Treatment Outcomes and Costs of Dental Sealants Among Children Enrolled in Medicaid

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Objectives. This retrospective cohort analysis of children enrolled in the North Carolina Medicaid program compared the likelihood of restorative treatments and associated cumulative Medicaid expenditures for teeth with or without dental sealants.

Methods. We assessed the dental experience of the cohort of 15 438 children from 1985 to 1992 on the basis of enrollment and claims files. We conducted regression analyses for outcomes (caries-related services involving the occlusal surface [CRSOs] of permanent first molars) and cumulative expenditures, controlling for characteristics of the child, the treating dentist, and the child's county of residence.

Results. Overall, 23% of children received at least 1 sealant and 33% at least 1 CRSO. Sealants were effective in preventing CRSOs, although the degree of effectiveness was highest for children with the greater levels of CRSOs before sealant placement. Estimated cumulative Medicaid expenditures indicated expenditure savings from sealants within 2 years of application for children with 2 or more prior CRSOs.

Conclusions. Sealant placement was associated with expenditure savings to Medicaid for certain high-risk children, so Medicaid and, more broadly, society will benefit by providing for sealant placement in these children. (*Am J Public Health.* 2001;91:1877–1881)

Dental sealants, placed primarily on occlusal molar surfaces to prevent dental caries (tooth decay), have been commercially available since 1971.[1] Since then, several generations of improved and highly effective products have followed,[2,3] but the proportion of children receiving sealants has remained low. Data collected as part of the 1988–1994 National Health and Nutrition Examination Survey (NHANES-III) show that only 23% of 8-year-olds had received sealants,[4] compared with the national oral health objective of 50%.[5]

Since the invention of sealants, it has become clear that some children and some teeth are more at risk for dental caries than others. Evidence strongly indicates that children of low-income families are at greater risk than other children, and occlusal surfaces of molars are at greater risk than other tooth surfaces.[6,7] Medicaid and State Children's Health Insurance Program (S-CHIP) recipients are assumed to be at high risk for caries because low family income is usually required for eligibility. All states now include sealants as a dental benefit for children enrolled in their dental Medicaid programs,[8] and all but 3 states have S-CHIPs that either include sealants in their preventive dental services or are expansions of the Medicaid Early and Periodic Screening, Diagnosis and Treatment coverage that already includes sealant benefits.[9]

Although the clinical efficacy of sealants is well established, the effectiveness and costs of this procedure in a statewide Medicaid population treated in private practice have not been evaluated. A smaller study assessed the cost-effectiveness of dental sealants in a low-income population in Flint, Mich.[10] The purpose of this larger study is to analyze the impact of dental sealants on the likelihood of restorative treatment and net expenditures for first permanent molars in a cohort of children enrolled in the North Carolina Medicaid Program from 1985, when the sealant benefit was initiated, until 1992.

METHODS

Study Design and Data Sources

We conducted a longitudinal retrospective cohort study. Because it was not a randomized clinical trial, we used data from multiple sources to control for as many factors as possible, other than sealant use, that might explain differences in treatment outcomes. Medicaid dental claims and enrollment administrative files for 1984 through 1992 were the primary data sources. These files provided demographic information about the children (e.g., age, sex, race/ethnicity, whether or not in foster care), enrollment (e.g., months eligible, proportion of time eligible), dental treatment (e.g., number of visits, number of prophylactic services, topical fluoride treatments, and restorative treatment on primary and permanent teeth), and dentists (e.g., number of Medicaid patients seen per year). Information about the child's dental provider (Table 1) was obtained from annual North Carolina dentist licensure surveys.

Because most children were seen by only 1 dentist each year, information about the child's first dentist seen each year was used. The 818 children (5%) who received dental care exclusively in community health centers, local health department clinics, or the state's only dental school were excluded because individual provider information was not available from those settings. The North Carolina Statistical Abstracts were used to obtain information about the child's county of residence. This information included whether the county was urban or rural, the average per capita income, the unemployment rate, and the number of Medicaid enrollees. Information regarding the percentage of the county's population with access to fluoridated water was obtained from the North Carolina Department of Health and Human Services.

