



Improving Oral Health Through Measurement

DENTAL QUALITY ALLIANCE: Practice- and Clinician-Level Quality Measure Development Reports

Report 2: Subsequent/Advanced Procedure Following Initial Procedure

NOVEMBER 2023

FOR COMMENT: DO NOT REFERENCE OR CITE IN ANY MANNER

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Background

The Dental Quality Alliance (DQA) approved a resolution that a workgroup be formed to explore the development of practice- and clinician-level dental quality measures. This workgroup reports to the DQA's Measure Development and Maintenance Committee (MDMC). This report is the second in a series of reports providing updates on measure development activities and findings.

Workgroup Charge

- **Resolved**, that a Workgroup reporting to MDMC be convened by the DQA Chair to explore the development of validated practice- and clinician-level quality measures using both clinical and patient-reported data; and be it further,
- **Resolved**, that the Workgroup include partners with access to data that could be used to validate any potential measures developed by the Workgroup.

Report Purpose

The purpose of this report is to **present the results of evaluating various measures under the broad concept of Subsequent, more Advanced Procedures following an initial procedure**. Examples include crowns, partial dentures, endodontic treatment, or extractions following restoration placement.

Identification of Advanced Procedures Concepts

Following an environmental scan conducted by DQA staff that identified 530 unduplicated metrics, the Workgroup determined that it would first identify a starter set of measures calculated using claims data, because they have the highest feasibility for near-term implementation. Of the 530 metrics, 124 were identified as potentially implementable with claims data.

The Workgroup used a Delphi consensus process, using both a questionnaire with quantitative analyses of the responses and a series of workgroup meetings, to evaluate each of the 124 measures. Measures were classified into one of four categories:

- 1) **Excluded** concepts – no further consideration for practice/clinician based measurement;
- 2) **Roadmap** concepts – important but feasibility challenges;
- 3) **Provisional** concepts – undergoing further evaluation to better understand the evidence base and extent of performance gaps; and
- 4) **Included** concepts – will be specified and tested for a Starter Set of claims-based measures.

The first report in this series, [Report 1: Project Introduction, Delphi & Excluded Measure Concepts](#) provides more detail regarding the environmental scan, consensus process, and concept classification.

Provisional Concepts and Conceptual Considerations

Provisional concepts reflected areas where the workgroup determined it needed more information to reach consensus. Within this category were several measures reflecting the concept of **Advanced Procedure Following Initial Procedure**, such as a crown being placed on a tooth that was previously restored, endodontic treatment on a tooth that had a crown, and extraction of a tooth after endodontic treatment.

The workgroup identified the following considerations in its evaluation:

- **Evidence.** Is there sufficient evidence to enable identification of what expected survival rates should be to inform expectations around performance related to quality of care?
- **Performance gap.** To what extent does the measure identify an overall performance gap versus outliers in performance?
- **Provider control.** To what extent can providers influence the outcome/measure score? To what extent are there other factors outside of the provider's control that could influence measure scores?
- **Interpretability.** Can the measure score alone (i.e., without further investigation) be used to signify better or worse quality of care with respect to a specific aspect of care?
- **Risk of adverse consequences.** Are there potential unintended adverse consequences that could result from implementing the measure?

To explore these considerations, the workgroup began by selecting specific subsequent/advanced procedures after initial procedure concepts to evaluate:

- Percentage of active patients who received crowns/ partials/ endodontic treatment/ extraction procedures following a restoration placement
- Percentage of active patients who received endodontic treatment following crowns;
- Percentage of active patients who received extractions following crowns;
- Percentage of active patients who received implants requiring subsequent removal; and
- Percentage of active patient who received restorations following sealant placement.

Detailed specifications were developed for the first concept, and two data partners with large databases of practice- and clinician-level dental claims data provided data to inform the workgroup's evaluation. The remaining four concepts were subsequently evaluated using data from existing reports.

Advanced Procedure (crowns, partials, endodontic treatment, or extractions) after Restoration Placement

In addition to the collective expert opinion and quality measurement experience of the Workgroup members, two additional sources of information were sought by the workgroup to inform its deliberations of this concept: (1) data that would illustrate example measure scores and lend insight into the frequency with which advanced procedures occur and (2) evidence regarding restoration survival rates and factors contributing to the need for subsequent treatment.

Data Analysis

Methods

Population. Adults aged 19 years and older were included with stratifications by age categories (19-30; 31-50; 51-64; ≥ 65).

Data Sources. Two data partners with large databases of practice- and clinician-level dental claims data ran sample measure scores using detailed specifications described below.

Time Frame. The data runs used data from 2016 through 2019. Four years of data were used to allow follow-up time frames as long as 36 months. To avoid confounding by reduced service use in 2020 due to COVID-19, 2019 was selected as the most recent year to include in the analyses.

Level of Analysis. Separate analyses were conducted at the **practice** level and at the **clinician** level.

Specifications. Detailed specifications were developed to ensure that the data needed for the workgroup's evaluation would be captured and to promote consistency in data runs across the data partners running the analyses.

Four different rates were calculated to assess different follow-up time frames after the initial restoration placement:

Rate 1: 6-month follow-up period

Denominator 1: Restoration in 2016

Numerator 1: Crown/Endo/Partial/Extraction within 6 months of restoration

Rate 2: 12-month follow-up period

Denominator 2: Restoration in 2016 AND any dental service in 2017

Numerator 2: Crown/Endo/Partial/Extraction within 12 months of restoration

Rate 3: 24-month follow-up period

Denominator 3: Restoration in 2016 AND any dental service in 2018

Numerator 3: Crown/Endo/Partial/Extraction within 24 months of restoration

Rate 4: 36-month follow-up period

Denominator 4: Restoration in 2016 AND any dental service in 2019

Numerator 4: Crown/Endo/Partial/Extraction within 36 months of restoration

Sample Size. Data partners were requested to provide data for **practices and clinicians that had at least 100 patients in the denominator for Rate 4** (36-month follow-up). The same sample was used to calculate all four rates. Data partners also were asked to provide data for at least 100 practices and 100 clinicians.

