as effective vehicles to provide general and oral health services [4], and school-based caries prevention increases access to care and reduces health inequities. The United States' Community Preventive Services Task Force recommends school-based dental sealants to prevent caries, which are consistently shown to be clinically and cost-effective [5]. Other approaches to school caries prevention include

* Corresponding author. 380 Second Avenue, Room 3-08, NY, 10010, USA. ryan.ruff@nyu.edu

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screening services [6], fluoride varnishes [7], and comprehensive care packages [8]. However, evidence suggests that key logistical and financial challenges may threaten the sustainability of existing models [9].

Silver diamine fluoride (SDF) is a topical liquid that can prevent and control dental caries [10–12], and is included on the World Health Organizations' Model Lists of Essential Medicines. SDF is fast to apply and cost-efficient, although a common adverse effect is irreversible staining of arrested caries lesions [12]. Recently, a series of pragmatic school-based clinical trials demonstrated the feasibility and effectiveness of using silver diamine fluoride for school caries prevention. In particular, school-based SDF is effective in both the primary and secondary prevention of caries when compared to glass ionomer sealants and atraumatic restorations [13,14], can be successfully applied by both registered nurses and dental hygienists [15], and may have positive secondary effects on educational performance [16].

Given the ubiquity of school caries prevention and the potential impact of SDF, large scale implementation of silver diamine fluoride into existing school-based dental programs could increase the reach and effectiveness of care and mitigate known limitations. The purpose of this study was to conduct an implementation pilot to integrate SDF into a current school-based preventive oral health program and document impacts on process outcomes including program costs, patients served, and application time.

2. Methods

The pilot utilized a single-group observational study design with a focus on program evaluation. Our objectives were to (1) develop potential implementation strategies and (2) evaluate post-implementation changes on program processes. The pilot project was conducted from August 2023 to September 2024 in 16 schools participating in Smiles For Students, a school-based preventive oral health program operating in Garfield County, Colorado.

Evaluation Outcomes. Data were collected through process evaluations, informal staff interviews, and analyses of enrollment and financial records. Outcomes included the number of program participants served (program reach), the time required to treat each individual program participant (program efficiency), and program costs which included supply costs, labor costs, and supply utilization.

Implementation Strategy Development. Implementation strategies were developed in collaboration with program staff, including dental hygienists, public health officials, and program administrators and consisted of training using an SDF implementation toolkit and interactive assistance (virtual technical assistance). The implementation toolkit included (1) training on comprehensive clinical protocols, consisting of didactic instruction and experiential learning approaches for reproducible procedures for screening, treatment, and outcomes monitoring; (2) standardization and calibration; (3) health messaging and community outreach, including how to address concerns and needs of patient stakeholders regarding SDF, successful engagement approaches, and communication strategies for adverse aesthetic effects; (4) logistical guidelines for project management including optimal packaging of supplies, storage, transport, and economies of scale; and (5) guidance on key performance indicators relevant to clinicians, parents, teachers, and other stakeholders. Interactive assistance was provided via on-demand virtual coaching.

Smiles For Students. Smiles For Students (SFS) is school-based preventive dental program operated by Garfield County Public Health since 2007. Prior to SDF integration, the program provided 2nd, 3rd, 6th and 7th grade public school students with an annual prophy, oral hygiene evaluation, fluoride varnish, and glass ionomer sealants. These grades were purposefully selected to target newly erupted first and second molars. SFS operates in 16 schools utilizing a team of dental hygienists and mobile equipment.

Pre-SDF Program Protocols and Procedures. Using mobile equipment including two ProSeal II Portable Hygiene Units and two patient chairs, a registered dental hygienist would complete oral cancer screenings extraorally and intraorally followed by dental hard tissue charting for missing teeth, restorations, existing sealants, and visible decay. The pre-SDF workflow (Fig. 1) then included a caries risk assessment, sealants applied to sound, posterior permanent pits and fissures, and fluoride varnish. For sealant application, teeth were isolated with cotton rolls and dry angle-type shields, and each tooth was etched for 15 s. Sealant material was flowed from one end of each fissure to the other to avoid air bubbles, and any that occur were expressed with a microbrush, explorer tip, or applicator tool prior to curing. Light curing for 20 s then followed, and sealants were then inspected for quality and retention.

