

Natural history of treatment outcomes of permanent first molars

A study of sealant effectiveness

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Many studies have evaluated the effectiveness of dental sealants in preventing fissure caries, the most common form of caries in the United States.¹⁻⁴ Most studies have used outcomes such as decayed, missing and filled surfaces in primary or permanent teeth or caries rates to evaluate sealant effectiveness.⁵⁻¹⁰ Few studies, however, have evaluated the treatment outcomes of teeth with and without sealants. What percentage of teeth with and without a sealant will receive a restoration over time? How soon is this likely to occur? Better information about the long-term outcomes of teeth with and without sealants can assist public health planners, dentists and patients in clinical decision making and program planning.

Greater use of sealants could reduce the need for subsequent treatment.

Several studies have used insurance claims data to assess retrospectively treatment outcomes of sealants provided under real-life situations.^{3,4,11} However, only one of these studies evaluated outcomes of sealants at tooth level,⁴ and none of the studies compared the natural history—a natural process or flow of events without any special interventions—of treatments provided to teeth with and without sealants.

To provide more information about the treatment history of teeth with and without sealants, we retrospectively evaluated the natural history of permanent first molars four years after presumed eruption in children at age 6 years.

Background. Few studies have used insurance claims data to retrospectively assess the natural history—a natural process or flow of events without any special interventions—and treatment outcomes of teeth with dental sealants.

Methods. The authors constructed treatment outcome trees (TOTs) from the Iowa Medicaid claims and eligibility data (1996-2000) of continuously enrolled 6-year-old children who routinely used Medicaid dental services. The authors used the TOTs to compare the restorative treatments of sealed permanent first molars with those of nonsealed permanent first molars.

Results. Forty percent of routine utilizers received a sealant during the four-year period. Overall, 25 percent of molars received at least one restoration. Sealed molars were less likely to receive further restorative treatment than were nonsealed molars (13 versus 29 percent). Sealed molars had fewer extensive restorative treatments (crowns, endodontic therapy and extractions) than did nonsealed molars. The median time to restorative treatment of the sealed molars also was greater than that of the nonsealed molars. All four first molars had comparatively similar patterns of subsequent care.

Conclusions. Permanent first molars with sealants received less subsequent restorative treatment than did those without sealants. TOTs are useful tools for identifying necessary outcome information needed for program evaluations.

Clinical Implications. Greater use of sealants could reduce the need for subsequent treatment and prolong the time until treatment may be necessary for permanent first molars.

Key Words. Treatment outcomes; permanent first molars; sealant effectiveness; dental claims data.



In the United States, 80 percent of untreated caries in permanent teeth occur in approximately 25 percent of children aged 5 to 17 years; these children are mostly from

low-income families and other vulnerable populations.¹² Many studies, however, indicate that among populations of children at high risk of developing dental caries, sealant use is less than the desired 50 percent rate set by the Healthy People 2010 goals and objectives.^{4,13,14} In the Medicaid population—a group at high risk of developing dental caries—sealant use rates have been found to be only 22 percent.^{4,14} Therefore, studying the effectiveness of sealants in this population group is essential.

In our study, we used Iowa Medicaid claims and eligibility data to construct treatment outcome trees (TOTs) that compared the treatment received by teeth with and without sealants of Medicaid-enrolled children. We developed TOTs as a way to depict graphically the natural history of a tooth subsequent to a defining event or procedure (in this case, the placement of a sealant after its presumed eruption). A TOT is an observational approach designed to provide assistance for clinical decision making by evaluating the long-term treatment outcomes of different procedures or events over time.

We conducted a study to determine the use of dental services by Medicaid-enrolled children, focusing on the receipt of preventive services including dental sealants, and to compare the treatment outcomes of permanent first molars with and without sealants over a four-year period using TOTs.