Denominator considerations

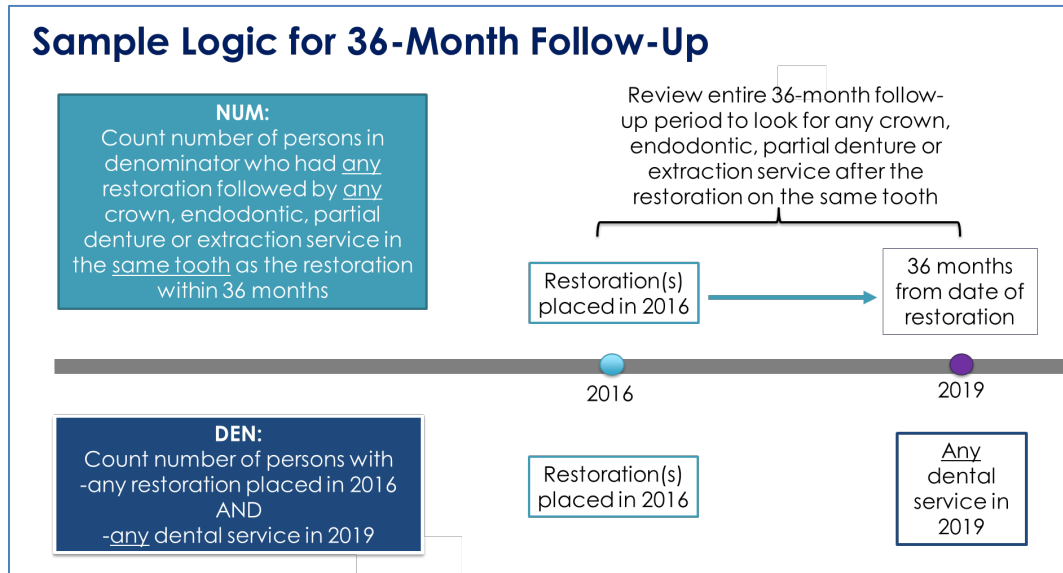
- The requirement for a dental service in Rates 2, 3, and 4 is to ensure that the patient is still present in the database at the time of follow-up measurement. For example, a patient who had a restoration in 2016 and then switched care to a practice or provider not contained within the database in 2017 should not be included in the measurements of Rates 2, 3, or 4 because it is not possible to assess whether any subsequent procedure was performed.
- A given patient was included in the denominator of each practice and of each clinician who placed a restoration in 2016. The measure score was at the patient level (and not the tooth level), but the same patient could be counted in the denominator of more than one practice or more than one clinician when the patient had an index restoration with more than one practice or more than one clinician, respectively, in 2016.

Numerator considerations

- An advanced follow-up procedure on the same tooth as the earlier restoration was counted if it occurred at any time during the follow-up time frame. For example, for Rate 4, any crown/endodontic/partial denture/extraction service that occurred at any time during the 36 months following the restoration placement would be counted in the numerator.
- The follow-up procedure for inclusion in the numerator could be performed by any practice or provider. It did not need to be with the same practice/clinician that placed the restoration in 2016.

Figure 1 illustrates the calculation logic for Rate 4, which has a 36-month follow-up period. The detailed specifications are contained in Appendix 1.

Figure 1. Sample Calculation Logic for Advanced Procedure Following Restoration Placement within 36 Months



Results

Table 1 provides summary statistics for each of the rates corresponding to the follow-up timeframes of 6, 12, 24, and 36 months. For example, for the 6-month follow-up time period for data partner 1, the average rate was 1.95% and the median rate was 1.52%. The median rate indicates that the percentage of patients who had a restoration in 2016 and also had an advanced procedure on the same tooth within 6 months was 1.52% or less for each 50% of the sample of practices and 50% of the sample of clinicians. When the follow-up timeframe was extended, the percentage of patients who had a restoration followed by more advanced treatment on the same tooth increased. For the 36-month follow-up period, the median rate increased to 10.91% for data partner 1. The rates for the two data partners were similar. The rates between practices and clinicians also were similar. Additional detailed results are contained in Appendix 2.

Table 1. Percentage of Patients Aged 19 Years or Older with an Advanced Procedure (crown, partial denture, endodontic service, extraction) Following Restoration Placement by Follow-Up Period

		6 months	12 months	24 months	36 months
PRACTICE					
Data Partner 1 (n=2,069)	Min	0.00%	0.00%	0.00%	0.00%
	Max	17.39%	27.19%	35.19%	46.15%
	Ave	1.95%	4.14%	8.09%	12.14%
	Median	1.52%	3.35%	7.19%	10.91%

