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Original article

Knowledge and Use of Silver Diamine Fluoride by Dentists in Libya: A Cross-Sectional Study

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Abstract
Silver diamine fluoride (SDF) is a minimally invasive cariostatic solution recommended by leading pediatric dentistry organizations; however, its uptake in dental practice differs across countries. To date, no nationally representative study has examined Libyan dentists' knowledge, attitudes, and practices regarding SDF. This study was conducted to assess awareness, knowledge, attitudes, clinical use, and perceived barriers towards SDF among Libyan dentists. A cross-sectional study was conducted from July 2025 to May 2026 among 527 Libyan dentists across multiple governorates using a validated electronic questionnaire. Data was analyzed using SPSS V 27. Descriptive statistics summarized responses; chi-square tests examined associations between demographic variables and history of SDF use. A composite overall Knowledge Score (OKS) was constructed from ten binary items. Overall, 81.8% of respondents were aware of SDF, predominantly through colleagues (28.8%) and online resources (28.1%). Only 34.3% had used SDF clinically. The mean OKS was 5.31 ± 2.69 / 10 (moderate level); 35.5% correctly identified the recommended 38% concentration, while 52.4% did not know it. Attitudes were broadly favourable for coronal caries arrest (non-cavitated: 71.9%; enamel-cavitated: 70.3%), but declined for deeper lesions. The primary barriers were tooth discoloration (56.6%), patient satisfaction concerns (53.6%), and parental acceptance (52.2%). University type was the only significant demographic predictor of SDF use: private-university graduates were significantly more likely to have used SDF than governmental-university graduates (54.3% vs. 30.9%; $\chi^2 = 15.674$, $p < 0.001$). SDF users demonstrated significantly higher OKS compared to non-users (mean 6.45 ± 2.04 vs. 4.72 ± 2.80; $p < 0.001$). Two-thirds (66.2%) anticipated increasing future SDF use. Libyan dentists demonstrate moderate awareness but suboptimal pharmacological knowledge and clinical adoption of SDF. Deficits are uniform across all demographic subgroups, indicating a systemic educational gap that requires coordinated curriculum reform and targeted continuing professional development. The use of SDF among Libyan dentists is still limited and has not yet become established in routine clinical practice. In Libya, it is necessary to increase training on SDF, primarily through the university, to promote its wider use and increase its use, especially as a non-invasive caries treatment.
Keywords. *Silver Diamine Fluoride, Pediatric Dentistry, Dental Caries, Minimal Invasive Dentistry.*

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Introduction

Dental caries remains the most prevalent non-communicable disease worldwide, with an estimated 2.3 billion people globally affected by untreated caries in their permanent teeth and more than 530 million children affected by caries in their primary teeth [1]. The continued high prevalence of dental caries has placed a considerable burden on health care systems across both the Arab region and North Africa, where challenges include limited availability of specialist resources, deficiencies in physical infrastructure, and inadequate access to preventive oral health services [2]. Accordingly, there is a clear need for affordable, accessible, and evidence-based approaches to caries management in Libya, particularly for clinicians providing dental care to children in the context of a shortage of pediatric dental specialists. In addition, the availability of general anesthesia services for young children is limited, further underscoring the need for alternative strategies for managing caries in this population.

Silver diamine fluoride (SDF) is a topical, alkaline, colourless solution, most used at a standard concentration of 38%, containing approximately 25% silver and 8% fluoride by weight [3]. Since its approval by the United States Food and Drug Administration (FDA) in 2014 for the treatment of dentinal hypersensitivity, SDF has attracted considerable research interest for its off-label use in arresting dental caries. This has led to its inclusion in clinical practice guidelines endorsed by

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the American Academy of Paediatric Dentistry (AAPD) and the American Dental Association (ADA) [4, 5]. Its mechanism of action is multifactorial: silver ions exert strong bactericidal effects against cariogenic microorganisms; fluoride enhances remineralisation through the formation of calcium fluoride; SDF inhibits collagenolytic enzymes involved in the degradation of the dentinal organic matrix; and silver microwire formation mechanically strengthens the structure of the arrested lesion [3, 6].

SDF offers important advantages in situations involving limited patient cooperation and when resources are limited, as it does not require local anaesthesia, can be applied quickly within 1-3 minutes, and is less costly than conventional restorative interventions [7]. A substantial body of evidence from systematic reviews and meta-analyses has demonstrated caries-arrest rates of 65–91% in primary teeth following SDF application, and a 2024 Cochrane review confirmed its superiority over both placebo and active treatments [8, 9, 10]. But despite all this evidence base, SDF isn't being used consistently around the world, with awareness rates ranging from 29.6% to 100%, and actual clinical use ranges from 13% to 85% according to published surveys [11].

