SCIENTIFIC ARTICLES

Four-Year Cost-Utility Analyses of Sealed and Nonsealed First Permanent Molars in Iowa Medicaid-Enrolled Children

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Abstract

Objectives: *Dental sealants, by their ability to prevent caries and maintain teeth in better health, have some inherent utility to individuals, programs, or society. This study assessed the 4-year incremental cost utility of sealing first permanent molars of 6-year-old Iowa Medicaid enrollees from a societal perspective and identified the group of teeth or children in whom sealants are most cost effective.* ***Methods:*** *Dental services for first permanent molars were assessed using claims and encounter data for a group of continuously enrolled Medicaid enrollees who turned 6 between 1996 and 1999. Previously published utilities were used to weight the different health states. The weighted sum of outcomes [Quality-Adjusted Tooth-Years (QATYs)] was the measure of effectiveness. Costs and QATYs were discounted to the time of the child's sixth birthday.* ***Results:*** *For all first molars, the cost of treatment associated with sealed teeth was higher but the utility was also slightly higher over the 4-year period. The relative incremental cost per 0.19 QATY ratio [changing the health state from a restored tooth (utility = 0.81) to a nonrestored tooth (utility = 1)] by sealing the molar ranged from $36.7 to $83.5 per 0.19 QATY. The incremental cost/QATY ratio was lower for sealing lower utilizers and for mandibular versus maxillary molars.* ***Conclusions:*** *Sealants improved overall utility of first permanent molars after 4 years. The 4-year cost/QATY ratio of sealing the first permanent molar varied by arch and type of utilizers. Sealing first permanent molars in lower dental utilizers is the most cost-effective approach for prioritizing limited resources.*

Key Words: pit and fissure sealants, cost-benefit analysis, first permanent molars, cost utility, Medicaid

Introduction

Pit and fissure caries accounts for over 85 percent of the total caries experience in pediatric and adolescent populations in the United States (1,2). Sealants are effective in preventing caries, but economic evaluations of sealants at a community level are limited (3).

Several economic analyses of dental sealants have been conducted using different definitions of effectiveness. For example, Werner et al. (4) estimated that sealants, provided in a school-based program in Michigan, cost from $43 to $65 per saved surface over a 6-year period. Weintraub et al. (5) reported that, after 11 years, the incremental cost-effectiveness ratio of sealants provided to children from low-income families in a health center was $4.06 per additional restoration-free tooth-year. Using information from a large private dental insurance company, Kuthy et al. (6) found that children with sealants had higher 3-year total costs per child compared with the nonsealed group ($532.70 versus $385.40) per approximately 2 months of restoration-free molars.

An alternative way of defining effectiveness when evaluating outcomes from dental sealants is to use utilities as the measure of effectiveness in a cost analysis. In economic terms, utility is satisfaction or value that someone receives from a commodity. In dentistry, there have been few studies evaluating the utility of different oral health states. In the few cost-utility studies in dentistry, carious, restored, and extracted teeth all had lower utilities than sound or nonrestored teeth (7-9). Sealants, by their ability to prevent carious teeth and keep teeth in a better health state, have some inherent utility to individuals, programs, or society. Therefore, cost-utility analysis could be important to assess additional cost per change in the weighted sum of all tooth states, the weight being utility of each outcome (10-13).

The purposes of this study were to a) assess the 4-year incremental cost utility of treatment outcomes of

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sealed first permanent molars, compared with nonsealed molars, of 6-year-old children enrolled in the Iowa Medicaid program, using a societal perspective and b) identify the group of children for whom sealants are most cost-effective.

Methods

A retrospective cohort study was used to assess the costs and outcomes of treatments rendered to sealed and nonsealed first permanent molars in a group of Iowa Medicaid-enrolled children. Data for this study were derived 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 periods of eligibility and demographic characteristics of enrolled children. The dental claims files included information about all dental services provided to Medicaid enrolled children that were submitted from participating dentists. The 1999 American Dental Association Code on Dental Procedures and Nomenclature was used to identify the dental terminology of the submitted procedures. SAS® version 8.2 (SAS Institute, Cary, NC) was used for data management and analyses. The Institutional Review Boards of University of Iowa and Managed Care and Clinical Services of Iowa Department of Human Services approved the study.

Inclusion Criteria. Children had to have a) their sixth birthday between January 1, 1996 and December 31, 1999, b) been continuously enrolled in the Iowa Medicaid program from 1996 to 2000 for at least 3 years, and c) a preventive visit when they were 6 years old and at least one other time during the study period. Length of time for each child was from age 6 until his or her last preventive visit. A preventive visit was defined as either a comprehensive oral examination, a periodic oral evaluation, a comprehensive oral evaluation, an intraoral complete series of radiographic examination, or a child's dental prophylaxis.