PRACTICE- AND CLINICIAN-LEVEL DENTAL QUALITY MEASURE DEVELOPMENT REPORTS

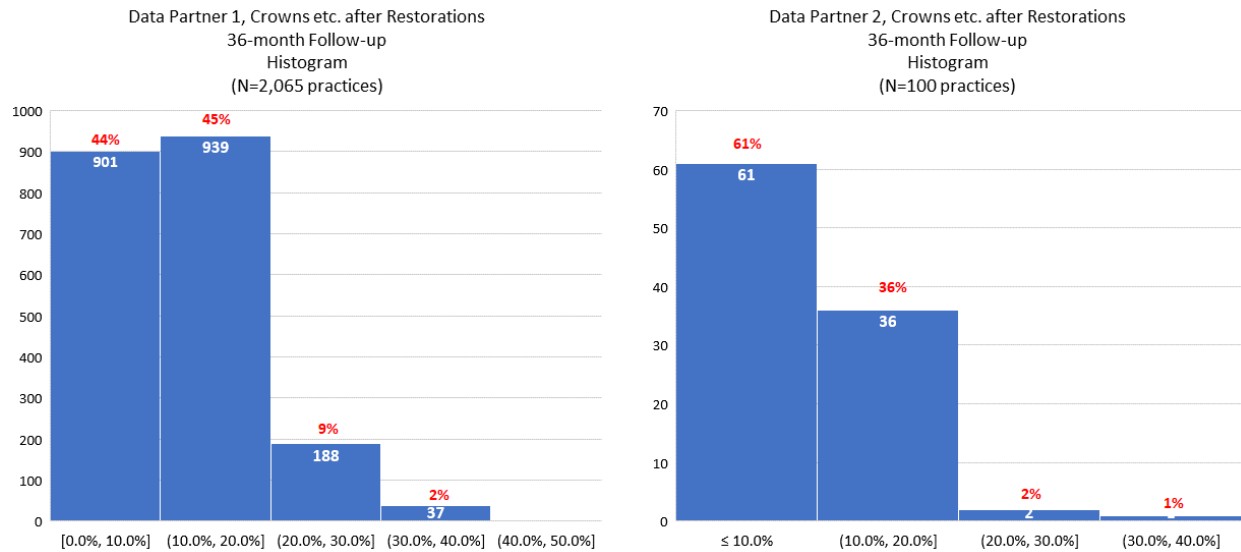
Data Partner 2 (n=100)	Min	0.00%	0.00%	0.71%	0.83%
	Max	10.00%	18.75%	34.48%	36.94%
	Ave	1.97%	3.87%	7.09%	9.70%
	Median	1.52%	3.33%	6.44%	8.80%
CLINICIAN					
Data Partner 1 (n=1744)	Min	0.00%	0.00%	0.00%	0.00%
	Max	16.58%	24.88%	39.67%	46.15%
	Ave	1.82%	3.86%	7.65%	11.51%
	Median	1.40%	3.15%	6.67%	10.26%
Data Partner 2 (n=100)	Min	0.00%	0.00%	0.79%	1.60%
	Max	10.00%	18.75%	34.48%	36.94%
	Ave	2.09%	3.93%	6.83%	9.85%
	Median	1.76%	3.29%	5.84%	8.21%

Table 2 summarizes the practice-level data for the 36-month follow-up period by selected percentiles. Figure 2 displays the practice level data for the 36-month follow-up period using histograms. The horizontal axis is the same in both figures and represents the rate ranges in 10% increments. The first column in each chart shows the number and percent of practices with rates of 10% or less: 44% of data partner 1 practices and 61% of data partner 2 practices had rates of 10% or less when looking for an advanced procedure following a restoration within 36 months.

Table 2. Rate 4 (36-month follow-up) Reported by Practice Percentiles

	Data Partner 1	Data Partner 2
10th percentile	5.03%	4.61%
25th percentile	7.55%	6.65%
50th percentile	10.91%	8.80%
75th percentile	15.25%	12.08%
90th percentile	20.67%	16.40%

Figure 2. Practice-Level Histograms for Rate 4 (36-month follow-up)



****NOTE: Data Partner 1 provided significant larger sample of data compared to Data Partner 2.****

Evidence

The workgroup also wanted to interpret the data in the context of what might be expected based on published, peer-reviewed research. Two questions were posed to staff at the ADA Science and Research Institute:

1. For posterior restorations in general, what are the expected survival rates for different follow-up time intervals?
2. What evidence exists regarding the effects of technical quality of the provider and patient factors with respect to survival?

The complete findings are provided in Appendix 3.

Regarding survival rates, the rates from the data partners were generally consistent with what has been observed in the literature. In general, survival rates tend to be quite high initially (i.e., during initial follow-up time frames) and decrease somewhat over time.

Regarding the contributions of patient versus provider factors in contributing to restoration survival, published research identifies a range of patient-level and provider-level factors that contribute to restoration survival. Contributing patient-related factors include caries risk, bruxism, periodontal status, oral hygiene, prior endodontic treatment, type of tooth restored and number of restored surfaces. Provider-related factors include experience level, skill level and treatment decisions.

Workgroup Determinations Regarding Advanced Procedure (crowns, endodontic treatment, partial dentures, or extractions) after Restoration Placement

The workgroup made the following determinations based on the group's collective expert opinion and experience, the data analyses, and related evidence from the literature.

Evidence and Interpretability. The research is not mature enough to draw conclusions about quality without further assessment of additional data and clinical information to understand why one practice or provider has higher/lower rates of subsequent treatment than others and the extent to which those rates are attributable to the performance of practices or clinicians.

Performance gap. At 36 months, median "survival" (no subsequent advanced procedure) is approximately 90%, raising questions about the extent to which there is a performance gap.

Provider control and measurement burden. Varying factors contribute to restoration survival rates. To have assessments that allow for use as a quality improvement measure in accountability applications (e.g., performance-based payment or public reporting), it would be important to take into account such factors such as age, number of surfaces, depth of restoration, previous treatment, patient risk factors, and so forth. Claims data limits the ability to assess and incorporate these factors when developing performance/quality of care measures.