Key factors underlying this variability include the degree of integration within undergraduate curricula, the national regulatory environment, the role of specialist professional organisations, and the capacity of professional networks to disseminate knowledge. The primary barrier consistently documented in published knowledge, attitudes, and practice (KAP) surveys is the permanent black discolouration of arrested lesions, which reduces patient and parental acceptance, particularly in the aesthetic zone [11, 12]. Understanding where a national dental workforce lies along the continuum of knowledge and adoption is, therefore, essential for developing targeted and effective educational interventions that address existing gaps and supporting the broader implementation of evidence-based practice.

The only published study specifically examining SDF knowledge in the Libyan context is that conducted by Ashlak et al .2026 in Benghazi, which reported an awareness rate of 80.4% among 240 dental practitioners working in both public and private clinics [13]. However, that study was limited to a single city. To date, no nationally representative investigation has been conducted in Libya. Accordingly, the present study was conducted to address this gap by evaluating knowledge, attitudes, clinical practices, barriers, and patient preferences related to SDF among a large, multi-governorate national sample of Libyan dentists, while also examining whether demographic characteristics were independently associated with clinical SDF use.

Methods

Study Design and Setting

The study was a cross-sectional web-based study conducted to assess the knowledge, attitudes, and practices of dentists regarding silver diamine fluoride (SDF) in Libya. The study was carried out between July 2025 and May 2026 and covered participants from multiple Libyan regions, with the largest proportions from Tripoli 35.3% and Benghazi 25.4%.

Study Population and Sampling

The target population consisted of dentists currently practicing in Libya. Participants were recruited using convenience and snowball sampling techniques. The survey link was distributed through official Libyan dental association networks and professional social media groups (e.g., WhatsApp, Facebook, Telegram). Participants were also encouraged to share the survey invitation link with their colleagues. Inclusion criteria included having a recognized dental qualification, currently engaged in clinical practice, and or academically active in Libya, and providing informed consent by completion of the survey. Dentists serving in full administrative roles with no patient contact, as well as dental students and interns, were excluded from this study. Based on a pilot study, the estimated proportion (p) of participants who had previously heard of Silver Diamine Fluoride (SDF) was 70% (14/20), using a 95% confidence level (Z = 1.96) and a 5% margin of error (d = 0.05), the determination of the minimum required sample size was to be 323 participants. To compensate for an anticipated 10% non-response or dropout rate, the target sample size was increased to 359 participants. The final sample comprised 527 participants, exceeding this target.

Data Collection Instrument

Data were collected using a structured, self-administered online questionnaire (e.g., Microsoft Forms). The questionnaire was adopted from a previously validated and published study on SDF utilization [11, 14, 15] and underwent content validity assessment by an expert panel comprising two faculty members in paediatric dentistry and one faculty member in preventive dentistry. The final questionnaire was organized into six domains: (a) demographic characteristics; (b) awareness of SDF and sources of knowledge; (c) undergraduate training in SDF; (d) clinical use and application protocols; (e) attitudes towards SDF indications; and (f) perceived barriers to its use, with attitudinal items assessed using a 5-point Likert scale.

The questionnaire was pre-tested on a small sample of 20 general dentists who were not included in the main survey. After completing the questionnaire, they were contacted to assess the clarity of the items and to identify any difficulties in

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understanding the questions. The pilot study demonstrated satisfactory content validity (Content Validity Index = 0.85) [16] and acceptable internal consistency (Cronbach's α = 0.78).

Ethical Considerations

Ethical approval for this study was obtained from the Scientific Research and Ethics Committee at the University of Tripoli, Libya; Approval No: [SREC/010/345]. Participation was voluntary and anonymous, completion of the questionnaire was taken to indicate implicit informed consent, and no personal identifiers were collected.

Statistical Analysis

Data were collected via Microsoft Forms and downloaded into a Microsoft Excel and then exported to IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated for all items to provide an overview of the results. Pearson chi-square tests of independence assessed associations between five demographic variables (sex, age groups, highest degree, place of practice, and professional experience) and history of SDF clinical use.

Results

Demographic characteristics of participants

A total of 527 Libyan dentists participated in the survey. Most respondents were female (74.2%, n = 391. The largest age group was 25–35 years (64.5%, n = 340), followed by 36–45 years (29.4%, n = 155), while those older than 45 years represented 6.1%(32) of the sample. The majority held a Bachelor's degree as their highest qualification (75.9%, n = 400. Most had graduated from public universities (84.6%, n = 444), whereas 15.4% (n = 81) had graduated from private universities.

In terms of workplace setting, combined public and private sectors were the most common (28.1%, n = 148), followed closely by private practice only (27.5%, n = 145). More than half of the respondents (51.8%, n = 273) reported having 1-5 years of professional experience; 19.0% (n = 100) had 6–10 years, and 29.2% (n = 154) had more than 10 years of clinical practice. Participants were geographically distributed across several Libyan governorates, with the largest proportions from Tripoli (35.3%, n = 186) and Benghazi (25.4%, n = 134), followed by Sabha (11.6%, n = 61), Zawia (4.7%, n =25), Zletin (4.2%, n =22), and other regions. These demographic characteristics are presented in (Table 1).

