

The Association Between Wisconsin Dentists' Use of Silver Diamine  
Fluoride (SDF) and the Theory of Planned Behavior (TPB)

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## **DEDICATION**

This thesis is dedicated to my husband and two children, who unwittingly came along on my master's degree journey. Thank you for your patience, support, and love along the way.

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## **SECTION 1**

## **INTRODUCTION**

Silver diamine fluoride (SDF) has been used outside the United States (U.S.) to arrest and prevent caries for over 40 years (1-2). The medicament consists of silver and fluoride ions in an ammonia-based liquid and can be applied topically to a carious lesion in minutes (1-2). SDF differs from preventative topical fluorides in that the silver and fluoride ions work synergistically to arrest existing caries, as well as preventing new incidence of caries (2).

Advantages of SDF include the conservation of dental tissues, the non-invasiveness of the treatment, low cost of materials, and minimal risks associated (2-4). Tooth preparation for traditional restorative dental treatments involves removal of existing caries along with a small amount of tooth structure at the margins of each carious lesion (2). However, excavation of caries is not required with SDF treatment, therefore, tooth structure can be preserved and neither a clinical setting nor specialized dental equipment is necessary (3-4). Additionally, SDF may be applied by a dental hygienist thereby saving time for the dentist (1-2). The primary adverse effect of SDF treatment is a permanent blackening of carious lesions which occurs due to oxidization of the silver ions; however, intact enamel does not stain (1-5). Clinicians may view the blackened appearance as an indicator of successfully arrested caries (2). There are concerns that the black stain will render SDF treatment undesirable to parents or patients, however, studies have found that parents and patients are largely accepting of the stain on posterior teeth, and less accepting on anterior teeth (6-12). Other adverse effects included temporary bleaching of gingiva or a stinging sensation on wounds or

abrasions of the tongue or buccal mucosa; however, these effects can be avoided with careful isolation (8,13).

In the past two decades, strong evidence of SDF's ability to arrest caries has been generated, finally awakening interest of dental professionals and researchers in the U.S. (2,6). SDF was approved by the Food and Drug Administration (FDA) for treating dental hypersensitivity in 2014, then granted "breakthrough status" for treating caries two years later [4,6]. Since then, U.S. clinical trials and in-vitro studies of SDF have reported caries arrest rates comparable to earlier international studies as well as similar levels of acceptance of the resulting stain (7,9,13-15). A study of U.S. dental schools reported in 2018 that 67.7% of responding schools have begun teaching SDF, though with significant variation in tooth selection criteria and application protocol (16).

Although SDF has been called a "silver bullet" for its potential as an alternative caries treatment for populations with limited access to care, U.S. dentists have not widely implemented its use (6,17-21). In 2017, a California study of dental hygienists in alternative practice found that 54% of respondents had no familiarity with SDF (19). Despite the demand for alternative treatments in pediatric dentistry, a recent survey of pediatric dentists in the U.S. reported that 33% of respondents had never used SDF to treat carious lesions in primary teeth, and 47% had never used it to treat permanent teeth (20). Prior to this study published in early 2019, no data quantifying the use of SDF in the United States was found. Since little is known about utilization, level of knowledge, and attitudes regarding SDF among dentists in the U.S., further exploration

and research is required, and could feasibly be investigated by state. To that end, this study will focus on Wisconsin dentists.

The first steps are to define the current level of SDF use by Wisconsin dentists, and to determine why dentists do or do not use the product. The Theory of Planned Behavior (TPB) approach to behavioral prediction will be used for this purpose and provides the framework for the study. Applied to SDF, TPB posits that providers' decision to use SDF follows reasonably from attitudes, perceived behavioral control, and subjective norms. Therefore, an intervention addressing these three constructs of TPB may serve to increase SDF use among Wisconsin dentists.

#### Purpose of the Study

Using both quantitative and qualitative data, the purpose of this study was to identify the association between SDF use and the Theory of Planned Behavior constructs of attitudes, perceived behavioral control, and subjective norms, among Wisconsin dentists.

#### Statement of the Problem

Dental caries is widespread in the United States despite advancements in dental technology that make this disease preventable (6,22,23). The Center for Disease Control and Prevention (CDC) reports that 20% of children, 13% of adolescents, and 32% of adults in the United States live with untreated caries (22). The majority of those suffering with untreated caries are low-income children, elderly adults with financial barriers to care, and patients with special needs that interfere with the placement of traditional restorative treatments (1,6,21-22). Dental caries may lead to pain, difficulties

eating or speaking, and inability to attend work or school, thus decreasing quality of life, if left untreated. Additionally, oral diseases have been linked with systemic conditions including diabetes and heart disease (22). Therefore, alternative ways to manage caries are necessary to relieve a portion of this disease for susceptible people who are unlikely to receive traditional restorative treatments.

Evidence points to SDF as an inexpensive, non-invasive, and effective method for treating dental caries in under-served populations (1,3-4,6). Although few studies report barriers to its use, the adoption of SDF into standard dental practice has been slow in the United States (1,3,6-7,18,20,23). More information is needed about the dental community's current utilization, knowledge, and attitudes regarding SDF, to form strategies for overcoming barriers and determining the best way to utilize SDF in caries management within the U.S.

#### Significance of the Study

Dental caries is a prevalent, despite being preventable, and left untreated, it causes pain and affects overall health and well-being. Vulnerable U.S. populations that are unlikely to receive traditional restorative dental treatments include low-income children, elderly adults, and patients with special needs. Silver diamine fluoride is a low-cost alternative caries treatment with potential to relieve a sizable portion of untreated caries in these populations.

The results of this study will inform the dental community of the current utilization levels and attitudes toward SDF in caries management among Wisconsin dentists. It will also identify associations between SDF use and the three TPB

constructs: attitudes, perceived control and social norms. These findings will help identify barriers to the adoption of SDF into standard practice, and form strategies for overcoming them. Ultimately, increasing utilization of SDF can reduce untreated caries rates in Wisconsin, improve overall health and quality of life for some of our most vulnerable citizens, and contribute to facilitation of improvements in oral health models nationwide.

#### Research Hypothesis

H<sub>0</sub>: There is no association between Wisconsin dentists' SDF use and the Theory of Planned Behavior constructs of attitudes, perceived behavioral control, and subjective norms.

## **SECTION 2**

## **REVIEW OF THE LITERATURE**

A systematic search of literature relevant to SDF utilization, was performed in PubMed, Ovid, and Google Scholar databases. Key search terms were “silver diamine fluoride” and “caries,” in combination with “deciduous teeth,” “primary teeth,” “permanent teeth,” or “elderly.” The last searches, conducted in September 2019, yielded 130 results. Items were excluded which were: duplications, unobtainable online, not printed in English, or editorial letters in response to published studies. Original articles and literature reviews with publication dates between 2000 and 2019 were included, as were two reviews of the history of SDF in dentistry. Since SDF in dentistry is a trending topic, the parameters for inclusion were broad, allowing for inclusion of a range of scholarly work related to SDF.

Silver compounds were widely used as antibacterial agents in dentistry since 1840 (24-26). However by the time SDF was developed in Japan in 1969, the use of silver in dentistry had declined in developed countries, in favor of improved restorative materials and techniques like sedation dentistry (24-26). Recently, worldwide demands for low cost, low risk medical and dental treatments have revived interest in alternatives such as SDF, hence inspiring renewed investigation into its attributes.

SDF combines the remineralizing effect of fluoride with the anti-bacterial effects of silver ions to arrest caries (1-2, 24-25). When applied to a carious lesion, the fluoride and silver ions synergistically react with hydroxyapatite in teeth to inhibit cariogenic bacteria, reduce dentinal collagen breakdown, and remineralize enamel and dentin (2). The precipitates that result from this chemical reaction occlude dentin

tubules and cause a permanent blackening in color of carious lesions (2,3, 24-35). The black stain serves as a clinical indicator that the silver has reacted as desired (1-2).

### Efficacy

In the past two decades, numerous clinical trials have collected evidence of SDF's ability to arrest and prevent active carious dental lesions. In 2002, Chu et al. tested the efficacy of a 30% concentration on smooth surfaces of primary teeth in 375 Chinese preschool children and reported the arrest of 81% of active caries, with annual applications of SDF over 30 months (5). This study also found that excavation of caries prior to application of SDF did not affect the results, and is therefore not recommended (5). In 2005, Llodra et al. recorded similar results showing 77% of caries arrested on primary teeth and 65% on permanent first molars of 463 6-year old children treated with semi-annual SDF applications in Cuba (36). Subsequently, researchers began studying various concentrations and application schedules. Research has consistently reported that 30% to 38% concentrations of SDF are effective for caries arrest, and bi-annual applications offer the most significant and long lasting benefits. (8, 28, 37-41). In a 30-month clinical trial in China, Fung et al. found that 38% SDF applied bi-annually to carious lesions on buccal, lingual, distal and occlusal caries on primary teeth arrested 74% of caries, compared to only 64% arrest rate with annual applications (41).