METHODS

We derived our data from eligibility and dental claims files for children enrolled in the Iowa Medicaid program from 1996 through 2000. The Iowa Medicaid eligibility file provided information about the enrollees' eligibility periods and demographic characteristics. Dental claims files included information about all dental services provided to Medicaid-enrolled children that were submitted from participating dentists. We merged the two using encrypted identification numbers generated to preserve the children's anonymity.

We included in this study children who had their sixth birthday in 1996, were enrolled continuously in the Iowa Medicaid program from 1996 through 2000 and were routine utilizers of dental services during this period. The children had to

be enrolled continuously to increase the likelihood that all services provided to these children during the study period would be captured in the claims data. To be considered a "routine utilizer," a child had to have had at least one dental preventive visit in 1996 and 2000 and at least one other preventive visit in between those visits. We defined a preventive visit as a comprehensive oral examination, a periodic oral evaluation, a complete series of intraoral radiographs or a dental prophylaxis for a child. We compared treatment characteristics of continuously enrolled routine utilizers with those of all 6-year-olds who were enrolled in Medicaid to evaluate whether our study popula-

tion was representative of the broader Medicaid population. Among the routine utilizers, we compared the characteristics of children who received at least one sealant with those of children without any sealants. We used the χ^2 test to compare the characteristics of the two groups at $\alpha = .05$.

We analyzed the natural history of each first molar (tooth nos. 3, 14, 19 or 30) separately to prevent the clustering effect that occurs when evaluating multiple teeth in a single child. To develop TOTs, we identified all of the services provided to the permanent first molars and placed the services in chronological order of occurrence. We then constructed TOTs to display all services provided to the permanent first molars over a four-year period beginning when children were 6 years old.

A TOT's structure is similar to that of a decision tree, but it has a treatment node instead of a decision or chance node. Thus, the branches in a TOT represent observed treatment outcomes, not necessarily true health states of the teeth as usually shown in a decision tree. Similar to decision and chance nodes, the percentages of events of each treatment node must add up to 100 percent.

We created each TOT by following treatment outcomes of each permanent first molar of each subject. Since we were interested in sealant effectiveness, the first treatment node identified whether the tooth received a sealant before any other treatment during the study period. The second treatment node indicated whether the sealed and nonsealed molars received any type of "restorative treatment," including restorations, crowns, endodontic therapy and extractions. To

The authors developed treatment outcome trees as a way to depict graphically the natural history of a tooth subsequent to a defining event or procedure.

show all the frequencies and types of treatment received by sealed and nonsealed molars, we added the third treatment node only when the molars received other subsequent restorative treatments.

We then simplified or “pruned” the TOTs, retaining branches on the basis of the severity and frequency of subsequent treatments. The final treatment outcomes (displayed on the right-hand side of a TOT) show the final tooth states resulting from all the treatments received during four years. To determine the timing of events, we calculated the median time—the time between the child’s birthday and the time of each treatment—until each treatment node and added it to each branch in the TOT.

The institutional review boards of the University of Iowa and the Managed Care and Clinical Services Division of the Iowa Department of Human Services approved the study proposal. We used a statistical software package (SAS, Version 8.2, SAS Institute, Cary, N.C.) to conduct data analyses and a software program for decision analysis (TreeAge Pro Healthcare, TreeAge Software, Williamstown, Mass.) to create TOTs.

RESULTS

There were 12,404 children enrolled in the Iowa Medicaid program who turned 6 years of age in 1996. Of these, 1,473 were enrolled continuously from 1996 through 2000. Of the continuously enrolled children, 308 were considered to be routine utilizers at that time. A comparison of demographic characteristics of the routine utilizers (54 percent female, 82 percent white, 57 percent lived in metropolitan areas and 50 percent at from 0 to 33 percent below the federal poverty level [FPL]) to all 6-year-olds enrolled in Medicaid (50 percent female, 79 percent white, 54 percent lived in metropolitan areas and 50 percent at from 0 to 33 percent below the FPL) demonstrated that there were no statistically significant differences regarding sex, race, urban-rural location (as defined by the U.S. Department of Agriculture¹⁵) and percentage below the FPL (as identified by U.S. Department of Health and Human Services for determining Medicaid eligibility).

