RETROSPECTIVE COHORT STUDY O

Costs and Resource Use Among Child Patients Receiving Silver Nitrate/Fluoride Varnish Caries Arrest

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Abstract: ***Purpose:*** *The purpose of this study was to assess the impact of silver nitrate/fluoride varnish (SN/FV) on care costs.* ***Methods:*** *A retrospective matched cohort study, using Oregon Medicaid claims (January 1, 2012 to December 31, 2014) for patients younger than 21 years old, compared patients treated with SN/FV to matched patients not treated with SN/FV. The number of services and costs were compared using student's t test and generalized estimating equation (GEE) regression models.* ***Results:*** *Patients treated with SN/FV (n equals 4,612) and matched patients treated conventionally (N equals 13,498) averaged 28±7 (SD) months of continuous eligibility based on initial treatment date. The number of first-year services and total services over an average of 28 months were higher for patients treated with SN/FV (10.6 versus 6.7 in year one; 19.3 versus 8.8 overall; P<0.0001). Excluding diagnostic/preventive services, costs were higher in patients treated conventionally than patients treated with SN/FV in the first year. Overall costs were similar ($698 versus $707; P=.52). The average number of services was 58 percent higher (95 percent confidence interval [CI] 1.54 to 1.63) for patients treated with SN/FV, but costs remained similar.* ***Conclusion:*** *Patients treated with silver nitrate/fluoride varnish accrued a greater number of services and higher total costs over approximately 28 months but lower treatment costs than patients treated conventionally.* *Pediatr Dent 2017;39(4):304-7) Received October 7, 2016 | Last Revision April 7, 2017 | Accepted April 9, 2017*

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Silver ion products, used to arrest dental caries,[1,2] are being adopted in residency education,[3] and clinical policy and guidelines are under discussion by the American Academy of Pediatric Dentistry. Silver nitrate, often in conjunction with sodium fluoride varnish, has been used to arrest carious lesions. Silver products are ubiquitous in medicine and have been accepted for decades. Topical silver nitrate, for example, is used in wound care[4] and has long been used in newborns for the prevention of gonorrhea blindness.[5] After assuring that the patient is not allergic to silver (an extraordinarily rare or nonexistent phenomenon) and the tooth is not abscessed, a microbrush is used to apply milligram amounts of the liquid silver nitrate, at a materials cost of less than $2 per session. The treatments are antimicrobial. In this approach, sodium fluoride varnish is applied as a separate treatment at the same appointment to promote remineralization of damaged tooth surfaces and treat unaffected tooth surfaces.[6] Primary teeth can then be exfoliated normally without further intervention or the teeth can be restored, often for cosmetic reasons.

Silver diamine fluoride (38 percent), which was cleared by the FDA in late 2014 and available since 2015, has largely supplanted the sequential combination treatment. Treatments using 38 percent silver diamine fluoride, similar in effect to the silver nitrate/fluoride varnish sequential treatment, have been shown to be an effective secondary prevention method, reducing the incidence of cavities in non-affected teeth more extensively than the sodium fluoride varnishes endorsed by the U.S. Preventive Services Task Force.[7,8] Silver diamine fluoride also has been used successfully to replace fissure sealants in school-age children.[9] Silver diamine fluoride was recently designated as a breakthrough therapy for dental caries arrest by the FDA.

Topical silver ion products have the potential for increasing access to dental care, reducing the morbidity associated with dental caries, and controlling costs. Nevertheless, little is known regarding the economic impact of using these medicaments in managing carious lesions.

The purpose of this study was to estimate the impact of the adoption of silver nitrate/fluoride varnish (**SN/FV**) treatment on dental care costs and resource use.

Methods

This analysis was determined to be not human subject research by the Human Subjects Division at the University of Washington through self-determination.