While early studies tested SDF on occlusal, buccal or lingual surfaces of primary teeth, subsequent studies explored the efficacy of SDF on carious lesions on permanent teeth, including interproximal lesions and root caries. In-vitro studies found SDF

effective at arresting interproximal caries in extracted adult premolars (15, 27-29). Despite the lower mineral content of cementum, compared to enamel and dentin, studies of SDF have also yielded high caries arrest and prevention rates for root caries (42-44). Multiple systematic reviewers of these studies found only three that were well-conducted, however, those three produced evidence of 65-71% arrest of root caries with multiple applications generating the greatest effect (34,45-48). Further randomized clinical trials are recommended to determine the optimal application schedule, and effectiveness of SDF on coronal caries in elderly patients (45,49).

While the evidence in favor of SDF is convincing, there are limitations to the research that must be acknowledged. There was considerable heterogeneity amongst early studies in terms of treatment of control groups, application schedules, and re-examination schedules, hence future studies using consistent methods are recommended (1, 45, 50-51). In-vitro and ex-vivo studies used extracted teeth, which may confound results since they do not account for oral conditions such as the presence of saliva or exposure to carbohydrates (27-29, 52-56). Evaluations of extracted teeth were conducted by various methods including human examination, Micro-CT, spectrometry, or a combination of those methods (2, 15, 27-29, 52-56). In contrast, examiners of live patients used visual and tactile methods of caries identification. Examination techniques were calibrated, and reasonable attempts were made to keep examiners blind (5, 8-9, 13-15, 36-44, 52-53, 57-64). However, caries treated with SDF immediately appear black in color, therefore it is arguable whether it is possible to conduct a study that is truly double-blind.

Selection bias is a concern in all of the studies reviewed, but there is little risk of allocation bias. Chu et al, used sequential allocation which threatens the internal validity of that study (5). However, the other trials used random allocation into treatment groups (8-9, 13-15, 27-32, 36-44, 57). Random sampling is not feasible for SDF trials, since participants must have existing carious lesions and be willing to participate. Consequently, convenience sampling was predominantly used. This may lead to selection bias since subjects were specific to geographic areas and were recruited from entire schools, nursing home populations, or from waiting rooms at dental schools (5, 8-9, 13-15, 36-44, 52-53, 57-64). Despite these limitations, however, in summation these studies encompassed more than 4,000 children and 300 elderly patients in eleven different countries, with similar results and conclusions.

#### Ease of Use

Some benefits that set SDF apart from traditional restorative dental treatment are its low cost and the ease and speed with which it can be applied. The cost of the medicament is estimated at less than \$1 per treatment (1, 3, 6, 17, 68). Application of SDF takes less than 5 minutes per lesion, compared to lengthier traditional restorations (6, 9, 18, 23-24). The affected area is isolated, dried with air or cotton, then SDF liquid is applied with a micro brush, cotton pellet, or super floss and allowed to penetrate the carious lesion for up to 3 minutes before rinsing (8-9, 13-14, 59, 63). The treatment is free of pain or discomfort, as long as care is taken to avoid contact between SDF liquid and soft tissues of the oral cavity (3, 8-9, 13-14, 59, 63). Furthermore, SDF does not require expensive equipment or even a clinical setting in which to apply it (1, 3-4). This

medicament is bound by the same guidelines as other fluorides; thus, SDF can be applied by physicians, physician's assistants, or nurses as well as dentists, hygienists, and dental assistants (3-4). These attributes make SDF treatment an attractive option for patients who cannot tolerate the physical discomfort of traditional restorations and a more attainable one for patients of low socio-economic status, and those with limited access to dental care.

#### Adverse Effects

The black staining of carious lesions is the primary adverse effect reported in response to SDF treatment of caries (1-2, 14, 21, 26, 35). Despite the doubts expressed by dental professionals that the black stain will be acceptable to patients or their parents, thus far, evidence points to high levels of acceptance (8-9,17, 23, 65). Recent research addressed this issue with parent satisfaction questionnaires and found that despite the black stain, parents reported acceptance and satisfaction of the stain, post treatment (8-11). Overall, less than 7% of patients/parents indicated that they were not comfortable with the appearance of SDF-treated carries, and only 3.3% of parents in a US study expressed dissatisfaction with the black stain (8-9, 17, 23, 65). Nevertheless, researchers continue to test variations of SDF in attempts to reduce blackening of the arrested caries. Trials using tannic acid have failed to produce significant results in stain reduction (37). However, initial studies of Nano-silver fluoride have shown some promise in reducing staining of arrested lesions, as have trials of SDF applications followed by potassium iodide (15, 53, 62).

Other adverse effects associated with treatment of carious lesions by SDF are minimal (6, 8-9, 13, 18, 23-24, 65). Dental professionals have raised concerns regarding the potential for tissue irritation or systemic toxicity due to the high concentrations of both silver and fluoride in the SDF liquid (8,13,63). However, studies report no increases in complaints of tooth or gum pain, gum swelling, or systemic toxicity in children who have received the treatment (6, 8-9, 13, 18, 23-24, 65). Furthermore, discomfort reported in response to SDF treatment was predictably much lower than discomfort reported during traditional dental restorations (63).

#### Slow implementation

The few studies recently conducted in the U.S. support earlier findings of SDF's ability to arrest active caries as well as parental acceptance of SDF stain in young patients. Milgrom et al reported 72% of active caries arrested in a 2017 study of 66 preschool children in Oregon. (14). In 2018, Clemens et al. studied both efficacy and parental acceptance of SDF on 32 Oregon children with 132 active carious lesions (9). This study resulted in 100% of caries arrest at both three-week and three-month follow up examinations and parental acceptance was favorable (9). Another survey of parental attitudes found that 68% would be accepting of the black stain on posterior teeth, and 30% would be accepting of the stain on anterior teeth (7).

Despite the growing evidence base supporting this alternative treatment, SDF is slow to gain traction in the U.S. In 2017, a California study of dental hygienists in alternative practice found that 54% of respondents had no familiarity with SDF (19). That same year, the American Academy of Pediatric Dentistry published

recommendations for the use of SDF to treat active dental caries in primary teeth and in special-needs patients (3). However, a survey of pediatric dentists in the U.S. reported in 2019, that 33% of respondents had never used SDF to treat carious lesions in primary teeth, and 47% had never used it to treat permanent teeth (20). The topic of SDF is, however, slowly being integrated into the curriculums of U.S. dental schools. Ngoc et al reported in 2018 that 67.7% of dental schools surveyed have begun teaching SDF, although with significant variation in tooth selection criteria and application protocol (16).

#### Theoretical Framework

While clinical advancements are essential to improving health outcomes in patients, the adoption rate of new, evidence-based practices by clinicians is unpredictable and affected by multiple factors. It is widely known among U.S. dental health professionals that implementation of new innovations is slow in our field. This resistance to change may stem from lack of knowledge about new technologies, or negative attitudes surrounding them (66-67). The fast pace at which new studies are published makes it difficult for health care providers to stay well-informed (66). Furthermore, attitudes and preferences of patients and clinicians may hinder the adoption rate of evidence-based practices (66-67).

The Theory of Planned Behavior (TPB) postulates that attitudes, subjective norms, and perceived behavioral control are strong influencers of behavioral intent (68). While numerous research studies have successfully used this model to predict patient behavior, relatively few have applied it to behavior of health care practitioners.

However, two systematic reviews of the literature concluded that TPB has successfully predicted behavior of healthcare professionals, compared to other social cognitive theories (69-70). According to Perkins, “Understanding clinicians’ attitudes, subjective norms, and perceived behavioral control and providing the necessary support are the keys to developing an intervention that is most likely to impact behavior” (2007). Therefore, this study investigates the attitudes regarding SDF within the context of the Theory of Planned Behavior (TPB).

### **SECTION 3**

## **OVERVIEW**

Objectives: Silver diamine fluoride (SDF) is a topical product used to arrest caries.

