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Increasing value, reducing waste: tailoring the application of dental sealants according to individual caries risk

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Abstract

Objectives: Despite a significant national investment in oral health, there is little understanding of the return in terms of quality. Value-based payments aim to refocus provider reimbursement based on the value created to the patient. Our objectives were to apply a set of dental quality measures to help determine the value of preventive dental care provided to children at two academic dental school clinics.

Methods: We queried the institutional electronic health records (EHRs) for patients between the ages of 6–14 years with sealable first or second permanent molars, determined caries risk status, identified if dental sealants were placed, and finally if the teeth showed evidence of new caries experience. In order to determine the cost-effectiveness of EHR-based triage of applying dental sealants, we calculated the incremental cost-effectiveness ratio (ICER) for the dental quality measures supported sealing program.

Results: Between the two academic sites, there were 6,155 unique children for a total of 12,302 eligible teeth without a sealant and 32,811 eligible teeth with a sealant. Teeth without a sealant were more likely to have decay (4.8 percent) than those with a sealant (1.7 percent). At both sites,

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patients with high caries risk were more likely to benefit from sealants compared to those patients with low risk.

Conclusion: Implementation of caries risk stratified fissure sealant quality measures demonstrates the potential for extracting better value in oral health care.

Keywords

quality; dental quality measures (DQMs); value; low-value Care; dentistry; EHR; caries; caries risk assessment; preventive dentistry

Introduction

Quality of care in dentistry can be defined as "an iterative process involving dental professionals, patients and other stakeholders to develop and maintain goals and measures to achieve optimal health outcomes."[1] Therefore, standardized and reproducible measures should be an indispensable part of clinical practice. As patients demand increased quality, safety and transparency, dentists have increasingly been more motivated to undertake efforts to meaningfully assess and improve the quality of care they provide to their patients.[1] Payors are struggling to implement quality measures in a fee for service world. Over the years, dentists have adopted three approaches to ascertain clinical quality: direct observation of patient care by a trained observer, chart review, and quality metrics.[2] Direct observation and chart review are inherently prone to subjectivity and are intensely time consuming; in contrast, the implementation of dental quality measures (DQMs) introduces a universal and more objective methodology that allows for analysis of all patient records. Currently, most DQMs are mainly procedure-based process measures and as such are not suitable for measuring if the preferred oral health outcomes (e.g., caries-free mouth) have been achieved.[3]

Oral health remains a significant burden in the United States, and a great deal of attention has been focused on the use of dental sealants. Going back to 1976, when sealants were approved as safe and effective in preventing pit and fissure caries lesions,[4] specific objectives have been in place for providing sealants to children.[5] Early on, Healthy People 2000 and 2010 objectives[6, 7] advocated a 50 percent prevalence of sealants on at least one permanent molar by the age of 14 years. However, reaching this goal remains elusive,[8] further illustrated by the fact that Healthy People 2020 set the target for sealant placements for adolescents age 6–9 years to 28.1 percent and 21.9 percent for children aged 13–15 years.[9] In efforts to spur improvement, entities such as the Dental Quality Alliance[10] and Oregon Health Authority[11] have developed DQMs to help assess how well sealants are placed in children. These measures rely on claims data. In our prior work, we have demonstrated that these traditional measures often underestimate sealant placement[12] and can be enhanced by using the rich data now available in dental electronic health records (EHRs).[13] Armed with these data, we now have the ability to accurately determine the caries risk status of patients, identify if teeth are eligible for sealants, and measure the effectiveness of the sealant in preventing future decay.

Value-based care refocuses the reimbursement to the provider, based on the value created to the patient rather than by the procedures performed.[14] Low-value health care can be defined as care that is unnecessary and provide no benefits to the patient.[15] Examples include cervical cancer screening for a woman younger than age 21, cardiac screening for low-risk asymptomatic patients, or PSA-based screening for prostate cancer in all men regardless of age.[16] Low-value care may even harm the patient and may lead to overtreatment and unnecessary testing.[15] Up to $26.8 billion could be saved annually if measures were taken to address overtreatment and low-value care in medicine.[17] Current payment incentives typically reward more services regardless of the value they create for the patient.[16] Although similar research is not available for the dental profession, we can extrapolate that low-value care exists in dental care simply from the fact that dentistry, even more than medicine, operates mainly as a fee-for-service model. Examples of low-value care in dentistry may include sealants for patients who are assessed at low risk for caries, or the prophylactic removal of third molars.