We conducted a retrospective matched cohort study. This was a human observational study that conforms to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. We used the Advantage Dental Services, LLC (Redmond, Ore., USA) administrative claims and insurance eligibility database from January 1, 2012 through December 31, 2014 for these analyses. Advantage is the largest provider, in terms of enrolled Medicaid clients, of managed dental care in Oregon, serving approximately 335,000 members statewide. The organization provides services in 183 primary care and 63 specialist private practices and 40 staff-model Advantage Dental Services-owned dental clinics. Advantage receives resources from the Oregon Health Authority by capitation payment through regional coordinated care organizations (Oregon's name for accountable care organizations) and has a global budget. Providers are paid either through capitation or discounted fee-for-service.

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During the study period, clinicians in the Advantage system received continuing education on the application of topical silver nitrate used sequentially with fluoride varnish at the same appointment and chose whether or not to use the treatment based on dental caries risk. SN/FV treatments were tracked administratively. We included all patients with Medicaid dental claims in the Advantage network younger than 21 years old. However, we excluded patients who received prosthodontic treatment (primarily children with cleft palate) during the study period. The SN/FV cohort was defined as patients with separate claims for CDT codes 1206 and 9910 on the same date of service. The first date with those two service codes was defined as the index or starting date for a patient treated with SN/FV.

Conventionally treated patients were selected from the remaining pediatric study eligible population from those who had a dental claim not classified as either diagnostic or preventive. The first date with a non-diagnostic/preventive claim was defined as the index or starting date for the conventionally treated children. Patients treated with SN/FV and conventionally treated subjects were statistically matched at a one-to-three ratio using a procedure (propensity score matching) that took into consideration age, gender, race, language spoken at home, family size, and county. The purpose of the matching was to create two groups of children for comparison that were as similar as possible regarding caries risk, given that no risk assessment or examination data were available in this administrative dataset.

We estimated the length of follow-up (months) from each subject's index date to his or her last recorded dental claim and simultaneously counted the number of days with a dental visit in the first-year post-index as well as over the entire post-index period of claims. Advantage Dental Services staff applied an internal methodology to standardize the costs of claims from capitated clinics to those of fee-for-service clinics. Dental care services and costs were tabulated over the first-year post-index and the entire post-index period separately (on average 28 months). Dental care costs were also classified by CDT code group and summarized over both one year and over the average 28-month follow-up period.

Statistical analyses. We first compared the children treated with SN/FV and those treated conventionally in terms of demographic characteristics and the initial treating dental provider's specialty. Continuous variables were compared using the student's *t* test, while categorical variables were compared using the chi-square test. The number of dental services and costs were summed at the patient level separately over one year and total follow-up time. Follow-up, dental service, and cost outcomes were compared using the student's *t* test. We then generated generalized estimating equation (**GEE**) regression models that accounted for the matched study design and used the gamma distribution with a log-link. Four regression models were estimated (one year number of dental services, total dental services over an average of 28 months, one year cost, and total cost over an average of 28 months). All regressions controlled for the age, sex, and initial provider type. All analyses were performed using SAS 9.3 for Windows (SAS Institute, Inc, Cary, NC).

Results

We identified 4,612 unique children who received SN/FV treatment during the study period. The matching procedure identified 13,498 conventionally treated patients. Patients treated with SN/FV were younger (6.6 versus 8.0 years, *P*<0.0001), and there were slightly fewer females (47 percent versus 48 percent, *P*=0.03). However, they were similar to the conventionally treated children in terms of race/ethnicity, language spoken at home, and county of residence (Table 1). Half the children in both groups were Caucasian, and 70 percent spoke English in the home. The number of household members was slightly higher (albeit statistically significant) in the families of the group treated with SN/FV (3.9 versus 2.8, *P*<.0001). The county of residence was broadly distributed across 36 different counties with the highest proportions in Lane, Douglas, Jackson, and Umatilla counties. The distribution of the provider's dental specialty at the start of treatment was significantly different between the two cohorts, with more general dentists initiating silver nitrate/fluoride varnish treatment (81.4 percent versus 74.7 percent). The combination of general dentists and pediatric dentists accounted for almost all of the care in both groups (97.9 percent versus 97.4 percent, *P*=.06).