Table 1. Demographic characteristics of study participants (N = 527).

Characteristic	Category	n	%
Sex	female	391	74.2
	Male	136	25.8
Age group (years)	25–35	340	64.5
	36–45	155	29.4
	>45	32	6.1
Highest degree	Bachelor	400	75.9
	Master	105	19.9
	PhD	22	4.2
University type	Governmental	444	84.6
	Private	81	15.4
Place of practice	Public + private	148	28.1
	Private only	145	27.5
	Public center only	94	17.8
	Academic + private	81	15.4
	Academic teaching only	59	11.2

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Professional experience	1-5 years	273	51.8
	6-10 years	100	19.0
	> 10 years	154	29.2

Awareness of SDF and Sources of Knowledge

Out of the 527 respondents, 431 (81.8%) indicated that they had prior awareness of silver diamine fluoride (SDF), while 96 (18.2%) reported no previous knowledge. Among those familiar with SDF (n = 431), the most frequently reported source of information was colleagues (28.8%, n = 124), closely followed by online resources (28.1%, n = 121). Dental conferences or workshops (8.4%, n = 36) cited by smaller proportions.

Self-reported levels of formal training in SDF were limited across participants. Of those who were aware of SDF, the majority (65.0%, n = 280) reported receiving little or no classroom-based instruction (not at all or 'a little'), whereas only 35.0% (n = 151) indicated a satisfactory level of formal theoretical education ('well' or 'very well'). Similarly, 61.3% (n = 264) reported little or no hands-on experience during clinical training, compared to 38.7% (n = 167) who reported adequate clinical learning. These findings suggest insufficient integration of SDF into undergraduate dental curricula in Libya. The corresponding data are presented in (Table 2).

Table 2. Awareness of SDF and sources of knowledge

Variable	N	%
A ware of SDF (Yes)	431	81.8
Aware of SDF (No)	96	18.2
Source of knowledge — among aware (n=431)		
By professional colleague	124	28.8
Online resources	121	28.1
Dental school / undergraduate curriculum	80	18.6
Continuing education programmes	69	16.0
Dental conferences / workshops	36	8.4
Classroom learning — Not at all / A little	280	65.0
Classroom learning — Well / Very well	151	35.0
Clinical training — Not at all / A little	264	61.3
Clinical training — Well / Very well	167	38.7

Clinical use and pharmacological knowledge

Of the total sample, 181 respondents (34.3%) reported prior use of SDF in their clinical practice, while a larger proportion (65.7%, n = 346) indicated no clinical experience with its use. When asked to identify the clinically recommended SDF concentration, only 187 respondents (35.5%) correctly identified 38% as the standard formulation. More than half of the participants (52.4%, n = 276) acknowledged they did not know the correct concentration, while 7.8% (n = 41) and 4.4% (n = 23) incorrectly identified 5% and 50% concentrations, respectively, reflecting active pharmacological misknowledge within the sample.

The mean Overall Knowledge Score (OKS) was 5.31 ± 2.69 out of a maximum of 10 (median = 6.0; IQR = 4.0–7.0), consistent with a moderate overall knowledge level. Based on pre-defined thresholds, 24.3% (n = 128) were classified as having poor knowledge (score 0–3), 38.9% (n = 205) as moderate (score 4–6), and 36.8% (n = 194) as good (score 7–10). Self-reported competence was highest for treating caries in paediatric patients (Well/Very well: 76.1%, n = 328), notably lower for dentine hypersensitivity management (39.9%, n = 172), and lowest for adult caries management (27.9%, n = 120), identifying these as priority domains for educational intervention. Detailed results are presented in (Table 3).

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Table 3. Clinical use of SDF, Knowledge of the recommended concentration and Overall Knowledge Score (OKS)

Variable	N	%
Has used SDF clinically (yes)	181	34.3
Has used SDF clinically (No)	346	65.7
Recommended concentration — Correct (38%)	187	35.5
Recommended concentration — Incorrect (5%)	41	7.8
Recommended concentration — Incorrect (50%)	23	4.4
Recommended concentration — Do not know	276	52.4
Overall Knowledge Score: poor (0–3)	128	24.3
Overall Knowledge Score: Moderate (4–6)	205	38.9
Overall Knowledge Score: Good (7–10)	194	36.8
OKS — Mean ± SD (max = 10)	5.31 ± 2.69	–
OKS — Median (IQR)	6.0 (4.0–7.0)	–
Self-assessed knowledge: tooth hypersensitivity — Well/Very well	172	39.9
Self-assessed knowledge: paediatric caries — Well/Very well	328	76.1
Self-assessed knowledge: adult caries — Well/Very well	120	27.9

OKS = Overall Knowledge Score (10-item binary composite). Poor: 0–3; Moderate: 4–6; Good: 7–10.

