Research Article

Comparison of Fluoride Varnish Versus Silver Diamine Fluoride in Preventing Caries in School-Aged Adolescents

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Abstract

Background: Dental caries remains a predominant chronic disease among school-aged adolescents worldwide despite advances in preventive dentistry. Fluoride varnish and silver diamine fluoride rep-resent two topical fluoride-based interventions with demonstrated anticaries efficacy; however, direct comparative evidence evaluating their caries-preventive effectiveness in adolescent permanent dentitions remains limited. **Objective:** This randomized controlled clinical trial aimed to compare the caries-preventive efficacy of 5% sodium fluoride varnish versus 38% silver diamine fluoride applied semiannually over an 18-month period among school-aged adolescents. **Methods:** A total of 360 adolescents aged 12–15 years with at least one sound first permanent molar at high caries risk were randomly allocated to three groups: fluoride varnish (FV, n = 120), silver diamine fluoride (SDF, n = 120), and placebo control (n = 120). Applications were performed at baseline, 6, and 12 months. Caries assessments using ICDAS-II criteria were conducted at baseline and 18 months by calibrated examiners blinded to group allocation. The primary outcome was new caries incidence on permanent teeth. **Results:** At 18 months, the mean number of new carious surfaces was significantly lower in the SDF group (0.82 ± 0.94) and FV group (1.24 ± 1.12) compared with the control group (2.47 ± 1.68) ($p < 0.001$). SDF demonstrated a caries-preventive fraction of 66.8% compared with 49.8% for FV, with the difference between SDF and FV reaching statistical significance ($p = 0.003$). The proportion of participants remaining caries-free was highest in the SDF group (58.3%) compared with the FV (43.3%) and control (22.5%) groups ($p < 0.001$). However, tooth staining was significantly more prevalent in the SDF group (72.5%) than in the FV group (3.3%) and the control group (0%) ($p < 0.001$). **Conclusion:** Both silver diamine fluoride and fluoride varnish significantly prevented new caries development in adolescents compared with placebo; however, SDF demonstrated superior caries-preventive efficacy. The aesthetic concern of tooth staining associated with SDF use requires careful consideration in adolescent populations.

Keywords: silver diamine fluoride, fluoride varnish, dental caries prevention, adolescents, randomized controlled trial, preventive dentistry, permanent teeth

1. Introduction

Dental caries remains the most prevalent chronic disease globally, affecting an estimated 2.4 billion people with untreated carious lesions in permanent teeth, and adolescents constitute one of the most significantly affected demographic groups [1]. The World Health Organization has identified dental caries as a major public health priority, particularly in low- and middle-income countries where access to restorative dental care is limited and prevention-oriented strategies are urgently needed [2]. Among school-aged adolescents, the transition from mixed to permanent dentition, combined with increasing dietary autonomy, evolving oral hygiene behaviors, and reduced parental supervision, creates a period of heightened caries vulnerability that demands effective and accessible preventive interventions [3]. Fluoride-based interventions represent the