Criteria were established to increase the likelihood that the claims data represented all treatment following at least two examinations by a dentist prior to the tooth being lost to follow-up (censored), extracted (failed), or the child turned 10 (terminated). Demographic characteristics of all Medicaid enrolled children who turned 6 between 1996 and 1999 and continuously enrolled dental utilizers were compared to determine if a selection bias resulted from the strict inclusion criteria used in this study. Costs and utilities of each first molar were assessed separately to assure the independence of observations.

Calculating Costs. Costs of treatments to the permanent first molars were applied using charges from the American Dental Association (ADA) 2001 Survey of Dentists Fees, which was the most current published schedule of average dental fees in the United States at the time of analysis. In a competitive market where charges of dental services are not regulated, these fees approximate the societal value of resources used for treatment. The total cost of each yearly interval for each tooth was calculated by multiplying the total number of each type of treatment (e.g., dental sealant, one surface amalgam restoration) with its fee.

Calculating Utilities: Quality-Adjusted Tooth-Years (QATYs). Utilities were measured as QATYs, which is the production of additional years of life (tooth-year) of each tooth adjusted for the quality of the tooth (14). A nonrestored tooth had a QATY equal to 1 in the year that it was restoration-free. A restored, crowned, or root canal treated tooth had a QATY less than perfect (i.e., less than 1) in the year that it was restored and subsequent years. QATY for an extracted tooth was equal to 0 in that year and subsequent years.

A tooth-year in each interval depended on whether the tooth survived (i.e., not extracted) during the interval. A tooth-year without previous caries experience was equal to 1 in each interval that it continued in that caries-free state. If the tooth was extracted, its tooth-year became 0. Therefore, for noncensored data, the total tooth-year in an interval was equal to $n - d$, where n is the total number of teeth entering the interval and d is the number of teeth that were extracted in the interval.

When there were censored data in an interval, the tooth-year was equal to 0.5 in that year and equal to 0 in the years after. Therefore, the total tooth-years in the interval with censored information was equal to $n - d - (c/2)$; where c is number of teeth being censored in the interval. This modification is similar to the method employed by the life-table method (15) to reduce the number of "at-risk" teeth of censored data. The rationale of this adjustment is that with a large sample size censored observations are assumed to be uniformly distributed over the interval, and 0.5 years is an average time survived in the interval (16).

Because the health states of teeth change over time, the tooth-years were weighted by utility values suggested by Fyffe and Kay (7) in a study where dentists and the general public were asked to determine their relative value of different health states of teeth. To assess QATYs from a societal perspective, average utilities of dentists and the general public were used to weight tooth-year. A tooth without any treatment (except sealants) was assumed to have the same tooth utility as a sound tooth (i.e., 1), whereas a permanently restored posterior tooth received a utility of 0.81, and an extracted tooth had a utility of 0. The average utility or QATY over four yearly intervals for sealed and nonsealed groups can be expressed as:

$$\text{Total average QATYs of four intervals} = \sum_{\text{int}=1}^{4} \frac{TiUi}{N}$$

where Ti = value of tooth-year of each tooth in each interval (1 if tooth survived, 0 if tooth was extracted, and 0.5 if tooth was censored in the interval), Ui = value of health state of teeth in the interval (1 if tooth was

restoration-free, 0.81 if tooth was restored, and 0 if tooth was extracted), and N is total number of at-risk tooth-years in each interval.

Discounting Costs and QATYs. To adjust for time preferences related to costs and QATYs, the costs and QATYS of the second, third, and fourth intervals were discounted to the base year, which was the child's sixth birthday. Using the shadow-price-of-capital approach (17), costs and QATYs were discounted 3 percent, which approximates the "social rate of time preference" that transforms the future consumption losses and gains into the present value of current investments and benefits.

This study evaluated the costs and QATYs of first permanent molars from the time the children were 6 years old until the tooth received either a restoration, a root canal, or was extracted, not just the failure of the sealant. Prior to the calculation of cost utility, possible outliers of costs and QATYs of each first molar were investigated. When possible outliers were identified, costs and QATYs were recalculated without outliers to assess the effect of the outliers.

Cost-Utility Analysis (CUA). Incremental costs and QATYs of sealed versus nonsealed molars were calculated based on probabilities of occurrence of subsequent treatment as determined using the Medicaid eligibility and claims files. The incremental cost/QATY ratio of each first permanent molar was calculated to compare additional cost per each QATY gained for each molar.