While particularly effective when traditional care is improbable, such as among children with special needs or the elderly, SDF is underutilized in the U.S. To identify current beliefs regarding SDF with its clinical use, this study identified the association between SDF use among Wisconsin dentists and the Theory of Planned Behavior (TPB) constructs of attitudes, subjective norms, and perceived behavioral control.

Methods: This mixed-methods, cross sectional study invited 816 Wisconsin dentists to participate via electronic survey. A TPB index quantified the three constructs with higher scores indicating greater positivity toward SDF. Data were analyzed using t-tests or one-way ANOVAs for continuous data and Chi-square tests for categorical data. Qualitative responses were coded by TPB construct with new codes generated for responses outside of the TPB framework.

Results: The response rate for the study was 10% (n=80) with 55% reporting SDF use. Mean total TPB index and sub-scores were higher in SDF-users versus non-users. Most respondents (74%) provided qualitative responses. Triangulation of qualitative and quantitative results strengthened the finding that higher TPB index scores correlated with SDF-use. One additional qualitative code revealed interest in continuing education about SDF among non-users.

Conclusions: More than half of study participants reported SDF use. Results support the TPB as attitudes, subjective norms, and perceived behavioral control sub-scores were

higher among SDF users. Non-users with higher TPB index scores expressed interest in SDF and supported the need for continuing education on SDF.

## **MANUSCRIPT**

This manuscript will be submitted to The Journal of Public Health Dentistry.

### **Introduction and Literature Review**

Dental caries is a widespread disease in the United States despite advancements in dental technology that make it preventable (6, 22, 23). The Center for Disease Control and Prevention reports that 20% of children, 13% of adolescents, and 27% of adults in the United States are living with untreated caries (22). The majority are low-income children or elderly adults, and many are patients with special needs that interfere with the placement of traditional restorative treatments (1, 18, 24-25).

Demands to relieve this discrepancy of care have inspired investigation into low cost, low risk alternative dental treatments.

One promising product, silver diamine fluoride (SDF), has been used to manage caries outside the U.S. since its development in 1969 (1-2, 25). Applied topically to a carious lesion, SDF works by remineralizing tooth enamel and dentin, inhibiting further progression, and reducing cariogenic bacteria (2). It can be applied in minutes by a dental hygienist, requires no clinical equipment, and the cost of materials is very low (3-4, 6). Clinical trials of SDF report 65-85% efficacy in arresting and preventing caries on occlusal, interproximal, and smooth surfaces of primary and permanent teeth, as well as root caries on permanent teeth (5, 36-44). Bi-annual applications of 38% SDF offer the most significant and long lasting benefits. (37-41). The primary adverse effect is a

permanent blackening of the carious lesion; however, most studies have found that parents and patients are largely accepting of the stain on posterior teeth, and less accepting on anterior teeth (6-12).

Adoption of SDF into standard dental practice has been slow in the United States, and only two studies have quantified SDF use to date (1, 6-8). A 2017 study conducted in California found that 54% of dental hygienists in alternative practice were not familiar with SDF, and a 2019 study of pediatric dentists reported 33% of respondents had never used SDF to treat carious lesions in primary teeth, and 47% had never used it to treat permanent teeth (19,20).

Use of evidence-based practices is essential to improving health outcomes in patients; however, the adoption rate of new practices is unpredictable and affected by multiple factors. These may include lack of knowledge regarding new evidence, inability to keep up with the pace and abundance of new information, negative reception of new practices by patients, or negative attitudes of clinicians themselves (67-68). The Theory of Planned Behavior (TPB) postulates that attitudes, subjective norms, and perceived behavioral control strongly influence behavioral intent (67). Attitudes are defined as an individual's perceptions about the advantages and disadvantages of a behavior (68-69). Subjective norms refer to normative beliefs about a behavior, and perceived behavioral control is characterized as a person's belief in the ability to carry out a behavior despite obstacles that may stand in the way of implementing it (68-69). While multiple cognitive theories have been used to predict behavior, TPB shows the most promise in predicting behavior changes in health care

practitioners because the fundamental constructs of TPB are, in fact, the three factors most commonly linked to practitioners' behavioral changes. (69-70).

More information is needed about the dental community's current utilization, familiarity and attitudes regarding SDF, to form strategies for overcoming barriers and determining the best way to utilize SDF in caries management within the U.S.

Therefore, the primary aim of this study was to identify the association between the current use of SDF and TPB constructs of attitudes, perceived control, and subjective norms regarding SDF in caries management among Wisconsin dentists. The null hypothesis was that there is no association between Wisconsin dentists' SDF use and the theory of planned behavior constructs of attitudes, perceived behavioral control, and subjective norms. Results will inform a potential educational intervention aimed at increasing the utilization of SDF with the intended result of reducing untreated caries among vulnerable populations in Wisconsin.

#### Methods and Materials

This concurrent mixed-methods, cross-sectional study conducted by electronic survey was deemed exempt by the University of Minnesota Institutional Review Board. Participants were recruited from a convenience sample of 858 licensed Wisconsin dentists who list an email address with the Wisconsin Department of Safety and Professional Services. Duplicate emails were condensed, and undeliverable emails were excluded, resulting in invitations emailed to a total of 816 dentists. Reminders were emailed to non-responders at eight-day intervals, and data was collected over a period

of six weeks between May and July 2019. An incentive drawing for three \$50 internet gift cards was offered to maximize response rate.

A TPB index was created to measure attitudes, perceived behavioral control, and subjective norms regarding SDF. The dependent variable item and items measuring the attitude construct were adapted from a survey used by researchers at the University of California San Francisco in 2017 to investigate alternative-practice dental hygienists' perception of SDF (19). Modifications were made to both reflect the methodology of TPB questionnaire as suggested by Ajzen (2002), and to address dentists rather than hygienists (68, 71). The remaining four items were constructed following guidelines outlined by Ajzen to measure subjective norms and perceived behavioral control (71). The survey was piloted among a representative sample of seven Wisconsin dentists, prompting minor adjustments to the wording and the sequencing of several items.

The final instrument included 21 items. The dependent variable was determined from the first item asking the level of familiarity with SDF, followed by seven forced-choice options. Those answering that they "have used the product once," "have used the product occasionally," or "use the product frequently" were categorized as SDF users. Those answering, "never heard of the product," "have heard of the product but not sure what it is," "aware of what the product is used for," or "have observed the product being used" were categorized as non-users. The next item asked the type(s) of dentistry currently practiced with selections including restorative, endodontics, oral and maxillofacial surgery, orthodontics, and periodontics. Participants could select more than one response. Those not selecting "restorative" dentistry were directed to the

demographic questions via a branching logic function, thereby skipping the TPB index. Restorative dentists were presented a brief description of SDF followed by the 13-item TPB index, including nine attitudinal, two perceived behavioral control, and two subjective norms items. Possible answers on a 5-point Likert-type scale ranged from “strongly agree” = 5 to “strongly disagree” = 1. Subjective norms items also included the possible response “I don’t know” = 0, to account for the likelihood that dentists may not know their colleagues’ positions on SDF. For respondents selecting “I don’t know,” data imputation was used to provide a value for the subjective norms sub-score. Scores for five negatively worded items were adjusted for the direction of phrasing prior to analysis. The TPB index items were analyzed both by totaling scores for each of the three constructs and summing all sub-scores to achieve a cumulative TPB index score. This resulted in a possible range of attitude sub-scores from 0-45, perceived behavioral control and subjective norms sub-scores of 0-10 each, and total TPB index scores of 0-65. Higher scores were predictive of SDF use. Cronbach’s alpha coefficient of 0.83 for the TPB index items indicated good internal consistency.

Five demographic items included years practicing (<5, 5-9, 10-14, 15-20, >20), dental setting (general practice, pediatric, public health, education, research, other), practice area population (>500,000, 250,000-500,000 75,000-200,000 25,000-75,000 >75,000), gender (male, female, other, prefer not to answer), and age in years (>30, 30-39, 40-49, 50-59, 60+). One qualitative question at the end of the survey invited participants to “write in any details regarding your experience and/or concerns in using silver diamine fluoride for caries management.” An optional incentive for a gift card

drawing was available immediately after survey submission. Entering the drawing directed participants instantly to another survey where names and mailing addresses were collected and stored separately from survey responses.

Descriptive data were summarized using frequencies, counts, and proportions for categorical data, and means and standard deviations for continuous data. Analytical comparisons were performed using Chi-square tests for categorical variables and t-tests or one-way ANOVAs for continuous variables.