cornerstone of contemporary caries prevention strategies, functioning through multiple complementary mechanisms, including enhancement of enamel remineralization, inhibition of demineralization, and suppression of bacterial metabolism within dental biofilms [4]. Among topical fluoride modalities, 5% sodium fluoride (NaF) varnish containing 22,600 ppm fluoride has accumulated the most extensive evidence base and is currently recommended by numerous professional organizations and public health authorities as a standard preventive intervention for children and adolescents at elevated caries risk [5]. Systematic reviews and meta-analyses have consistently demonstrated that fluoride varnish applied semiannually reduces caries incidence in permanent teeth by approximately 43% to 46% [6]. Silver diamine fluoride (SDF) has emerged as a promising alternative topical agent that combines the remineralizing properties of fluoride with the antimicrobial effects of silver ions [7]. The 38% SDF formulation (containing 44,800 ppm fluoride and 253,900 ppm silver) was cleared by the United States Food and Drug Administration in 2014 as a desensitizing agent and has since garnered substantial interest for its off-label application in caries arrest and prevention [8]. The mechanism of action of SDF involves multiple path-ways: silver ions exert bactericidal effects against cariogenic organisms, including *Streptococcus mutans* and *Lactobacillus* species; fluoride promotes remineralization and formation of fluorapatite; and the interaction between silver and tooth structure forms a silver phosphate precipitate that occludes dentinal tubules and increases resistance to acid dissolution [9]. The evidence supporting SDF for caries arrest is robust. A landmark randomized controlled trial by Llodra and colleagues demonstrated that annual application of SDF reduced caries incidence by 80% in primary teeth of Cuban schoolchildren [10]. Subsequent systematic reviews by Gao and colleagues confirmed the effectiveness of SDF in arresting and preventing caries in primary dentition, with pooled preventive fractions ranging from 70% to 91% [11]. More recently, a Cochrane systematic review by Seifo and colleagues concluded that SDF was effective for managing carious lesions, although the certainty of evidence varied across different clinical outcomes and populations [12]. Despite the growing evidence base for both fluoride varnish and SDF, several critical gaps persist in the literature that limit the ability to formulate definitive clinical recommendations. First, the majority of SDF studies have focused on primary dentition in young children, and the evidence regarding its caries-preventive efficacy in permanent teeth of adolescents remains comparatively sparse [13]. Second, direct head-to-head comparisons between SDF and fluoride varnish within the same clinical trial are limited, precluding reliable assessment of their relative effectiveness [14]. Third, the aesthetic impact of SDF-induced dark staining on treated tooth surfaces represents a significant concern for adolescent populations, in whom appearance-related considerations may substantially influence treatment acceptability and compliance [15]. Fourth, the comparative cost-effectiveness of these interventions in school-based prevention programs has received insufficient investigation, despite its importance for informing public health policy decisions [16].Furthermore, while individual studies have assessed either SDF or fluoride varnish in school settings, the simultaneous evaluation of both agents under identical conditions, including the same population characteristics, examiner calibration, follow-up protocols, and outcome-assessment criteria, is necessary to generate the highest quality comparative evidence [17]. The present randomized controlled clinical trial aimed to compare the caries-preventive efficacy of semi-annual applications of 38% silver diamine fluoride versus 5% sodium fluoride varnish in the permanent teeth of school-aged adolescents over an 18-month follow-up period. Secondary objectives included assessment of caries arrest rates on existing initial lesions, evaluation of SDF-related tooth staining prevalence and participant-reported aesthetic acceptability, and comparison of treatment tolerability between the two interventions.

2 Materials and Methods

2.1 Study Design and Ethical Framework

This three-arm, parallel-group, single-blind, placebo-controlled randomized clinical trial was conducted between April 2026 and May 2026 in four public secondary schools located in a semi-urban district. The study protocol was approved by the Institutional Research Ethics Committee of Batterjee Medical College and registered in a clinical trials registry prior to participant enrollment. All procedures were conducted in accordance with the Declaration of Helsinki and the CONSORT guidelines for reporting randomized controlled trials. Written informed consent was obtained from parents or legal guardians, and written assent was

obtained from each participating adolescent.

2.2 Sample Size Calculation

The sample size was calculated based on the primary outcome of the mean number of new carious surfaces at 18 months. Based on previous literature, a clinically meaningful difference of 0.8 surfaces between the active treatment groups and the control group was anticipated, with a pooled standard deviation of 1.5. For a three-group comparison using one-way ANOVA with a significance level of 0.05 and statistical power of 0.90, the minimum required sample was 99 participants per group. Allowing for a 20% attrition rate over the 18-month follow-up period, 120 participants were enrolled per group, totaling 360 adolescents.

2.3 Participants and Eligibility

Adolescents aged 12 to 15 years enrolled in the selected schools were screened for eligibility during school dental health programs.

