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Original Article

A Randomized Trial of a School-Based Silver Diamine Fluoride Program for Reducing Untreated Dental Caries in High-Risk Children

Muhammad Kazim[1], Muhammad Rafeh Zafar[2], Maham Shafique[3], Ayesha Khan[4], Fahad Hassan[5]

[1] Senior Registrar in Prosthodontics, Fatima Jinnah Dental College and Hospital, Karachi, Pakistan.
[2] PEI/District Health Information System Coordinator / District Surveillance Coordinator, Health Department KPK, DHO Office, Haripur, Pakistan.
[3] Dental Surgeon, Health Department KPK, Pakistan.
[4] General Dentist, Ziauddin University, Karachi, Pakistan.
[5] Physiotherapy Department, Dear Life Rehabilitation Center for Specially-abled Children and Youngsters, Lahore, Pakistan.

***Corresponding author: Muhammad Kazim, kazialwani786@gmail.com**

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ABSTRACT

Background: Untreated dental caries remains a major public health problem among school-aged children, particularly in underserved communities where access to preventive and restorative dental care is limited. Silver diamine fluoride is a minimally invasive, low-resource intervention that may be suitable for school-based caries control. Objective: To determine whether a single school-based application of 38% silver diamine fluoride is more effective than standardized oral health education alone in reducing active untreated dental caries among high-risk children aged 5–12 years. Methods: A parallel-group randomized controlled trial was conducted among high-risk children attending government schools in Central Punjab, Pakistan. Eighty-four children with at least one active untreated cavitated carious lesion were randomized equally to receive either single-dose topical 38% silver diamine fluoride or standardized oral health education. Outcomes were assessed at baseline and follow-up. The primary outcome was mean number of active untreated carious lesions; secondary outcomes included new lesion development, Simplified Oral Hygiene Index scores, and dental pain-related absenteeism. Results: Final complete-case analysis included 77 participants. At final follow-up, the silver diamine fluoride group had fewer active untreated lesions than controls (2.1 ± 1.0 vs 4.3 ± 1.4; mean difference −2.2, 95% CI −2.75 to −1.65; $p<0.001$). New lesion development, oral hygiene scores, and pain-related absenteeism were also significantly lower in the intervention group. Conclusion: A single school-based application of 38% silver diamine fluoride significantly reduced active untreated carious lesions and improved clinically relevant secondary outcomes compared with oral health education alone. Keywords: Child; Dental Caries; Fluorides, Topical; Oral Health; Randomized Controlled Trial; Schools; Silver Diamine Fluoride

INTRODUCTION

Dental caries remains one of the most common chronic conditions affecting children and continues to impose a substantial clinical, educational, and public health burden, particularly in socioeconomically disadvantaged communities where access to preventive and restorative dental services is limited. Among school-aged children, untreated carious lesions may progress from localized enamel and dentinal disease to pain, infection, eating difficulty, sleep disturbance, impaired concentration, and school absenteeism, thereby affecting both oral health and broader child development. The burden is especially relevant in underserved settings, where delayed dental attendance, limited parental awareness, financial constraints, poor dietary patterns, inadequate oral hygiene practices, and insufficient preventive coverage contribute to persistent untreated disease. In this context, childhood dental caries reflects not only individual biological susceptibility but also inequities in timely access to oral healthcare and preventive intervention (1).

Conventional caries management often depends on clinic-based restorative care requiring dental equipment, trained personnel, repeated visits, and patient cooperation. Although restorative treatment remains essential for advanced disease, such care may be difficult to deliver at scale in public-sector or low-resource environments, particularly among children attending government schools or living in areas with limited oral-health infrastructure. Dental anxiety, transportation barriers, cost of treatment, and delayed referral may further reduce the likelihood that children with active lesions receive timely care. These barriers create a practical gap between the high prevalence of untreated disease and the availability of accessible treatment models. Consequently, public health dentistry has increasingly emphasized minimally invasive, low-cost, community-deliverable approaches that can arrest disease progression before more complex intervention becomes necessary (2,3).