Risk of adverse consequences. Concerns were raised that there could be unintended adverse consequences, particularly given the considerations listed above. For example, providers could improve performance by skipping conservative treatment approaches and going directly to more advanced treatment; the measure could unintentionally promote practice at the extremes of standards of care (i.e., overtreatment with crowns as the initial restorative choice) or reduce the engagement of patients in care decisions.

Benefit. Despite the above considerations, the workgroup concluded that a measure of advanced procedures following restorations **is beneficial for internal use to identify levels of practice or clinician performance that might be deemed to be statistical outliers, in order to spur further investigation** and inquiry to understand the reasons that a practice or clinician is a statistical outlier and determine whether practice or clinician modifications are warranted.

Related Concepts

The workgroup evaluated existing data for the following related "advanced procedure following initial procedure concepts":

- Endodontic treatment following crowns;
- Extractions following crowns/endo;
- Implants requiring removal; and

- Restorations following sealant placement.

One of the data partners provided data from existing reports related to the first three concepts, and data from the American Dental Association's Dental Experience and Research Exchange (DERE)[™] registry were used to evaluate the concept of restorations following sealant placement. The data reviewed are contained in Appendix 4.

All of the related measure concepts were evaluated for a 36-month follow-up time frame. 90% of providers had rates of less than 5%. Thus, the frequency of occurrence of these related measure concepts (4 concepts in bullets noted above) was significantly lower than those observed for the measure related to crowns, endodontic treatment, partial dentures, or extractions after restoration.

Based on the similarity of the concepts conceptually and the lower frequency of occurrence with patterns similar to *the crowns, endodontic treatment, partial dentures, or extractions after restoration placement* measure, the workgroup determined that it was not necessary to develop detailed specifications and run additional data analyses to further evaluate these concepts.

Additional considerations for measures of implant repair or removal. The workgroup noted additional considerations related to the concept of implants that require subsequent repair or removal. Based on their expert opinion, the Workgroup determined that given the overall expected survival rates of implants, the time frame of 36-months was too short to allow an accurate assessment of implant repair or removal. However, it was also recognized that using significantly longer follow-up time frames would be challenging from a measurement perspective due to patient mobility between plans, practices, and clinicians. It was also noted that expansions in coverage over the last 5 years have increased the number of dentists placing implants. Thus, the workgroup suggested that this concept should continue to be monitored for future measure development.

Workgroup Conclusions

The Workgroup determined that these measure concepts of advanced procedures following initial procedure best fit in the category of measures that can be used in the identification of practices or providers with "statistical outlier" performance. Identification of statistical outliers, by itself, does not provide a clear indication of performance quality without further investigation; rather, statistical outlier status warrants additional study or analysis. Causation may be related to unique variation in practitioner performance, but it may also be related to unique variation in one or more input factors, resource factors, or external factors affecting clinical processes of care. The Workgroup also recognizes that subsequent, more complex treatment may hold varying degrees of importance to and influence the care experience of individual patients who may be affected by outlier performance.

Based on the considerations above, the workgroup determined that the various measure concepts under the category of advanced procedure should not advance to reliability testing, at this time. The DQA prioritizes development of standardized measures to enable comparison between entities and over time, for the greatest public health impact. The Workgroup believes that all of the measure concepts reviewed in this report will increase measurement burden without concomitant public health impact.

Because the workgroup recognized the value of these concepts for internal use by organizations in assuring quality, it also determined that further consideration of how measures related to statistical outlier identification could be considered within an overall quality framework.

Measures for Multiple Quality Implementation Purposes

Assuring and improving quality of care encompasses a broad range of activities. Different measures can support different quality-focused activities. The workgroup distinguished measurement for quality assurance from measurement for quality improvement, recognizing that quality assurance activities are a precursor to and support quality improvement efforts. It further distinguished between internal quality improvement efforts and external/accountability quality improvement efforts.¹⁻⁴

Figures 3 and 4 summarize the conceptual differences between these different and complementary quality activities, and their supporting measurement systems, all of which feed into an overall quality assurance and performance improvement program.

Quality assurance activities tend to be retrospective in nature and focus on compliance with policies, procedures and minimum care expectations/requirements. Quality assurance focuses on provider competencies and measures that can identify outliers with respect to identified norms. The measure flags a provider or area that merits further investigation to determine if self-improvement or corrective actions are needed.

Quality improvement activities are more forward-looking and reflect an overall organizational approach to improving quality of care with the goal of not simply ensuring minimum performance criteria are met, but to raise overall organizational or system level performance. Quality improvement activities can be categorized as internal quality improvement or external quality improvement. **Internal** quality improvement activities focus on learning within the organization. Measurement is used to support internal quality improvement activities (e.g., as part of PDSA cycles), including internal comparative performance and monitoring progress over time. Performance results are used internally and, often, confidentially. **External** quality improvement involves external motivation for performance improvement and typically has “higher-stakes” applications, such as being reported publicly or being used in performance-based payment programs. External quality improvement is more likely to involve comparisons between entities.

Measures for both internal and external quality improvement should be grounded in the best available evidence (e.g., clinical guidelines) that improvement on the measure is associated with improvement in outcomes. The measures should also have clear interpretation related to care quality (e.g., a higher score signifies better quality) to guide improvement efforts. Although all quality measures should have demonstrated reliability (consistency and comparability of measurement) and validity (accurate representation of the quality concept), measures used in external quality improvement applications are held to the highest standards of quality measurement criteria because of the need to reliably compare entities and the more significant consequences of measurement. As a result, measures used in accountability applications, such as public reporting, payment-based programs, and accreditation, undergo evaluation and testing that demonstrates the measure is supported by evidence, has a demonstrated performance gap, meets scientific acceptability criteria for reliability and validity, and has low risk of adverse or unintended consequences.^{1,5,6}

Figure 4 illustrates how measures used for different purposes work together as part of an overall quality assurance and performance improvement program. The workgroup emphasized the value of all three activities (quality assurance, internal quality improvement, and external quality improvement) and the supporting measures.