Using the TPB as a framework, two researchers independently coded qualitative comments as representative of one of three constructs: attitudes, subjective norms, or perceived control. Each entry was then scored as either a positive or negative comment for each construct. An inductive approach was used to create new codes for comments falling outside the TPB framework. Inconsistent scoring between the researchers was resolved by reviewing each comment in question and reaching consensus as to the most appropriate code. Data triangulation was then accomplished by comparing each code with the respondent's TPB index score and sub-scores.

Electronic survey distribution and data collection were accomplished using Qualtrics Research Core Academic Suite software (Qualtrics, 2019).

## Results

Eighty-three of the 816 Wisconsin dentists invited to participate, began the survey. Of these, 80 surveys were completed resulting in a response rate of 10%. Four surveys completed by dentists who did not identify as restorative dentists were excluded, resulting in 76 surveys available for analysis (n=76).

The dependent variable, SDF use, was determined based on responses to the first survey item. Respondents reporting “use the product frequently” (32%), “have used the product occasionally” (21%), or “have used the product once” (<3%) were combined and re-coded as “SDF use.” Those reporting “never heard of the product” (4%), “have heard of the product but not sure what it is” (<3%), “aware of what the product is used for” (33%), or “have observed the product being used” (5%), were coded as “No SDF use”.

A comparison of participants’ demographic characteristics by SDF use is reported in Table I. Most respondents reported either being in practice for less than five years (n=18, 24%) or more than 20 years (n=36, 47%) with no clear pattern as to geographical setting. More males (n=43, 57%) responded than females, and the distribution of respondents was similar across age groups. Results show that SDF use was statistically significantly higher compared to no SDF use for dentists who practice in pediatric dental clinical settings (p=0.04). No statistically significant differences were found between demographic factors by SDF use, although dentists practicing periodontics neared statistical significance (p=0.05). It should be noted that dentists may not practice exclusively in one practice setting or specialty and survey respondents could select multiple responses for both categories.

Table II reports responses to each TPB index item, by SDF use. Significant differences were found between responses of SDF users and non-users for all except three items. Exceptions were “SDF is a good tool for caries management in patients with high anxiety or special needs,” “SDF is a good tool for caries management because

it is less expensive than restorative treatment,” and “the decision to use SDF is up to me alone.” Overall, however, SDF users and non-users agreed or strongly agreed that SDF “is a good tool for managing caries” in geriatric patients (n=67, 88%), pediatric patients (n=67, 88%), patients with high anxiety or special needs (n=64, 84%), and patients with financial limitations (n=55, 76%).

Results displayed in Table III support rejection of the study’s null hypothesis as dentists reporting SDF use had statistically significantly higher mean TPB index scores compared to those who do not use SDF. This finding was consistent for all three sub-scores as higher scores were associated with greater SDF use.

As displayed in Table IV, TPB index scores were also analyzed by demographic characteristics. A statistically significant difference was found by “years in practice.” While no clear pattern was detected, mean (SD) TPB index scores were highest for dentists practicing more than 20 years (50, 7.8), followed by dentists practicing less than five years (48, 6.9). A statistically significant difference was also found in mean TPB index scores by age of dentist. Again, no clear pattern was detected, although dentists aged 60 or more had the highest mean (SD) TPB index scores (52, 8.2). Mean TPB index scores were significantly higher for dentists who practice in general, pediatric, or public health settings, compared with dentists who do not practice in those settings (p=0.04). Both practice setting, and type of dentistry allowed multiple responses, but TPB index scores were analyzed by individual category, making these results suspect. No difference in mean TPB index scores were associated with dentists’ gender or city size.

Qualitative data from the open-ended item comments were available in 56 (74%) of the 76 surveys used for analysis. Table V displays results of the coding scheme as applied to each comment. The TPB constructs were used to categorize the written responses. Participants' comments reflecting attitudes were coded as "A," those reflecting perceived behavioral control were coded as "B," and those reflecting subjective norms were to be coded as "SN," however, none of the comments reflected subjective norms. Comments that were favorable in regard to SDF were further coded as positive "+" and unfavorable comments as negative "-." Comments outside the TPB framework were coded as "other" and those that were neither positive nor negative in regard to SDF were coded as "neutral." One additional code, "CE", was generated and defined as "requests for continuing education regarding SDF." It was possible for written responses to receive multiple codes since there were no parameters placed on the qualitative text.

Once coded, it was noted that participants' comments represented both attitudes and perceived behavioral control, however, none of the comments were categorized as reflective of subjective norms. Favorable comments included, "I love it," and "now we are not doing Civil War dentistry." Unfavorable comments included, "I have found SDF to be ineffective," and SDF is "making substandard care available to patients who should have teeth restored." An example of a comment coded "A+" was, "Could be a conservative treatment option for geriatric and special needs patients", while an example of a comment coded "B-" was "I have mentioned it to a few patients, but they declined due to aesthetics."

Table VI displays aggregated data sorted by code, positive or negative value and displayed with mean TPB index total and sub-scores. Comments with no relationship to SDF use were omitted from the summary. Results support TPB as the majority of comments coded as “B+” were made by SDF users (92%) and had the highest mean TPB index score. Comments coded as “A-” were made by both SDF users (43%) and non-users (57%) and were associated with the lowest mean TPB index score (43). The majority of comments coded as “CE+” were made by SDF non-users (91%) with moderate TPB index scores and sub-scores compared to respondents in other coding strata.

## Discussion

To our knowledge, this survey is the first to report Wisconsin dentists’ use and attitudes, subjective norms, and perceived behavioral control regarding SDF. While previous literature suggests SDF is underutilized, no studies document usage rates or attitudes surrounding SDF use, by Wisconsin dentists (6-7,17-18). As expected based on Azjen’s predictive theory, SDF users had significantly higher TPB index scores than non-users, indicating more positive overall attitudes toward SDF. Silver diamine fluoride users also had significantly higher sub-scores for each TPB construct, attitudes, perceived behavioral control, and subjective norms, supporting the premise that each is a strong influencer of behavior specific to SDF use for Wisconsin dentists. The concurrent triangulation strategy corroborated the findings that SDF use was associated with the theoretical constructs posited by TPB.

Qualitative results confirmed the quantitative findings. Dentists whose comments were coded as positive in regard to SDF behaviors were associated with the highest TPB scores, and those whose comments were negative in regard to attitudes about SDF, were associated with the lowest TPB scores.

Only three respondents (4%) reported having “never heard of SDF” and two (3%) reported that they have “heard of the product but not sure what it is used for.” Thus, 93% of respondents reported familiarity with SDF in caries management. However, requests for more education about SDF was a common theme expressed within the written responses, especially from non-users. It was also noted that some of the written responses were not consistent with the evidence-based practice guidelines, calling into question the accuracy of dentists’ existing knowledge about SDF. This suggests that while SDF is a point of interest among Wisconsin dentists, additional dissemination of evidence-based guidelines is needed before it may be adopted into standard routine.

The frequency with which SDF is used to treat caries varied widely among respondents. Despite the high proportion that reported familiarity with SDF, 45% of respondents had never used it, while 32% used it frequently, and 21% used it occasionally. Since SDF is an alternative treatment, some of these differences may be attributed to dentists’ patient-base and whether alternative treatments for caries are indicated. Pediatric patients are a targeted population for SDF treatment, and of the 13 respondents who identified as pediatric dentists, 11 reported use of SDF in caries treatment (85%). This ratio suggests relatively high SDF use by respondents compared

to the findings of Antonioni et al (2019) in which 67% of US pediatric dentists had used SDF in their clinics to treat caries on primary teeth, and only 53% had used it to treat permanent teeth. The same study found that higher reported knowledge about SDF, was associated with more frequent use of SDF (20).

There were several limitations to this study that are common to survey research. First, the 10% response rate was lower than desired, resulting in fewer than 100 participants. It is difficult to determine whether such a small sample size is representative of Wisconsin dentists. However, our response rate was similar to the 11% reported by Hardigan et al. for dentists' response rate to Web surveys in the United States (72). In addition, the small sample size and use of a convenience sample prohibit generalizability of the study results. Another limitation was the potential for response bias. In this study, dentists who are familiar with SDF may have been more likely to complete the survey than those who are unfamiliar with SDF. Further, although the survey instrument was found to have acceptable internal validity, it has not been validated.