In this article, we explore how to apply caries-related process and outcome-based DQMs, designed for use in EHRs, to determine the value for money of dental sealants according to individual caries risk status.

Methods

Our research team applied three EHR-based quality measures to assess a) caries risk status, b) provision of sealants on sealable teeth, and c) caries outcome as defined as incidence of new decay. These measures were implemented by running database queries in the EHR at two dental schools. Each institution belongs to the Consortium for Oral Health Research and Informatics (COHRI),[18] uses the axiUm EHR platform (Exan Corp, Coquitlam, BC, Canada) and the SNODDS[19] dental diagnostic terminology, and obtained Institutional Review Board (IRB) approval.

Identifying caries risk status

Caries risk status is documented in three places within the dental EHR. Caries risk status was reported with each exam. The status was based on the patient's most recent caries risk recorded at least 30 days prior to the exam and in one of the following three places: a) SNODDS diagnosis of caries risk; b) CDT Dental Procedure codes D0601 (caries risk low), D0602 (caries risk moderate), or D0603 (caries risk high or extreme); or c) caries risk assessment (CRA) form. In the cases where a patient received more than one type of CRA on the same date, the CRA was taken in the prioritized order of items 1–3 above. The CRA form used was the evidenced based, validated, caries risk assessment tool developed at UCSF, providing clinic decision support for providers.[20–23] The caries risk was the risk level determined (selected) by the provider as low, moderate, high, or extreme for SNODDS diagnosis, CDT dental procedure code or use of the CRA form.

Identifying the placement of sealants

We applied our previously developed EHR-based sealant measure in order to determine the rate of sealant placement among sealable teeth.[13] A sealable tooth was defined as "permanent molars eligible for sealant treatment, thereby excluding teeth that were either unerupted, carious, restored, or previously sealed from our evaluation."[13] A sealant was identified using the CDT Dental Procedure Code D1351.

Identifying incidence of new decay

For each tooth, new caries experience was identified as a tooth previously recorded as sound (erupted adult tooth with no prior caries or restorations) at the last examination, that is now diagnosed with active and cavitated decay (D), has been filled (F), or was extracted (M) due to decay.

Study population—The study population consisted of patients between the ages of 6 and 14 years who were treated within the dental care clinics of two US dental schools. During the period from January 1, 2016 until December 31, 2018, a retrospective extract of data was obtained from each site's dental EHR. For inclusion, a first or second molar had to be present and had not previously sealed or treated. The data collected included: exam dates, age, gender, race, primary language spoken at home, zip code, per tooth sealant status on either a first or second molar, per tooth decay status, and caries risk. The inclusion criteria for our measure denominator included children aged 6–14 years who had either a completed D0120 (periodic oral evaluation) or D0150 (comprehensive oral evaluation) with at least one or more sealable tooth/teeth on the date of the exam. The age criteria for our study population were applied as of the date of the exam. Each patient in our sample data had two exams. The first exam was scripted to be between 3 and 36 months prior to the second exam. As a result, all second exams (T1 exams) occurred within the given time period from January 1, 2016 to December 31, 2018. The measure took a retrospective look to see whether there had been any change in decay since the initial visit. The subsequent analysis was conducted at the tooth level rather than at the patient level. We compared all sealed versus non-sealed sealable teeth, comparing the levels of new decay in each set.

Due to the retrospective nature of the data, the information needed for dental quality indicators had been already been collected (in the process of routine care) through the EHR and was available for analysis. Since all the participating institutions were axiUm EHR users, the Structured Query Language (SQL) script was developed for both sites. Cost of sealant placement per tooth was also ascertained through the National Dental Advisory Service (NDAS) fee report for Sealants (D1351 procedure). The currency used for the incremental cost-effectiveness ratio (ICER) was the United States Dollar ($USD). The fees for sealants were set at $70.00 USD which represented the 70th percentile (middle of the range from 40th to 95th percentile) of fees for sealants in 2020. The amount was based on the NDAS 2020 Comprehensive Fee Report,[24] which is a nationwide marketplace analysis that consisting of confidential fee surveys and augmented by national claims data.