Forty percent of the routine utilizers (n = 123) received at least one sealant during the study period. The table compares the demographic

characteristics of children without sealants and those with at least one sealant. We found no statistically significant differences between the two groups with respect to demographics and utilization of preventive services. Thirty-six percent of the routine utilizers received only preventive visits without receiving sealants or restorative treatment during the four-year period. Overall, 25 percent of molars received at least one restoration.

For each first molar (tooth nos. 3, 14, 19 or 30), there was little difference in the amount of treatment received. For example, 47.5 percent of the first molars received no sealants or restorative treatment during the study period, between 41 and 45 percent received one restorative procedure, and between 8 and 11 percent received more than one restorative procedure. Sealed molars were less likely to receive further restorative treatment than were nonsealed molars (13 versus 29 percent).

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The natural history of each permanent first molar is shown in a TOT (Figure 1 [page 1269] and Figure 2 [page 1270]). For teeth with sealants, about 88 percent of maxillary first molars and 86.5 percent of mandibular first molars did not receive restorative treatment during the study period. For maxillary first molars without sealants, however, about 72 percent did not receive restorative treatment. For mandibular first molars without sealants, 72.5 percent of teeth no. 19 and 68 percent of teeth no. 30 did not receive restorative treatment. The greatest differences were the percentages of one-surface restorations. Four percent of sealed maxillary first molars received a one-surface restoration compared with 18 percent of nonsealed maxillary first molars. For mandibular first molars, 4.5 percent of sealed teeth received a one-surface restoration compared with 19.5 percent of nonsealed teeth. Relatively few teeth in both groups received extensive treatment during the four-year period (that is, crowns, endodontic therapy or extractions). Approximately 4 percent of the sealed teeth received another sealant.

The median age at sealant placement was 7.5 years for all four permanent first molars. Most of the teeth were restored after the child was 8.5 years old. TOTs show that the extensive treatments (crowns, endodontic therapy or extractions) were provided later than the restorations.

TABLE

CHARACTERISTICS OF ROUTINE UTILIZERS OF IOWA MEDICAID DENTAL SERVICES WITH AND WITHOUT SEALANTS.

CHARACTERISTICS	CHILDREN WITHOUT SEALANTS (n = 185)	CHILDREN WITH AT LEAST ONE SEALANT ON PERMANENT FIRST MOLARS (n = 123)
Sex (%)		
Male	46	46
Female	54	54
Race (No.)		
White	84	79
African-American	13	18
Other	2	3
Residential Area (%)		
Living in metropolitan area	52	62
Living in urban area	46	35
Living in rural area	3	3
Median Family's Percentage of the FPL*	28	33
Percentage of Children in Family With 0% Below the FPL	30	29
Percentage of Children in Family With > 0-33% Below the FPL	22	20
Percentage of Children in Family With > 33-66% Below the FPL	22	30
Percentage of Children in Family With > 66-133% Below the FPL	26	21
Median Number of Preventive Visits per Year of Medicaid Enrollment	1.0 (range, 0.6 to 1.8)	1.0 (range, 0.6 to 1.6)
Median Number of Fluoride Treatments per Year of Medicaid Enrollment	0.8 (range, 0.6 to 1.6)	1.0 (range, 0 to 1.6)

* FPL: Federal poverty level.

When comparing the time that one-surface and two-surface restorations were provided, nonsealed teeth received restorative treatments before the sealed teeth.

DISCUSSION

TOTs showed that in a study sample of children from 6 to 10 years of age, permanent first molars with sealants were less likely to receive subsequent restorative treatment than were those without sealants. In addition, the median time to the restorative treatment for sealed teeth was greater than that for the nonsealed molars. These results are consistent with previous studies using different methodologies and different outcome measures that found sealants to be effective in preventing caries.^{1,3,4} Thus, a TOT is a useful tool for evaluating the natural history of teeth receiving a given procedure (in this case, a sealant) and the sequential order in which a tooth receives subsequent treatment. Future studies could use TOTs to identify outcomes from other

dental procedures or to evaluate dental public health programs.