Silver diamine fluoride has emerged as an important minimally invasive agent for caries control because it combines the antimicrobial action of silver ions with the remineralizing effect of fluoride. Its topical application can arrest active carious lesions without drilling, local anesthesia, or restorative preparation, making it particularly suitable for children who may have limited tolerance for conventional dental procedures. The procedure is brief, inexpensive, technically simple, and feasible in non-clinical environments when delivered by trained personnel using standardized infection-control procedures. These characteristics make 38% silver diamine fluoride a potentially useful intervention for school-based oral health programs, especially where the primary public health objective is to reduce the burden of untreated active lesions among high-risk children rather than to provide definitive restorative rehabilitation at the first point of contact (4,5).

Schools offer a pragmatic platform for preventive and early therapeutic oral-health interventions because they provide direct access to large numbers of children in a familiar setting and reduce reliance on caregiver-initiated clinic attendance. School-based programs may improve equity by reaching children who are least likely to receive regular dental care, particularly in government schools and underserved communities. Existing evidence supports the role of fluoride-based interventions, sealants, atraumatic restorative approaches, and oral health education in reducing caries risk; however, education alone may be insufficient for children who already have active cavitated lesions. While oral health education can improve knowledge and encourage preventive behaviors, it does not directly arrest established carious lesions. Therefore, combining school access with a clinically active, minimally invasive treatment may address both service-delivery barriers and the biological progression of disease (6–8).

Despite growing support for silver diamine fluoride in pediatric dentistry, important evidence gaps remain regarding its implementation as a single-dose school-delivered intervention in high-risk children, particularly in low-resource or public-sector school settings. Much of the available literature has focused on clinical environments, repeated applications, specific age groups, or programmatic models that may not be directly transferable to routine school health services. In addition, fewer randomized trials have compared single-application silver diamine fluoride with standardized oral health education alone while assessing clinically meaningful outcomes such as active untreated lesion counts, new lesion development, oral hygiene status, and pain-related absenteeism over follow-up. This distinction is important because the feasibility and scalability of school-based caries control depend not only on biological efficacy but also on whether a brief, low-resource intervention can produce sustained improvement using minimal infrastructure (9,10).

The present randomized controlled trial was therefore designed according to a PICO framework in which the population comprised high-risk children aged 5–12 years with at least one active untreated cavitated carious lesion attending government schools in Central Punjab, Pakistan; the intervention was a single topical application of 38% silver diamine fluoride delivered in the school setting; the comparator was standardized school-based oral health education without therapeutic fluoride application; and the primary outcome was the mean number of active untreated carious lesions assessed over follow-up, with secondary outcomes including new lesion development, oral hygiene status, and dental pain-related absenteeism. The study aimed to determine whether a single school-based application of 38% silver diamine fluoride is more effective than oral health education alone in reducing active untreated dental caries among high-risk schoolchildren.

MATERIALS AND METHODS

A parallel-group individually randomized controlled trial was conducted among high-risk schoolchildren attending selected government primary schools in Central Punjab, Pakistan. Recruitment and baseline procedures were undertaken between August and September 2025, and each participant was followed at predefined post-intervention intervals of 6 and 12 months after baseline assessment. The trial was designed to evaluate the effectiveness of a single topical application of 38% silver diamine fluoride compared with standardized school-based oral health education alone for reducing active untreated dental caries in children at elevated caries risk. A school-based design was selected because schools provide a feasible public-health platform for reaching children who may not routinely access clinic-based dental care, while the randomized controlled design allowed direct comparison of clinical outcomes between the active minimally invasive intervention and the education-only comparator.

Children aged 5–12 years enrolled in participating government schools were screened through school-based oral examinations performed by trained dental practitioners. Children were considered eligible when they had at least one active untreated cavitated carious lesion in either the primary or permanent dentition, had written parental or guardian consent, were expected to remain enrolled at the school during follow-up, and were able to cooperate with oral examination and intervention procedures. Children were excluded if they had received professional fluoride therapy within the preceding six months, had a known allergy or hypersensitivity to silver compounds or fluoride products, had systemic conditions substantially affecting oral health or salivary function, were undergoing orthodontic treatment that interfered with clinical assessment, had advanced pulpal infection or dental sepsis requiring urgent referral, or were unlikely to complete scheduled follow-up assessments because of irregular school attendance or anticipated relocation.

