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Assessing the validity of existing dental sealant quality measures

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Abstract

Background.—Although sealants are highly effective in preventing caries in children, placement rates continue to be low. The authors' goals were to implement and assess the performance of 2 existing sealant quality measures against a manual audit of charts at 4 dental institutions and to identify measurement gaps that may be filled by using data from electronic health records.

Methods.—The authors evaluated the performance of 2 quality measures designed for claims-based data: the Dental Quality Alliance (DQA) sealant measure, which includes patients at risk of developing elevated caries, and the Oregon Health Authority (OHA) sealant measure (irrespective of caries risk). The authors adapted and validated these measures at 4 sites: 3 dental schools and 1 large dental accountable care organization.

Results.—The overall modified DQA and modified OHA measure scores in the 6- through 9-year-old age group were 37.0% and 31.6% and in the 10- through 14-year-old age group were 15.8% and 6.6%, respectively. Results from the manual review of charts showed that 67.6% of children who did not receive sealants did not have any teeth to seal because their molars had not yet erupted, had been extracted, had been sealed previously, or had existing caries or restorations.

Conclusions.—Both the DQA and OHA measures, which rely mainly on Current Dental Terminology procedure codes, led to underestimation of the care delivered from a practice perspective. Future sealant quality measures should exclude patients whose teeth cannot be sealed.

Practical Implications.—This study's results support the suitability of using electronic health record data for assessing the quality of oral health care, particularly for measuring sealant placement in children.

Keywords

Dental sealants; oral health; quality of care; caries risk assessment; caries

Caries is one of the most common oral diseases worldwide.[1,2] Caries development occurs in all races and age groups, and the disease affects 60% to 90% of school children and most adults in industrialized countries.[3] Despite established preventive and treatment strategies, caries continues to be a major public health problem producing substantial pain and distress.[4] Up to 90% of carious lesions are found in the pits and fissures of permanent posterior teeth, and, not surprisingly, occlusal surfaces of permanent teeth are 5 times more likely to have caries than are approximal surfaces.[5–9] According to the results of several studies, placement of dental sealants is highly effective in preventing the disease.[5,9–16] Although the placement of dental sealants is improving, actual sealant prevalence rates continue to be low.[17] Results from the 2010 National Health and Nutrition Examination Survey oral health survey[18] show that 32% of 6- through 9-year-olds and 51% of 13- through 15-year-olds had at least 1 sealant placed; caries development risk levels for patients without sealants were not reported, so it is difficult to determine the appropriateness of care from this survey.

National and state agencies have set quality goals to increase sealant placement.[19–21] For example, the Healthy People 2020 objectives[22] are aimed at achieving an increase in sealant placement from 25.5% to 28.1% for 6- through 9-year-old children and from 19.9% to 21.9% for 13- through 15-year-old adolescents. To track progress quantitatively toward these goals, investigators have developed and evaluated clinical quality measures that mainly rely on insurance claims data submitted to government or private payers.[23,24] Although numerous sealant quality measures exist, there are differences in the definitions and specifications of each measure.[25,26] For example, the Oregon Health Authority (OHA) measures define the specifications to evaluate sealants placed on any permanent molar in children aged 6 through 9 years and 10 through 14 years who are enrolled in Medicaid.[27] In contrast, the Dental Quality Alliance (DQA) measure evaluates sealants placed only on permanent first molars for 6- through 9-year-olds and on permanent second molars for 10- through 14-year-olds.[28,29] Moreover, the DQA established that the denominator of the sealants preventive care measure should include only children at moderate or high risk of developing caries. In 2015, Herndon and colleagues[24] validated DQA measures by using administrative claims data from the Florida and Texas Medicaid programs, the Children's Health Insurance Program, and a national dental benefits administrator. They found that rates of sealant placement for 6– 9-year-old children at elevated caries development risk ranged from 21.0% to 31.3%, whereas rates of sealant placement for 10- through 14-year-olds were lower (8.4%−11.1%).