The workgroup is prioritizing measures used for external quality improvement for the Starter Set of measures because they support standardized measures, enabling comparisons between entities or clinicians and over time for the greatest public health impact.

The Workgroup encourages practices to monitor measures based on concepts such as those below to identify causes of variation, statistical outliers, and provide targeted support for improvement on an ongoing basis.

- Percentage of active patients who received crowns/ partials/ endodontic treatment/ extraction procedures following a restoration placement
- Percentage of active patients who received endodontic treatment following crowns;
- Percentage of active patients who received extractions following crowns;
- Percentage of active patients who received implants requiring subsequent removal; and
- Percentage of active patient who received restorations following sealant placement.

Figure 3. Measurement for Quality Assurance and Quality Improvement

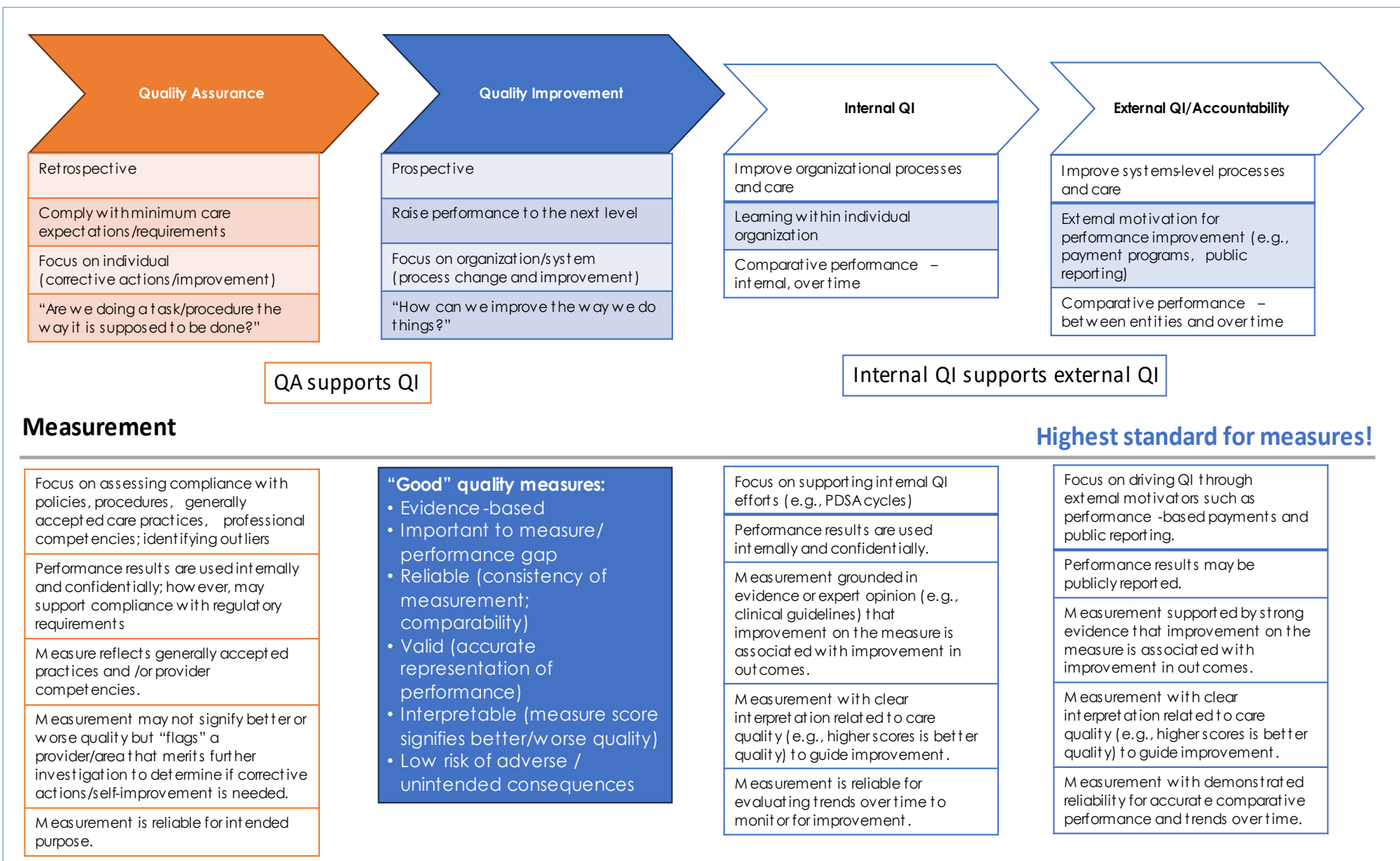
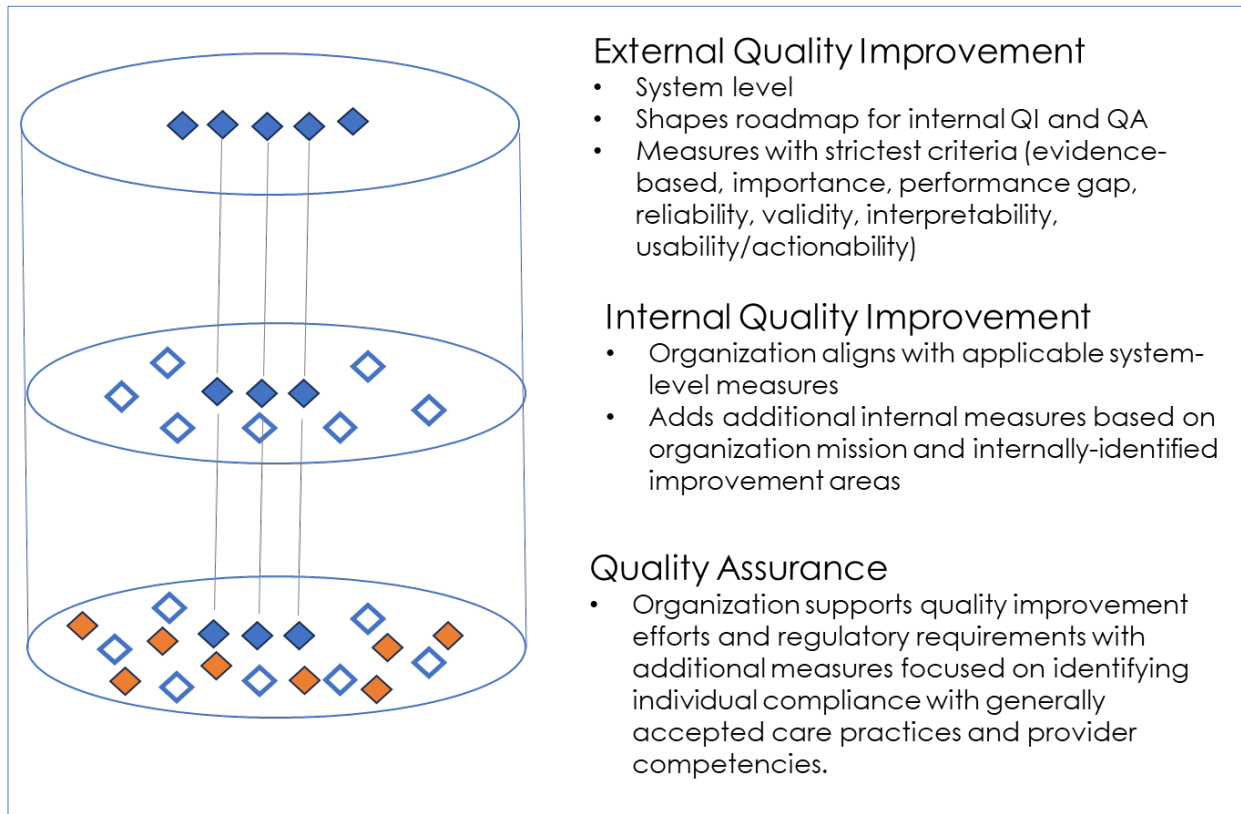