Eligible participants were selected after screening and consent procedures were completed. Parents or guardians received information regarding the purpose of the study, the nature of the intervention, possible discoloration of arrested lesions after silver diamine fluoride application, expected benefits, potential risks, voluntary participation, and the right to withdraw without academic or healthcare consequences. Children provided age-appropriate assent before examination and intervention. Participants requiring urgent dental care at screening were not randomized and were referred for appropriate management. Baseline demographic and clinical data were recorded before allocation, including age, sex, number of active untreated carious lesions, oral hygiene status, and dental pain-related school absenteeism.

Participants were randomly assigned in a 1:1 ratio to the silver diamine fluoride group or the control group using a computer-generated random sequence prepared by an investigator who was not involved in screening, enrollment, intervention delivery, or outcome assessment. Allocation concealment was maintained using sequentially numbered, sealed, opaque envelopes that were opened only after baseline examination and confirmation of eligibility. Randomization was performed at the individual participant level. Because children were recruited within school settings, intervention delivery and follow-up procedures were standardized to reduce contamination, and participants in both groups received only the procedures assigned to their allocation. Blinding of participants and intervention providers was not feasible because silver diamine fluoride produces characteristic dark staining of arrested carious lesions. Outcome assessment was performed using standardized criteria by trained examiners who were not involved in allocation or intervention delivery, and data analysis was performed using coded group identifiers.

Children allocated to the intervention group received a single topical application of 38% silver diamine fluoride to active untreated cavitated carious lesions at baseline. The procedure was performed in the school setting using disposable examination materials and standard infection-control precautions. Affected tooth surfaces were visually identified, isolated as far as practicable, dried with gauze or cotton rolls, and treated with 38% silver diamine fluoride using disposable microbrush applicators. Care was taken to limit contact with soft tissues and to apply the agent only to clinically identified active lesions. The application required approximately 3–5 minutes per child. After treatment, children were instructed to avoid eating or drinking for 30 minutes. Parents or guardians were informed that treated lesions may darken, which is an expected sign associated with caries arrest. The control group received a standardized 20-minute school-based oral health education session covering tooth-brushing technique, dietary counseling, avoidance of frequent sugary snacks, oral hygiene habits, and the importance of dental consultation when pain or visible decay was present. No therapeutic fluoride application was provided to the control group during the intervention session.

The primary outcome was the mean number of active untreated carious lesions per child assessed at baseline, 6 months, and 12 months after intervention. Active untreated carious lesions were defined as cavitated lesions judged clinically active on visual-tactile examination and not restored, extracted, or otherwise definitively treated at the time of assessment. Secondary outcomes included the number of newly developed carious lesions during follow-up, oral hygiene status measured using the Simplified Oral Hygiene Index, and dental pain-related absenteeism expressed as school days missed per month because of tooth pain as reported through school attendance records and parental or caregiver confirmation. Baseline and follow-up examinations were conducted under comparable school-based conditions using the same clinical assessment procedures across study arms. To improve measurement consistency, examiners received training before data collection, and clinical assessment forms were standardized for all visits.

The sample size was determined before recruitment using expected differences in caries-arrest outcomes from previously published interventional evidence on school-based silver diamine fluoride application. The calculation assumed 80% power, a two-sided 5% alpha level, and allowance for anticipated follow-up loss. Based on these assumptions, 84 children were enrolled and randomized equally into the intervention and control groups. Follow-up retention was monitored through school attendance records, direct coordination with school administration, and parental contact when children were absent during scheduled assessments.