Statistical analysis and analytical methods

Our analysis used three methods: a) using two-sample test of proportions analysis, we determined the difference in decay among those who were sealed and those who were not for each caries risk category. The assumptions of its use are that that each population follows a binomial distribution, observations are independent, and both $np > 10$ and $n(1-p) > 10$. b) A generalized linear model for count data was used to assess the multivariate relationship between dental decay and patient factors such as age, gender, race, caries risk, and number sealants placed. The key assumption for its use is that the new decay outcome follows a Poisson distribution. c) We calculated a stratified incremental cost-effectiveness ratio for each category of caries risk. Descriptive statistics were calculated for all patient characteristics. For categorical variables, frequencies and percent contributions were reported and for numeric/continuous variables, mean and standard deviations were reported. All patient characteristics, sealant treatments, and dental decay were extracted from the dental EHR data pulls. In order to estimate the univariate differences in the percentage of decayed teeth between those who had sealed teeth versus those who did not was assessed using the independent sample z-test for proportions. A zero-inflated generalized linear model for count data (negative binomial) was developed to assess multivariate associations with decay and all relevant patient characteristics. The model adjusted for age, gender, race/ethnicity, urban or rural status, the time between visits, caries risk, and number of teeth with and without sealants. The average cost of sealed was calculated by average number of sealants per exam (*) average cost per sealant. All tests were conducted at the standard significance level (0.05) and analyses were performed using Stata statistical software and R Project for Statistical Computing.[25, 26] Further, the results of the cost-effectiveness analysis were reported in accordance with the Consolidated Health Economic Evaluation Reporting Standards Statement (CHEERS).[27]

Approach for economic evaluation

The cost-effectiveness of DQM-supported versus non-DQM-supported application of dental sealants was modeled from the perspective of a societal decision maker and applying a 3-year time-horizon. The reporting of this part of the study leans on the CHEERS statement.[27] In order to determine the cost-effectiveness of the EHR-based sealant measure, we calculated the incremental cost-effectiveness ratio (ICER) for sealing versus not sealing. Thereby, it was distinguished between onset of new decay between ordinal categories of caries risk (low, moderate, and high). Sealants are indicated for retentive pits and fissures likely to become carious. In addition, caries risk status is a key factor in the determination of whether a sealant is eventually placed. To this end, establishing the cost effectiveness of sealant placement relative to the caries risk level would allow for more targeted interventions. Both the costs and health benefits were evaluated over the period from January 1, 2016 until December 31, 2018. This represents a window relevant to the gestation of decay.[28, 29] The health outcome of specific interest is the proportion of eligible teeth with dental decay among those patients who have been sealed (PR(Dental Decay | Sealed)) and those who have not (PR(Dental Decay | Un-Sealed)) at each given risk level. In the calculation of the ICER, the denominator will represent the risk difference (PR(Dental Decay | Sealed) - PR(Dental Decay | Un-Sealed)). Given that this part of the study was aimed at demonstrating the proof-of-principle of DQM-based sealant triage representing good value for money, the application of discount rates and sensitivity analyses was not used.

Results

Patient characteristics

Between the two academic sites, there was 6,155 unique children. The average age was 9.6 years (SD = 2.4) and 52.9 percent were male and 47.1 percent were female. Hispanic (30.1 percent) was the most frequently reported racial category and "non-Hispanic" (29.1 percent) was the most frequently cited ethnicity. The most frequently reported primary language spoken at home was English (63.8 percent) followed by Spanish (22.3 percent). The plurality of child patients reported home residences that were categorized as considered urban (91.5 percent) according to the RUCA code (See Table 1).

Tooth characteristics

There was a total of 12,302 eligible teeth without a sealant and 32,811 eligible teeth with a sealant between the two sites. Among those, there were 594 decayed teeth without a sealant (4.8 percent) and 555 decayed teeth without a sealant (1.7 percent) (Risk Difference = 3.14 percent; z-test = −18.8; *P*-value <0.0001). Table 2 shows the percentages of decayed teeth in the sealed group and the unsealed group by caries risk assessment categories. There are significant differences in the percentages of teeth with new decay between those with and without sealants at all elevated risk levels.