Attitudes toward clinical indications of SDF

Among respondents who were familiar with silver diamine fluoride (n = 431), overall attitudes toward SDF's caries-arresting potential were broadly positive for coronal lesions; however, the level of agreement declined consistently with increasing lesion severity. For non-cavitated carious lesions, 71.9% (Agree: 48.7% + Strongly agree: 23.2%) indicated that SDF is effective in achieving caries arrest, and a comparable proportion endorsed its effectiveness in enamel-cavitated lesions (70.3%; Agree: 53.1% + Strongly agree: 17.2%). Additionally, 69.1% (Agree: 53.8% + Strongly agree: 15.3%) reported that SDF demonstrates superior caries arrest efficacy relative to other fluoride formulations. Slightly over half of the respondents 53.1% supported the use of SDF without subsequent restorative intervention (Agree: 44.5% + Strongly agree: 8.6%).

In contrast, Agreement decreased notably for dentine-cavitated lesions, with only 46.1% agreeing (Agree:36.4 + Strongly agree:9.7). Support for SDF use in cavitated root caries was considerably lower (25.9%), with disagreement being the most common response (Disagree + Strongly disagree: 49.4%). The application of SDF after removal of infected soft dentine elicited the highest degree of uncertainty (Don't know: 27.4%), with proportions of agreement (37.5%) and disagreement (41.5%) that were nearly equal. These attitudinal findings are presented in (Table 4).

Table 4: Attitudes towards SDF clinical indications among aware respondents (n=431)

Statement (among aware, n =431)	Strongly agree n(%)	Agree n(%)	Disagree n(%)	I don't know n(%)
SDF arrests non-cavitated caries lesions	100 (23.2%)	210 (48.7%)	68 (15.8%)	53 (12.3%)
SDF arrests enamel-cavitated lesions	74 (17.2%)	229 (53.1%)	70 (16.2%)	58 (13.5%)
SDF arrests dentine-cavitated lesions	42 (9.7%)	157 (36.4%)	148 (34.4%)	84 (19.5%)
SDF arrests cavitated root caries	23 (5.3%)	89 (20.6%)	213 (49.4%)	106 (24.6%)

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SDF effective after removing infected dentin	20 (4.6%)	142 (32.9%)	151 (35.0%)	118 (27.4%)
SDF can be used without restorative treatment	37(8.6%)	192 (44.5%)	108 (25.1%)	94 (21.8%)
SDF has higher caries -arrest rate than other fluoride formula	66(15.3%)	232(53.8%)	23(5.3%)	110(25.5%)

Frequency of SDF application by clinical indication

Respondents were asked about the frequency of SDF use across four specific clinical indications. The most commonly reported application was to stop cavities in primary teeth, with 36.9% reporting 'very often' and 24.8% 'often' yielding a combined often/very often rate of 61.7%. Caries prevention was the second most frequent indication (often/very often: 42.2%), followed by treatment of cavitated lesions without filling them (often/very often: 32.5%). In contrast, SDF use for the management of tooth hypersensitivity was markedly less common: 47.3% reported never using SDF for this purpose, with an additional 22.3% indicating rare use. Only 28.1% using it often or very often for hypersensitivity. These frequency patterns reflect the clinical evidence base, which most strongly supports SDF application for primary tooth caries arrest. Detailed findings are presented in (Table 5).

Table 5. Frequency of SDF application by clinical indication among aware respondents(n =431)

Clinical indication (431)	Never n (%)	Rarely n (%)	Often n (%)	Very Often n (%)
Tooth hypersensitivity	204 (47.3%)	96 (22.3%)	90 (20.9%)	31 (7.2%)
Caries prevention	172 (39.9%)	69 (16.0%)	103 (23.9%)	79 (18.3%)
Arrest caries in primary teeth	120 (27.8%)	43 (10.0%)	107 (24.8%)	159 (36.9%)
Cavitated lesion without restoration	211 (49.0%)	72 (16.7%)	81 (18.8%)	59 (13.7%)

Willingness to Use SDF in Specific Patient Groups and Tooth Zones

A high level of willingness to use SDF was expressed for patients with special needs (Yes: 76.3%, n = 329), followed by those with behavioural management challenges (73.3%, n = 316), and individuals with severe dental anxiety (64.7%, n = 279). Moderate levels of Willingness were reported for low-income patients (57.3%, n = 247) and patients undergoing or shortly after radiotherapy or chemotherapy (46.2%, n = 199). In contrast, Respondents were considerably more uncertain about SDF use in patients on bisphosphonate therapy (Don't know: 50.8%, n = 219; Yes: 34.3%), and for those receiving oncology treatment (Don't know: 42.5%, n = 183).