Figure 4. Measurement for Different and Complementary Purposes



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Appendix 1: Advanced Procedure (crowns, partials, endodontic treatment, or extractions) after Restoration Placement Measure Specifications

*****NOTE: THESE SPECIFICATIONS WERE DEVELOPED SOLELY TO INFORM EVALUATION OF THIS CONCEPT. THESE SPECIFICATIONS ARE NOT APPROVED SPECIFICATIONS TO BE USED IN QUALITY IMPROVEMENT PROGRAMS.*****

PRACTICE/CLINICIAN LEVEL MEASUREMENT: PROVISIONAL MEASURE CONCEPT SPECIFICATIONS FOR CONCEPT EVALUATION

CONCEPT: CROWNS/PARTIALS/ENDODONTIC/EXTRACTIONS FOLLOWING RESTORATION PLACEMENT

*****DATA TESTING PARTNERS: PLEASE DO NOT MAKE ANY ASSUMPTIONS. IF SOMETHING IS NOT CLEAR, THEN PLEASE CONTACT THE DQA AT DQA@ADA.ORG. ENSURING THE CLARITY AND UTILITY OF THE SPECIFICATIONS IS PART OF THIS PROCESS.*****

This report evaluates the percentage of active patients who received crowns/ partials/ endodontic/ extraction procedures following a restoration placement, using different follow-up time periods.

- **TESTING NOTES:**
 - We are testing four denominators and numerators that correspond to four different follow-up time frames: 6, 12, 24 and 36 months.
 - Please use CLAIMS data from 2016 through 2019.
- **Age**
 - Include adults >19 years. Measure scores will be stratified by the following age groups: 19-30; 31-50; 51-64; >=65.
- **Measuring Entity and Data Sources**
 - Third party [e.g., payer or business associate] using enrollment and claims data.
Claims data note: Include both paid and unpaid claims (including pending, suspended, and denied claims).

- Practice or provider or business associate with access to Practice Management System (PMS) and/or Electronic Dental Record (EDR) data
Billing/EDR data note: Include all posted procedures for completed treatment whether paid or unpaid. The code does NOT need to have been billed to an insurance company. Do not include procedures for which treatment was not completed (i.e., planned treatment).

- **Months to Days Conversion:** To accommodate months ranging from 28 to 31 days, the following standards apply:

Years	Months	Days
	1 month	30 days
	2 months	61 days
	3 months	91 days
	4 months	122 days
	5 months	152 days
	6 months	183 days
	7 months	213 days
	11 months	334 days
1 year	12 months	365 days
	13 months	395 days
2 years	24 months	730 days
3 years	36 months	1095 days
5 years	60 months	1826 days

- **Level of Reporting:**

- **Practice** (identified by TIN)

Note: When a single TIN is used across multiple locations within a group practice, the measure will result in an average score across locations. Conversely if one group practice uses individual TINs for each of its locations, then the measure will result in a score by location. Such contextual information will be useful in interpreting scores when used for comparisons.