Table 3 shows a multivariate, generalized linear model for count data modeling the rate/risk ratio of dental decay over the 3-year study period. The frequency of eligible patients without a sealant was associated with a 69 percent increased risk of decay (IRR = 1.69, 95% CI = 1.03–2.77). Similarly, the frequency of eligible patients with a sealant was associated with a 45 percent decreased risk of decay (IRR = 0.55, 95% CI = 0.35–0.85). Higher lengths of time between appointments, elevated caries risk, older ages, male gender, and primary language spoken at home "other" were all significantly associated with increased risk of dental decay (*P*-values < 0.05). Race and rural–urban status were not associated with increased risk of dental decay in our cohort (Table 3).

Cost-effectiveness

There were 2,329 teeth sealed and categorized as "low risk." The cost per sealant, per tooth within the two sites during the study period was $70.00/per tooth/ per sealant (average cost per sealant based on private insurer). As reported in Table 2, there is no statistically significant difference in the risk of dental decay for those low risk patients who have had a sealant placed versus those who did not. This result represents a low-value care scenario where the introduction of sealants to a low-risk population has no statistical impact on dental decay among those that have been sealed. Had this sub-group of teeth not been sealed, there would be a total cost savings for patients of $163,030 and a savings of ~365 hours of provider time over the 3-year time horizon.

Alternatively, there were 26,262 teeth sealed and categorized as "Elevated risk" which consists of caries risk categories "moderate," "high," and "extreme." The cost per sealant placed, per tooth was $70.00/per tooth/per sealant. There was a significant difference in decay between sealed and unsealed teeth for each elevated category. The total cost of the sealants placed in the elevated risk categories is $1,838,340 over the three-year time horizon.

The incremental cost-effectiveness ratio was calculated to illustrate the value proposition for sealants among patients age 6–14 with low and elevated risk teeth. Table 4 shows the ICER for each risk level. The ICER for placing sealants in “Low” caries risk persons is $413,870.47/per percent of decay averted per exam over a 1-year time horizon. That means a societal decision maker would need to be willing to invest more than a hypothetical $400 k per exam to avert 1 percent of caries over a year. On the other hand, the ICER for placing sealants in “elevated” caries risk persons is −$1,452.14/per percent of decay averted per exam over a 1-year time horizon. This means that a societal decision maker would gain more than a hypothetical ~$1,500 per exam due to averting 1 percent of caries per year. Qualitatively similar results were obtained when ICERS were calculated per tooth instead of per exam.

Discussion

Our results at two dental school clinic practices suggest that the placement of sealants in patients who are assessed as low caries risk is not cost-efficient because it would not prevent more caries while the placement of sealants implies unnecessary treatment costs (i.e., waste of resources). Correctly executed sealants that are fully retained prevent caries and in turn will likely help to reduce cost to the patient and/or the health care system as a more expensive restoration is avoided.[5] However, improper techniques may damage tooth structure and compromise retention where improper patient/tooth selection misuses limited resources.[30, 31] Hence, in an effort to address low-value care in dental practice, the dental community may consider moving from an indiscriminately public health approach of “sealing every available tooth” to only “sealing teeth that are assessed as high caries-risk.” Applying risk adjustment in DQMs is hence relevant and appropriate.[12, 32]

Our study is an initial attempt to demonstrate how a set of dental quality measures (DQMs) may be used by individual dental practices to determine the value for money for preventive sealant programs. We acknowledge that it is not completely accurate to compare the cost of a sealant with the cost of a restoration as not all unsealed teeth are certain to become carious.[33] Our analysis was also conducted at the tooth level rather than at the patient level. Additionally, the comparison does also not take into account the amount of suffering the carious lesion may cause or the potential for further pain and care over the lifetime of the patient and tooth. However, the fact remains that sealants have proven to be cost-effective and do prevent caries. Our study was also limited by the time period of the study. Moreover, the incremental cost-effectiveness ratios for sealants have proven to become more favorable in the tenth and eleventh year after application, thus emphasizing the importance of preventive dental care for high caries risk patients.[34] However, providing sealants to low-caries patients or teeth that are not prone to caries decreases the cost-effectiveness and cost-savings of sealant placements,[35] and hence would be considered low-value health care.