Zone-specific willingness was strongly influenced by aesthetic considerations. The posterior zone of primary teeth received by far the highest endorsement (Yes: 79.1%, n = 341), while willingness declined for the posterior zone of permanent teeth (49.9%, n = 215). In the aesthetic zone, willingness was markedly lower: 28.5% (n = 123) reported acceptance of it's application in the aesthetic zone of primary teeth, and only 13.5% (n = 58) in the aesthetic zone of permanent teeth. Notably, the majority of respondents clearly rejected aesthetic-zone permanent tooth application (No: 67.1%, n = 289). These findings are summarized in Table 6.

Table 6. Willingness to use SDF in specific patient groups and tooth zones (n = 431)

Clinical context (N 431)	Yes n(%)	NO n(%)	Don't know n (%)
Patients with special needs	329 (76.3%)	31 (7.2%)	66 (15.3%)
Patients with severe dental anxiety	279 (64.7%)	61 (14.2%)	83 (19.3%)
Patients with behavioural issues	316 (73.3%)	37 (8.6%)	72 (16.7%)
Low-income patients	247 (57.3%)	80 (18.6%)	95 (22.0%)

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Patients on bisphosphonate therapy	148 (34.3%)	55 (12.8%)	219 (50.8%)
Patients during/after radiotherapy or chemotherapy	199 (46.2%)	41 (9.5%)	183 (42.5%)
Willingness-Aesthetic zone, primary teeth	123(28.5%)	237(55.0%)	71(16.5%)
Willingness - Posterior zone, primary teeth	341 (79.1%)	31 (7.2%)	59 (13.7%)
Willingness - Aesthetic zone, permanent teeth	58 (13.5%)	289 (67.1%)	84 (19.5%)
Willingness- posterior zone, permanent teeth	215(49.9)	118(27.4%)	98(22.7%)

Perceived barriers to SDF utilization

Among the six evaluated barriers, permanent discoloration of the tooth was the most commonly reported concern (Yes: 56.6%, n = 244), followed by concern regarding patient satisfaction (53.6%, n = 231) and acceptance by parents (52.2%, n = 225). Additionally, 44.1% of participants (n= 190) identified the inability of SDF to restore functional tooth anatomy as a notable limitation, while financial considerations were less frequently cited, with 30.4% (n = 131) reporting cost to the patient as a barrier. Notably, poor scientific evidence emerged as the least frequently endorsed barrier (22.3%, n = 96), whereas 36.2% of respondents clearly indicated that they did not regard it as a barrier. A considerable proportion of participants reported uncertainty (Don't know) across several barrier items, with the greatest uncertainty for poor scientific evidence (41.5%) and treatment cost to the patient (29.9%). Barrier data are presented in (Table 7).

Table 7. Perceived barriers to SDF use among aware respondents (n =431)

Barrier (n 431)	Yes n (%)	No n (%)	Don't know n (%)
Permanent tooth discolouration	244 (56.6%)	74 (17.2%)	113 (26.2%)
Concern for patient satisfaction	231 (53.6%)	62 (14.4%)	138 (32.0%)
Parent/guardian acceptance	225 (52.2%)	78 (18.1%)	128 (29.7%)
Failure to restore functional tooth anatomy	190 (44.1%)	123 (28.5%)	118 (27.4%)
Cost to the patient	131 (30.4%)	171 (39.7%)	129 (29.9%)
Poor scientific evidence	96 (22.3%)	156(36.2%)	179(41.5%)

Application protocols and future expectations for use

Among the 181 participants who had used SDF, the most frequently adopted protocol was a single one-time application (28.7%, n = 52), followed by biannual application at six-month intervals (23.8%, n = 43), and individualized protocols based on caries risk or lesion characteristics (18.2%, n = 33). Less commonly reported approaches included trimonthly application (10.5%, n = 19), weekly application for one month (7,7%, n =14), and annual application (5.0%, n = 9). Regarding future utilization, most respondents (66.2%, n = 349) expected to increase their use of SDF, while 27.7% (n = 146) were uncertain about expanding its use, and only 6.1% (n = 32) did not anticipate increasing usage. These data are summarized in (Table 8).

Table 8. SDF application protocol among clinical users (n=181) and future use intentions (n=527).

Variable	n	%
Application protocol used (among SDF users, n=181):		
One-shot application	52	28.7
Every 6 months	43	23.8
Based on lesion/risk characteristics	33	18.2
Every 3 months	19	10.5

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Weekly for 1 month	14	7.7
Every 12 months	9	5.0
Future SDF use (all respondents, N=527):		
Expect to increase — Yes	349	66.2
Expect to increase — Don't know	146	27.7
Expect to increase-No	32	6.1

Association between demographic variables and SDF clinical Use

Chi-square tests of independence were performed to determine whether five demographic variables: gender, age group, highest qualification, place of practice, and professional experience were associated with prior clinical use of SDF. Additionally, university type was examined as a sixth predictor variable. There were no significant associations between sex, age groups, professional experience, highest degree, or place of practice and history of clinical SDF use.