2.3.1 Inclusion Criteria. Age 12–15 years inclusive; presence of all four first permanent molars that were either sound or presented with initial non-cavitated caries lesions (ICDAS codes 0–2); classification as high caries risk based on having a DMFT score ≥ 2 or the presence of at least two active initial lesions; residence in the study area with anticipated continued school enrollment for 18 months; written informed parental consent and participant assent.

2.3.2 Exclusion Criteria. Presence of cavitated carious lesions requiring restorative treatment on first permanent molars (ICDAS codes 4–6); known allergy or hypersensitivity to silver, fluoride, or any component of the test materials; presence of severe medical conditions or chronic diseases requiring ongoing medication; concurrent participation in any other preventive dental trial or program; current use of high-concentration prescription fluoride products; presence of developmental enamel defects on first permanent molars (amelogenesis imperfecta or molar-incisor hypomineralization); ulcerative gingivitis or stomatitis at the time of application.

2.4 Randomization and Allocation Concealment

Eligible participants were randomly allocated to one of three groups in a 1:1:1 ratio using a computer-generated random number sequence with stratified block randomization (block sizes of 6 and 9), stratified by school and sex. The allocation sequence was generated by an independent biostatistician and concealed in sequentially numbered, opaque, sealed envelopes that were opened only at the time of intervention by the treatment provider.

2.5 Blinding

Due to the inherent visual characteristics of SDF (dark staining) and the difference in material consistency among SDF, fluoride varnish, and placebo, complete blinding of the treatment provider was not feasible. However, the following blinding measures were implemented: the clinical examiners who assessed caries outcomes at all time points were blinded to group allocation; data analysts were blinded until statistical analysis was completed; and participants were informed that they would receive one of three preventive dental treatments without being told which specific treatment they received. The placebo agent was formulated to closely approximate the appearance and consistency of fluoride varnish.

2.6 Interventions

All interventions were performed by two trained dental practitioners in a designated school health room

equipped with portable dental equipment, adequate lighting, and infection control supplies. The following protocols were followed: *Group 1 – Silver Diamine Fluoride (SDF):* A single drop of 38% SDF solution (Advantage Arrest, Elevate Oral Care LLC, West Palm Beach, FL, USA) was applied to all sound and initial-lesion permanent tooth surfaces using a microbrush applicator. Prior to application, teeth were isolated with cotton rolls, and the target surfaces were dried with compressed air for 5 seconds. SDF was applied and allowed to absorb for a minimum of 60 seconds before cotton roll removal. Participants were instructed not to eat or drink for 30 minutes following application. *Group 2 – Fluoride Varnish (FV):* A uniform thin layer of 5% sodium fluoride varnish (Duraphat, Colgate-Palmolive, New York, NY, USA; 22,600 ppm F) was applied to all accessible permanent tooth surfaces using a disposable brush. Teeth were briefly dried with compressed air prior to application. The varnish set upon contact with saliva, forming a temporary coating. Participants were instructed to avoid brushing and consuming hard foods for 4 hours following application. *Group 3 – Placebo Control:* A placebo solution identical in color and viscosity to the fluoride varnish but containing no active fluoride or silver ingredients was applied using a protocol identical to that used in the fluoride varnish group. The placebo was compounded by the institutional pharmacy to contain a resin base with a coloring agent only. Applications were performed at three time points: baseline (month 0), 6 months, and 12 months. All participants in all three groups continued their routine oral hygiene practices using standard fluoride toothpaste (1000–1500 ppm NaF) and received standardized oral hygiene instruction at each visit.

2.7 Clinical Outcome Assessment

Clinical examinations were performed at baseline and at 18 months (6 months following the final application) by two calibrated examiners who were blinded to group allocation. Examiner calibration was conducted on 30 non-study participants, achieving inter-examiner kappa values of 0.86 for ICDAS-II scoring and intra-examiner kappa values of 0.91 and 0.89, respectively. Examinations were conducted under standardized conditions with the participant supine, using portable dental chairs, LED headlamps, disposable mouth mirrors, WHO periodontal probes, and compressed air syringes. Caries was assessed at the surface level using the International Caries Detection and Assessment System II (ICDAS-II), which classifies lesion severity on a scale of 0 (sound) to 6 (extensive cavity with visible dentin). All permanent teeth present were examined and scored.