Although administrative claims data are readily available, computer readable, and inexpensive to acquire, they may lack the clinical content necessary to assess accurately the quality of oral health care delivered at a practice level.[23] Measures derived from electronic health records (EHRs) incorporate richer information, such as clinical findings, diagnoses, medical and dental histories, medications, patient complications, severity of illness, and interactions with other aspects of the health care system.[30,31] Recognizing the potential of EHRs to improve quality measurements, the Centers for Medicare & Medicaid Services has offered eligible providers financial incentives for showing meaningful use of EHRs and reporting on the quality of care. This incentive comes in the form of the American Recovery and Reinvestment Act of 2009, which authorized $19 billion in funding for the deployment

and meaningful use of EHRs and introduced a national framework for the adoption of health information technology.[32]

The DQA also has expressed interest in reporting clinical quality measures by using EHR data and has proposed the adaptation of its starter set of pediatric oral health measures (administrative and claims data) to e-measures.[33] Unlike claims-based measures that involved using Current Dental Terminology (CDT) procedure codes,[34] the proposed DQA e-measure logic relies on the Systematized Nomenclature of Dentistry and Systematized Nomenclature of Medicine to capture sealant treatment and caries risk levels. Results from a study in which the investigators tested 2 pediatric oral health care electronic quality measures by using synthetic data showed the feasibility of EHR-based measures despite the challenges of infrastructure standards, achieving interoperability, access to unstructured data, and variability in how data are captured in different EHRs.[35] Our goals were to use 2 existing claims-based sealant quality measures from the OHA and DQA and determine how well the measures performed compared with a manual audit of charts at 4 institutions and to identify measurement gaps in the 2 claims-based measures that may be filled by using additional data available in EHRs.

METHODS

We evaluated sealant placement in children as defined by the DQA (with elevated caries risk) and OHA (irrespective of risk) quality measures.[27–29] After receiving institutional review board approval, we implemented the measures at 4 sites: 3 US dental schools and 1 large dental accountable care organization, with 54 dental offices, dispersed across the Pacific Northwest. All 4 sites used the EHR from axiUm (Exan). Investigators originally used the DQA and OHA measures to assess the prevalence of sealant placement on permanent molars in children aged 6 through 9 years and 10 through 14 years by using administrative claims data. These measures were designed for use at a program or system level rather than at the practice level. After reviewing the original measures, we identified the corresponding data points recorded within the EHR to construct the adapted EHR measures in this study.

Specifications for the modified DQA measure

We defined each measure according to 2 components: the denominator and the numerator. For the denominator (modified DQA), we included unduplicated patients aged 6 through 9 years and 10 through 14 years, as of the last day of the reporting year (December 31, 2014), who had elevated caries risk and who had received at least 1 dental-related procedure code as identified by using CDT codes D0100 through D9999 during the 2014 reporting year. We used the original DQA measure to assess elevated caries risk by checking whether the patient had received either of the following:

- CDT visit codes of D0602 (caries risk assessment and documentation, with a finding of moderate risk) or D0603 (caries risk assessment and documentation, with a finding of high risk) during the reporting year;
- any 1 of the service codes listed in the Appendix (available online at the end of this article) during or 3 years before the reporting year.

We used the same approach, as described, at each institution to assess elevated caries risk. We did not include patients who did not meet the elevated caries risk criteria (that is, who had low risk of developing caries) in the denominator. In our modified measure, we substituted the requirement of 180 days of continuous enrollment criteria of the DQA measure with the requirement of at least 1 dental-related procedure code during the reporting year, and we retained the original DQA method for assessing elevated caries risk. For the numerator (modified DQA), we included unduplicated patients, as identified by using the query, from the denominator populations aged 6 through 9 years and 10 through 14 years who received a sealant (D1351) on a permanent first or second molar, respectively.