This study reveals multiple directions for additional investigation into the relationship between the Theory of Planned Behavior and dentists' use of SDF. Replication of this study on a national level using both electronic and mailed surveys could produce a much larger sample size and allow for generalizability of findings. Investigating more detail about dentists' existing level and accuracy of knowledge regarding SDF in caries management would be helpful in designing a TPB-modeled educational intervention. Once developed, additional research may be conducted to

determine how best to deliver an SDF educational intervention to dentists, and to determine the efficacy of said educational intervention..

### Conclusion

This study found that nearly all participating Wisconsin dentists are familiar with SDF's role in caries management, and more than half of participants already use it for that purpose. Respondents overall, agreed that SDF is a good tool for treating caries in pediatric, geriatric, special needs, and financially compromised patients. Both quantitative and qualitative results were consistent with the premises of TPB, since attitudes, perceived behavioral control, and subjective norms were strongly associated with the behavior of SDF use, both individually and cumulatively. Qualitative data also revealed that participating Wisconsin dentists recognize a need for further education regarding the use of SDF in caries management.

### Practical Application

SDF is an effective alternative treatment that has potential to alleviate a significant portion of untreated caries in the US. While the utilization of SDF appears to be on the rise, many dentists are still unsure about exactly when and how to use this product in their practices. Therefore, additional educational efforts directed to dental provider teams are required to ensure consistency in information and to make current, evidence-based practice guidelines easily accessible. Dental hygienists play a key role as both providers of SDF and educators of patients and their families.

According to the Theory of Planned Behavior (TPB), the decision to use SDF follows reasonably from a provider's attitudes, perceived behavioral control, and

subjective norms regarding the product. The results of this study support this theory, as all three constructs were associated with SDF use among Wisconsin dentists, individually and cumulatively. The large amount of qualitative data that was collected strengthened these findings and gave additional insight into questions, concerns and experiences that Wisconsin dentists have had about SDF. Based on these findings, TPB may serve as a framework on which to build an educational intervention aimed at increasing the use of SDF in caries management. More research is needed to determine whether increasing perceived behavior control or the perception of SDF use as a social norm may facilitate the adoption of SDF into standard dental practice in the US.

## **SECTION 4**

## **TABLES**

**TABLE I: Characteristics of restorative dentists by SDF Use (N=76)**

	n (%)		p-value <sup>1</sup>
	SDF Use 42 (55)	No SDF Use 34 (45)	
Type of dentistry practiced <sup>2</sup>			
Endodontics	13 (31)	17 (50)	0.15
Oral Surgery	13 (31)	17 (50)	0.15
Orthodontics	11 (26)	7 (21)	0.76
Periodontics	3 (7)	9 (27)	0.05
Dental practice setting <sup>2</sup>			
Clinical			
General Practice	30 (71)	31 (91)	0.06
Pediatric	11 (26)	2 (6)	0.04
Community or Public Health	11 (26)	4 (12)	0.20
Education	2 (5)	1 (3)	>0.99
Years in practice			0.35
Less than 5years	13 (31)	5 (15)	
5-9 years	3 (7)	5 (15)	
10-14 years	5 (12)	3 (9)	
15-20 years	2 (5)	4 (12)	
More than 20 years	19 (45)	17 (50)	
City setting			>0.99
Metropolitan	5 (12)	4 (12)	
Large city	8 (19)	6 (18)	
Medium sized city	12 (29)	9 (26)	
Small City	6 (14)	5 (15)	
Very Small Municipality	11 (26)	10 (29)	
Gender			>0.99
Female	18 (43)	15 (44)	
Male	24 (57)	19 (56)	
Age			>0.47
Under 30	9 (21)	4 (12)	
30-39 years	9 (21)	7 (21)	
40-49 years	5 (12)	9 (26)	
50-59 years	10 (24)	6 (18)	
60 years or more	9 (21)	8 (24)	

1. The p-values were calculated using a Chi-square test.
2. Respondents were able to select more than one response.

**TABLE II: Individual TPB index items by SDF use (N=76)**

Item	n (%)		p-value <sup>2</sup>
	SDF Use <sup>1</sup> n = 42	No SDF Use <sup>1</sup> n = 34	
<b>Attitudinal items</b>			
SDF is a good tool for caries management			
In geriatric patients			<0.001
Strongly disagree	0 (0)	0 (0)	
Disagree	0 (0)	0 (0)	
Neither agree nor disagree	3(7)	6 (18)	
Agree	7 (17)	20 (59)	
Strongly agree	32 (76)	8 (24)	
In pediatric patients			<0.001
Strongly disagree	0 (0)	0 (0)	
Disagree	0(0)	1 (3)	
Neither agree nor disagree	1(2))	7 (21)	
Agree	7(17))	16 (47)	
Strongly agree	34(81)	10 (29)	
In patients w/high anxiety or special needs			0.14
Strongly disagree	0 (0)	0 (0)	
Disagree	2 (5)	2 (6)	
Neither agree nor disagree	4 (10)	4 (12)	
Agree	13 (31)	16 (47)	
Strongly agree	23 (55)	12 (35)	
In patients w/financial limitations			0.04
Strongly disagree	1 (2)	0 (0)	
Disagree	0 (0)	3 (9)	
Neither agree nor disagree	8 (19)	9 (26)	
Agree	15 (36)	15 (44)	
Strongly agree	18 (43)	7 (21)	
Because it is time efficient			0.002
Strongly disagree	0 (0)	0 (0)	
Disagree	2 (5)	5 (15)	
Neither agree nor disagree	7 (17)	13(38)	
Agree	18 (43)	12 (35)	
Strongly agree	15 (36)	4 (12)	
Because it is less expensive than restorative			0.48
Strongly disagree	2 (5)	2 (6)	
Disagree	12 (29)	6 (18)	
Neither agree nor disagree	14 (33)	13 (38)	
Agree	10 (24)	9 (26)	
Strongly agree	4 (10)	4 (12)	
SDF is not a good tool for caries management			
Because it irritates tissues <sup>3</sup>			<0.001
Strongly disagree	9(21)	1(3)	

Disagree	22(52)	13(38)	0.005
Neither agree nor disagree	9(21)	13(38)	
Agree	2(5)	7(21)	
Strongly agree	0 (0)	0 (0)	
Due to the permanent black staining <sup>3</sup>			
Strongly disagree	9(21)	1(3)	0.004
Disagree	15(36)	5(15)	
Neither agree nor disagree	8(19)	18(53)	
Agree	9(21)	6 (18)	
Strongly agree	1 (2)	4(12)	
In the patients I customarily treat <sup>3</sup>			
Strongly disagree	9(21)	1(3)	
Disagree	13(31)	4(12)	
Neither agree nor disagree	8(19)	15(44)	
Agree	11(26)	9 (26)	
Strongly agree	1(2)	5(15)	
Perceived Behavioral Control Items			
I require additional training prior to using SDF <sup>3</sup>			<0.001
Strongly disagree	13(31)	0(0)	
Disagree	18(43)	6(18)	
Neither agree nor disagree	4(10)	3(9)	
Agree	6(14)	14(41)	
Strongly agree	1 (2)	11 (32)	0.15
The decision to use SDF is up to me alone			
Strongly disagree	0 (0)	2 (6)	
Disagree	8 (19)	7 (21)	
Neither agree nor disagree	4 (10)	5 (15)	
Agree	10 (24)	9 (26)	
Strongly agree	20 (48)	11 (32)	
Subjective Norms Items			
My dental colleagues use SDF			0.006
Strongly disagree	1 (3)	1 (4)	
Disagree	6 (16)	9 (39)	
Neither agree nor disagree	5 (14)	5 (22)	
Agree	19 (51)	8 (35)	
Strongly agree	6 (16)	0 (0)	0.003
My dental colleagues do not advocate SDF use <sup>3</sup>			
Strongly disagree	11(35)	0 (0)	
Disagree	12(39)	9(43)	
Neither agree nor disagree	5(16)	7(33)	
Agree	3(10)	5 (24)	
Strongly agree	0 (0)	0 (0)	

1. Summaries shown are n (percent)
2. The p-values were calculated using a Wilcoxon rank-sum test
3. These items were reverse scored

**TABLE III: Mean TPB index scores and sub-scores by SDF use**

	$\mu$ (SD)		Difference in scores between groups (95% CI)	p-value <sup>1</sup>
	SDF Use n = 42	No SDF Use n = 34		
Attitudes sub-score	36 (5.4)	31 (4.4)	4.7 (2.5, 7.0)	<0.001
Perceived behavioral control sub-score	7.9 (1.7)	5.7 (1.8)	2.2 (1.3, 3.0)	<0.001
Subjective norms sub-score	7.7 (2.0)	6.1 (1.6)	1.6 (0.6, 2.6)	0.003
TPB Index Score	52 (7.2)	43 (5.3)	8.4 (5.6, 11)	<0.001