University type was the only demographic variable significantly associated with SDF use ($\chi^2 = 15.674$, df = 1, $p < 0.001$). Graduates of private universities were substantially more likely to have used SDF (54.3%, n = 44/81) than those from public universities (30.9%, n = 137/444). These data are summarised in (Table 9).

Table 9. Associations between demographic variables and SDF use

Variable	Users, n (%)	Non-Users, n (%)	χ^2 (df)	P value
University type			15.67 (1)	< 0.001*
Governmental (n = 444)	137 (30.9)	307 (69.1)		
Private (n = 81)	44 (54.3)	37 (45.7)		
Gender			1.01 (1)	0.315
Female (n = 391)	129 (33.0)	262 (67.0)		
Male (n = 136)	52 (38.2)	84 (61.8)		
Age group			2.44 (2)	0.295
Highest degree			0.91 (2)	0.635
Place of practice			7.07 (4)	0.132
Professional experience			1.26(2)	0.533

Overall Knowledge Score in Relation to SDF Use History

Dentists with prior clinical experience using SDF demonstrated significantly higher Overall Knowledge Scores than those who had never used it (mean 6.45 ± 2.04 vs. 4.72 ± 2.80; median 7.0 vs. 5.0; Mann–Whitney U, $p < 0.001$). They were also significantly more likely to correctly identify the recommended 38% concentration (50.0% vs. 28.1%; $\chi^2 = 23.481$, df = 1, $p < 0.001$). These findings suggest that hands-on clinical experience with SDF is strongly associated with broader knowledge.

Discussion

This national cross-sectional study was the first of its kind in Libya and included a multi-governorate sample of 527 dentists and offers a comprehensive overview of SDF -related knowledge, attitudes, and practices within the Libyan dental workforce. The main findings were: relatively high awareness (81.8%), largely derived from informal sources; moderate overall knowledge levels (OKS mean 5.31/10); notably limited pharmacological knowledge, with only 35.5% correctly identifying the recommended concentration and suboptimal clinical adoption (34.3%). Black discoloration was the dominant barrier, and university type was the only significant demographic factor significantly associated with clinical use.

Awareness of SDF

The awareness rate of 81.8% observed in this national study closely aligns with 80.4% reported in the Benghazi -based study by Ashlak et al. (2026)[13], offering important intra-Libyan validation: SDF awareness appears to be broadly uniform across Libyan cities, regardless of whether practitioners are surveyed in Tripoli or the main eastern centre: Benghazi. Both studies

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identified informal channels, particularly peer communication and online resources, as the main sources of awareness, whereas formal undergraduate education played only a minority role. Taken together, the close agreement between the Benghazi findings and the present national data suggests that the educational gap identified in this study is systemic and widespread throughout the country.

Compared with the international literature, the awareness rate of 81.8 observed in the present study is considerably higher than the 61.58% reported among 406 Iraqi dental practitioners by Al Haidar et al. (2025) [17], the 62.7% reported in the Hail region of Saudi Arabia by Alshammari et al. (2021) [18], and the 59.70% reported among Egyptian dentists [33]. However, it remains lower than the 92.45% reported in the national Saudi survey by Robaian et al. (2022) [19] and the 100% familiarity reported in Hong Kong, where SDF has been incorporated into public health programmes since the 1990s [20]; however, that study included only 86 dentists out of the 173 originally invited to participate. The systematic review by Mohammed et al. (2022), which included 14 cross-sectional studies from nine countries, reported that global awareness ranged from 29.6% to 87.8% [11], placing our Libyan figure in the upper-moderate range. In Spain, Serna-Munoz et al. (2025) found that awareness of the indications for SDF use was only 56.8% among general dentists, compared with 94.7% among final year dental students who had received more contemporary training [21], powerfully highlighting the important role of curriculum integration in shaping awareness.

The finding that 65.0% of aware Libyan dentists reported minimal classroom instruction and 61.3% reported minimal clinical training in SDF is in line with a nationwide Italian survey by Salerno et al. (2025), which included 3,876 dentists, found that fewer than 13% had received SDF training at any formal academic level [22]. It is also in agreement with the Netherlands study [24], which stated that basic dental education played a limited role in the acquisition of knowledge about SDF. Similarly, Antonioni et al. (2019) in the United States reported that only 3% of pediatric dentists felt well educated about SDF in dental school classroom teaching [14], while the updated survey by Benas Jakubauskas et al. (2025) showed that clinical implementation of SDF in US dental school curricula remains limited [23]. Taken together, these converging findings from different settings demonstrate that the slow integration of SDF into dental curricula is a broader international issue, of which Libya reflects this pattern at the regional level.

Clinical use and pharmacological knowledge

The clinical use rate of 34.3% observed in the present Libyan study lies between the rates reported separately for general dental practitioners (16%) and paediatric dentists (74%) in the Dutch national survey by Schroë et al. (2022), highlighting comparable differences in adoption across practitioner groups [24]. It is also broadly similar to the 27.4% reported among aware respondents in Lahore by Palwasha Babar et al. (2022) [25], and the 26.1% reported among Spanish participants in the study by Clara Serna-Munoz et al.2024 [21].