Specifications for the modified OHA measure

For the denominator (modified OHA), we included unduplicated patients aged 6 through 9 and 10 through 14 years, as of the last day of the reporting year (December 31, 2014) who had received at least 1 dental-related procedure code as identified by using CDT codes D0100 through D9999 recorded in the EHR. We substituted the requirement of 45 days of continuous enrollment of the OHA measure with the requirement of at least 1 dental-related procedure code during the reporting year. We also stratified the broad age range of 6 through 14 years in the original measure into 2 separate age groups: 6 through 9 years and 10 through 14 years. The OHA measure did not consider elevated risk of developing caries. Therefore, we included all eligible patients, regardless of risk, in the denominator from all 4 institutions.

For the numerator (modified OHA), we included all unduplicated patients aged 6 through 9 years and 10 through 14 years in the denominator population who received a sealant (D1351) on a permanent molar. For the 10- through 14-year-old age group, to make the modified OHA measure comparable with the DQA measure, we included only patients who had received a sealant on a permanent second molar.

Assessing validity

We used the following approach to determine the validity of both quality measures compared with a manual review of charts.

Step 1: Generating the Sample Frame by Using the EHR—Because all the participating institutions were axiUm EHR users, we developed a Structured Query Language script for all sites. We used the Structured Query Language queries to identify patients eligible for both the measures by using a prespecified set of CDT[34] codes. For each site, we calculated the proportion of patients who had received a sealant by using the query for both the modified DQA and OHA measures. This proportion was the outcome of interest and represented the underlying prevalence of sealant placement for each site for each of the measures.

Step 2: Estimation of Sample Size for Manual Chart Reviews—There were 4 sites, 2 measures, and 2 age categories, which required 16 separate sample size calculations. Given a queried population for the specific measure, site, and age group, we calculated the measure score and gave it the designation p. For a calculated measure score p given by the

queried population, with a margin of error (precision) of 0.05 ($d = 0.05$), a standard significance level of .05 ($\alpha = .05$), and a normal curve with a 2-tailed cutoff of 1.96 ($z = 1.96$), we estimated the sample size required for manual review for each measure according to site and age group for a total of 3,373.[37]

Step 3: Validation of the Automated Query—A manual audit of charts served as the reference standard to assess the validity of the automated query. Two reviewers from each site (S.K, S.B, O.T, J.W, E.O, J.E, J.M) trained in using the axiUm EHR and quality measures research conducted manual chart reviews at each site by using the predefined criteria for the numerator and the denominator as a guide. In the manual review, we determined whether any of the erupted permanent molars had received a sealant. We calculated the interrater reliability of the reviewers on the basis of an independent review of 50 randomly selected charts included in the denominator. The 2 reviewers met to resolve any discrepancies. After reaching an interrater reliability greater than 0.9, a single reviewer completed the remaining sampled charts at each site. We assessed the validity of the automated query by calculating the sensitivity, specificity, positive predictive value, and negative predictive value by using the manual review as the reference standard.

Step 4: Quality Measure Rate—We calculated both sealant quality measure rates (modified DQA and modified OHA) as a percentage of the numerator divided by the denominator for each site. We also calculated an overall measure rate across all sites.

Step 5: Analyzing the Results of the Manual Query and Enumerating the Reasons for Not Including the Participants in the Numerator—To identify gaps in the sealant quality measures, we extensively reviewed the records of patients excluded from the numerator. The reviewers (S.K, S.B, O.T, J.W, E.O, J.E, J.M) looked for specific reasons that precluded any 1 of the 4 permanent molars from receiving sealant treatments.

Data analysis

We used descriptive summary statistics to characterize respondent demographic characteristics (age and sex) by using frequency distributions and percentage contributions and 95% confidence intervals for bounded rate variables. Using a standard significance level of .05, we calculated independent sample *z-scores* for proportions and χ^2 tests for homogeneity of proportions with 3 degrees of freedom to determine statistically significant differences in measure scores across the 4 sites (for example, do the 4 sites perform differently for the modified DQA sealant measure for 6- through 9-year-olds?). We performed all statistical analyses by using software (Stata 13, StataCorp).