Subgroup analyses. A selection bias may exist as a result of the non-randomization of sealant placement. One important bias could be related to differences in the use of dental care among children (i.e., children who visited dentists for preventive care more frequently were more likely to receive sealants). Therefore, molars were stratified into two groups for some of the analyses by the number of preventive visits to evaluate the influence of this possible confounding effect. Those with ≤1 preventive visits per year of enrollment were classified as "low" utilizers (n = 1,259), while those with >1 preventive visit per year of enrollment were called "high" utilizers (n = 863).

Table 1
Percentage of Iowa Medicaid-Enrolled Children (n = 2,132) Receiving Dental Sealants for Each First Permanent Molar, by Five Independent Variables

Independent variables	% Sealed in each first permanent molar			
	#3 (28.6%)	#14 (28.4%)	#19 (29.0%)	#30 (29.0%)
Gender				
Male	25.2*	25.5*	25.6*	25.9*
Female	30.7	30.0	30.7	30.4
Ethnicity				
White	28.2	27.8	28.3	28.2
African-American	29.6	30.2	30.2	30.2
Others	15.9	17.4	17.4	17.4
Family percent of the Federal Poverty Level				
0%	29.1	28.5	28.1	28.3
>0 to 33%	26.8	26.8	26.8	27.1
>33 to 66%	27.8	27.4	28.6	28.6
>66%	29.1	29.3	30.2	29.7
Area of residence				
Metro	29.6	29.2	29.6	29.8*
Urban	25.7	25.4	25.6	25.3
Rural	28.7	31.5	34.3	33.3
Number of preventive visits per year of enrollment				
≤1	25.6*	25.5*	25.3*	25.3*
>1	31.6	31.2	32.5	32.3

* P-value < 0.05.

Table 2
Percent of Different Procedures Delivered to Sealed and Nonsealed First Permanent Molars

Number of teeth receiving treatment over 4 years	Maxillary first permanent molars				Mandibular first permanent molars			
	Tooth #3		Tooth #14		Tooth #19		Tooth #30	
	Nonsealed (%) n = 1,532	Sealed (%) n = 600	Nonsealed (%) n = 1,536	Sealed (%) n = 596	Nonsealed (%) n = 1,524	Sealed (%) n = 608	Nonsealed (%) n = 1,525	Sealed (%) n = 607
No restorative treatment	82.0	92.5	82.6	95.6	82.3	92.9	80.3	92.8
1-surface restoration	10.0	4.0	9.7	2.4	10.6	4.6	12.2	4.4
2-surface restoration	3.9	2.5	3.9	1.4	3.0	1.5	2.9	1.6
3+-surface restoration	0.2	0.0	0.1	0.0	0.1	0.0	0.3	0.0
Crown	0.4	0.3	0.5	0.1	0.3	0.2	0.3	0.2
Pulp/root canal treatment	0.8	0.2	0.7	0.1	0.9	0.2	1.1	0.3
Extraction	2.7	0.5	2.6	0.4	2.6	0.7	2.9	0.7