Post-SDF Program Protocols and Procedures. Following toolkit training and technical support for implementation, SFS protocols were modified to integrate silver diamine fluoride into the existing workflow (Fig. 2). During dental hard tissue charting, presence of existing SDF was documented in addition to pre-treatment diagnoses. Patients then received a simple chairside caries risk assessment: high risk was determined if any decay was present; moderate risk if poor oral hygiene was determined but no caries visible, and low risk if neither of these were present. SDF application was based on the caries risk assessment. For any patient determined to be low or moderate risk, SDF was applied to sound posterior pits and fissures followed by fluoride varnish. For high risk patients, GI sealants were applied to sound posterior pits and fissures and SDF was applied to posterior decay, followed by fluoride varnish.

In applying SDF, vaseline was first applied to lips to protect from potential superfluous staining, and posterior teeth were isolated with dry angles, cotton rolls, and/or gauze. Registered Dental Hygienists then used a microbrush that was dipped into the SDF solution to apply SDF to all posterior pits and fissures, including sound teeth (primary prevention) and decayed teeth (caries arrest). Eligible primary teeth were molars, and eligible secondary teeth were premolars and molars. SDF was not applied to any anterior teeth, and SDF was also not applied if any pulp was exposed.

Additional program modifications to optimize patient care in SFS included the adoption of lapboards instead of mobile dental chairs and the substitution of the finger sweep technique when applying glass ionomer sealants.

Ethical Considerations. As the pilot was an evaluation of program changes, ethical approval was not required. For the Smiles For Students program, all children in participating schools were eligible to receive care if informed consent was provided.

3. Results

In the 2022–2023 school year prior to silver diamine fluoride implementation, 868 children were enrolled in SFS and the average time per patient for treatment was 15 min. This resulted in a total supplies cost of $11,850 and total labor expenses for registered dental hygienists of $33,291 (Table 1).

After SDF implementation, 1070 children were enrolled in the Smiles For Students program for the 2023–2024 school year (Table 2). Of enrolled children, 291 (27 %) presented with cavities, encompassing 1061 total cavitated teeth. Approximately 35 % of children presented with no evidence of having ever seen a dentist. For insurance status, 293 participants (27 %) had Medicaid, 67 (6 %) had Child Health Plus, and 23 % had private insurance. Over 31 % of SFS children (338) did not have any insurance. Of SFS participants, 83 % (888) received SDF for prevention, and 22 % (240) received SDF for treatment in 641 teeth.

Post-SDF, the per-child treatment time decreased by 53 % (7 min), enabling SFS to expand enrollment to all grades (kindergarten through grade 8) and increase the number of patients seen by 23 % (1070). It also substantially reduced the amount of time students were absent from class, minimizing lost seat time. Despite the increase in the number of

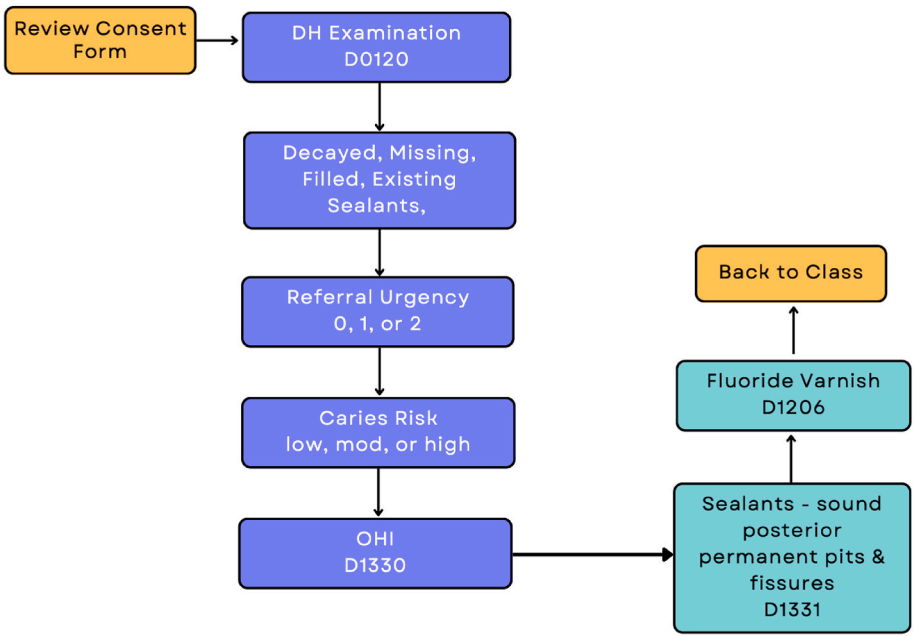

Fig. 1. Smiles For Students process workflow prior to SDF integration with associated procedure codes.