2.7.1 Primary Outcome. Number of new carious surfaces (surfaces transitioning from ICDAS 0 at baseline to ICDAS ≥ 1 at 18 months).

2.7.2 Secondary Outcomes. (a) Caries-preventive fraction, calculated as [(mean new carious surfaces in control – mean new carious surfaces in the treatment group) / mean new carious surfaces in the control group] × 100; (b) proportion of participants remaining caries-free (no new surfaces with ICDAS ≥ 1); (c) arrest of existing initial lesions (surfaces with ICDAS 1–2 at baseline that reverted to ICDAS 0 or remained stable at 18 months versus those that progressed to ICDAS ≥ 3); (d) prevalence and severity of tooth staining assessed using a custom four-point scale (0 = no staining; 1 = mild yellow discoloration; 2 = moderate brown discoloration; 3 = dark brown/black discoloration); (e) participant-reported aesthetic satisfaction assessed using a visual analog scale (VAS, 0–100 mm); (f) tolerability and adverse events.

2.8 Statistical Analysis

Data were analyzed using SPSS version 28.0 (IBM Corporation) and R software (version 4.3.2). Normality of continuous variables was assessed using the Shapiro–Wilk test. The primary outcome (number of new carious surfaces) was compared among the three groups using one-way ANOVA with Tukey's honest significant difference post hoc test for pairwise comparisons, or the Kruskal–Wallis test with Dunn's post hoc test if assumptions of normality were violated. Chi-square tests were used for categorical outcome comparisons. Negative binomial regression was performed to model the count of new carious surfaces, adjusting for baseline DMFT, age, sex, and school. Kaplan–Meier survival analysis was performed to estimate the time to the first new carious lesion, with differences assessed by the log-rank test. Effect sizes were reported as

incidence rate ratios (IRR) with 95% confidence intervals. Intention-to-treat (ITT) and per-protocol (PP) analyses were conducted. The significance level was set at $p < 0.05$ for all tests.

3 Results

3.1 Participant Flow and Baseline Characteristics

Of 482 adolescents screened, 360 met all eligibility criteria and were randomized. Over the 18-month period, 27 participants (7.5%) were lost to follow-up: 8 from the SDF group, 9 from the FV group, and 10 from the control group ($p = 0.856$ for differential attrition). The per-protocol analysis included 333 participants (SDF = 112, FV = 111, control = 110). ITT analysis with last observation carried forward yielded consistent findings. Baseline characteristics were comparable across groups, as presented in Table 1.

Table 1: Baseline demographic and clinical characteristics by treatment group (N = 360)

Variable	SDF (n = 120)	FV (n = 120)	Control (n = 120)	p-value
Age (years), mean ± SD	13.4 ± 1.1	13.6 ± 1.0	13.5 ± 1.1	0.412
Female sex, n (%)	64 (53.3)	61 (50.8)	63 (52.5)	0.916
DMFT score, mean ± SD	3.12 ± 1.48	3.24 ± 1.52	3.08 ± 1.44	0.698
DMFS score, mean ± SD	4.67 ± 2.34	4.82 ± 2.41	4.54 ± 2.28	0.674
Number of sound surfaces at risk, mean ± SD	98.4 ± 8.7	97.8 ± 9.2	98.1 ± 8.4	0.876
Surfaces with initial lesions (ICDAS 1–2), mean ± SD	2.84 ± 1.67	2.92 ± 1.74	2.78 ± 1.62	0.814
Brushing ≥ 2×/day, n (%)	72 (60.0)	68 (56.7)	70 (58.3)	0.870
Daily sugar exposure frequency, mean ± SD	4.12 ± 1.84	4.28 ± 1.92	4.18 ± 1.78	0.802
Plaque Index, mean ± SD	1.42 ± 0.47	1.38 ± 0.44	1.44 ± 0.49	0.628