Data were entered into a structured database using predefined variable labels and range checks to minimize entry errors. Continuous variables were summarized as mean and standard deviation when normally distributed, while categorical variables were summarized as frequency and percentage. Normality of continuous outcomes was assessed using the Shapiro–Wilk test and inspection of distributional patterns. Baseline comparability between groups was assessed using independent-samples t-tests for continuous variables and chi-square or Fisher's exact tests for categorical variables, as appropriate. Between-group differences in 12-month outcomes were analyzed using independent-samples t-tests with mean differences and 95% confidence intervals. Within-group baseline-to-follow-up changes were examined using paired-samples t-tests. Longitudinal change in active untreated carious lesions across baseline, 6 months, and 12 months was assessed using repeated-measures analysis to evaluate time, group, and time-by-group interaction effects. Associations between oral hygiene status and active untreated lesion counts at follow-up were assessed using Pearson correlation analysis when assumptions were met. A two-sided p-value of <0.05 was considered statistically significant.

The primary analytic approach followed the randomized allocation as far as permitted by available follow-up data. Participants lost to follow-up were described by group, and complete-case outcome analyses were supplemented by sensitivity consideration of attrition patterns to assess whether losses were balanced between study arms. Missing outcome data were not replaced by fabricated values. Analyses were conducted using SPSS version 26.0. Data integrity was supported through standardized data collection forms, independent verification of entered values against source records, coded participant identifiers, and restricted access to the final analysis file. Ethical conduct was maintained through prior institutional approval, written parental or guardian consent, child assent, confidentiality of participant information, voluntary participation, and referral of children requiring urgent dental care.

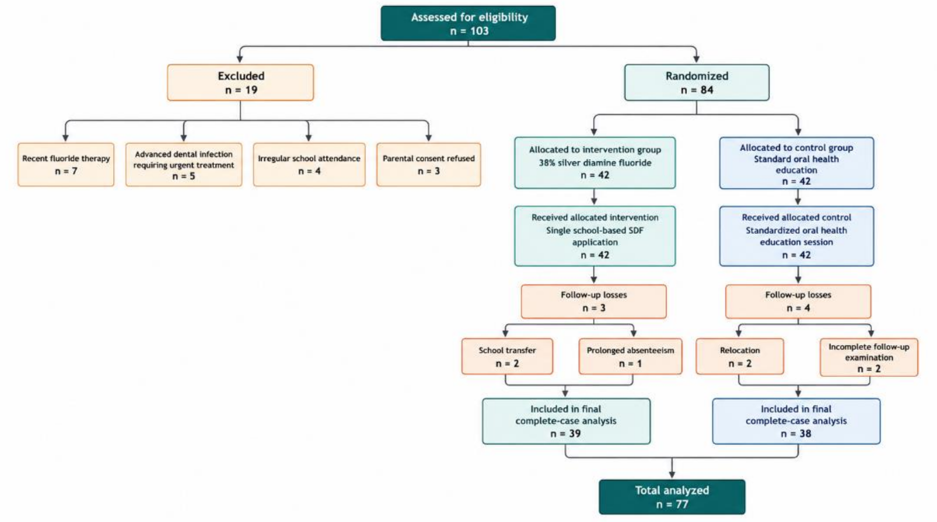

Figure 1 CONSORT Flowchart

RESULTS

A total of 103 children were screened for eligibility across selected government schools in Central Punjab. Nineteen children were excluded before randomization, and 84 eligible participants were randomized equally to the silver diamine fluoride intervention group (n=42) and the oral health education control group (n=42). During follow-up, 7 participants were lost, including 3 from the intervention group and 4 from the control group. Final complete-case analysis included 77 participants, comprising 39 children in the intervention group and 38 children in the control group. The participant screening, randomization, follow-up, and analysis flow is presented in Figure 1.

Baseline demographic and clinical characteristics were comparable between the two groups. The randomized cohort had a mean age of 8.4 ± 2.1 years, and 46 participants (54.8%) were male. Mean baseline active untreated carious lesion counts were similar in the intervention and control groups (4.9 ± 1.4 vs 4.7 ± 1.6 lesions; mean difference 0.2, 95% CI −0.45 to 0.85; p=0.583). Baseline Simplified Oral Hygiene Index scores and dental pain-related absenteeism also showed no statistically significant between-group differences.