Overall, 40 percent of the routine utilizers in this study received at least one sealant on a permanent first molar during the study period. The sealant utilization rate of this sample of children is greater than in some other Medicaid studies.^{4,14} In one North Carolina study, for example, 23 percent of children enrolled in the Medicaid program between 1984 and 1992 received at least one sealant on a permanent first molar when they were between 5 and 7 years of age.⁴ In another study, 22 percent of children in the Alabama Medicaid program had at least one sealant on at least one permanent molar by 12 to 14 years of age.¹⁴

Rates of sealant used in Medicaid-enrolled children depend on the number of months they are eligible and their utilization of services. The higher rate in this study might be related, in part, to the use of a denominator that includes only routine utilizers over a five-year period.

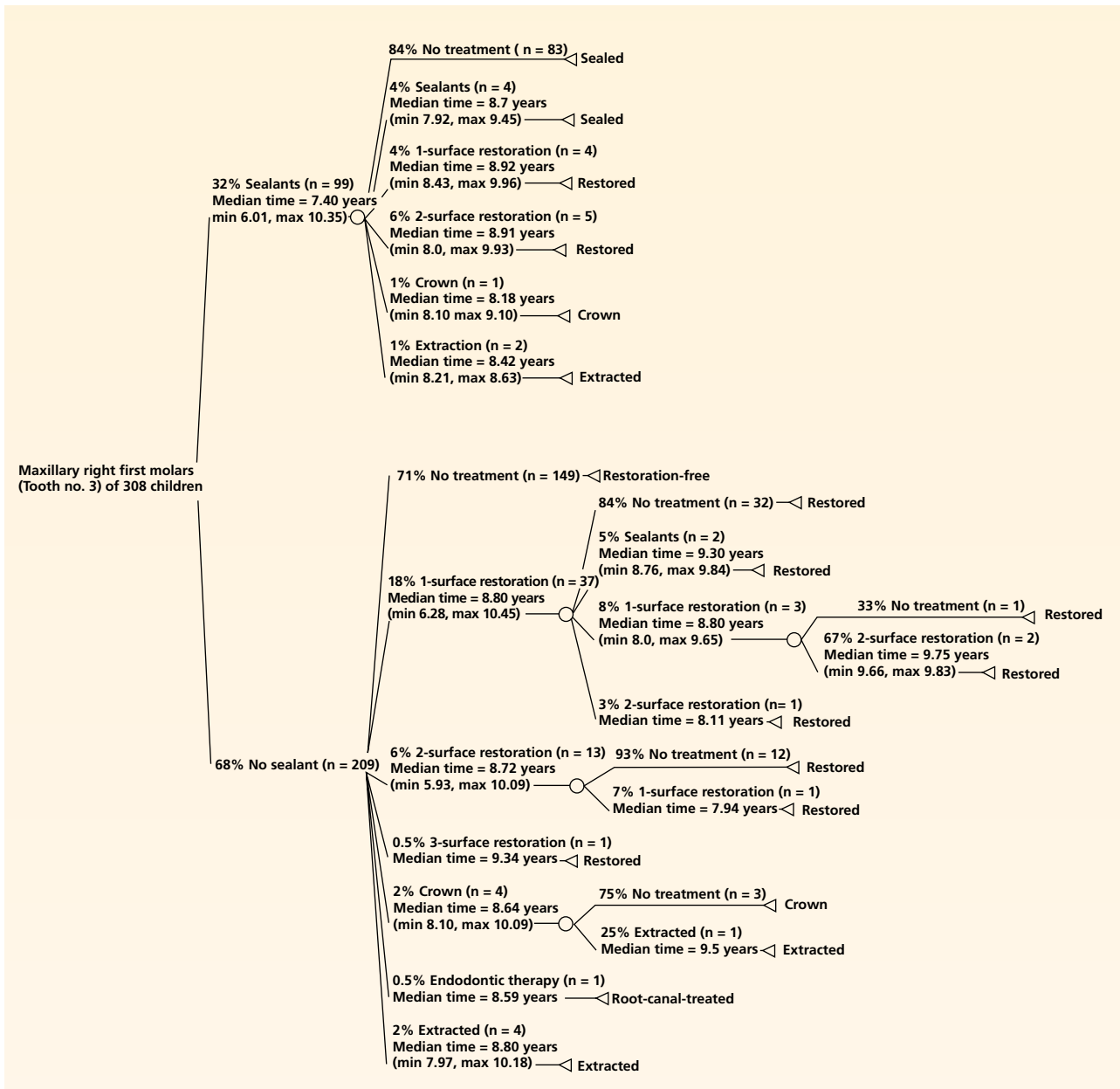


Figure 1. A treatment outcome tree depicting natural history of tooth no. 3 during a four-year period. Min: Minimum. Max: Maximum.

Using only continuously enrolled routine utilizers is most appropriate for evaluating sealant outcomes; however, it is not as good for evaluating sealant use in a Medicaid population. Since children enrolled in Medicaid are at higher risk of developing caries, our research supports outreach and other activities to encourage enrollees to receive dental examinations and necessary preventive regimens, especially sealants.

Because sealants were placed at some point during the follow-up period in our study, it is important to note that the length of time could

not be compared directly with that in Dennison and colleagues³ and Weintraub and colleagues⁴ studies, as those studies started follow-up at the time of sealant placement. With a five-year follow-up in an insured population, Dennison and colleagues³ found that 21 percent of nonsealed first and second molars had received an occlusal restoration compared with 10 percent of sealed first and second molars. The absolute preventive effect of occlusal restoration was 11 percent in these children who were from higher-income families as compared with approximately 16 percent