Inclusion Criteria

To be selected for the cohort, children had to (1) have been enrolled in Medicaid at between 5 and 7 years of age, (2) have been aged 4 to 6 years in July 1985, when the sealant benefit began, and (3) have had at least 1 Medicaid dental claim submitted on

TABLE 1—Characteristics of the Cohort, by Child Sealant Status at the End of the Observation Period: North Carolina, 1985–1992

	Children With 4 Unsealed Molars	Children With at Least 1 Sealed Molar	All Children in Cohort
Sociodemographic characteristics			
No. of children (%)	11 838 (77)	3600 (23)	15 438
Male, %	49.6	48.2	49.3
White, %	32.5	40.2	34.3
In foster care, %	4.0	5.1	4.2
Mean age at first observation, y	5.9	6.1	6.0
Medicaid dental use history			
No. of years viewed[a]	4.7	4.8	4.7
No. of years enrolled in Medicaid[b]	3.8	4.1	3.9
Average no. of visits	3.8	6.7	4.5
Average maximum fluoride treatments per year	0.13	0.25	0.16
Average maximum prophylactic treatments per year	0.05	0.07	0.05
Characteristics of first dentist seen			
White, %	75.1	83.9	77.1
Male, %	95.5	93.1	95.0
Mean age, y	41.7	40.0	41.3
Time in practice, y	13.4	11.9	13.0
Solo or nonsolo dentist (vs group practice), %	97.7	98.8	98.0
Office-based dentist (vs non–office-based; e.g., hospital), %	95.1	96.3	95.4
General dentist (vs pediatric dentist), %	88.3	76.0	85.5

[a]Number of years viewed is calculated as the difference between the child's age at the first and last visit during the eligibility period.
[b]Number of years enrolled is equal to the number of years viewed minus any periods of noneligibility.

their behalf between July 1985 and December 1992. The intent was to select children who were enrolled in Medicaid around the time of the eruption of their first permanent molars, thereby minimizing potential restorative treatment to those teeth before sealants could be placed. Claims from 1984 provided information about treatment to primary and permanent teeth for some children younger than 5 years. A cohort that was of the approximate age at which molar eruption could be expected in 1985 permitted follow-up for the maximum time period with the available data. The analyses were limited to first permanent molars. During the study period, the North Carolina Dental Medicaid Program had several requirements for sealant placement. Preauthorization was required; reimbursement was only for permanent molars; reimbursement per tooth was a once-per-lifetime benefit; and sealants were to be placed on teeth within 3 years of eruption.

Analytic Methods: Sealant Effectiveness

Claims data were aggregated annually by each child's age for each of the 4 permanent first molars, resulting in up to 4 observations per child for up to 8 years of observation. Years of Medicaid noneligibility were excluded, as no service use could be recorded. Sealant effectiveness was analyzed by a discrete time hazard model of the annual probability of any caries-related services involving the occlusal surface (CRSOs), including restorations, pulp treatments, crowns, and extractions. The discrete time hazard model, which is based on logistic regression techniques,[11] enables flexible effects for duration (age) and time since sealant placement. The model for estimating sealant effectiveness had CRSO as the dichotomous outcome variable (restored or not). The estimation included 40 predictor variables in the following categories: demographics (age, sex, race/ethnicity, whether or not in foster care, time enrolled in Medicaid before observations began), dental history (prior restorations, preventive treatments), dentist characteristics (demographics, training, practice), geographic characteristics (urban status, unemployment, income, dentists per Medicaid enrollee), and sealant status (yes or no, years since placement, risk interactions).

The estimated parameters measure the impact of the covariates on the propensity for a molar to be restored. Standard errors were adjusted for clustering effects owing to each child having 4 molars and multiple years of observation.[12]

Once a molar was restored (CRSO=1), subsequent annual observations were excluded from the effectiveness estimation. We hypothesized that children having a permanent first molar CRSO are at higher risk for a subsequent CRSO on other first molars. Two measures of caries risk (middle risk represented by having 1 prior CRSO, high risk represented by having 2 or more prior CRSOs) were included in the model and were interacted with the sealant dummy. These interactions enabled determination of differences in sealant effectiveness according to estimated risk. Analytically, children are considered to be at low risk until they have a restorative service for 1 of their permanent first molars. Simulations were conducted to compare the likelihood of CRSOs on unsealed molars with the likelihood of CRSOs on molars sealed at 5, 6, and 7 years of age.