Table 1. Baseline Demographic and Clinical Characteristics of Randomized Participants

Variable	Total Sample (N=84)	Intervention (n=42)	Control (n=42)	Mean Difference	95% CI	Effect Size	p-value
Age, years	8.4 ± 2.1	8.3 ± 2.0	8.5 ± 2.2	−0.2	−1.11 to 0.71	−0.10	0.671
Male sex, n (%)	46 (54.8)	24 (57.1)	22 (52.4)	4.7%			0.662
Active untreated carious lesions	4.8 ± 1.5	4.9 ± 1.4	4.7 ± 1.6	0.2	−0.45 to 0.85	0.13	0.583
Simplified Oral Hygiene Index	2.3 ± 0.6	2.2 ± 0.5	2.3 ± 0.6	−0.1	−0.34 to 0.14	−0.18	0.448
Dental pain-related absenteeism, days/month	1.8 ± 0.9	1.7 ± 0.8	1.8 ± 0.9	−0.1	−0.47 to 0.27	−0.12	0.731

At final follow-up, children who received silver diamine fluoride had significantly fewer active untreated carious lesions than those who received oral health education alone. The intervention group had a mean of 2.1 ± 1.0 active untreated lesions compared with 4.3 ± 1.4 lesions in the control group, corresponding to a mean difference of −2.2 lesions (95% CI −2.75 to −1.65; p<0.001). New carious lesion development was also lower in the intervention group (0.7 ± 0.8 vs 1.9 ± 1.1; mean difference −1.2, 95% CI −1.64 to −0.76; p<0.001). Final Simplified Oral Hygiene Index scores and dental pain-related absenteeism were also significantly lower in the intervention group, indicating better oral hygiene status and fewer missed school days related to dental pain.

Table 2. Final Follow-Up Comparison of Primary and Key Clinical Outcomes

Outcome	Intervention (n=39)	Control (n=38)	Mean Difference	95% CI	Cohen's d	p-value
Active untreated carious lesions	2.1 ± 1.0	4.3 ± 1.4	−2.2	−2.75 to −1.65	−1.81	<0.001
New carious lesions developed	0.7 ± 0.8	1.9 ± 1.1	−1.2	−1.64 to −0.76	−1.25	<0.001
Simplified Oral Hygiene Index	1.5 ± 0.4	2.1 ± 0.5	−0.6	−0.81 to −0.39	−1.33	<0.001
Dental pain-related absenteeism, days/month	0.5 ± 0.4	1.4 ± 0.7	−0.9	−1.16 to −0.64	−1.58	<0.001

Within-group analysis showed a marked reduction in active untreated carious lesions among children receiving silver diamine fluoride. Mean lesion count declined from 4.9 ± 1.4 at baseline to 2.1 ± 1.0 at final follow-up, with a mean change of −2.8 lesions. In the control group, lesion count declined from 4.7 ± 1.6 to 4.3 ± 1.4 lesions, with a mean change of −0.4 lesions. The reduction was clinically larger in the intervention group, while the control-group change remained comparatively small.

Table 3. Within-Group Change in Active Untreated Carious Lesions

Group	Baseline	Final Follow-Up	Mean Change	Change SD	95% CI	Cohen's dz	p-value
Intervention	4.9 ± 1.4	2.1 ± 1.0	−2.8	1.1	−3.16 to −2.44	−2.55	<0.001
Control	4.7 ± 1.6	4.3 ± 1.4	−0.4	0.9	—	−0.44	0.084

Repeated-measures analysis demonstrated significant time, group, and time-by-group interaction effects for active untreated carious lesions. The significant interaction effect indicated that the reduction in lesion burden over time was greater among children treated with silver diamine fluoride than among children receiving oral health education alone.