1. The p-value was calculated using a two-sample t-test.

**TABLE IV: Mean TPB index scores by demographic characteristics**

Demographic characteristic	n	TPB index score $\mu$ (SD)	p-value <sup>1</sup>
Years in practice			0.03
Less than 5	18	48 (6.9)	
5-9	8	43 (5.9)	
10-14	8	45 (7.4)	
15-20	6	44 (5.5)	
More than 20	36	50 (7.8)	
City setting (population in thousands)			0.52
Metropolitan (>500)	9	47 (8.4)	
Large city (200-500)	14	56 (6.3)	
Medium sized city (75-200)	21	47 (8.2)	
Small city (25-75)	11	51 (6.7)	
Very small municipality (<25)	21	49 (8.1)	
Gender			0.19
Female	33	47 (7.9)	
Male	43	43 (7.3)	
Age in years			0.01
Under 30	13	47 (6.3)	
30-39	16	47 (7.7)	
40-49	14	43 (4.7)	
50-59	16	49 (7.9)	
60 or more	17	52 (8.2)	
Clinical practice setting <sup>2</sup>			
General	61	53 (7.1)	<0.001
Not general	15	47 (7.3)	
Pediatric	13	53 (7.1)	0.008
Not pediatric	63	47 (7.3)	
Community or public health	15	52 (5.9)	0.009
Not community or public health	61	47 (7.7)	
Type of dentistry practiced <sup>2</sup>			
Endodontics	30	47 (7.0)	0.35
No endodontics	46	49 (8.0)	
Oral surgery	30	47 (7.1)	0.25
No oral surgery	46	49 (7.9)	
Orthodontics	18	49 (8.5)	0.66
No orthodontics	58	48 (7.4)	
Periodontics	12	48 (5.1)	0.81
No periodontics	64	48 (8)	

1. The p-values were calculated using a two-sample t-test or one-way ANOVA as appropriate
2. Participants were able to select more than one response

**TABLE V: Coding of qualitative comments with TPB index scores, sub-scores, SDF use, and level of familiarity**

Qualitative Comments	TPB Construct Code(s), Pos (+) or Neg (-) <sup>1</sup>	Attitude Sub-Score	Perceived Behavior Control Sub-Score	Subjective Norms Sub-Score	TPB Index Score	SDF Use No=0 Yes=1	Level of Familiarity with SDF <sup>2</sup>
For the patients that are most in need of this treatment the possibility is very high of decay continuing which I feel reduces the confidence with which SDF or any product can be relied upon. Additionally, the coding makes it somewhat difficult to utilize to best effect as it can be tedious entering the code repeatedly for the application maintenance for each area but I have no better suggestion at this time as the alternative (coding like Fl-Varnish) is overly vague.	A -	37	9	4	50	1	6
I don't have any direct experience with the product. I'm concerned about it being touted as a low-cost solution - people with limited financial resources have enough differences in care than those with money, and I'm concerned that blackening their teeth will cause the divide to widen.	A-	29	3	NA	38	0	3
My concern is explaining to parents and patients about marking their carious lesions with something black. I am afraid they will refuse this treatment due to cosmetic concerns.	A-	34	8	4	46	0	3
Hardest part is changing dietary or hygiene habits. SDF in someone who continues to drink a large amount of soda or continues only brushing 1 their teeth once a week will not be as effective as it could be	A-	37	10	8	55	1	7
needs to be reapplied from what I understand, may stain teeth and gingival tissues, teeth may need a permanent restoration after application of SDF.	A-	30	8	7	45	1	6
Staining of teeth making substandard care available to patients who should have teeth restored Not restoring tooth to function and form Tooth will continue to structurally fail	A-	20	8	5	33	0	3
I have no experience with it but have heard it can be fairly difficult to use.	A-	25	3	NA	33	0	3
Could be a conservative treatment option for geriatric and special needs patients	A+	36	5	NA	48	0	1
I have limited knowledge of product... have watched demonstrations but no experience with live patients. Have purchased product but there it sits on my shelf waiting for the right situation. I would like to incorporate it into my practice especially for patient with special needs and elderly.	A+	31	6	NA	44	0	3
Have not personally used it. It is being implemented in our FQHC in the coming weeks.	A+	39	5	6	50	0	3
silver diamine has its place in the dental office	A+	38	7	NA	53	1	6

I agree it is a great tool for specific patients and situations. It will soon be more accepted, when patients understand what it can do and insurance companies pay for the service.	A+	38	5	4	47	0	3
have used minimally, staining is the problem	B-	28	7	5	40	0	4
In the high caries risk/low compliance population, I have found SDF to be ineffective in complete caries arrest.	B-	32	8	8	48	1	7
I have mentioned it to a few patients, but they declined due to aesthetics.	B-	29	9	NA	43	0	3
Frequently use in hospital setting on disabled patients. Occasionally use in private practice under alloys or with pediatric patients.	B+	29	9	5	43	1	6
Good for use with pediatric patients and in adults where restorations/caries extend deep to the pulp and wish to avoid exposure due to patient not being able to afford RCT. You must excavate as much decay as would allow for the SDF to work best as it can only penetrate so deep.	B+	33	7	10	50	1	7
Patients have been very accepting of it as a treatment option. I utilize it most days that I am practicing.	B+	41	10	NA	57	1	7
My Pediatric Dentist Spouse and I have researched SDF and used it for over 2 years with patients of all Ages. If carious deciduous teeth, Geriatric teeth with non-restorable root surface caries, and incipient interproximal or occlusal lesions can be preserved in their original state without compromising function or esthetics I would say that Silver Diamine Fluoride is VERY effective in treating many conditions. I tell patients that teeth are stronger WITHOUT restorations placed on them when you can avoid it and intervene with alternative treatments such as SDF...Game Changer...	B+	44	4	7	55	1	7
I use it mainly in geriatric populations where health &/or financial concerns leave patients not willing &/or not able to complete large treatment plans. We've also used it in some young children to avoid need for sedation. In patients in good health with good ability to tolerate normal dental treatment, I prefer a more definitive restoration like a crown or filling. But it is a great tool to have to use in situations that warrant it. I have not used it this way yet, but I could also see it being useful in arresting rampant decay while we work through a large treatment plan at a slower pace if the patient wants/needs that due to financial or health reasons.	B+	32	9	5	46	1	6
love it my drilling has dropped 90 % now we are not doing Civil War Dentistry	B+	45	10	10	65	1	7
I utilize primarily for my high risk ECC patients at the community health center I practice as a pediatric dentist. I have been using SDF for three years.	B+	35	10	10	55	1	6
I have been using SDF for 2 (3?) years. I use it on very young pediatric patients, elderly patients with rampant root decay and limited finances or ability to sit in a dental chair, around leaky crown margins when the patient can't afford a new crown, and a couple of times under a large restoration when I leave some decay to	B+	39	10	NA	58	1	7

avoid pulp exposure. Usually i ask my hygienists to reapply it at prophylaxis appointments at no charge since it takes very little time. I have been amazed at how well it works. The very first patient I used it on was a man from Africa who I see every 2 years or so when he visits our country. He had multiple areas of interproximal root decay but unfortunately he did not have time to have them restored before he left. I placed SDF and at follow up 2 years later the decay had not progressed. Crazy!							
game changer	B+	39	10	NA	57	1	7
I Love it	B+	42	9	NA	60	1	7
My typical patient on whom I have used SDF is elderly and does not want to do any definitive treatment because of their age, the cost of treatment, and they are not in pain at the time. They do not care about staining	B+	30	9	8	47	1	6
I had experience in school using it and loved it. I work for the military and do not see pediatric or geriatric patients, and there are no financial concerns so I do not use SDF in current practice. I fully plan on using it when I am in private practice.	B+	38	6	8	52	1	6
I have had good luck with SDF on the patients that have had the initial ans follow up application. Selecting appropriate lesions has been critical to the success rate	B+	38	8	NA	53	1	6
Riva Star has a silver diamine fluoride that is 2 step -- I understand it does not stain -- I have not tried it yet but I understand it is as effective as the Elevate product I am currently using.	B+	35	8	8	51	1	7
I've used it for geriatric, pediatric and pts with sensitivity or financial restraints.	B+	36	7	8	51	1	7
SDF is a wonderful treatment option and is used very frequently in my practice.	B+	39	6	NA	53	1	7
At this point I have only used SDF a few times - all use has been in geriatric patients with the purpose of arresting caries to extend the life of the tooth treated. Unfortunately, I left that practice before I was able to judge the longer-term effects/usefulness	B+	32	4	6	42	1	6
I am a pediatric dentist and I use SDF frequently on younger children with early childhood caries. So far my experience has been a very positive one.	B+	41	10	10	61	1	7
I have used it on two family members, and about 15 other patients. It is a new addition to our practice.	B+	40	8	10	58	1	6
SDF is a good product and used in the right situations can be an effective method of caries management. My team uses it multiple times per week.	B+	30	7	3	40	1	7
I believe it is a great tool for caries management in rampant caries cases, in uncooperative pedodontic cases, and in cases where financial challenges are present. It does require strong counseling of the individual or parent regarding the staining aspect, and I believe it SHOULD be promoter more by our ADA and dental schools.	B+	37	8	8	53	0	3
Used frequently in pediatric population, special needs, and geriatric. With some additional knowledge, a great adjunct for caries management.	B+	38	7	9	54	1	7