Analytic Methods: CRSO Expenditures

CRSO Medicaid expenditures were measured by aggregating expenditures for each of the 4 molars for each child up to the last age the child was enrolled in Medicaid. Expenditures included sealant or initial treatment expenditures plus any expenditures for procedures subsequent to the initial CRSO. A 2-part estimation model with a separate estimation of the likelihood and level of expenditures accounted for the log-normal expenditure distribution. Both models controlled for the same variables as in the effectiveness model, except for time since sealant placement.

Expenditures were assigned to procedures by the Medicaid 1992 fee schedule. The reimbursement rate for a sealant in 1992 was $11.60; for a 1-surface amalgam it was $18.57. Simulations provided estimates of aggregate restoration expenditures per first molar with and without sealants.

RESULTS

Characteristics of the Cohort Children and Their Dentists

The cohort contained 15 438 children with 279 680 molar tooth–year observations for 61 752 first molars (4 per child). Some child characteristics were constant (e.g., sex and race), whereas others changed over time (e.g., dental history and risk class). Table 1 presents key statistics for the cohort by sealant status at the end of the observation period. Some factors did not vary substantially by sealant status (e.g., number of years viewed, number of years enrolled, mean age at first observation). Children receiving sealants were more likely to be White, to have seen a pediatric rather than a general dentist at their first visit, and to have made, on average, 3 more dental visits over the time period than children without sealants (about 7 vs 4 visits). Children receiving sealants by the end of the observation period also had a somewhat higher rate of fluoride treatment per years of Medicaid eligibility. The cohort was treated by 1022 dentists, the majority of whom were White, male, general dentists; the number of children seen by a dentist ranged from 1 to 173.

Distribution of Sealants and CRSOs Received by the Cohort

Sealant and restoration rates in this cohort were low. Twenty-three percent of the children and 19% of the first molars received sealants. Eighty-two percent of the children received sealants at between 6 and 9 years of age. One third of the children and only 20% of first molars received at least 1 CRSO. Unsealed molars were almost 3 times more likely than sealed molars to receive a CRSO (22.2% vs 7.9%). If CRSOs involving the occlusal surface only or extractions are considered, excluding multisurface restorations, unsealed molars were still more than twice as likely to be affected as sealed molars (9.7% vs 3.8%).

Sealant Effectiveness

When molar observations subsequent to restoration were eliminated, 252 306 tooth–year observations were available for analysis. Full estimation results are available from the corresponding author upon request. Calculations using the coefficients and standard errors showed that sealants had a protective main effect when initially placed in low-risk children with no prior restorations, but the coefficients of the variables related to years since sealant placement indicate that sealant effectiveness declines over time after placement. Among low-risk children with no prior restorations, sealants were effective in reducing the likelihood of restorations in the sealed molars for up to 4 years. Among middle-risk children, sealant placement resulted in substantially lower odds of having a restoration for 6 years. The relative reductions were even greater for sealants placed on molars at high risk, with the reductions being statistically significant for 7 years.

Table 2 shows the simulated effect on CRSOs of sealants placed when the child was 5 years old, by age and according to whether the child had prior molar restorations. The patterns were very similar for simulations of sealant placement at 6 and 7 years of age, so we present the simulations at 5 years only because they maximize the length of follow-up and are consistent with sealant placement soon after eruption.

The annual likelihood of occlusal restorations increased with higher risk. Sealants were effective during this viewing period in preventing restorations, although the effects were greatest for children deemed to be at high risk on the basis of their restoration history up to that year. Restoration rates for high-risk children peaked at 8 years for unsealed teeth

TABLE 2—Effects of Sealants on Occlusal Restoration and Treatment Expenditures for Nonsealed Molars vs Molars Sealed at 5 Years of Age: North Carolina, 1985–1992