Table 4. Repeated-Measures Analysis of Active Untreated Carious Lesions

Effect	F-value	p-value
Time effect	48.6	<0.001
Group effect	39.2	<0.001
Time × group interaction	31.8	<0.001

A significantly higher proportion of children in the silver diamine fluoride group remained free from new carious lesions during follow-up. In the intervention group, 30 of 39 children (76.9%) developed no new lesions, compared with 14 of 38 children (36.8%) in the control group. The absolute risk difference was 40.1 percentage points, the relative risk was 2.09, and the odds ratio was 5.71, indicating a substantially higher likelihood of remaining free from new lesions among children treated with silver diamine fluoride.

Table 5. Participants With No New Carious Lesions at Final Follow-Up

Outcome	Intervention (n=39)	Control (n=38)	Risk Difference	Relative Risk	Odds Ratio	95% CI for OR	p-value
No new carious lesions, n (%)	30 (76.9)	14 (36.8)	40.1%	2.09	5.71	2.11 to 15.45	<0.001

Pearson correlation analysis showed a moderate positive association between Simplified Oral Hygiene Index scores and active untreated carious lesion counts at final follow-up. This indicated that poorer oral hygiene status was associated with a higher residual burden of active untreated dental caries.

Table 6. Association Between Oral Hygiene Status and Active Untreated Carious Lesions

Variables Analyzed	Correlation Coefficient	p-value
Simplified Oral Hygiene Index and active untreated carious lesions	0.58	<0.001

Overall, the results showed consistent clinical benefit of school-based silver diamine fluoride across the primary lesion outcome and clinically relevant secondary outcomes. The intervention group had approximately half the final active untreated lesion burden of the control group, fewer newly developed lesions, better oral hygiene scores, and fewer dental pain-related missed school days. The magnitude and consistency of these findings support the clinical relevance of single-application silver diamine fluoride as a school-delivered intervention for high-risk children.

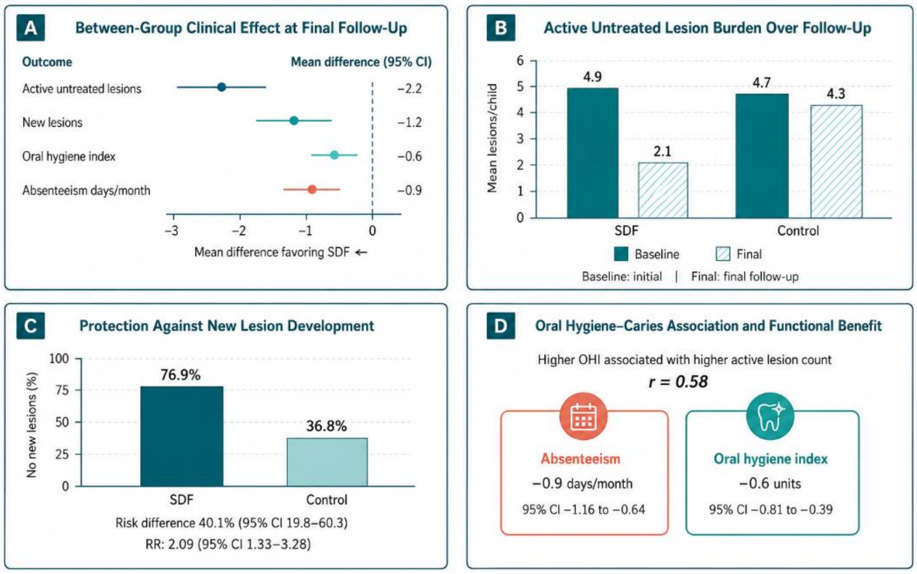

Figure 1. Clinical Effect Profile of School-Based Silver Diamine Fluoride in High-Risk Children

The panelled figure demonstrates a consistent clinical advantage of school-based 38% silver diamine fluoride over oral health education alone across lesion burden, new lesion prevention, oral hygiene status, and functional absenteeism outcomes. At final follow-up, the intervention group showed a large reduction in active untreated carious lesions compared with controls, with a mean between-group difference of −2.2 lesions per child (95% CI −2.75 to −1.65), while new lesion development was also lower by −1.2 lesions (95% CI −1.64 to −0.76). Children receiving silver diamine fluoride were more than twice as likely to remain free of new lesions than controls (76.9% vs 36.8%; RR 2.09, 95% CI 1.33 to 3.28), corresponding to an absolute risk difference of 40.1 percentage points. The intervention was also associated with fewer dental pain-related missed school days (mean difference −0.9 days/month, 95% CI −1.16 to −0.64) and better oral hygiene scores (mean difference −0.6, 95% CI −0.81 to −0.39). The positive correlation between oral hygiene index and active lesion count ($r=0.58$, $p<0.001$) further indicates that poorer oral hygiene status remained clinically linked with greater residual untreated caries burden.