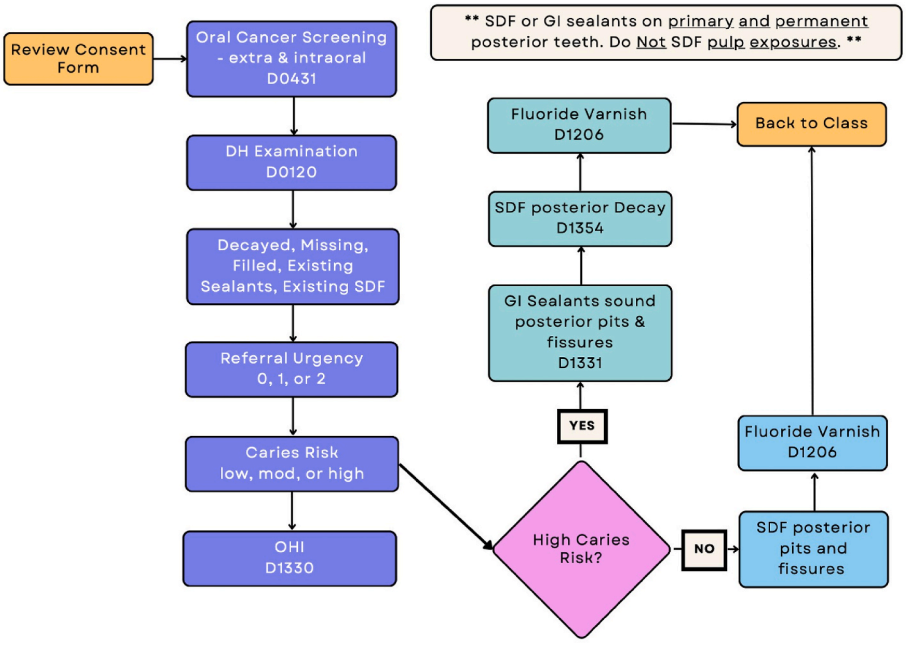

Fig. 2. Smiles For Students process workflow following SDF integration with associated procedure codes.

Table 1
Process outcomes pre/post SDF implementation.

Outcome	Pre-Implementation	Post-Implementation
Patients seen	868	1070
Time per patient	15 min	7 min
Supplies Cost	$11,850	$11,304
RDH Labor Expenses	$33,291	$22,634

students served, supplies cost (based on the per-person cost of sealant material, fluoride varnish, SDF, toothbrushes, and disposable materials including gloves, sanitizing agents, cotton rolls, and dry angles) reduced by 24 % ($13.65 per student to $10.56). The largest impact was the observed decrease in labor cost. Dental hygienists represented the most significant programmatic expense for Smiles For Students, at a contracted rate of $47 per hour. Following SDF integration and increased patient enrollment, contracted labor costs decreased from $38.35 per student to $21.15 per student, a 45 % reduction (Table 1).

No complaints were received from any parent, guardian, or school official in regards to SDF staining or treatment function. Prior to SF implementation, SFS operators met with district administrators, nurses, and nurses aids to discuss the staining effect of SDF for arresting decay. School personnel expressed concerns over potential aesthetic impacts and inquired as to how best to present the issue of staining with students and guardians, should it be a concern. Post-implementation debrief meetings had no questions or concerns regarding SDF staining, as no

Table 2
Smiles For Students patient characteristics post-SDF integration (2023–2024 school year).

	N	%
Total children enrolled	1070	100
Children with cavities	291	27.20
Children receiving SDF (prevention)	888	82.99
Children with evidence of dental care	699	65.33
Insurance Medicaid	293	27.38
CHP	67	6.26
Private	242	22.62
None	338	31.59
Unknown	130	12.15
Total teeth with cavities	1061	100
Cavities receiving SDF (arrest)	641	60.41

students or guardians raised concerns to the schools. There were no other implementation challenges regarding changes in supplies or protocols, nor the additional training needed to integrate SDF into clinical workflows. However, RDH acceptance of SDF for primary prevention when applied to sound, healthy dentition was not immediate, as the visual indication of arresting decay was more easily understood.