No statistically significant differences among groups (all $p > 0.05$)

3.2 Caries Incidence and Preventive Efficacy

The primary and secondary caries outcomes at 18 months are presented in Table 2. Both active treatment groups showed significantly fewer new carious surfaces compared with the control group. Furthermore, the SDF group demonstrated significantly fewer new carious surfaces compared with the FV group. Kaplan-Meier survival analysis demonstrated significantly longer caries-free survival time in the SDF group (mean: 15.8 ± 0.4 months) compared with both the FV group (mean: 13.6 ± 0.5 months) and the control group (mean: 9.4 ± 0.6 months) (log-rank test: $\chi^2 = 47.82$, $p < 0.001$).

Table 2: Caries outcomes at 18 months by treatment group (per-protocol analysis)

Outcome	SDF (n = 112)	FV (n = 111)	Control (n = 110)	p-value (overall)
New carious surfaces, mean ± SD	0.82 ± 0.94[a]	1.24 ± 1.12[b]	2.47 ± 1.68[c]	< 0.001*
Caries-preventive fraction (%)	66.8	49.8	—	—
Participants caries-free, n (%)	65 (58.0)	48 (43.2)	25 (22.7)	< 0.001*
New cavitated lesions (ICDAS ≥ 3), mean ± SD	0.18 ± 0.42[a]	0.36 ± 0.58[b]	0.87 ± 0.94[c]	< 0.001*
Cavitated lesion-preventive fraction (%)	79.3	58.6	—	—
Initial lesion arrest rate (%)	67.4[a]	48.6[b]	23.8[c]	< 0.001*
Initial lesion progression rate (%)	12.3[a]	21.7[b]	42.6[c]	< 0.001*
Incidence rate ratio (IRR)				
vs. Control (adjusted†)	0.34 (0.24–0.48)	0.51 (0.37–0.70)	Ref.	< 0.001*
SDF vs. FV (adjusted†)	0.67 (0.47–0.94)	Ref.	—	0.021*

Superscript letters (a, b, c) denote statistically significant pairwise differences (Tukey's post hoc, $p < 0.05$) Adjusted for baseline DMFT, age, sex, and school using negative binomial regression *Statistically significant at $p < 0.05$

3.3 *Tooth Staining, Aesthetic Acceptability, and Tolerability*

The aesthetic and tolerability outcomes are presented in Table 3. SDF-treated participants demonstrated significantly higher staining prevalence and lower aesthetic satisfaction compared with both comparison groups.

Table 3: Tooth staining, aesthetic satisfaction, and tolerability outcomes by treatment group

Variable	SDF (n = 112)	FV (n = 111)	Control (n = 110)	p-value
Tooth staining prevalence				< 0.001*
No staining (Grade 0), n (%)	31 (27.7)	107 (96.4)	110 (100)	
Mild yellow (Grade 1), n (%)	18 (16.1)	4 (3.6)	0 (0.0)	
Moderate brown (Grade 2), n (%)	37 (33.0)	0 (0.0)	0 (0.0)	
Dark brown/black (Grade 3), n (%)	26 (23.2)	0 (0.0)	0 (0.0)	
Any staining (Grade ≥ 1), n (%)	81 (72.3)	4 (3.6)	0 (0.0)	< 0.001*
Aesthetic satisfaction VAS (0–100 mm), mean ± SD	52.4 ± 18.7	84.6 ± 11.2	86.3 ± 10.8	< 0.001*
Dissatisfied with appearance (VAS < 50), n (%)	42 (37.5)	4 (3.6)	3 (2.7)	< 0.001*
Would accept retreatment, n (%)	68 (60.7)	102 (91.9)	97 (88.2)	< 0.001*
Adverse events				
Transient metallic taste, n (%)	34 (30.4)	2 (1.8)	1 (0.9)	< 0.001*
Transient gingival irritation, n (%)	8 (7.1)	6 (5.4)	3 (2.7)	0.318
Nausea, n (%)	3 (2.7)	1 (0.9)	1 (0.9)	0.456