Strategies to reduce low-value care include awareness campaigns for both the patient and provider; implementation of clinical decision tools and quality improvement measures; and involving the patient in informed decision making.[15] Now rich data are available through EHRs, payers may reimburse based on an accurate assessment for elevated caries risk. Combining health promotion, health education, health literacy, and disease prevention (appropriate placement of sealants, caries risk assessments) are needed to advance the general understanding of the public how to improve their oral health.[33] The use of clinical decision support (CDS) is a rather sophisticated health IT component and can "significantly impact improvements in quality, safety, efficiency, and effectiveness of health care."[36] When intelligently filtered or presented at appropriate times, CDS can provide the dental team with knowledge and person-specific information to improve oral health care.[36] CDS tools can warn the dental care team of potential problems, or provide suggestions for the clinical team and patient to consider,[37] that is, placing sealants when the caries risk assessment comes back as high. Lastly, increasing the involvement of patients in their oral care is part of patient-centered care, which has proven to improve quality and safety.[38]

Moving the dental providers to confront low-value care will take a significant change of the established culture. The current fee-for-service (FFS) reimbursement system incentivizes doing more procedures. Value base payment (VBP) on the other hand, rewards disease prevention, health promotion, and improving population health, as such turning the focus on results rather than services.[39] VBP can take on several forms, including a) FFS with a link to a value model, in which there is some payment tied to performance, reporting, or care management; b) FFS where some payment is linked to managing a segment of the population with respect to both cost and quality, in which the savings are shared upside only or upside and downside; and c) Prospective payment model where there is no link to volume and the provider is paid in advance with a fixed fee to provide a defined set of dental services. These services may include specific services (sub capitation), certain episodes of care, for example, new patient visits and risk assessment for a population, or integrated delivery system capitation (per patient per month payment linked to specific services and quality metrics). Quality pays a pivotal role in VBP as specific quality metrics need to be met in order to receive the full incentive payment.[39]

When considering the value of preventive dental services, it is also important to reflect upon the present state of oral healthcare. The COVID-19 pandemic has impacted the dental community significantly. The pandemic will likely create a perfect storm with vulnerable people, who have lost their job and health/dental insurance turning to Medicaid/CHIP for dental benefits and stretching an already over-burdened provider network. This may in turn create the real possibility that actual benefits may be cut, and hence increasing their risk for not receiving preventive dental services including sealants to prevent dental caries. Now is indeed the time to generate evidence to help extract the most value for patients from the limited resources in the dental public health safety net. Policy makers are also urged to maintain dental benefits and to genuinely campaign to add dental providers to the Medicaid/CHIP safety net to assure that the most vulnerable of our population receive preventive oral health services. Our study highlights the suitability of using data available in the EHR for measuring and helping to extract better value in oral health care.

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TABLE 1

Characteristics of Patients

	UCSF (*N* = 3,495)		UTH (*N* = 2,660)		Total (6,155)	
	Frequency	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Gender						
Male	1,857	53.1%	1,398	52.6%	3,255	52.9%
Female	1,637	46.8%	1,260	47.4%	2,897	47.1%
Trans. (T)	1	0.0%			1	0.0%
Other (O)	0	0.0%	2	0.1%	2	0.0%
Blank/unknown	0	0.0%	0	0.0%	0	0.0%
Age	AVG. = 9.4	SD = 2.4	AVG. = 9.9	SD = 2.4	AVG. = 9.6	SD = 2.4
Race						
White	375	10.7%	396	14.9%	771	12.5%
Asian	813	23.3%	56	2.1%	869	14.1%
African-American/Black	312	8.9%	395	14.8%	707	11.5%
Hispanic or Latino	874	25.0%	1,004	37.7%	1878	30.5%
Native Hawaiian or Pacific Islander	10	0.3%	3	0.1%	13	0.2%
More than one race provided	230	6.6%	78	2.9%	308	5.0%
Other	224	6.4%	14	0.5%	238	3.9%
Unknown/blank	657	18.8%	714	26.8%	1,371	22.3%
Ethnicity						
Non-Hispanic or Non-Latino	1784	51.0%	101	3.8%	1885	30.6%
Hispanic or Latino	1,067	30.5%	679	25.5%	1746	28.4%
Unknown/blank	644	18.4%	1880	70.7%	2,524	41.0%
Primary language spoken at home						
English	2,488	71.2%	1,437	54.0%	3,925	63.8%
Spanish	641	18.3%	730	27.4%	1,371	22.3%
Chinese (Chinese, Cantonese, Mandarin)	195	5.6%	2	0.1%	197	3.2%
Other	133	3.8%	1	0.0%	134	2.2%
Unknown/blank	38	1.1%	490	18.4%	528	8.6%
Rural urban status						