	Low Risk (No Prior Molar Restorations)		Middle Risk (1 Prior Molar Restoration)		High Risk (≥2 Prior Molar Restorations)	
Age, y	Unsealed Teeth	Expected Decrease if Sealed	Unsealed Teeth	Expected Decrease if Sealed	Unsealed Teeth	Expected Decrease if Sealed
	Annual Likelihood of Occlusal Restoration per Molar[a]					
5	0.0073	0.0057	0.0178	0.0148	0.0229	0.0199
6	0.0271	0.0229	0.0633	0.0556	0.0800	0.0725
7	0.0517	0.0385	0.1159	0.0918	0.1439	0.1205
8	0.0658	0.0327	0.1444	0.0850	0.1777	0.1198
9	0.0582	0.0121	0.1296	0.0477	0.1604	0.0806
10	0.0484	0.0051	0.1095	0.0325	0.1364	0.0614
11	0.0356	0.0069	0.0820	0.0302	0.1030	0.0526
12	0.0303	0.0049	0.0704	0.0245	0.0887	0.0440
	Cumulative CRSO Expenditures (in Dollars) for All Occlusal Surface Treatments per Molar[b]					
5	0.23	0.17	1.56	1.30	3.94	2.95
6	0.85	0.76	4.57	4.15	9.64	8.61
7	1.41	1.32	7.04	6.60	13.57	12.50
8	2.01	1.84	9.21	8.42	16.49	14.60
9	2.62	2.27	11.18	9.54	18.93	15.21
10	2.92	2.31	12.06	9.36	19.97	14.15
11	3.10	2.26	12.61	8.97	20.66	13.11
12	3.16	2.13	12.80	8.48	20.92	12.24

Note. CRSO = caries-related service involving the occlusal surface.
[a]Conditional on the tooth's not having received a CRSO at the beginning of the year.
[b]Including tooth extractions.

and at 9 years for sealed teeth (18% vs 8%). It is notable that the effects of sealants by age are greatest when the child is roughly 8 years old; both sealant effectiveness and annual restoration rates subsequently decline.

Aggregate Treatment Expenditures

The 2-part estimation model of aggregate CRSO expenditures showed that sealants significantly reduced both the likelihood and the level of expenditures. The lower half of Table 2 contains simulation results estimating the effect of sealants on expenditures, assuming sealant placement at 5 years of age. The difference between expenditures for sealed and for unsealed teeth widens initially with age: to $15.21 at 9 years for the high-risk group, to $9.54 at 9 years for the middle-risk group, and to $2.31 at 10 years for the low-risk group. Thus, the effects on the level of expenditures are greatest for high-risk children; expenditure savings are greatest at 9 years, but they are reduced over subsequent years and have almost disappeared by 12 years because of observed declines in sealant effectiveness with years since sealant placement. If we subtract sealant costs of $11.60 from these numbers, we see that expenditure savings occur for high-risk children as early as 7 years of age and peak at 9 years, although the observed decline in sealant effectiveness dissipates these savings in subsequent years.

Sealants did not save expenditures among low-risk children, but the analysis could not consider the implications for treatment expenditures beyond 13 years of age. Although sealants were effective overall, the savings to the Medicaid program from 1984 to 1992 for placing sealants in the percentage of children estimated to be at high risk (22%) were not sufficient to offset the cost of placing sealants in first permanent molars of all Medicaid-eligible children who received them.

DISCUSSION

This analysis is based on administrative data from 8 years of dental Medicaid claims. The strengths of this study include the large number of children, the relatively long duration of follow-up, and the many factors controlled for in the analyses. The findings are estimates that we based on empiric data while statistically controlling for many other significant factors. They provide more comparable outcome measures between sealed and unsealed teeth than would uncontrolled analyses that compare children with and without sealants.

We expected that the Medicaid children would be at high risk of dental caries. The results indicate that two thirds of the children did not receive a CRSO paid for by Medicaid during their time enrolled. On the basis of our findings, sealants would be more cost-effective in aggregate (or would save expenditures for more individuals) in a population with a higher caries and restorative treatment rate than was found in our study population. Prior restorative experience available from administrative claims was sufficient to identify children for whom sealants save expenditures. The disadvantage of using these risk indicators is that they occur too late, after a child has already experienced disease. Low-cost, easily administered, accurate caries risk assessment methods are needed that can identify high-risk children before they need restorations.

Several limitations are inherent to this retrospective analysis. First, the study is observational. It uses retrospective claims data in which sealant placement occurs as a result of dentists' treatment choices. Children were not randomly assigned to treatment groups as in a randomized clinical trial. Using the same claims data sources, Robison and colleagues[13] detected some selection bias in the use of sealants. Children at lower risk of dental caries were being selected for sealant application. This bias could cause an underestimate of sealant effectiveness, making the effects of sealants appear less favorable than they might be otherwise. To mitigate potential bias, we controlled for other nonrandom sources of variation in CRSOs by using as many variables as possible in the regression analyses, including characteristics of the child, dentist, and area. Still other potential measures of caries risk, such as salivary bacterial levels, salivary fluoride levels, and occlusal anatomy, were not available in this retrospective analysis of administrative data, so some bias may remain.