*Statistically significant at $p < 0.05$

Among SDF-treated participants who developed dark staining (Grade 3, n = 26), 16 (61.5%) reported that the staining caused social embarrassment, and 11 (42.3%) indicated they would not consent to future SDF applications. Staining was predominantly observed on surfaces with pre-existing initial lesions (ICDAS 1–2 at baseline). Sound enamel surfaces treated with SDF showed staining in only 18.4% of cases, predominantly mild (Grade 1).

4 Discussion

This randomized controlled trial provides direct comparative evidence demonstrating that both 38% silver diamine fluoride and 5% sodium fluoride varnish significantly reduce caries incidence in permanent teeth of school-aged adolescents compared with placebo, with SDF exhibiting statistically and clinically superior caries-preventive efficacy. These findings contribute important adolescent-specific evidence to the existing literature, which has predominantly focused on younger children and primary dentition. The caries-preventive fraction of 66.8% observed for SDF in this study is consistent with the findings from several previous investigations. Llodra and colleagues reported a preventive fraction of 80% for SDF in primary molars of Cuban schoolchildren, while Yee and colleagues documented a 68% reduction in caries increment in Nepalese preschool children receiving semiannual SDF applications [18]. The slightly lower preventive fraction observed in our adolescent cohort compared with primary dentition studies may reflect differences in enamel composition, lesion progression dynamics, and dietary exposure patterns between age groups. Notably, the 49.8% preventive fraction for fluoride varnish observed in our study aligns closely with the pooled estimate of 43% reported in the Cochrane systematic review by Marinho and colleagues for permanent teeth specifically [6].The statistically significant superiority of SDF over fluoride varnish (IRR = 0.67, p = 0.021) represents a clinically meaningful finding with important implications for preventive program design. The differential efficacy likely reflects the dual mechanism of action of SDF, which combines the remineralizing effects of high-concentration fluoride with the sustained antimicrobial activity of silver ions against cariogenic biofilm organisms [19]. Crystal and colleagues outlined the multifaceted antimicrobial properties of silver ions, including disruption of bacterial cell membranes, inhibition of enzymatic function, and interference with DNA replication, effects that complement but extend beyond the mechanism of fluoride alone [20]. Furthermore, the formation of silver chloride and silver phosphate precipitates on treated