The average Medicaid eligibility was 28.2±6.6 (SD) months for SN/FV patients and 28.1±6.8 months for controls. Patients treated with SN/FV had more dental visit days in both the first year (4.6 versus 1.9) and over the average 28-month follow-up period (7.7 versus 3.1) compared to conventionally treated patients (both *P*<.0001; Table 2).

The number of dental services was higher for patients treated with SN/FV both in the first year (10.6 versus 6.7, *P*<0.0001) and overall (19.3 versus 8.8, *P*<0.0001). Excluding

Table 1. DEMOGRAPHIC AND PROVIDER CHARACTERISTICS OF SILVER NITRATE AND FLUORIDE VARNISH (SN/FV) VERSUS CONVENTIONAL TREATMENT PATIENT STUDY

Populations	SN/FV N=4,612	Conventional treatment N=13,498	*P*-value
Age (years) Mean±SD	6.6±3.8	8.0±3.6	<.0001
Female N (%)	2,181.0 (47.2)	655 (48.4)	.03
Race N (%)			.60
Hispanic/Latino	1,513 (32.3)	4,186 (30.9)	
Caucasian	2,365 (50.5)	6,929 (51.2)	
Other	806 (17.1)	2,415 (17.8)	
Language spoken at home N (%)			.12
English	3,282 (70.2)	9,676 (71.5)	
Non-English	1,402 (29.8)	3,822 (28.5)	
Total household size (people) Mean±SD	3.9±15.0	2.8±4.1	<.0001
Household members younger than 21 years old Mean±SD	2.2±2.5	1.8±2.5	<.0001
Household members 21 years and older Mean±SD	2.2±17.1	1.8±3.4	.24
Provider type at index visit N (%)			<.0001
General dentist	3,829 (81.4)	10,105 (74.7)	
Other*	874 (18.6)	3,393 (25.3)	

* Other providers: endodontist, dental hygienist (with or without expanded practice permit), federally qualified health center, orthodontist, oral surgeon, or pediatric dentist.

diagnostic and preventive services, over all dental treatment costs in the first year were higher for conventionally treated patients than for the SN/FV group. Total dental care costs in the first year were similar between the two groups, including the cost of SN/FV ($698 versus $707, $P \leq .52$). Total average dental care costs over the entire average 28-month follow-up period were higher overall for the patients treated with SN/FV ($1,456 versus $945, $P<.0001$). Similarly, the diagnostic and preventive costs were higher and restorative costs were nearly the same for patients treated with SN/FV during the 28 month follow-up period, but costs for endodontics, periodontics, oral surgery, and adjunctive services were all higher for the conventionally treated patients.

Table 2. UNADJUSTED RESOURCE USE AND COSTS COMPARING SILVER NITRATE AND FLUORIDE VARNISH (SN/FV) VERSUS CONVENTIONAL TREATMENT PATIENT COHORTS, 2012-2014