- **Clinician** (identified by Rendering Provider NPI)

Note: This measure specification should be used with an understanding of the context of the clinical workflow within the practice. For practices with a team-based approach to care (i.e., one dentist always performs the evaluation, and a second dentist or hygienist always performs the fluoride application), all patients will be attributed to the first dentist. The second dentist or hygienist cannot be “scored” based on these specifications even if they are responsible for applying the topical fluoride.

Sample Selection for Testing with Claims Data:

- **Practice:** Randomly select 100 practices among those that have at least 100 patients who qualify for DEN 4.
- **Clinician:** Randomly select 100 providers among those that have at least 100 patients who qualify for DEN 4.
- **Note:** These samples will be used to calculate all four denominators.

Specification

Four denominators and numerators that correspond to four different follow-up time frames (6, 12, 24, and 36 months) will be evaluated.

DENOMINATOR 1: RESTORATION IN 2016

Check if subject had a restoration placed in 2016.

1. Check if the subject meets age criterion:
 - a. If subject is ≥ 19 years as of December 31st, 2016, then proceed to next step.
 - b. If the age criterion is not met or there are missing or invalid field codes (e.g., date of birth), then STOP processing. This subject is not counted in the denominator.
2. Check if subject has **any restorations** placed in 2016:
 - a. If [SERVICE CODE] = any one or more code in range [D2140 through D2664] **AND**
 - b. If January 1, 2016 \leq [RESTORATION DATE OF SERVICE] \leq December 31, 2016, then proceed to next step.
 - c. If either SERVICE CODE or DATE OF SERVICE is not met, or there are missing or invalid field codes (e.g., date of service), then STOP processing. This subject is not included in denominator 1.
3. Attribute subject to **all practices** that placed **restorations in 2016**:
 - a. Assign subject to the *unique TIN* associated with each practice that placed at least one restoration in 2016.
 - b. Include in **Denominator 1 for the practice**.

Note: In this step, all **claims** with missing or invalid CDT CODE, missing or invalid billing provider TIN should not be included in the denominator.

4. Attribute subject to **all clinicians** that placed restorations in 2016:
 - a. Assign subject to the * unique RENDERING PROVIDER NPI* associated with each clinician that placed at least one restoration in 2016.
 - b. Include in **Denominator 1 for the clinician**.

Note: In this step, all **claims** with missing or invalid CDT CODE, missing or invalid billing provider TIN should not be included in the denominator.

YOU NOW HAVE THE PRACTICE-SPECIFIC AND CLINICIAN-SPECIFIC DENOMINATOR 1 (DEN1)

NUMERATOR 1: CROWN/ENDO/PARTIAL/EXTRACTION WITHIN 6 MONTHS OF RESTORATION

For each practice and clinician: Among the subjects in Denominator 1, **for each restoration placed in 2016**, check if subject received any crown, endodontic, partial denture, or extraction service in the same tooth as the restoration within 6 months of the restoration placement with any practice/clinician:

5. Select subjects in the practice-specific or clinician-specific Denominator 1.
6. For **each restoration placed in 2016**, check if subject has any crown, endodontic, partial denture, or extraction service **in the same tooth within 6 months** (can be placed by any practice/clinician):
 - a. Crowns:
 - i. If any [CROWN CODE] = [D2710 through D2794]; AND
 - ii. [CROWN TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. $0 < [\text{CROWN DATE OF SERVICE}] - [\text{RESTORATION DATE OF SERVICE}] \leq 183$ days

OR

- b. Endodontic services:
 - i. If any [ENDODONTIC CODE] = [D3110 through D3999]; AND
 - ii. [ENDO TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. $[\text{ENDO DATE OF SERVICE}] - [\text{RESTORATION DATE OF SERVICE}] \leq 183$ days

OR

- c. Partial denture services:
 - i. If any [PARTIAL DENTURE CODE] = [D5211 through D5286]; AND
 - ii. [PARTIAL TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. $0 < [\text{PARTIAL DATE OF SERVICE}] - [\text{RESTORATION DATE OF SERVICE}] \leq 183$ days

OR

- d. Extraction services:
 - i. If any [EXTRACTION CODE] = [D7111 through D7999]; AND
 - ii. [EXTRACTION TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. $0 < [\text{EXTRACTION DATE OF SERVICE}] - [\text{RESTORATION DATE OF SERVICE}] \leq 183$ days
- e. If subject had ANY follow-up procedure contained in (a) – (d) within 183 days, then **include in practice-specific or clinician-specific numerator 1**.

- f. If subject did not have any follow-up procedure contained in (a) – (d) within 183 days, then STOP processing; this subject is included in denominator 1, but will not be included in numerator 1.

NOTES:

- The crown/endo/partial/extraction procedure can be with any practice or clinician. It does not need to be with the practice/clinician that provided the restoration in 2016.
- If either SERVICE CODE or DATE OF SERVICE criteria are not met, or there are missing or invalid field codes (e.g., TOOTH NUMBER), then STOP processing. This subject is included in denominator 1, but is not included in numerator 1.