Qualitative data from onsite program coordinators and school administrators indicated a high degree of support for the new program operations, as the reduction in cumbersome supplies following the introduction of lapboards reduced the burden of moving and setting up clinical areas. Before integrating SDF and lapboards, SFS clinical operations required a room with a minimum available space of 225 square feet to accommodate 2–3 staff, two patient chairs, two dental units, and supplies. Post implementation, room requirements decreased to less than 115 square feet, and patient chairs and dental units were no longer utilized as patients were now treated by sitting in school-provided chairs and reclined onto the providers' lap. Additionally, changes to the finger-sweep technique obviated the need for a sink in the treatment rooms, simplifying where providers could set up. On-site coordinators also reported reductions in setup time from 2 h to 15 min, and changes from heavy chairs and ProSeal II units to lapboards reduced physical exertion, minimized injury risk, and eliminated the need for a trailer.

4. Discussion

Possessing both preventive and arresting capabilities, SDF is viewed as an affordable approach to community caries prevention and is particularly appealing to support increasing access for underserved populations [17]. Although SDF has been provided internationally in preschool oral health programs and community trials [17,18], it has not been systematically implemented in school caries prevention in the United States. Based on established evidence from multiple pragmatic trials [13,14], we conducted an implementation pilot project to integrate SDF into an existing school-based dental practice and observed multiple improvements in patient enrollment, program efficiency, and costs.

Integrating silver diamine fluoride into the Smiles For Students program expanded program services and also supported the use of lapboards instead of large patient chairs. Prior to implementation, SFS needed to use a four foot by six foot trailer for transporting equipment. This was especially difficult during the winter season, as SFS clinicians needed to drive up to sixty miles in between sites, and clinicians had previously reported physical burdens resulting from equipment transport. Financially, costs to provide care before SDF implementation restricted the number of grades and children that were able to be seen in the program. Following SDF, more children were able to be seen in less time, reducing the per-patient treatment costs and labor costs, and resulted in expanding services to additional grades in participating schools. This 23 % increase in service reach among rural schools suggests progress towards improving equity in access, and future studies should further explore the impact of these modifications on underserved populations.

Our implementation strategies were designed with the overarching goal of supporting the adoption of SDF in existing school-based dental programs, but the actual approach for integrating silver diamine fluoride into participating sites was left unspecified. This is to ensure that local programs can adapt new evidence-based interventions into current practice to meet specific program needs and ameliorate local challenges. Thus, we anticipate a range of approaches to SDF implementation. As observed in the Smiles For Students program, SDF application was based on a caries risk assessment. Participants deemed to be at low risk of caries received only SDF on sound posterior pits and fissures and fluoride varnish, and those at moderate or high risk received both sealants and SDF: sealants for sound posterior surfaces and SDF for any posterior decay. This allowed SFS to prioritize their limited dental sealant resources for children at higher risk, and treat more children in the program. Alternative approaches could be similarly based on need or aesthetics: for example, using SDF on deciduous teeth for either prevention or arrest and glass ionomer sealants and atraumatic restorations for permanent dentition, to minimize any potential negative effect of staining if it is a concern. Still further, programs could consider combinative approaches such as the silver modified atraumatic restorative technique (SMART), which can both arrest existing decay and seal the tooth from further bacterial exposure [19]. This could result in greater efficacy while obviating the need for repeated applications, which is recommended to maximize the impact of silver diamine fluoride for caries arrest [20]. Ultimately, this empowers existing providers to leverage SDF in a variety of ways, deriving the greatest benefit for each program by maximizing resource efficiency.

Despite the utility of existing approaches to school-based dental medicine, sustainability remains an elusive goal. School-based health centers currently operate in 49 states, but few locations offer dental care [21], and while over 65 % of states have school sealant programs, most serve less than a quarter of high need children [22]. Furthermore, the quality of evidence supporting school screening programs to increase dental participation is low [6]. Particularly for under resourced areas that lack access to traditional disease prevention and management, silver diamine fluoride is considered a caries "silver bullet" [23]. SDF holds considerable promise for school-based caries prevention, and can be a useful complement to existing caries prevention practices.

CRediT authorship contribution statement

Carrie Godes: Formal analysis. **Lisa Westhoff:** Formal analysis. **Tamarinda Barry Godín:** Investigation. **Ryan Richard Ruff:** Conceptualization, Supervision, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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