	SN/FV N=4,612	Conventional treatment N=13,498	*P*-value
Length of follow-up coverage (months) Mean±SD	28.2±6.6	28.1±6.8	0.38
No. of days with visits in the first year after silver nitrate Mean±SD	4.6±2.4	1.9±1.3	<.0001
No. of days with dental visits over entire follow-up period Mean±SD	7.7±4.7	3.1±2.0	<.0001
No. of dental care services in the first year after silver nitrate Mean±SD	10.6±6.2	6.7±4.7	<.0001
No. of dental care services over entire follow-up period Mean±SD	19.3±13.1	8.8±6.0	<.0001
Dental cost (U.S. $) over the first year post-index Mean±SD	698.0±574.5	706.7±1033.5	0.52
Dental cost (U.S. $) over the entire follow-up period Mean±SD	1,455.9±1125.1	944.7±1192.4	<.0001
Dental cost distribution over the first year post-index (U.S. $) Conditional mean±SD*			
Diagnostic services (N=2,731 | N=9,646)	152.1±113.8	173.9±145.0	<.0001
Preventive services (N=4,281 | N=8,929)	240.1±163.1	241.5±207.7	<.0001
Restorative dentistry (N=1,751 | N=7,161)	342.0±306.4	557.8±743.0	0.016
Endodontics (N=397 | N=1,371)	329.5±322.8	483.9±620.3	<.0001
Periodontics (N=3 | N=34)	49.3±34.6	271.1±249.6	0.029
Oral and maxillofacial surgery (N=759 | N=2,997)	181.0±95.3	308.4±385.4	<.0001
Adjunctive services (N=3,998 | N=3,272)	185.6±155.3	290.4±410.5	0.0016
Dental cost distribution over the entire follow-up period (U.S. $) Conditional mean±SD*			
Diagnostic services (N=3,841 | N=8,237)	319.9±224.4	139.2±121.2	<.0001
Preventive services (N=4,457 | N=7,519)	484.1±359.9	191.2±173.3	<.0001
Restorative dentistry (N=2,732 | N=5,155)	528.0±457.9	505.3±693.6	<.0001
Endodontics (N=880 | N=942)	359.5±338.7	465.8±628.6	<.0001
Periodontics (N=14 | N=24)	164.6±72.6	253.4±196.1	0.08
Oral and maxillofacial surgery (N=1,510 | N=2,166)	226.3±140.2	299.6±399.0	<.0001
Adjunctive services (N=4,141 | N=2,346)	264.7±247.3	268.3±381.4	<.0001

* N reported is conditional on use of each dental cost category (silver nitrate | controls).

Multivariable regression analyses, controlling for age, sex, and initiating provider specialty, maintained statistical significance in the same direction for the one-year and 28-month number of dental services and for costs (Table 3). That is, the one-year number of services received by patients treated with SN/FV was estimated to be 58 percent higher than the number of services received by the conventionally treated patients (rate ratio equals 1.58; 95 percent confidence interval [**CI**] equals 54 percent to 63 percent; $P<0.0001$). The overall number of services received by patients treated with SN/FV was estimated to be 121 percent higher than that received by conventionally treated patients (rate ratio equals 1.21; 95 percent CI equals 115 percent to 127 percent; $P<0.0001$). The average one-year costs of patients treated with SN/FV (including the cost of SN/FV) were estimated to be similar to the costs for those treated conventionally (rate ratio equals 1.0). However, the overall 28-month costs of patients treated with SN/FV were estimated to be 55 percent higher than those treated conventionally (rate ratio equals 1.55; 95 percent CI equals 50 percent to 60 percent; $P<0.0001$). Sensitivity analyses, which limited the available conventionally treated population to only children with a claim containing a code for restorative treatment, yielded similar statistically significant associations.

Discussion

In this Oregon-based study, we compared the dental costs and resource use of patients who received topical silver nitrate treatment followed by fluoride varnish at the same visit for treatment of dental caries with those who were treated conventionally and did not receive the combination treatment. Our analyses found that children treated with SN/FV received more treatment services during the first year and overall over an average of 28 months than children treated conventionally, but similar one-year costs were observed. Focusing on services in the restorative and surgical treatment alone and excluding diagnostic and preventive procedures, the average costs for the children treated with SN/FV were markedly lower than those treated conventionally. The results are consistent with a recent case report suggesting fewer children need extensive invasive treatment when treated with SN/FV.[1] Fewer extractions were performed in the children treated with SN/FV. The number of claims for adjunctive services (e.g., nitrous oxide and child management)were also reduced. Furthermore, the results match reports that parents often do not demand cosmetic fillings to hide the dark color of arrested cavities in teeth that will be shed anyway.