RESULTS

The query generated 22,068 patients aged 6 through 9 years and 28,582 patients aged 10 through 14 years, yielding a total study population of 50,650 in which each patient satisfied the denominator inclusion criteria. The study population was 50.4% male and 49.1% female.

Performance of automated EHR query compared with manual reviews

To evaluate the validity of the query for the 6- through 9-year-old and 10- through 14-year-old age groups, we manually reviewed 949 charts in the 6- through 9-year-old age group and 551 charts in the 10- through 14-year-old age group for the modified DQA measure and 914 charts in the 6- through 9-year-old age group and 978 charts in the 10- through 14-year-old age group for the modified OHA measure. We validated the automated query by testing the sampled manually reviewed (reference standard) charts versus those extracted by means of the query. Interrater reliability between the 2 manual reviewers at each site was excellent (1.00). The sensitivity, specificity, positive predictive value, and negative predictive value of the automated query in identifying patients who received sealants during the reporting year were 100%.

Measure scores

The table presents the modified DQA and modified OHA automated measure scores in the 6- through 9-year-old and 10- through 14-year-old age groups across the 4 sites. The overall (all sites combined) modified DQA and modified OHA measure scores in the 6- through 9-year-old age group were 37.0% and 31.6% and in the 10- through 14-year-old age group were 15.8% and 6.6%, respectively. Sites 1 and 4 had the highest scores for the modified DQA and OHA measures regardless of age category. In the 6- through 9-year-old age group, the modified DQA measure score was higher than the modified OHA measure score. The difference in the measure score was statistically significant ($P < .001$) for all sites except site 2 ($P = .2331$). The modified DQA measure score in the 10- through 14-year-old age group ranged from 11.5% to 16.5%, and the lowest modified OHA measure score was 3.4%, with the highest measure score reaching 7.0%. Results of the χ^2 test for proportions showed that there were significant differences in both measure scores across sites and for both age categories. The table shows that there were significant differences in the modified DQA measure score across sites in the 6 through 9 and 10 through 14 age groups, respectively ($P \leq .0001$ and $P = .0078$). Similar significant variations were also observed in the modified OHA measure score across the sites in the 6 through 9 and 10 through 14 age groups, respectively ($P \leq .0001$ and $P \leq .0001$).

Assessment of patients not receiving sealants

Across the 4 sites, our manual review of sampled charts for the modified DQA measure (n = 1,500) and the modified OHA measure (n = 1,892) for both age groups identified 429 (28.6%) and 530 (28.0%) patients who had received a sealant during the reporting year. A substantial proportion of the study population, 1,071 patients for the modified DQA measure and 1,362 for the modified OHA measure, were unable to be included in the numerator of both the measures. We reviewed the excluded charts and identified 9 reasons why the patients did not receive sealants (Figure). Overall, around 67.6% of the patients did not receive sealants because of lack of sealable permanent first and second molars. We observed that 40.1% of the patients who did not receive sealants in our study did not have teeth to be sealed because the permanent first or second molars had not yet erupted or that in 0.1% of patients these teeth had been extracted, 7.1% of patients had existing caries and restorations, and 20.3% of patients already had had sealants placed on their permanent molars before the

reporting year. Other reasons for not sealing teeth included patients receiving only limited or specialty care, teeth not being eligible for sealants because of caries or restorations, sealants being planned but not completed, and patients being inactive or discontinued from treatment.

DISCUSSION

Clinicians at all 4 institutions placed sealants at a higher rate in children aged 6 through 9 years than in children aged 10 through 14 years. However, on a comprehensive review of patients who did not receive sealants, we found that both measures led to underestimation of the appropriate level of care delivered. The results of our review showed that more than 67% of children did not receive sealants because their permanent first and second molars were not sealable as the molars had not yet erupted, had been extracted already, had been sealed previously, or could not be sealed because of existing caries or restorations.