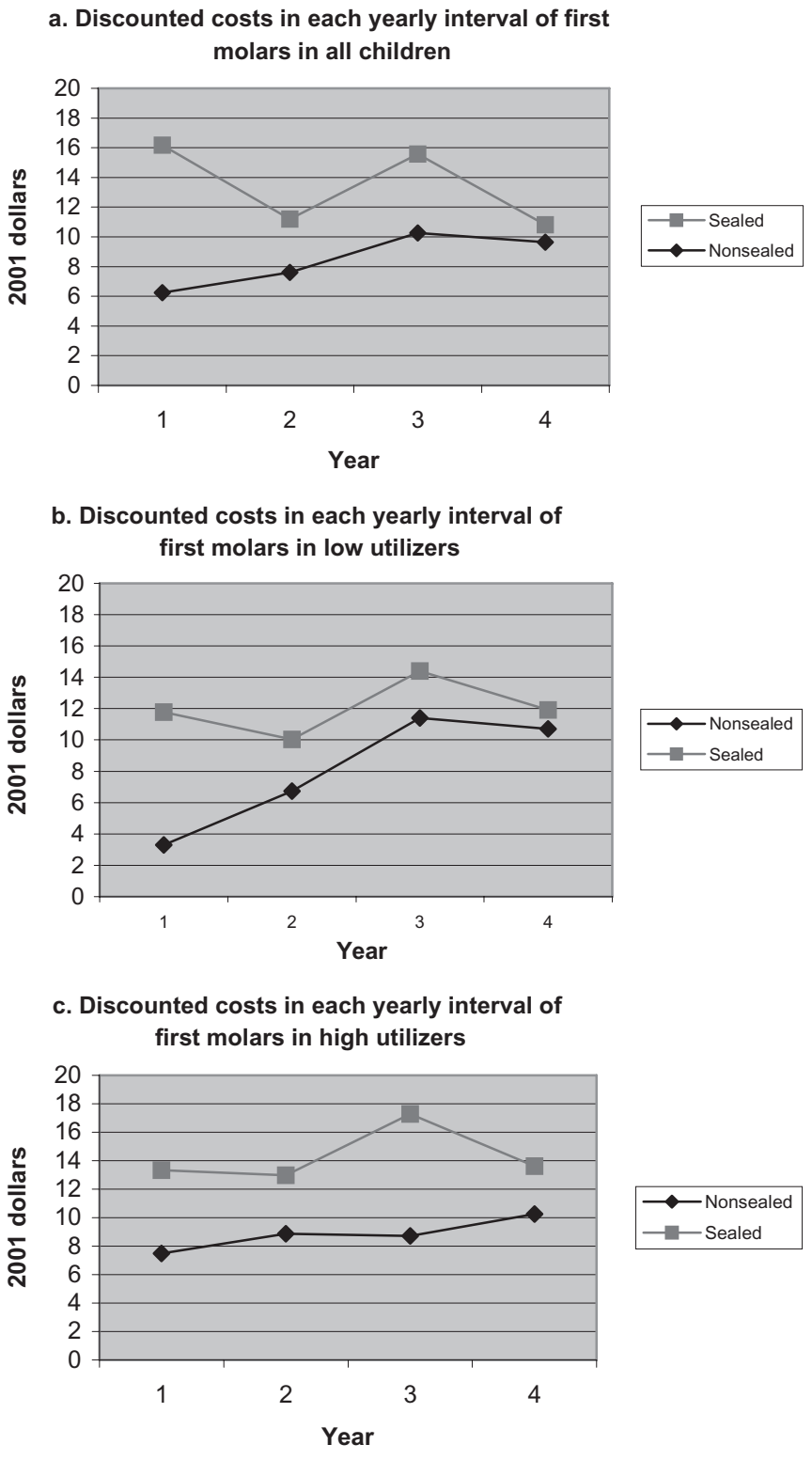
Sensitivity Analysis. A one-way sensitivity analysis was conducted to evaluate the stability of the conclusions of the CUA and to identify the most critical parameters of analysis (18). The parameters that were adjusted included the set of charges for sealants and restorative treatments, utility values applied to different health states of the tooth, and discount rates. For the sensitivity analysis, costs and QATYs for sealed and nonsealed teeth and incremental ratios were recalculated for each tooth, stratified for high and low utilizers.

Results

Of the 12,404 6-year-olds enrolled in the Iowa Medicaid program between 1996 and 1999 for at least 2 years, 57 percent were enrolled for at least three years. Of these nontransient enrollees, 30 percent (n = 2,132) had a dental examination when they were 6 years old and another dental exam during the study period, qualifying them for inclusion. These children are hereafter referred to as "utilizers." There were no statistically significant differences between this group of utilizers and all 6-year-old Medicaid-enrolled children regarding gender (50 percent female), ethnicity (79 percent White), urban–rural location as defined by the US Department of Agriculture (54 percent in metro areas) (19), and percent poverty as identified by the US Department of Health and Human Services (50 percent, from 0 to 33 percent of the Federal Poverty Level).

Only 32 percent of children received at least one sealant during the study period. Among these children, 7, 10, 9, and 74 percent had one, two, three, or four of their first permanent molars sealed, respectively. Table 1 compares the characteristics of the utilizers who received sealants in each first permanent molar. Sealants were more likely to be placed on first permanent molars of females and those who had more than one preventive visit per year of enrollment.

Figure 1
Discounted costs (averaged of all four first permanent molars) in each interval of sealed and nonsealed first permanent molars in children with different number of preventive visits per year of enrollment



About 18 percent of nonsealed first permanent molars received some type of treatment during the 4-year study period compared to about 8 percent of sealed molars (Table 2). More nonsealed molars received both restorative treatment and extensive treatments (crowns, endodontic therapies, and extractions) than did sealed teeth.