It is markedly higher than the 13.2% reported in Brazil by Vollú et al. (2020), where SDF use was largely restricted to university-based and paediatric specialist practitioners [26], and is considerably lower than the 85% reported in Hong Kong, where institutional integration, national oral health policy, and professional society endorsement have supported near-universal adoption [20]. In the Benghazi study, SDF use was not directly reported as a proportion of the total sample; however, the identified gaps in pharmacological and protocol knowledge led the authors to conclude that active clinical SDF use was limited among Benghazi practitioners [13]. This interpretation is consistent with the present national findings.

Among SDF users in our sample, application frequency varied considerably. The most commonly reported regimen was a single one-time application (28,7%, n =52), followed by biannual application (23.8, n = 43), individualized or risk-based protocols (18.2%, n =33), trimonthly application (10.5%, n = 19), weekly application for one month (7.7%, n = 14), and annual application (5.0%, n = 9). This marked heterogeneity is consistent with the wider literature, in which no universally accepted application protocol has been established [17,22]. Similarly, in the Benghazi study, 52.1% of dentists were unable to identify the recommended application interval, indicating a comparable gap in applied pharmacological knowledge [13]. Taken together, this discrepancy between awareness and practice mirrors the protocol inconsistency observed in our sample and suggests that variation in application patterns is driven less by unfamiliarity with SDF itself than by limited structured training**.**

Self-reported levels of formal training in SDF were limited among participants. Among those who were aware of SDF, 65.0% (n = 280) reported little or no classroom-based instruction, whereas only 35.0% (n = 151) reported adequate theoretical education. Likewise, 61.3% (n = 264) indicated little or no hands-on clinical training, compared with 38.7% (n = 167) who reported adequate clinical exposure. These findings suggest that SDF remains insufficiently integrated into undergraduate dental curricula in Libya. This pattern is consistent with, although somewhat less pronounced than, findings from a large Italian survey in which almost all participants reported receiving no education on SDF in either lectures or clinical practice during undergraduate training [22]. Similar deficits have also been documented internationally: in a U.S. national survey of paediatric dentists, only 3% reported being well or very well educated about SDF in dental school classrooms, and only 9.6% during residency [14], while in the Saudi Eastern Province survey, more than 60% reported no prior clinical experience with SDF and 65.5% reported no exposure during dental school [32]. The Spanish study likewise found that only 20.98% of general practitioners had received training on SDF [21], and the Benghazi study reported that only 52.5% of dentists had

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attended lectures or discussions on SDF, with 52.1% unable to identify the correct application interval [13]. Taken together, these findings indicate that inadequate undergraduate education in SDF is not unique to Libya but reflects a broader gap across the Middle East and North Africa region and beyond, underscoring the need for structured curriculum reform.

A key and clinically important finding was that dentists with prior experience using SDF were significantly more likely to identify the correct concentration and had significantly higher overall knowledge scores than non-users. A similar pattern was reported by Fujita. 2023 among dental students at Kyushu Dental University in Japan, where students with clinical experience of SDF achieved significantly higher knowledge scores than those without such experience [27]. Collectively, these findings highlight the educational value of hands-on clinical exposure in strengthening pharmacological and procedural understanding beyond what is achieved through didactic teaching alone. This has important implications for curriculum development, suggesting that structured clinical training in SDF should be prioritized in both undergraduate programmes and continuing professional development.

Attitudes Towards SDF Clinical Indications

The generally favourable attitudes observed in the present study, with 71.9% agreeing SDF arrests non-cavitated lesions,70.3% supporting its use for arresting enamel-cavitated lesions, and 69.1% considering it superior to other fluoride formulations, are consistent with findings reported in Saudi Arabia [19], the Netherlands [24], Italy [22], Brazil [26], and Iraq [17]. In the Saudi national survey, 61% of respondents agreed that SDF could arrest carious lesions [19], a proportion somewhat lower than that observed in the Libyan sample but broadly aligned in direction. Similarly, the Dutch study reported generally positive attitudes among both general and paediatric dentists, with the latter demonstrating higher use rates [24].

The stepwise decline in endorsement with increasing lesion severity observed in our findings from 71.9% for non-cavitated to 46.2% for dentine cavitated lesions and only 25.9% for root caries may partly reflect differences in the strength of the available evidence. Several systematic reviews and meta-analyses have confirmed the high efficacy of SDF in arresting coronal caries in primary teeth [8,9,10]. A systematic review by Satish Vishwanathaiah et al. 2024 confirmed the effectiveness of SDF in both primary and mixed dentition [28], while the 2024 Cochrane review by Worthington et al. demonstrated its superiority for managing pediatric coronal caries [10]. Although the evidence supporting the use of SDF for root caries is growing, it remains more limited than that for other indications, and the lower level of endorsement among Libyan dentists may therefore reflect an appropriate alignment of clinical confidence with the current strength of evidence. The high level of uncertainty regarding the use of SDF after removal of infected dentine (27.4% unsure) indicates a clinical knowledge gap warranting targeted educational attention.