We included these patients in the quality evaluation owing to the inherent limitations of relying on procedure codes, which make up the bulk of claims data. Our findings are not novel,[38] but they are concerning because state Medicaid programs and the Children's Health Insurance Program are beginning toadoptdental quality measures to drive payment and accountability with their dentalplans and providers. The most robust use of these metrics has come from Oregon, where the accountable care structure of coordinated care organizations set up through the Oregon health transformation initiative integrates a 20% benchmark for sealants among 6- through 9-year-olds and 10- through 14-year-olds as a core performance measure for which Medicaid bonus payments are available.[27] Nationally, it is unclear to what extent these measures are driving provider behavior, although preliminary evidence in Oregon points to an effect, with a 65% increase in annual sealant placement from 2014 through 2015, from 11.2% to 18.5%, although not yet to the benchmark level of 20%.[39]

On the basis of study results showing the high efficacy of dental sealants, sealants are indicated for placement on permanent molars in children and adolescents who are at moderate to high risk of developing caries.[24,40–42] Hence, it is important to identify the patient's caries risk level because there is little evidence to suggest that those at low risk benefit from sealants.[43,44] A 2016 American Dental Association and American Academy of Pediatric Dentistry guideline recommends sealing teeth in all children, regardless of risk, although the authors conclude that "sealant use should be increased along with other preventive interventions to manage the caries disease process, especially in patients with an elevated risk of developing caries."[11] As originally designed for use with claims data, the DQA measure defined elevated caries risk by using a set of CDT procedure codes (Appendix). Thus, if a patient had received a restoration in the past, he or she would be considered at elevated caries risk. Among states, some policy makers assume that all recipients of Medicaid are at high risk because these patients tend to be more vulnerable and poor populations are at greater risk of developing disease at the population level. However, evidence that this population risk translates to the individual clinical level is lacking. To ease documentation, the American Dental Association added a procedure code for elevated caries risk. EHRs provide richer data, beyond just CDT procedure codes, to determine a patient's risk status more accurately.[45] For example, all 4 of our institutions document a patient's

caries risk level by using a caries risk assessment form, as well as a structured diagnostic term for caries risk.

Our study results support the suitability of using EHR data for assessing the quality of oral health care at the practice level. Although both the DQA and OHA measures are designed for use at a system level by using claims data, our results suggest that relying on these measures, without modification, is problematic because claims-based data are derived from practices that submit data for payment purposes to either a government or private payer. However, in the absence of the widescale availability of EHR data, claims-based quality measures still serve as an important tool for assessing performance at the system level. These types of standardized measures allow consistent comparison between measured entities and can show trends over time and improvements or changes in care quality. There also may be opportunities to improve on the claims-based measures in the short term. For instance, can the age bands of the measures be modified to reduce the likelihood of including patients with unerupted molars? Our study results also show the need to harmonize measures that are designed for use by using claims data that may drive plan performance and EHR data, which can drive delivery system or practice performance.

In prior work, we used EHR data to measure the delivery of fluoride varnish[46] and results in patients with diabetes who underwent annual oral and periodontal evaluations.[47] EHRs have many of the necessary data elements captured as structured data.[48] For example, a patient's medical and dental histories are coded as discrete form questions that readily can be queried. Further use of existing standards such as the Systematized Nomenclature of Medicine—Clinical Terms to document a patient's medical history and the Systematized Nomenclature of Dentistry for dental diagnoses[49] would facilitate greatly the wider adoption of EHR-based quality measures. The pediatric oral health electronic clinical quality measures address some of the drawbacks of claims-based data by excluding teeth not eligible for sealants. In 2016, Herndon and colleagues[35] validated 2 pediatric oral health electronic clinical quality measures: oral health care continuity for patients aged 2 through 20 years and oral health sealants for children aged 6 through 9 years. In further work, investigators can assess the feasibility of using these measures in EHRs installed in dental practices.