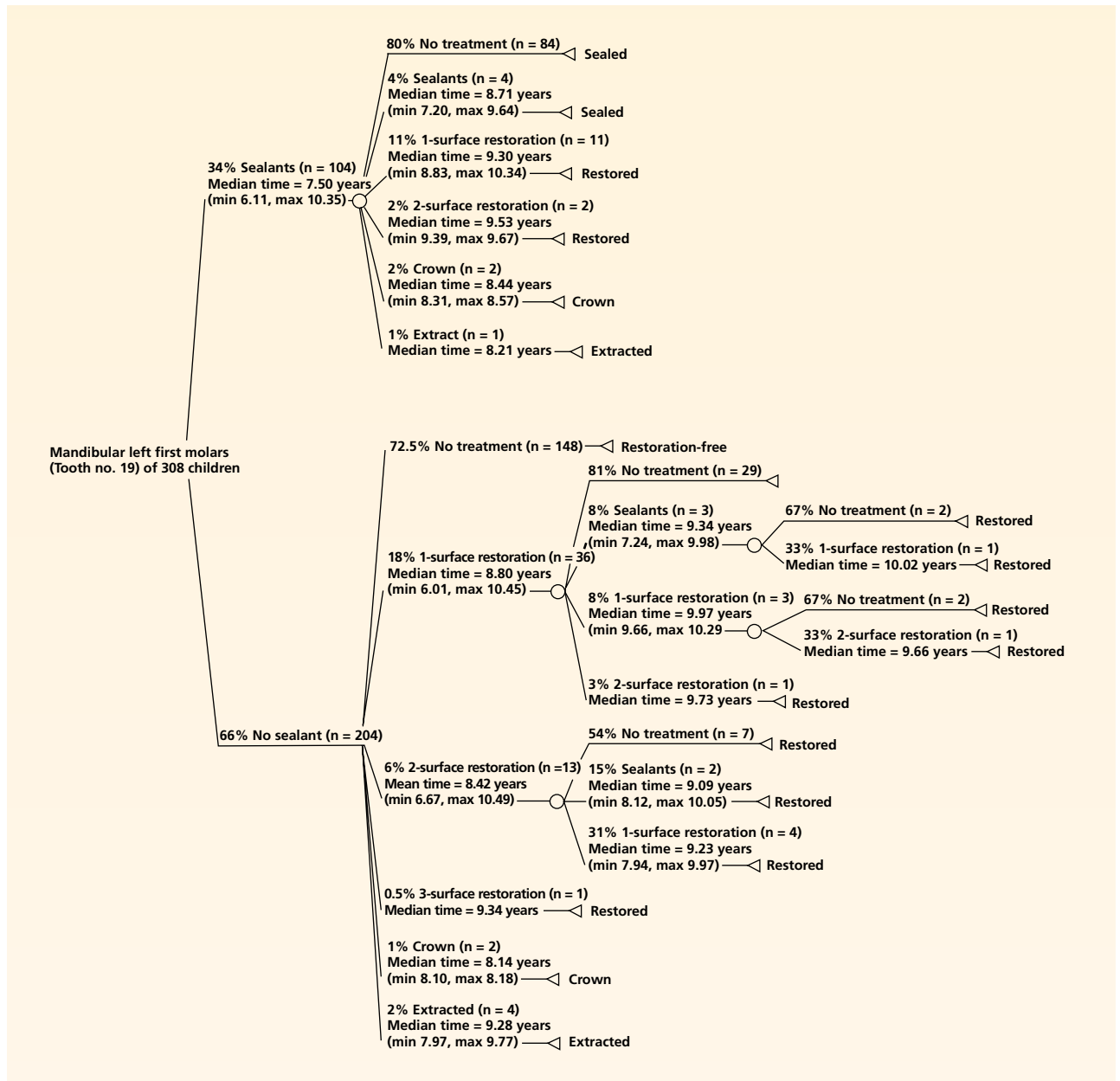


Figure 2. A treatment outcome tree depicting natural history of tooth no. 19 during a four-year period. Min: Minimum. Max: Maximum.

in approximately four years in the Medicaid-enrolled children in our study.³ After following Medicaid children for eight years, Weintraub and colleagues⁴ concluded that sealants placed on molars at high risk had longer preventive effect than those placed on molars at low risk of developing occlusal-related caries.

Even though we followed first molars from presumed eruption based on age, our results consistently showed that not all nonsealed permanent first molars received a restoration. There-

fore, sealing all “at-risk” teeth in this group of children would be the most cost-effective method to prevent future restorative treatments.

There was little difference in restorative treatment rates among all maxillary and mandibular molars in our study (22.5 versus 24 percent, respectively). Although there are no studies in the literature that have evaluated the differences in treatment received by maxillary and mandibular molars, previous studies have reported different patterns of caries rates in maxillary and

mandibular molars. Carlos and Gittelsohn¹⁶ reported that, in both sexes, maxillary first molars had greater caries attack patterns than did mandibular first molars. On the other hand, using the 1979-1980 and the 1986-1987 National Institute of Dental Research surveys, Li and colleagues¹⁷ reported that the seven-year attack rates of all surfaces of mandibular first molars (596.8/1,000 surfaces) were slightly greater than those of maxillary first molars (549.2/1,000 surfaces).

There was no difference in the preventive effect of sealants on sealed maxillary and mandibular molars (16 versus 16.5 percent). The median time to restoration for both sealed maxillary and mandibular molars also was similar. Even though studies have reported that sealants are retained better in mandibular molars, the failure rate of mandibular molar sealants increases if they are applied too early, owing to interferences from the distal operculum.¹⁸⁻²⁰ In addition, children's cooperation when sealants are placed improves when they are older.^{19,21,22} We found that sealants were delivered to a similar proportion of the children's teeth at each year of age from 6 to 9 years old, with a median age of 7.5 years. Since most of the teeth were restored after children were 8.5 years old, sealants may be most effective when placed at the earliest time subsequent to the molars' complete eruption and before the time children are 8.5 years old.