The finding that 53.1% of respondents endorsed the use of SDF without restorative treatment is clinically significant. This suggests a meaningful shift from the traditional drill-and-fill paradigm, although nearly half the sample was either uncertain or opposed. The silver-modified atraumatic restorative treatment (SMART) approach, which combines SDF with glass ionomer cement to achieve both caries arrest and anatomical restoration [4], may serve as a practical transitional option for practitioners who are hesitant to use SDF as a standalone intervention. Greater emphasis on this approach within Libyan continuing professional development programmes could support broader clinical uptake.

Perceived Barriers to SDF Use

The pattern of barriers identified in the present study showed that permanent tooth discolouration was the highest-ranked barrier (56.6%), followed by concern about patient satisfaction (53.6%) and parental acceptance (52.2%), which is closely consistent with the international literature. In Iraq, Al Haidar and Bawazir (2025) found permanent black staining was cited by 77.6% of respondents, making it by far the most prominent barrier [17]. Similarly, the national Saudi survey ranked staining as the leading barrier (52.1%), followed by concerns about improper tooth contour (40.5%) and patient acceptance (33.1%) [19]. In the Netherlands, parental acceptance was the main barrier reported by SDF users, while lack of knowledge was the predominant obstacle among non-users [24]. Similarly, the Benghazi study identified tooth discolouration as the primary concern among Benghazi practitioners [13]. The Spanish study also highlighted aesthetic concerns as the principal limiting factor [21], while the systematic review by Mohammed et al. (2022) showed that staining and patient acceptance were the most consistently reported barriers across all 14 included studies [11].

The low proportion of respondents identifying poor scientific evidence as a barrier (22.3%) is the least frequently reported barrier, which is an encouraging finding and is consistent with reports from Saudi Arabia [19], Italy [22], and Iraq [17]. This suggests that the main obstacles to SDF adoption in Libya are not doubts about the evidence base, but rather concerns related to aesthetics and communication. This distinction has practical implications: instead of focusing primarily on reinforcing evidence of efficacy to a workforce that is already broadly receptive to the expectations, the promotion of modified protocols that help reduce discolouration.

The marked variation in willingness according to tooth zone documented in the present study, 79.1% for the posterior zone of primary teeth versus 28.5% for the aesthetic zone of primary teeth, and only 13.5% for the aesthetic zone of permanent teeth closely reflects findings from Germany, where parental satisfaction was about 95% for posterior applications of SDF

but only 36% for anterior applications [29]. This tooth zone-specific reluctance reflects the well-recognized aesthetic trade-off associated with SDF use in clinical practice. Modified protocols that combine SDF with potassium iodide (SDF+KI) may reduce or delay the silver-related discolouration [30] and may enhance acceptance in aesthetic cases. Promoting these approaches through continuing education in Libya should be considered a practical priority.

University type as the Sole Significant Demographic Predictor

A clear finding was the absence of significant associations between SDF use and sex, age group, highest degree, place of practice, or professional experience, suggesting that knowledge and practice gaps are systemic rather than confined to specific subgroups. Although older dentists showed descriptively lower use rates, the overall pattern indicates a broad educational deficit across the profession. This highlights the need for system-wide training and continuing professional development.

The finding that private-university graduates were significantly more likely to have used SDF raised concerns about curriculum equity within Libyan for dental education. This may reflect greater exposure to evidence – based preventive care in private institutions or simply better product availability during training. In either case, such disparities may place graduates of governmental schools at a disadvantage and could contribute to unequal access to preventive care across sectors.

Conclusion

This study shows Libyan dentists have moderate awareness but limited clinical use of SDF. Attitudes are favourable, though aesthetic concerns remain the main barrier to adoption. These findings highlight the need for curriculum reform, continuing education, and national guidelines to support SDF use. Addressing these gaps is essential for equitable access to this minimally invasive option, especially for children and medically compromised individuals.

Limitations

Several limitations should be acknowledged. The cross-sectional design does not permit causal inferences, and the use of convenience sampling via professional networks may limit representativeness, particularly for dentists working in rural, conflict-affected, or digitally under-connected areas. In addition, the recent introduction of the product in Libya may mean that insufficient time has elapsed for its use to become widespread, and the low response rate may partly reflect limited knowledge of the topic and, consequently, low motivation to complete the questionnaire. As the data were self-reported, they are also subject to social desirability bias, and self-assessed competence may not accurately reflect objective knowledge. Future research should use stratified probability sampling, incorporate objective knowledge measures and standardised validated instruments, and, to support greater awareness and uptake in Libya, universities should strengthen cariology curricula by integrating SDF into undergraduate and postgraduate teaching, while broader market availability of SDF-containing products may further enhance awareness.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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