The results of our analysis reveal that if clinicians adapt and use the DQA and OHA measures at a practice level, these measures likely will lead to underestimation of the rate of appropriate sealant placement because of their broad inclusion criteria for the denominator that inadvertently includes patients with no sealable teeth or those who already have sealants. Although the original intent of the DQA and OHA measures was to compare entities and track changes over time, they may not be optimal for use by a practice seeking to improve the placement of sealants in their population. To determine the appropriate rate of sealant placement for a practice, we need to define the sealable potential of each relevant tooth by establishing the sealable criteria of the denominator population. The sealable criteria, in broad terms, narrow the focus to patients in need of sealants—that is, patients with permanent molars eligible to receive sealants. Now that we have recognized the EHR as a robust data resource to evaluate the sealant quality measures, we can explore the potential scalability of EHRs to determine elevated caries risk correctly, as well as the sealable teeth criteria in the denominator to estimate the actual prevalence of sealant treatment in this

population. Because caries risk is documented explicitly at each of the 4 institutions in our study through either a risk assessment form or diagnosis, there is great potential to use the rich data from EHRs to identify patients who are at elevated caries risk. In future work, armed with the findings from this research, we will seek to develop and validate an improved approach to measure the placement of sealants in children more accurately by using data from EHRs.

CONCLUSIONS

We evaluated how well 4 dental institutions placed sealants in children by using quality measures defined by the DQA (with elevated caries risk) and OHA (irrespective of risk). After we adapted the measures at a practice level, both the DQA and OHA measures, which rely mainly on CDT procedure codes, led to underestimation of the care delivered. We propose that to determine the appropriate rate of sealant placement for a practice, it would be pertinent to define the sealable potential of each relevant tooth by establishing specific sealable criteria for the relevant population. The results of our study support the suitability of using EHR data for more accurately measuring sealant placement in children.

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APPENDIX

Current Dental Terminology procedure codes.

D2140	D2394	D2630	D2720	D2791	D3120
D2150	D2410	D2642	D2721	D2792	D3220
D2160	D2420	D2643	D2722	D2794	D3221
D2161	D2430	D2644	D2740	D2799	D3222
D2330	D2510	D2650	D2750	D2930	D3230
D2331	D2520	D2651	D2751	D2931	D3240
D2332	D2530	D2652	D2752	D2932	D3310
D2335	D2542	D2662	D2780	D2933	D3320
D2390	D2543	D2663	D2781	D2934	D3330
D2391	D2544	D2664	D2782	D2940	
D2392	D2610	D2710	D2783	D2950	
D2393	D2620	D2712	D2790	D3110	

Source: Dental Quality Alliance.[36]

ABBREVIATION KEY

CDT Current Dental Terminology

DQA	Dental Quality Alliance
EHR	Electronic health record
NA	Not applicable
OHA	Oregon Health Authority