	UCSF (*N* = 3,495)		UTH (*N* = 2,660)		Total (6,155)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Rural	363	10.4%	159	6.0%	522	8.5%
Urban	3,132	89.6%	2,501	94.0%	5,633	91.5%
Length of time between appt 1 and 2	AVG. = 267.2	SD = 142.9	AVG. = 284.2	SD = 155.0	AVG. = 274.2	SD = 148.3
Caries risk status (by number of exams)						
Low	365	4.3%	429	7.2%	794	5.5%
Moderate	1,119	13.2%	1,557	26.2%	2,676	18.6%
High	5,687	67.1%	3,017	50.7%	8,704	60.4%
Unknown/blank	1,299	15.3%	948	15.9%	2,247	15.6%
Sealants placed						
Yes	19,745	71.5%	13,066	74.7%	32,811	72.7%
No	7,868	28.5%	4,434	25.3%	12,302	27.3%

TABLE 2

Difference in Risk of New Decay Among Those With and Without Sealants

	Total	**CRA low**	**CRA elevated (Mod/High/Ext)**
Number of eligible teeth with sealant	32,811	2,329	26,262
Number of teeth with decay	555	22	456
% of teeth with decay	1.69%	0.94%	1.74%
Number of eligible teeth without sealant	12,302	862	8,651
Number of teeth with decay	594	8	471
% of teeth with decay	4.83%	0.93%	5.44%
Difference in decay (RD: w/sealant minus w/o sealant)	−3.14%	0.02%	−3.71%
z-test	−18.83	0.043	−18.61
P-value	<0.0001	0.9657	<0.0001

TABLE 3

Regression Analysis Modeling the Risk of New Dental Decay

Length of time between appt. 1 and 2	IRR 1.0016	Std. Err. 0.0003	z 5.8300	*P*-value <0.0001	95% Conf. Int. 1.0011	1.0021
Caries risk status (by number of exams)						
Low	–	–	–	–	–	–
Elevated	2.2119	0.8853	1.9800	0.0470	1.0094	4.8468
Age at time 1	1.1096	0.0210	5.4800	<0.0001	1.0691	1.1515
Gender						
Male	–	–	–	–	–	–
Female	1.2643	0.1107	2.6800	0.0070	1.0650	1.5010
Race/ethnicity						
White	–	–	–	–	–	–
Asian	0.7642	0.1251	−1.6400	0.1010	0.5545	1.0534
African American/Black	1.4218	0.2233	2.2400	0.0250	1.0451	1.9343
Hispanic	1.0123	0.1425	0.0900	0.9310	0.7681	1.3340
Other	1.1438	0.2586	0.5900	0.5520	0.7344	1.7815
More than one race selected	0.6772	0.1530	−1.7300	0.0840	0.4350	1.0545
Primary language spoken at home						
English	–	–	–	–	–	–
Spanish	0.9190	0.1119	−0.6900	0.4880	0.7239	1.1666
Other	1.4370	0.2640	1.9700	0.0480	1.0026	2.0597
Rural urban status						
Urban	–	–	–	–	–	–
Rural	0.9436	0.1630	−0.3400	0.7370	0.6726	1.3237
Number of eligible teeth W/O sealant						
No	–	–	–	–	–	–
Yes	1.6957	0.4287	2.0900	0.0370	1.0331	2.7832
Number of eligible teeth with sealant						
No	–	–	–	–	–	–
Yes	0.5487	0.0093	−7.1600	0.0080	0.3521	0.8548

TABLE 4

ICER Comparison by Caries Risk

	Overall	**CRA low**	**CRA elevated**
Average number of sealants placed/per exam	2.28	2.93	2.31
ICER sealants/exam/per year	−$1,692.56	$413,870.47	−$1,452.14
Average number of sealants placed/per tooth	0.73	0.73	0.75
ICER sealants/per tooth/per year	−$541.05	$102,981.25	−$473.33