Have used in Pediatric and Geriatric patients. Would use only for E1 and E2 caries lesions.	B+	28	8	5	41	0	3
I used this more in IL when I worked with public aid and HMO patients, I have not come across the need for it here in the Madison area.	B+	27	6	4	37	1	6
I use SDF frequently to stop further decay until I can restore the teeth in primary molars. It is very effective. There is a lot of education available, especially for pediatric dentists	B+	42	10	10	62	1	7
I primarily use it for cervical desensitizing. Or deep decay varnish under amalgam filling. I do not quite trust its ability of arrest caries. We don't know how deep the decay is, and how deep it can remineralize. using SDF might mask the caries progress. For decay that's anterior smooth surface, it stains and not good esthetically. Maybe for special need pt that's not able to get hospital dentistry for some time, it doesn't hurt to use it.	B+ and B-	26	5	6	37	1	7
I love online CE, and if there were a low-priced online CE that could help general dentists specifically with all of the uses of diamine fluoride, that could be helpful. Thank you!	CE	32	4	6	42	0	3
The exact technique on how to use and what are the best scenarios to use them would be helpful.	CE	31	6	3	40	0	3
I have not used it myself and only learned about it within the past 18 months. It is something that I need to research because I practice in a town without communal water fluoride and spend at least over 60% of each day in practice restoring teeth with active decay.	CE	33	5	NA	45	0	3
I think SDF would be a great tool to use for management of caries in patients I often see. However, due to its potential to stain or irritate soft tissues, I would require additional training before I would feel comfortable applying it on a patient.	CE	31	4	8	43	0	3
none need to know more about it	CE	39	6	NA	53	0	2
I have used this product just once in practice and do believe it has a place in any general dental practice. I will seek more training in its use and like the clinical results that I've seen with this product.	B+	39	7	9	55	1	5
I'd like to read research regarding the use of silver diamine fluoride. I feel that treatments that are less expensive and less time consuming could be a good and useful option in some cases.	CE	33	6	7	46	0	3
My concerns would be what to do after using SDF. If you use it in an area of large decay on an adult (they could with special needs and unable to tolerate dentistry without sedation or an elderly patient with financial limitations) and use a spoon to scoop out the decay and then apply SDF, you still have a hole. What do you do with that hole and how is it maintained long term? I know the answer will be different depending on the situation. That is the education I need.	CE	31	5	7	43	0	4
please send more information	CE	42	6	NA	57	0	1

Unsure of when to place GI fill...how many applications does it take to verify disease resolve before sealing?	CE	30	6	8	44	0	4
I am under the impression that this will need reapplication to control the lesions. Therefore, that isn't testing the caries it is delaying treatment. I am interested in learning more and think it is great for special needs/poor.	CE	33	6	6	45	0	3
heard of it by my hygienist	Neutral	28	9	NA	44	0	2
not familiar with the product	Neutral	26	7	5	38	0	1
None	Neutral	26	8	8	42	1	6
Don't let it spill especially on counter tops	Other	36	6	8	50	1	6

1. A = Attitudinal, B = Behavioral, SN = Subjective Norm, CE = Continuing Education requested, Other = Not relatable to TPB constructs, (+) = Positive, (-) = Negative, Neutral = neither positive or negative in regard to SDF
2. Level of familiarity key: 1 = Never heard of SDF, 2 = Heard of SDF, but not sure what it is, 3 = Aware of what SDF is used for, 4 = Have observed SDF being used, 5 = Have used SDF once, 6 = Have used SDF occasionally, 7 = Use SDF frequently

**TABLE VI. Qualitative data summary using the Theory of Planned Behavior Framework\***

TPB Code	SDF use users, non-users	TPB index score mean (range)	Attitude sub-score mean (range)	Perceived behavioral control sub-score mean (range)
A+ Attitudinal, positive	1 user, 4 non-users	49 (44,53)	36 (31,39)	6 (5, 7)
A- Attitudinal, negative	3 users, 4 non-users	43 (33,50)	30 (25, 37)	7 (3, 10)
B+ Behavioral, positive	23 users, 2 non-users	52 (37-65)	36 (27, 45)	8 (4,10)
B- Behavioral, negative	1 user, 2 non-users	44 (40,48)	30 (28, 32)	8 (7,9)
CE Continuing education request	1 user, 10 non-users	47 (42, 57)	34 (7, 42)	6 (4,7)
*Subjective norms scores were omitted as no comments reflected this subcategory				

## **SECTION 5**

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## **SECTION 6**

## **APPENDICES**

EXEMPTION DETERMINATION

April 30, 2019  
 Priscilla Flynn  
 507-459-0420  
 flynn125@umn.edu

Dear Priscilla Flynn:  
 On 4/30/2019, the IRB reviewed the following submission:

Type of Review:	Initial Study
Title of Study:	Utilization, knowledge, and attitudes regarding silver diamine fluoride (SDF) among Wisconsin dentists.
Investigator:	Priscilla Flynn
IRB ID:	STUDY000006037
Sponsored Funding:	None
Grant ID/Con Number:	None
Internal UMN Funding:	None
Fund Management Outside University:	None
IND, IDE, or HDE:	None
Documents Reviewed with this Submission:	<ul style="list-style-type: none"> <li>• WI SDF Thesis Study Survey, Category: Other Form;</li> <li>• WI SDF Thesis Study Consent 2, Category: Consent Protocol;</li> <li>• WI SDF Thesis Study Recruitment email, Category: Recruitment Materials</li> </ul>

The IRB determined that this study meets the criteria for exemption from IRB review. To arrive at this determination, the IRB used "WORKSHEET: Exemption (HRP-312)." If

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you have any questions about this determination, please review that Worksheet in the [HRPP Toolkit Library](#) and contact the IRB office if needed.

This study met the following category(ies) for exemption:

- (2) Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met: (i) Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation

Ongoing IRB review and approval for this study is not required; however, this determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these activities impact the exempt determination, please submit a Modification to the IRB for a determination.

In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the [HRPP Toolkit Library](#) on the IRB website.

For grant certification purposes, you will need these dates and the Assurance of Compliance number which is FW/A00000312 (Fairview Health Systems Research FW/A00000325, Gillette Children's Specialty Healthcare FW/A00004003).

Sincerely,

Clinton Dietrich, MA, CIP  
IRB Analyst

We value feedback from the research community and would like to hear about your experience. The link below will take you to a brief survey that will take a minute or two to complete. The questions are basic, but your responses will help us better understand what we are doing well and areas that may require improvement. Thank you in advance for completing the survey.

Even if you have provided feedback in the past, we want and welcome your evaluation.

[https://um.qualtrics.com/SF/SID-SV\\_5B1YrPMMJROSBr](https://um.qualtrics.com/SF/SID-SV_5B1YrPMMJROSBr)

## **APPENDIX B: INTIAL INVITATION EMAIL**

Subject: Please share your thoughts about silver diamine fluoride

### **“An investment in knowledge pays the best interest.” – Benjamin Franklin**

Please contribute to our research at the University of Minnesota by participating in our study. Regardless of how much or how little you know about silver diamine fluoride (SDF), your response will help us understand Wisconsin dentists’ awareness and perceptions of this tool.

This brief electronic survey contains **up to 21 questions** and takes approximately 10 minutes to complete. To show our appreciation, participants may enter a drawing for one of three \$50 Amazon gift cards. Gift cards will be mailed to winners within a week after the survey closes on July 1, 2019.

Please click the link below to participate.