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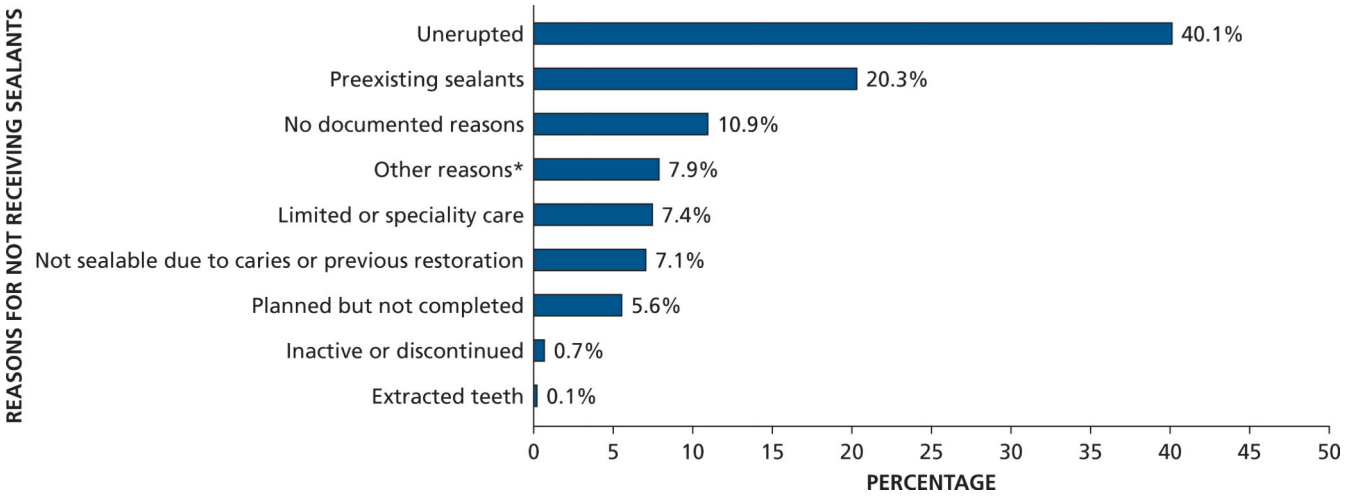

Figure.

List of reasons for patients included in the denominator (modified Dental Quality Alliance and modified Oregon Health Authority measures) not receiving a sealant treatment and their frequency of occurrence (n = 2,433). * Other reasons are the patient's first visit was in the middle of or late in 2014, the parents declined sealants, the patient was referred to an outside specialist, sealant placement was not complete, or the patient was not at elevated caries risk according to the Dental Quality Alliance methods for identifying risk.

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Table.

Significant differences between the modified DQA [*] measure score and the modified OHA [†] measure score.

CATEGORY	MODIFIED DQA NUMERATOR/DENOMINATOR MEASURE SCORE (% [95% CI [‡]])	MODIFIED OHA NUMERATOR/DENOMINATOR MEASURE SCORE (% [95% CI])	Δ (%)	*z* SCORE	*P* VALUE
Aged 6–9 Years					
Site 1	262/670 39.1 (35.4 to 42.8)	365/1,225 29.8 (27.2 to 32.4)	9.30	4.11	< .0001
Site 2	7/28 25.0 (8.9 to 41.0)	15/98 15.3 (8.2 to 22.4)	9.70	1.19	.2331
Site 3	245/806 30.4 (27.2 to 33.6)	311/1,323 23.5 (21.2 to 25.8)	6.90	3.52	.0004
Site 4	2,263/6,011 37.6 (36.5 to 38.9)	3,904/11,907 32.8 (31.9 to 33.5)	4.80	6.65	< .0001
χ^2 Test	19.16	61.76	NA [§]		
***P* Value**	< .0001	< .0001			
Aged 10–14 Years					
Site 1	109/660 16.5 (13.7 to 19.3)	75/1,527 4.9% (3.8 to 6.0)	11.60	8.98	< .0001
Site 2	7/58 12.1 (3.6 to 20.0)	7/206 3.4 (0.9 to 5.7)	8.70	2.63	.0085
Site 3	83/722 11.5 (9.2 to 13.8)	73/1,466 5.0 (3.8 to 6.0)	6.50	5.66	< .0001
Site 4	1,163/7,169 16.2 (15.3 to 17.1)	1,167/16,774 7.0 (6.5 to 7.3)	9.20	22.29	< .0001
χ^2 Test	11.86	20.14	NA		
***P* Value**	.0078	< .0001			

[*] DQA: Dental Quality Alliance.

[†] OHA: Oregon Health Authority.

[‡] CI: Confidence interval.

[§] NA: Not applicable.