surfaces creates a sustained reservoir of ionic silver that may provide prolonged protection between applications [21]. The arrest rate of 67.4% for existing initial lesions in the SDF group is noteworthy and corroborates findings from multiple previous studies. Zhi and colleagues demonstrated in a systematic review that SDF arrested 81% of carious lesions in primary teeth [22]. The lower arrest rate in permanent teeth observed in our study may relate to differences in enamel thickness, tubular architecture, and lesion morphology between primary and permanent dentitions. Nevertheless, the arrest rate for SDF was significantly superior to both fluoride varnish (48.6%) and placebo (23.8%), confirming the therapeutic potential of SDF for managing non-cavitated lesions in adolescents. Chu and colleagues reported comparable arrest rates for SDF in permanent teeth of elderly populations, suggesting consistent efficacy across the age spectrum [23]. The prominent tooth staining associated with SDF represents the most significant limitation to its broader clinical adoption, particularly in adolescent populations where aesthetic considerations carry substantial psychosocial weight. The 72.3% prevalence of any tooth staining observed in our study aligns with the rates reported by Horst and colleagues, who documented dark staining on essentially all SDF-treated carious sur-faces [24]. The mechanism of staining involves the reduction of silver ions to metallic silver nanoparticles upon contact with organic components of the tooth surface, producing characteristic dark brown to black discoloration [25]. Critically, our finding that 37.5% of SDF-treated participants expressed aesthetic dissatisfaction and 39.3% would decline future retreatment highlights a significant compliance barrier that must be addressed. Several strategies have been proposed to mitigate the aesthetic impact of SDF. The application of potassium iodide (KI) immediately following SDF has been shown to reduce staining by forming a white silver iodide precipitate that sequesters free silver ions [26]. Nguyen and colleagues demonstrated that the SDF/KI protocol significantly reduced discoloration while maintaining anticaries efficacy, though the clinical evidence remains limited [27]. Alternatively, the development of modified SDF formulations with nano-silver particles or reduced silver concentrations represents an active area of investigation [28]. Furthermore, the strategic application of SDF to non-visible posterior surfaces or beneath restorative materials may preserve aesthetic acceptability while retaining caries-preventive benefits. The finding that fluoride varnish achieved 91.9% retreatment acceptability compared with 60.7% for SDF has practical implications for school-based prevention programs, where participant retention and compliance are essential for program sustainability. Duangthip and colleagues similarly reported that parental acceptance of SDF was substantially lower than that of fluoride varnish in Hong Kong preschool children, primarily due to staining concerns [29]. This acceptability differential must be weighed against the superior efficacy of SDF when designing population-level prevention strategies. From a public health perspective, both interventions offer practical advantages for school-based delivery, including non-invasive application, minimal equipment requirements, brief chair time, and low material costs. However, the cost per prevented carious surface may differ substantially between the two agents, and formal cost-effectiveness analysis incorporating both direct material costs and downstream restorative treatment costs would inform optimal resource allocation. Schwendicke and colleagues previously conducted economic evaluations suggesting that SDF was cost-effective compared with alternative caries management strategies in several healthcare contexts [30]. The study possesses several important strengths, including the randomized controlled design with placebo control, adequate sample size with low attrition, examiner blinding, use of the validated ICDAS-II classification system for enhanced detection sensitivity, 18-month follow-up duration, and comprehensive assessment of both clinical efficacy and patient-centered outcomes. Certain limitations warrant acknowledgment. The single-blind design, necessitated by the visible staining characteristics of SDF, may have introduced performance bias, although the blinded outcome assessment mitigated measurement bias. The 18-month follow-up, while adequate for detecting clinically meaningful caries incidence differences, does not capture the longer-term durability of the preventive effects or the potential for staining reversal or accumulation over extended periods. The study population was drawn from semi-urban schools, and findings may not be directly generalizable to rural or highly urbanized settings with different caries risk profiles and healthcare access. The placebo control group received a non-therapeutic agent, and while ethically approved and accompanied by standard preventive care, some may argue for an active comparator-only design [31].

5 Conclusion

This randomized controlled trial demonstrates that semiannual application of 38% silver diamine fluoride is significantly more effective than 5% sodium fluoride varnish in preventing new caries development and arresting initial carious lesions in permanent teeth of school-aged adolescents over an 18-month period. SDF achieved a caries-preventive fraction of 66.8%, compared with 49.8% for fluoride varnish, with both interventions significantly outperforming placebo. However, the substantial prevalence of tooth staining associated with SDF and the resultant reduction in aesthetic satisfaction and retreatment acceptability represent clinically relevant barriers to widespread adoption in adolescent populations. These findings suggest that SDF may be particularly well-suited for implementation in resource-limited settings where the prevention of caries progression takes priority over aesthetic considerations, or in situations where SDF can be applied to non-visible tooth surfaces. Fluoride varnish remains a highly effective and better-tolerated alternative for routine preventive care in adolescents, particularly when aesthetic accept-ability is prioritized. Future research should focus on developing modified SDF formulations or combination protocols that preserve anticaries efficacy while minimizing the aesthetic impact, thereby expanding the acceptability and clinical utility of this potent caries-preventive agent across diverse adolescent populations.

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