Figure 1 shows the average discounted costs during each yearly interval for sealed and nonsealed first molars (Figure 1a) and those stratified by number of preventive visits (Figure 1b,c), using 2001 dollars. The cost of sealed molars in each interval was less than the reimbursement rate of a sealant ($31.89) because not all of the molars were sealed each year. Among low utilizers, sealed teeth incurred much higher costs in the beginning, but the difference was reduced in later time intervals. Among high utilizers, costs of sealed-molars were more consistently higher than costs of nonsealed molars.

The 4-year average discounted costs, QATYs, and the cost/QATY ratios for each first permanent molar, by high and low utilizers are presented in Table 3. For all first molars, cost of treatment associated with the sealed group was higher but the utility was also slightly higher. The slightly elevated cost for tooth #3 in high utilizers was because of a single crown that was placed on one child. When this cost was recalculated without the crown, the cost was in line with other first molars.

The relative incremental cost per one additional QATY from the placement of sealants (changing from worst health state of being extracted = 0, to a perfect health state = 1) varied by arch and type of utilizer. Sealant placement was most cost effective for tooth #19 in low utilizers (cost/QATY ratio of $171.1) and least cost effective for tooth #3 in high utilizers (cost/QATY ratio of $510.3). When the cost/QATY ratio was recalculated without the extra crown on tooth #3, the ratio was reduced from $510.3/QATY to $325.5/QATY, which continues to be

Table 3

Average Yearly Discounted Costs, Quality-Adjusted Tooth-Years (QATYs), and Yearly Incremental Cost and QATYs of Each First Permanent Molar, by High and Low Users of Preventive Care

Average yearly discounted Costs and QATYs of each group	Maxillary first permanent molars						Mandibular first permanent molars					
	Tooth #3			Tooth #14			Tooth #19			Tooth #30		
	Nonsealed	Sealed	ΔCost/ΔQATY	Nonsealed	Sealed	ΔCost/ΔQATY	Nonsealed	Sealed	ΔCost/ΔQATY	Nonsealed	Sealed	ΔCost/ΔQATY
All												
Total costs	7.81	13.30	439.6 or 83.5 per 0.19QATY	7.48	13.21	327.43 or 62.2 per 0.19QATY	9.15	12.53	193.0 or 36.7 per 0.19QATY	9.14	12.68	202.3 or 38.4 per 0.19QATY
Total QATYs	0.94	0.95		0.93	0.95		0.93	0.95		0.93	0.94	
≤1 Preventive visits per year of enrollment												
Total costs	7.59	11.56	318.0 or 60.4 per 0.19QATY	7.36	12.29	329.2 or 62.5 per 0.19QATY	8.53	11.52	171.1 or 32.5 per 0.19QATY	8.75	11.84	211.8 or 40.2 per 0.19QATY
Total QATYs	0.94	0.95		0.93	0.95		0.93	0.95		0.93	0.94	
>1 Preventive visits per year of enrollment												
Total costs	7.98	15.63	510.3 or 97.0 per 0.19QATY	7.60	14.28	333.9 or 63.4 per 0.19QATY	10.12	13.70	204.7 or 38.9 per 0.19QATY	9.64	13.60	226.1 or 43.0 per 0.19QATY
Total QATYs	0.93	0.94		0.93	0.95		0.93	0.95		0.93	0.94	

Base model: 2001 American Dental Association Survey of Fees and Fyffe and Kay's (7) utilities: restore-free = 1; restored = 0.81; extracted = 0.

the most expensive group. The incremental cost/QATY of sealing first molars of high utilizers ($204.7 to $510.3 per QATY) was greater than incremental cost/QATY of each molar of low utilizers ($171.1 to $329.2 per QATY). The incremental cost/QATY of sealing mandibular molars ($171.1 to $226.1 per QATY) was lower than costs of sealing maxillary molars ($318.0 to $510.3 per QATY), regardless of preventive user category.

To assess the costs needed to prevent first molars from being restored, Table 3 also shows incremental ratios of cost per 0.19 QATY [i.e., difference from a perfect health state (1.00) to a restored state (0.81)]. Assuming a linear relationship between cost and QATY, relative incremental cost per 0.19 additional QATY derived from placement of sealants (sealants improve health states of molars from the restored health state to a perfect health state) reduced the original incremental cost by approximately 80 percent. Similar to cost/1 QATY ratios, incremental cost/0.19 QATY ratios varied by arch and type of utilizers. For example, the cost per 0.19 QATY for those with one or less preventive visits per year was less for mandibular ($32.5 and $40.2) than maxillary molars ($60.4 and $62.5).