Because we used administrative data for this study, we had to estimate an age when permanent first molars erupted in each child. We selected 6 years of age as the time of first molar eruption on the basis of previous studies that found that the mean eruptive ages were 5.94 to 6.4, 6 to 7, and 5.9 to 6.9 years as reported by Graber,²³ Mathewson and Primosch²⁴ and Welbury,²⁵ respectively. Therefore, by targeting a cohort of 6-year-olds, we ensured that at least 68 percent (1 standard deviation) of all permanent first molars should have erupted in the year the children turned 6 years and were at risk of developing caries and receiving subsequent restorations. Since the standard deviation of mean eruption age varies from 5 to 9 months,²³ some teeth may erupt at 5.2 years and be restored when the children are 6 to 7 years old, resulting in some of the earlier restorations.

The use of administrative data has some additional limitations. The Medicaid database included only submitted claims and did not

include procedures for which dentists did not submit claims for reimbursement. Claims also were not submitted from community health centers, where reimbursement is made on a per visit basis and no individual procedure codes are recorded. The impact of this, however, is unclear because differences, if any, between children using dental services in the health centers and children eligible for Medicaid are unknown.

To try and make sure that the claims data included as much information as possible about the services needed and received by children with and without sealants, our inclusion criteria for selecting children for the study were relatively strict. The children had to be enrolled continuously in Medicaid and have had an examination at the beginning, middle and end of the study period to allow for the detection and treatment of necessary services. These strict inclusion criteria may have introduced some bias into the study, however. Only 12 percent of all 6-year-olds enrolled in the Iowa Medicaid program in 1996 were enrolled continuously for the entire five-year period, and only 2 percent were continuously enrolled routine utilizers. While this is a small percentage of the overall population, it does increase the likelihood of capturing all procedures received by the children for evaluating sealant outcomes.

Our attempt to generalize these results beyond a Medicaid population may have been imprecise. While a Medicaid insured population should receive the same treatment in theory as a nonpublicly insured population, differences might occur owing to access problems related to the lack of providers accepting Medicaid insurance, differences in care-seeking behavior for a lower income population and lower oral health status for a Medicaid population. This also could affect the treatment received by teeth with and without sealants.

The length of follow-up time (four years after presumed eruption) for evaluating the outcomes of sealants was long enough to identify some differences in the receipt of restorations. We found that restorations were more likely to occur in our cohort when the children were 8 to 10 years old, which corresponds with a two- to four-year period when the teeth were at risk of developing caries. Having data available for a lengthier evaluation period after the sealant placement would provide valuable information about longer-term outcomes of sealants. Future studies evaluating the receipt of services by teeth with and without sealants after five and 10 years would add greatly to the

evidence base of sealant effectiveness.

The strengths of our study are that the results were captured from the real-life treatment outcomes resulting from dentists' diagnoses and treatment plans. Furthermore, we followed teeth longitudinally over a four-year period with a continuously enrolled cohort of children who had at least three examinations and time for treatment if necessary. It was advantageous that only the most extensive treatment delivered to a tooth on the same day was used as the treatment provided to a tooth; this helped identify preventive resin restorations versus a sealant alone. Also, we studied each first molar separately to avoid the nonindependence effect and to compare the treatment patterns and TOTs of the permanent first molars separately.

CONCLUSIONS

Permanent first molars with sealants received less subsequent restorative treatment than did permanent first molars without sealants in our 6-year-old cohort. A TOT is a useful tool for identifying important outcomes necessary for program evaluations. Greater use of sealants could reduce the need for subsequent treatment and prolong the time until treatment may be necessary for permanent first molars.

TOTs can help practitioners identify outcomes from alternative dental procedures. Outreach programs to provide dental services, including sealants, to at-risk children who otherwise do not visit the dentist could increase sealant placement and reduce caries rates among Medicaid and other populations who are at high risk of developing caries. ■

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