DISCUSSION

The present randomized controlled trial demonstrated that a single school-based application of 38% silver diamine fluoride was associated with a clinically meaningful reduction in active untreated dental caries among high-risk children compared with standardized oral health education alone. Children in the intervention group had substantially fewer active untreated lesions at final follow-up, with a mean lesion burden of 2.1 ± 1.0 compared with 4.3 ± 1.4 in the control group, corresponding to a mean between-group difference of −2.2 lesions per child. The intervention group also developed fewer new lesions, showed better oral hygiene scores, and experienced fewer dental pain-related missed school days. These findings indicate that school-delivered silver diamine fluoride may provide practical clinical benefit in settings where conventional restorative dental care is difficult to access, particularly among children already presenting with active untreated cavitated lesions.

The magnitude of lesion reduction observed in the intervention group is biologically plausible and consistent with the established mechanism of silver diamine fluoride, which combines the antimicrobial effect of silver ions with fluoride-mediated remineralization of demineralized tooth structure. Prior clinical and community-based studies have reported that silver diamine fluoride can arrest active dentinal lesions and reduce caries progression in children, particularly when delivered to populations with high baseline disease burden and limited access to restorative care (11,12). The present findings extend this evidence by supporting the feasibility of a school-based delivery model, in which a brief, noninvasive application was administered in a familiar environment without the need for dental drilling, anesthesia, or complex equipment. This has important public health implications because school-based delivery may reduce logistical barriers associated with clinic attendance and enable earlier disease control among children who might otherwise remain untreated.

The lower number of newly developed lesions in the silver diamine fluoride group suggests that the intervention may have influenced the broader caries trajectory during follow-up, although this finding should be interpreted cautiously because the study was primarily designed around reduction in active untreated lesion burden rather than detailed microbiological or behavioral pathways. The higher proportion of children with no new lesions in the intervention group, 76.9% compared with 36.8% in controls, further supports the clinical relevance of the intervention. Previous work has suggested that fluoride-based and minimally invasive approaches may contribute to caries prevention by reducing lesion activity, strengthening tooth resistance, and suppressing cariogenic bacterial activity (13,14). However, because the study did not measure plaque microbiology, salivary fluoride concentration, dietary change, or brushing adherence as mechanistic variables, the observed reduction in new lesions should be interpreted as a clinical outcome rather than direct evidence of a specific biological pathway.

The improvement in oral hygiene scores and the positive correlation between Simplified Oral Hygiene Index scores and active untreated lesion counts at final follow-up provide additional clinically meaningful context. Children with poorer oral hygiene had a higher residual burden of untreated active lesions, as reflected by a moderate positive correlation between oral hygiene index and lesion count. This association reinforces the importance of oral hygiene as a continuing determinant of caries burden even when a therapeutic intervention is delivered. Nevertheless, the difference between groups also highlights a key limitation of education-only models in children who already have established cavitated lesions. Oral health education remains essential for long-term behavior modification, but education alone may not be sufficient to arrest existing active caries in high-risk children. For such populations, combining behavioral education with minimally invasive lesion-directed therapy may be more clinically effective than relying on awareness-based strategies alone (15,16).