We did not discount expenditures (i.e., we used a discount rate of 0%) to avoid an inherent bias against preventive services in which expenditures occur during the initial period but benefits or savings accrue only gradually over time. Discounting would reduce or delay expenditure savings for children with prior permanent molar restorations and would reduce the relative cost-effectiveness of sealants compared with a no-sealant strategy. From a public payer perspective, where fees remain relatively fixed over time and funds cannot be easily invested in other higher-return ventures, the lack of discounting may be appropriate.

Although this analysis did not include children seen in public health clinics, over 95% of the children were treated in private practices, so the results are fairly generalizable to the Medicaid program. If public dental clinics have a greater share of high-risk children, then the net expenditure implications become more favorable for the Medicaid program. Two other factors limit the generalizability of the results to the current Medicaid program experience. Since 1992, the fee for a sealant in the North Carolina Dental Medicaid Program has increased relative to the fee for a 1-surface restoration and the preauthorization requirement was discontinued. These changes most likely increased sealant use by participating dentists and may affect the cost-effectiveness of sealants in practice.

In this population, sealants were paid for, and presumably applied, only once. The sealant retention rate is not known. Given the estimated decline in sealant effectiveness over time, some sealants were probably lost during the study period. Those molars that became unsealed could not be distinguished from those that remained sealed. This limitation reduces the measured effectiveness of the sealant, as reflected by the dissipation of expenditure savings over time for the children with 2 or more prior CRSOs. Although the high-risk group could potentially have increased expenditure savings from sealant reapplication, the effect would depend on how children and teeth were selected for reapplication, the caries incidence in the population at the age of reapplication, and the fee for reapplying the sealant.

Children were not followed beyond 13 years of age in this analysis. Data collected over a longer period would help determine whether CRSO treatments and costs increase

through adolescence and adulthood. Conceivably, cumulative CRSO treatment costs could increase with time as restorations are repaired or replaced with more costly restorations, thus increasing the possibility that sealants contribute to cost savings for society.

The perspective of our analysis is essentially that of the Medicaid payer rather than of society, so our analyses underestimate reductions in total costs from sealant use because not all treatment and indirect costs are measured. It is unlikely that all disease is treated within the observed time frame. Data on oral health status from the most recent statewide survey of schoolchildren in North Carolina suggest that most children enrolled in the state's Medicaid program have unmet restorative treatment needs.[14] Costs that were not billed, were incurred outside the Medicaid program, or were never incurred could not be included in this analysis. This analysis also did not include any intangible costs incurred owing to dental pain or dysfunction, and the analysis does not measure total benefits because it does not put a value on maintaining a sound tooth. Determination of the cost-effectiveness of sealants for children at relatively low risk of CRSOs would require estimates of lifetime treatment costs and benefits of reduced pain or improved dental health as well as an assessment of society's willingness to pay for such benefits.

Despite these limitations, the study is characterized by a number of important strengths and conclusions. Sealants were effective in preventing restorations in this Medicaid population, even though restoration rates were low among unsealed first permanent molars. However, expenditure savings were achieved only among children with high levels of prior restorations and thus considered to be at high risk. It is important to recognize that the less prevalent a disease, the smaller the potential for cost savings from preventive treatments. If low-cost methods for successfully identifying young children at high caries risk become available, Medicaid sealant programs conceivably can accrue expenditure savings at a higher rate by targeting appropriate children for sealants. Yet society may still benefit substantially from programs to prevent dental disease in the proportion of the population in which that disease occurs, or even more broadly from achieving health benefits at some cost.[15] Lack of expenditure savings for the Medicaid program or of cost savings for society does not mitigate the potential value of gains in dental health for historically underserved segments of the population. ■

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Contributors

J.A. Weintraub, S.C. Stearns, and R.G. Rozier conceived and designed the study, analyzed and interpreted the results, and wrote the paper. C.-C. Huang contributed to the development of the analysis plan, conducted data analysis, and reviewed the manuscript.

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