Sincerely,

Lisa Johnson, RDH, BS  
MSDH candidate  
Joh14968@umn.edu

#### **Follow this link to the Survey:**

[\\${1://SurveyLink?d=Take the Survey}](#)

Or copy and paste the URL below into your internet browser:

[\\${1://SurveyURL}](#)

Follow the link to opt out of future emails:

[\\${1://OptOutLink?d=Click here to unsubscribe}](#)



You are invited to participate in a study investigating Wisconsin dentists' utilization, knowledge, and attitudes about silver diamine fluoride (SDF). You have been contacted for this study because you hold an active license in dentistry in Wisconsin and provided a contact email address to the Wisconsin Department of Safety and Professional Services.

If you participate, you will be presented with up to 20 multiple-choice items and 1 open-ended question. The estimated time commitment is 10 minutes, and your responses will be kept private and confidential. Research records will be stored securely, with no identifying information attached, and only researchers will have access to the records.

Participation in this study is voluntary. You have the right to withdraw from the study at any point, for any reason. Your decision whether to participate will not affect your current or future relations with the University of Minnesota.

Participants may enter a drawing to receive one of three \$50 Amazon gift card incentives. Entries will be stored separate from survey data and will not affect the confidentiality of your responses.

**Contacts and Questions:**

The researchers conducting this study are: Lisa Johnson and Dr. Priscilla Flynn. You are encouraged to contact them at the University of Minnesota Division of Dental Hygiene with any questions:

Lisa Johnson: 608 279 4269, [ljh14968@umn.edu](mailto:ljh14968@umn.edu)  
Dr. Priscilla Flynn: 612 625 1639, [flynn125@umn.edu](mailto:flynn125@umn.edu)

This research has been reviewed and approved by an IRB within the Human Research Protections Program (HRPP). To share feedback with the HRPP about your research experience, call the Research Participants' Advocate Line at 612-625-1650.

Please note that this survey will be best displayed on a laptop or desktop computer. Some features may be less compatible for use on a mobile device.

By clicking the button below, you acknowledge that your participation in the study is voluntary and that you are aware that you may choose to terminate your participation in the study at any time and for any reason.

- I consent, begin the study
- I do not consent, I do not wish to participate

## APPENDIX C: INFORMED CONSENT

Please select the answers that most closely reflect you.

How familiar are you with the product silver diamine fluoride?

- Never heard of this product
- Have heard of the product but not sure what it is
- Aware of what the product is used for
- Have observed the product being used
- Have used the product once
- Have used the product occasionally
- Use the product frequently

What type(s) of dentistry do you practice? Check all that apply.

- Restorative
- Endodontics
- Oral and Maxillofacial Surgery
- Orthodontics
- Periodontics

If interested, you may refer to the following brief description of silver diamine fluoride.

Silver diamine fluoride (SDF) is an FDA-approved topical treatment for dental hypersensitivity that was granted breakthrough therapy status in treatment of active caries. As of January 2016, it is included under the CDT code 1354: Caries Arresting Medicament. SDF is an ammonia-based liquid containing both silver and fluoride ions. The mechanism of action combines the antibacterial properties of silver with the remineralizing effects of fluoride. This product effectively arrests 60-80% of active caries and has been used extensively for this purpose in other countries for several decades. SDF can be applied to an isolated carious lesion with a micro-brush, or interproximally with super floss in approximately 3 minutes. When treated with SDF, a carious lesion hardens and turns black in color. Staining of the carious lesion is permanent, and soft tissues exposed to SDF will stain temporarily. Contact with soft tissues may cause mild, temporary irritation. The efficiency, low cost and non-invasiveness of this treatment makes it especially promising for patients who are unlikely to proceed with restorative treatment.

Please answer the following questions selecting the answer that most closely reflects your personal opinions about silver diamine fluoride (SDF).

SDF is a good tool for managing caries in geriatric patients.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

SDF is a good tool for managing caries in pediatric patients.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

SDF is a good tool for managing caries in patients with high anxiety or other special needs.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

SDF is a good tool for managing caries in patients with financial limitations.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

I would require additional training prior to implementing the use of SDF in my practice.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

My dental colleagues use SDF as an alternative treatment for caries management.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree
- I do not know

SDF is a good tool for caries management because it is time efficient.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

SDF is not a good tool for caries management because of the black staining of carious lesions.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

The decision to utilize SDF in my practice is up to me alone.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

My dental colleagues do not advocate the use of SDF as an alternative treatment for caries management.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

SDF is a good tool for caries management because it is less expensive than restorations.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

SDF is not a good tool for caries management because of its potential to irritate soft tissues.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

SDF is not a good tool for caries management in the patients I customarily treat.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

Please answer the following questions about yourself.

How many years have you been practicing as a dentist?

- Less than 5 years
- 5-9 years
- 10-14 years
- 15-19 years
- 20 years or more

In which of the following settings do you currently practice? Choose all that apply

- Clinical, general practice
- Clinical, pediatric
- Clinical, community or public health
- Education
- Research
- Not Practicing
- Other, please specify

Which best describes the area in which you practice?

- Metropolitan, Population more than 500,000
- Large city, Population 200,000 – 500,000
- Medium sized city, Population 75,000 – 200,000
- Small city, Population 25,000 – 75,000
- Very Small city or municipality, Population less than 25,000

What is your gender?

- Male
- Female
- Other
- Prefer not to answer

What is your age?

- Under 30
- 30-39
- 40-49
- 50-59
- 60+
- Prefer not to answer

Please write in any details regarding your experience and/or concerns in using silver diamine fluoride for caries management.

Thank you for your participation!

- Submit survey and exit
- Submit survey and enter the drawing for one of three \$50 Amazon gift cards

## **APPENDIX E: FIRST REMINDER EMAIL**

Subject: There's still time to contribute to our research on silver diamine fluoride.

Reminder: We are hoping to hear from you!

### **“An investment in knowledge pays the best interest.” – Benjamin Franklin**

Regardless of how much or how little you know about silver diamine fluoride (SDF), your response will help us understand Wisconsin dentists' awareness and perceptions of this tool. Please contribute to our research at the University of Minnesota by participating in our study!

This brief electronic survey contains **up to 21 questions** and takes approximately 10 minutes to complete. To show our appreciation, participants may enter a drawing for one of three \$50 Amazon gift cards. Gift cards will be mailed to winners within a week after the survey closes on July 1, 2019.

Please click the link below to participate.

Sincerely,

Lisa Johnson, RDH, BS  
MSDH candidate  
Joh14968@umn.edu

**Follow this link to the Survey:**

[\\${1://SurveyLink?d=Take the Survey}](#)

Or copy and paste the URL below into your internet browser:

[\\${1://SurveyURL}](#)

Follow the link to opt out of future emails:

[\\${1://OptOutLink?d=Click here to unsubscribe}](#)

## **APPENDIX F: SECOND REMINDER EMAIL**

Subject: Reminder: We'd love to hear from you about silver diamine fluoride

Please contribute to our research at the University of Minnesota by participating in our study. Regardless of how much or how little you know about silver diamine fluoride (SDF), your response will help us understand Wisconsin dentists' awareness and perceptions of this tool.

This brief electronic survey contains **up to 21 questions** and takes approximately 10 minutes to complete. To show our appreciation, participants may enter a drawing for one of three \$50 Amazon gift cards. Gift cards will be mailed to winners within a week after the survey closes on July 1, 2019.

**“An investment in knowledge pays the best interest.” – Benjamin Franklin**

Please click the link below to participate.

Sincerely,

Lisa Johnson, RDH, BS  
MSDH candidate  
Joh14968@umn.edu

**Follow this link to the Survey:**

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Or copy and paste the URL below into your internet browser:

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## **APPENDIX G: THIRD REMINDER EMAIL**

Subject: Last Chance! WI Dentists SDF survey closes July 1<sup>st</sup>.

Regardless of how much or how little you know about silver diamine fluoride (SDF), your response will help us understand Wisconsin dentists' awareness and perceptions of this tool.

Please contribute to our research at the University of Minnesota by participating in our study.

This brief electronic survey contains **up to 21 questions** and takes approximately 10 minutes to complete. To show our appreciation, participants may enter a drawing for one of three \$50 Amazon gift cards. Gift cards will be mailed to winners within a week after the survey closes on July 1, 2019.

**“An investment in knowledge pays the best interest.” – Benjamin Franklin**

Click the link below to participate.

Sincerely,

Lisa Johnson, RDH, BS  
MSDH candidate  
Joh14968@umn.edu

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