The reduction in dental pain-related absenteeism is an important functional finding because untreated caries can affect children beyond the oral cavity through pain, sleep disturbance, difficulty eating, impaired concentration, and missed school attendance. In this trial, children receiving silver diamine fluoride had fewer pain-related missed school days than controls, suggesting that lesion control may translate into tangible educational and quality-of-life benefits. Although the study did not include a validated oral health-related quality-of-life instrument, the reduction in absenteeism provides a practical indicator of functional improvement. Future studies should include validated pediatric oral health quality-of-life measures, caregiver satisfaction, and child acceptability outcomes to determine whether clinical lesion arrest is accompanied by sustained improvements in daily functioning and perceived wellbeing.

Several methodological features strengthen the interpretation of the findings. The randomized parallel-group design reduced allocation bias, while concealed allocation before group assignment helped protect the randomization process. Standardized school-based examination procedures, predefined clinical outcomes, and use of recognized oral health indices improved consistency across assessments. The inclusion of children from government schools also enhanced the public health relevance of the study because these populations often represent children with greater barriers to routine dental care. Reporting both mean differences and 95% confidence intervals improved clinical interpretability by showing the size and precision of the treatment effect rather than relying only on p-values.

Despite these strengths, several limitations should be acknowledged. The analysis was based on participants with available final follow-up data, and although attrition was limited and balanced between groups, a complete-case approach may introduce bias if children lost to follow-up differed systematically from those retained. The study should therefore be interpreted as showing strong complete-case evidence, with future trials encouraged to use prespecified intention-to-treat methods supported by multiple imputation or other transparent missing-data procedures. Participant blinding was not feasible because silver diamine fluoride causes dark staining of arrested lesions, and this visible effect may also have limited the masking of outcome assessors. Although examiners were not involved in intervention delivery, visible staining could have influenced clinical judgment, particularly when classifying lesion activity. Future studies should consider independent masked photographic assessment where feasible, examiner calibration reporting, and inter-rater reliability testing.

Another limitation is the school-based recruitment context. If children within the same schools interacted across allocation groups, some contamination may have occurred, particularly for oral hygiene behaviors and awareness. Individual randomization is efficient, but cluster randomization at the school or classroom level may better reflect programmatic implementation and reduce contamination in future trials. The sample size was adequate to detect the primary difference reported, but the study was not powered for subgroup analyses by age, sex, dentition type, baseline severity, dietary risk, or socioeconomic factors. The findings may also have limited generalizability beyond government schools in Central Punjab, especially to private schools, rural areas with different fluoride exposure, or populations with different dietary patterns and dental service access. In addition, the study did not include cost-effectiveness analysis, caregiver acceptability of staining, adverse-event reporting in detail, or long-term follow-up beyond the reported assessment period. These elements are important for deciding whether school-based silver diamine fluoride programs can be adopted at scale (17,18).

The findings have practical implications for pediatric oral health policy in resource-constrained settings. A single application of 38% silver diamine fluoride is brief, minimally invasive, and deliverable in schools, which may make it suitable for integration into public-sector oral health screening and prevention programs. However, implementation should not be framed as a replacement for comprehensive dental care. Children with advanced infection, pain, pulpal involvement, or functional impairment still require referral and definitive dental management. Silver diamine fluoride may be best positioned as an early lesion-arrest strategy within a stepped-care model that includes screening, parental communication, oral health education, lesion-directed treatment, referral pathways, and periodic follow-up. Larger multicenter trials with cluster-adjusted designs, longer follow-up, acceptability assessment, adverse-event monitoring, and economic evaluation are needed to define the optimal delivery schedule and programmatic value of school-based silver diamine fluoride in underserved pediatric populations (19,20).

CONCLUSION

A single school-based application of 38% silver diamine fluoride was associated with a significant reduction in active untreated carious lesions, fewer newly developed lesions, improved oral hygiene status, and reduced dental pain-related absenteeism among high-risk children compared with standardized oral health education alone. These findings support silver diamine fluoride as a practical minimally invasive intervention that may strengthen school oral health programs in underserved settings. The results should be interpreted in light of complete-case analysis, limited blinding feasibility, and the need for larger multicenter trials with longer follow-up, cluster-adjusted designs, acceptability assessment, adverse-event reporting, and cost-effectiveness evaluation before broad programmatic implementation.

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