Table 4 shows the parameters that were changed as part of one-way sensitivity analysis. Charges were changed from ADA average fees to reimbursement rates of the Iowa Medicaid program. Utility values suggested by Fyffe and Kay (7) were changed to a set of utility values that differentiate more between the health utility of restored, crowned, and root canal treated teeth. The 3 percent discount rate was changed to 0 and 5 percent, rates that are frequently used in other cost studies.

Table 5 shows results of one-way sensitivity analysis for each first molar, using Medicaid fees, utility values, and two discount rates. The most significant change in cost/QATY ratio was related to changing costs from ADA survey of fees to Iowa Medicaid fee schedule. Varying utilities of restored, crowned, and root canal treated teeth reduced QATY of nonsealed molars more than sealed molars. Again, the single crown on tooth #3 substantially affects the results when compared to other molars. Changing discount rates changed both incremental costs and QATYs. The directions of cost/QATY ratios from changing utilities and discount rates cannot be predicted because the effect size was different in each group. However, none of the changes affected the results regarding overall cost-effectiveness of sealing first permanent molars.

Table 4
Variables, Values, and Sources Tested in the Sensitivity Analysis Subsequent to Sealing the First Permanent Molars of Iowa Medicaid-Enrolled Children

Parameters	Base values	Sensitivity analysis ranges
Charges		
Sealant	$31.89*	$19.40†
1-surface restoration	$73.21*	$43.65†
2-surface restoration	$91.11*	$55.29†
3-surface restoration	$109.14*	$66.93†
Crown	$630.20*	$106.70†
Pulp/RCT	$611.73*	$373.45†
Extraction	$87.76*	$48.30†
Utility values		
Restoration-free	1	1
Restored	0.81‡	0.8¶
Crown	0.81‡	0.6¶
Root canal treated	0.81‡	0.4¶
Extracted	0	0
Discount rates	3%§	5 and 0%

RTC, root canal treatment.
* 2001 American Dental Association survey of fees.
† 2001 Iowa Medicaid reimbursement rates.
‡ Utility values (7).
¶ Arbitrary utility values.
§ Discount rate (17).

Discussion

The results showed that sealants improved overall health states of first permanent molars measured in QATYs over approximately the first 4 years after eruption. Sealed molars, however, incurred more costs than nonsealed molars. Thus, in our base model, relative incremental cost to gain one additional QATY [from an extraction (QATY = 0) to a nonrestored tooth (QATY = 1)] from placement of a sealant ranged from $171.1 to $510.3. Variation by arch and utilization level indicated that sealing mandibular teeth, especially among low utilizers, was more cost-effective than maxillary teeth in high utilizers.

Incremental cost of sealing molars in each age interval is different for low and high utilizers. Among low utilizers, costs of sealed teeth tended to decrease after the third year, while costs associated with sealed teeth in high utilizers tended to increase over the years (Figure 1). With a longer study period, nonsealed molars may need more restorations; however, percentages of teeth requiring reapplications of sealants may also increase with time, thus increasing overall costs of sealed molars (20-22). Because we were able to follow teeth for only 4 years and the number of at-risk teeth was low in the fourth interval, more studies with a longer follow-up period are needed to determine cost implications of sealants in later years. Furthermore, future studies should collect data on the opportunity cost of parents including transportation costs, wages lost, and baby-sitting costs that were not included in our study because such additional

Table 5
One-Way Sensitivity Analysis of Costs, Quality-Adjusted Tooth-Years (QATYs), and Discount Rates