The analysis suggests that with a focus on SN/FV treatment of exposed carious lesions, children and their parents are more likely to return to the dentists for continuous care. One uncertainty clinically is the optimal periodicity of SN/FV treatment. The limited literature available suggests that biannual treatment with SN/FV or silver diamine fluoride may be sufficient to arrest over 90 percent of lesions,[10] while typically children at high risk are treated with fluoride varnish four times per year. Following the quarterly regimen drives up costs, including the opportunity

Table 3. REGRESSION ANALYSES* OF NUMBER OF DENTAL CARE SERVICES AND TREATMENT COSTS COMPARING MATCHED CHILDREN WHO RECEIVED SILVER NITRATE/FLUORIDE VARNISH TREATMENT TO CHILDREN WHO WERE TREATED CONVENTIONALLY (OREGON, 2012-2014)

		95% confidence interval		
	Rate ratio†	Minimum	Maximum	*P*-value
No. of dental care services in 1 year	1.58	1.54	1.63	<0.0001
No. of dental care services over an average of 28 months	1.21	1.15	1.27	<0.0001
Dental costs over 1 year	1.00	0.97	1.04	0.82
Dental costs over an average of 28 months	1.55	1.50	1.60	<.0001

* Generalized estimating equations (GEE) models, Gamma family, log-link, controlling for age, sex, and initial dental provider type.
† A rate ratio compares the rate of services or costs for the group of children treated with silver nitrate/fluoride varnish to that of the group of children who were treated conventionally. A rate ratio of 1 means there is no association between the number of services or costs and the treatment provided. A ratio of greater than 1 indicates an association.

costs for parents who must miss work or other activities to bring their young child to the dentist.

It is possible that the dental practices involved underreported application of SN/FV. The use of the two CDT codes on the same date of service was new when these data were collected. On the other hand, the managed dental care organization did extensive continuing education and outreach to its providers to promote adoption. In addition, large numbers of children were reported treated, and most dentist practices had financial incentives to record the treatment (fee-for-service reimbursement).

Given the retrospective nature of our study, two additional limitations should be considered when interpreting our findings. First, because our study identified treated patients, selection bias most certainly may exist within our findings. However, selection bias, in which the underlying need is greater in the group of children treated with SN/FV than the group of children treated conventionally, would have reduced our ability to detect differences. Still, the differences are substantial. It appears that SN/FV treatments are substitutes rather than complements to conventional treatment; however, there is little evidence that dentists using SN/FV were denying other services to the children.

Second, we are unable to eliminate confounding by indication from our analyses, since patients treated with other caries arrest techniques are not easily identified by claims data. This occurs when the clinical indication for selecting a particular treatment (e.g., severity of the illness) also affects the outcome. To test the impact of potential confounding, we performed a sensitivity analysis (data not shown) in which we limited the available conventionally treated population to only children with a claim containing a code for restorative treatment. While this reduced our sample size and slightly attenuated the results, the direction of the signal and high statistical significance remained; thus, the conclusions were unchanged. Moreover, since the time of our study cohort, 38 percent silver diamine fluoride has been cleared by the FDA and reached the market (Advantage Arrest, Elevate Oral Care, LLC, West Palm Beach, Fla., USA). Future studies in the U.S. will be aided by a new CDT code (D1354) for caries arrest as state Medicaid programs and commercial insurers include coverage of this treatment as expected.

Finally, it is unknown if our results are generalizable outside of the patient population covered by Advantage Dental Services; however, we note that patients included in this study came from across the state of Oregon and diverse demographic backgrounds.

Conclusions

Based on this study's results, the following conclusions can be made:

1. Silver nitrate/fluoride varnish treatments and silver diamine fluoride offer potentially cost-effective treatments for dental caries with the potential to improve oral health in the U.S. and other countries.
2. As this is a relatively new technology, guidelines for treatment are needed.

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