Average yearly discounted Costs and QATYs of each group	Maxillary first permanent molars						Mandibular first permanent molars					
	Tooth #3			Tooth #14			Tooth #19			Tooth #30		
	Nonsealed	Sealed	ΔCost/ΔQATY	Nonsealed	Sealed	ΔCost/ΔQATY	Nonsealed	Sealed	ΔCost/ΔQATY	Nonsealed	Sealed	ΔCost/ΔQATY
Medicaid fees												
All	4.3	7.6	265.8	4.0	7.9	220.4	20.0	29.8	139.1	5.0	7.4	134.1
Preventive visits ≤	4.3	7.0	219.8	4.3	7.5	211.7	18.6	27.9	133.4	4.6	7.0	148.0
Preventive visits >	4.3	8.4	278.2	4.0	8.3	213.2	22.2	31.9	138.4	5.6	8.0	139.9
Change utilities												
All	0.9	0.9	549.5	0.9	0.9	229.2	3.7	3.8	225.2	0.9	0.9	283.2
Preventive visits ≤	0.9	1.0	318.0	0.9	0.9	219.4	3.7	3.8	199.7	0.9	0.9	247.0
Preventive visits >	0.9	0.9	1,020.7	0.9	0.9	222.6	3.6	3.8	238.8	0.9	0.9	263.8
0% discount rates												
All	N/A	N/A	457.8	N/A	N/A	239.1	N/A	N/A	196.3	N/A	N/A	217.0
Preventive visits ≤	N/A	N/A	272.0	N/A	N/A	205.6	N/A	N/A	171.9	N/A	N/A	214.8
Preventive visits >	N/A	N/A	585.8	N/A	N/A	233.0	N/A	N/A	211.0	N/A	N/A	233.0
5% discount rates												
All	N/A	N/A	535.5	N/A	N/A	223.1	N/A	N/A	222.8	N/A	N/A	209.4
Preventive visits ≤	N/A	N/A	312.8	N/A	N/A	214.0	N/A	N/A	234.0	N/A	N/A	222.0
Preventive visits >	N/A	N/A	493.3	N/A	N/A	216.3	N/A	N/A	234.0	N/A	N/A	222.0

NA, not applicable.

information is necessary to have a complete societal perspective.

Because this study is the first to use utilities to assess the cost utility of sealants, methods used to assess 4-year cost/QATY ratios can be used in future comparison of preventive regimens other than sealants, such as fluoride varnish, professional cleaning, and oral hygiene instruction, in preventing caries. However, a more important issue is understanding the societal willingness to pay for a QATY. This goes beyond the scope of this study. More research is required within dentistry (and the rest of health care) before policy makers can venture into a definitive cost per quality of life year gained.

The relatively low rate in which teeth received any treatment over the 4-year period (i.e., less than 20 percent of the nonsealed teeth received treatment) greatly affected the cost-effectiveness calculation of sealants in this population of continuously enrolled utilizers. As a result, it is more expensive to seal *all* first molars of children in the population than to selectively seal first molars of children with higher risk of caries. This finding is similar to other studies of cost-effectiveness of sealants (23,24), even though our study included all types of caries experience (as compared with studies that focused only on occlusal or occlusal-related caries) and used QATYs as the effectiveness measure, giving greater weight to sealed teeth. Had complete dental utilization data been available for all children enrolled in Medicaid who turned six during the study period (not just continuous utilizers), especially the intermittent or nonusers of dental services, the cost/QATY ratio would likely have been much lower.

These findings support the 1994 Workshop on Guidelines for Sealant Use (25), which recommended that, for each community, access to care, utilization of dental care, and likelihood of an individual receiving future dental care should be considered when assessing caries risk for prioritizing populations for sealant programs.

Even though the four first permanent molars are not independent from each other, it was more cost-effective (i.e., cost/QATY) to seal the mandibular first molars than the maxillary first molars. While it makes sense from a societal perspective to prioritize sealant programs toward lower-utilizing populations, it is less practical or cost-effective to only seal the maxillary first molars in a child that is in a dental chair (i.e., small marginal cost of sealing two more molars).

Most findings were robust to one-way sensitivity analyses, with mandibular teeth in low utilizers being the most cost-effective to seal after all parameters were adjusted. Reducing the cost of the dental services by using the Medicaid fee schedule did produce a substantial change in the effectiveness ratio; however, the ability to hold down costs with lower Medicaid reimbursement could adversely affect access to care by reducing dentists' participation in the program (26,27).

Use of Medicaid administrative data has some limitations for evaluating outcomes from dental sealants. For example, only 17 percent of all 6-year-old children eligible for the Iowa Medicaid program between 1996 and 1999 met our inclusion criteria. While this is a relatively small percentage of the potential population, using stringent criterion for inclusion was important to strengthen the assumption that the claims data included as much of the necessary treatment following examinations as possible for this population. While there was no measurable bias introduced by including only longer enrolled utilizers of services in this study, the limited number of variables for comparison allow only for cautious generalizability to the rest of the children enrolled in Iowa Medicaid at that time.

The database only includes submitted claims and does not include procedures that dentists did not submit for reimbursement. Overall, Iowa Medicaid claims and eligibility files provided sufficient information concerning subsequent treatment for teeth with and without sealants to evaluate the 4-year incremental cost/utility of sealed and nonsealed first permanent molars.

Given the limited resources available to most public health programs, these results support policies that target dental sealants to those in most need and are least likely to utilize other dental services. Outreach programs are very much needed to most cost-effectively deliver sealants to children. Sealants are effective in improving the health states of first permanent molars, yet come at a price. Sealing first permanent molars in low utilizers is the most cost-effective approach for prioritizing these resources.

References

1. Hicks MJ, Flaitz CM. Epidemiology of dental caries in the pediatric and adolescent population: a review of past and current trends. J Clin Pediatr Dent. 1993;18:43-9.
2. Siegal MD, Farquhar CL, Bouchard J-M. Sealants: who needs them? Public Health Rep. 1997;112:99-106.
3. Truman BI, Gooch BF, Sulemana I, Gift HC, Horowitz AM, Evans CA, Griffin SO, Carande-Kulis VG. Reviews of evidence on interventions to prevent dental caries, oral and pharyngeal cancers, and sports-related craniofacial injuries. Am J Prev Med. 2002;23(1S):21-54.
4. Werner CW, Pereira AC, Eklund SA. Cost-effectiveness study of a school-based sealant program. ASDC J Dent Child. 2000;67:93-7.
5. Weintraub JA, Stearns SC, Burt BA, Beltran E, Eklund SA. A retrospective analysis of the cost-effective of dental sealants in a children's health center. Soc Sci Med. 1993;36:1483-93.
6. Kuthy RA, Branch LG, Clive JM. First permanent molar restoration differences between those with and without dental sealants. J Dent Educ. 1990;54:653-60.
7. Fyffe HE, Kay EJ. Assessment of dental health state utilities. Community Dent Oral Epidemiol. 1992;20:269-73.
8. Allister JH, Spencer AJ. Judgements on oral health outcomes by the general public. IADR (ANZ Division) 33rd annual meeting. J Dent Res. 1993;73:741:(# 33).
9. Lewis JM. Improving dental health status indicators for evaluation. Community Dent Oral Epidemiol. 1996;24:32-6.
10. Niessen LC, Douglass CW. Theoretical considerations in applying benefit-cost and cost-effectiveness analyses to preventive dental programs. J Public Health Dent. 1984;44:156-68.
11. Forbes JF, Donaldson C. Economic appraisal of preventive dental techniques. Community Dent Oral Epidemiol. 1987;15:63-6.
12. Donaldson C. Economic evaluation in dentistry: an ethical imperative? Dent Update. 1996;25:260-4.
13. Deery C. The economic evaluation of pit and fissure sealants. Int J Pediatric Dent. 1999;9:235-41.
14. Birch S. Measuring dental health: Improvements on the DMF index. Community Dent Oral Epidemiol. 1986;3:303-11.
15. Lawless JF. Statistical models and methods for life-time data. New York: John Wiley & Sons, Inc.; 1982.
16. Hosmer DW, Lemeshow S. Applied survival analysis: regression modeling of time to event data. New York: John Wiley & Sons, Inc.; 1998.
17. Gold MR, Siegal JE, Russell LB, Weinstein MC. Cost-effectiveness in health and medicine. New York: Oxford University Press; 1996.
18. Petitti DB. Meta-analysis, decision analysis, and cost-effectiveness analysis: methods for quantitative synthesis in medicine. New York: Oxford University Press; 1994.
19. Butler MA, Beale CL. Rural-urban continuum codes for metro and nonmetro counties. Washington (DC): Agriculture and Rural Economy Division, Economic Research Service, U.S. Department of Agriculture; 1993. Staff Report No. AGES 9425.
20. Weintraub JA. The effectiveness of pit and fissure sealants. J Public Health Dent. 1989;49(Spec Iss):317-30.
21. Ripa LW. Sealants revisited: an update of the effectiveness of pit- and fissure sealants. Caries Res. 1993;27(Suppl 1):77-82.
22. Simonsen RJ. Pit and fissure sealant: review of the literature. Pediatr Dent. 2002;24:393-413.
23. Weintraub JA, Stearns SC, Rozier RG, Huang C-C. Treatment outcomes and costs of dental sealants among children enrolled in Medicaid. Am J Public Health. 2001;91:1877-81.
24. Griffin SO, Griffin PM, Gooch BF, Barker LK. Comparing the costs of three sealant delivery strategies. J Dent Res. 2002;81:641-5.
25. Workshop of guidelines for sealants use: recommendations. J Public Health Dent. 1995;55(Spec Iss):263-73.
26. Damiano PC, Momany ET. Factors affecting dentists' participation in Medicaid and the impact on access to care. J Dent Res 1993;72(Spec):172:(# 548).
27. Burt BA, Eklund SA. Dentistry, dental practice, and the community. 6th ed. Philadelphia (PA): WB Saunders; 2005.