YOU NOW HAVE THE PRACTICE-SPECIFIC AND CLINICIAN-SPECIFIC NUMERATOR 1 (NUM 1)

- 7. Report (using reporting template):
 - a. Number of patients in practice-specific or clinician-specific denominator, overall and by age stratification category
 - b. Number of patients in practice-specific or clinician-specific numerator, overall and by age stratification category

DENOMINATOR 2: RESTORATION IN 2016 AND ANY DENTAL SERVICE IN 2017

Among those subjects in **Denominator 1**, select those who also have any dental service in 2017. The dental service in 2017 is not restricted to the same practice or clinician. It is simply to establish that the patient is still active in the database.

- 1. **For each practice**, select subjects in Denominator 1 who also have any dental service in 2017 (where the dental service in 2017 does not need to be restricted to the same practice):
 - a. If subject is in Denominator 1 **AND**
 - b. If [SERVICE CODE] = [D0100 – D9999] **with any practice** AND
 - c. If [DATE OF SERVICE] >= January 1, 2017 AND <= December 31, 2017, then include in **Denominator 2 for the practice**.
 - d. If either SERVICE CODE or DATE OF SERVICE is not met, or there are missing or invalid field codes (e.g., date of service), then STOP processing. This subject is not included in denominator 2.

NOTE: The dental service in 2017 can be with any practice. It does not need to be with the practice that provided the index restoration in 2016.

- 2. **For each clinician**, select subjects in Denominator 1 who also have any dental service in 2017 (where the dental service in 2017 is not restricted to the same clinician):

- a. If subject is in Denominator 1 **AND**
- b. If [SERVICE CODE] = [D0100 – D9999] **with any clinician** AND
- c. If [DATE OF SERVICE] >= January 1, 2017 AND <= December 31, 2017, then include in **Denominator 2 for the clinician**.
- d. If either SERVICE CODE or DATE OF SERVICE is not met, or there are missing or invalid field codes (e.g., date of service), then STOP processing. This subject is not included in denominator 2.

NOTE: The dental service in 2017 can be with any clinician. It does not need to be with the clinician that provided the index restoration in 2016.

YOU NOW HAVE THE PRACTICE-SPECIFIC AND CLINICIAN-SPECIFIC DENOMINATOR 2 (DEN2)

NUMERATOR 2: CROWN/ENDO/PARTIAL/EXTRACTION WITHIN 12 MONTHS OF RESTORATION

For each practice and clinician: Among the subjects in Denominator 2, **for each restoration placed in 2016**, check if subject received any crown, endodontic, partial denture, or extraction service in the same tooth as the restoration within 12 months of the restoration placement with any practice/clinician:

3. Select subjects in the practice-specific or clinician-specific Denominator 2.
4. For **each restoration placed in 2016**, check If subject has any crown, endodontic, partial denture, or extraction service **in the same tooth within 12 months** (can be placed by any practice/clinician):
 - a. Crowns:
 - i. If any [CROWN CODE] = [D2710 through D2794]; AND
 - ii. [CROWN TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. $0 < [\text{CROWN DATE OF SERVICE}] - [\text{RESTORATION DATE OF SERVICE}] \leq 365$ days

OR

- b. Endodontic services:
 - i. If any [ENDODONTIC CODE] = [D3110 through D3999]; AND
 - ii. [ENDO TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. $[\text{ENDO DATE OF SERVICE}] - [\text{RESTORATION DATE OF SERVICE}] \leq 365$ days

OR

- c. Partial denture services:
 - i. If any [PARTIAL DENTURE CODE] = [D5211 through D5286]; AND
 - ii. [PARTIAL TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND

- iii. $0 < [\text{PARTIAL DATE OF SERVICE}] - [\text{RESTORATION DATE OF SERVICE}] \leq 365 \text{ days}$

OR

- d. Extraction services:
 - i. If any [EXTRACTION CODE] = [D7111 through D7999]; AND
 - ii. [EXTRACTION TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. $0 < [\text{EXTRACTION DATE OF SERVICE}] - [\text{RESTORATION DATE OF SERVICE}] \leq 365 \text{ days}$
- e. If subject had ANY follow-up procedure contained in (a) – (d) within 365 days, then **include in practice-specific or clinician-specific numerator 2.**
- f. If subject did not have any follow-up procedure contained in (a) – (d) within 365 days, then STOP processing; this subject is included in denominator 2, but will not be included in numerator 2.

NOTES:

- The crown/endo/partial/extraction procedure can be with any practice or clinician. It does not need to be with the practice/clinician that provided the restoration in 2016.
- If either SERVICE CODE or DATE OF SERVICE criteria are not met, or there are missing or invalid field codes (e.g., TOOTH NUMBER), then STOP processing. This subject is included in denominator 2, but is not included in numerator 2.

YOU NOW HAVE THE PRACTICE-SPECIFIC AND CLINICIAN-SPECIFIC NUMERATOR 2 (NUM 2)

- 5. Report ([using reporting template](#)):
 - a. Number of patients in practice-specific or clinician-specific denominator, overall and by age stratification category
 - b. Number of patients in practice-specific or clinician-specific numerator, overall and by age stratification category

DENOMINATOR 3: RESTORATION IN 2016 AND ANY DENTAL SERVICE IN 2018

Among those subjects in **Denominator 1**, select those who also have any dental service in 2018. The dental service in 2018 is not restricted to the same practice or clinician. It is simply to establish that the patient is still active in the database.

- 1. **For each practice**, select subjects in Denominator 1 who also have any dental service in 2018 (where the dental service in 2018 does not need to be restricted to the same practice):
 - a. If subject is in Denominator 1 **AND**
 - b. If [SERVICE CODE] = [D0100 – D9999] **with any practice** AND

- c. If [DATE OF SERVICE] >= January 1, 2018 AND <= December 31, 2018, then include in **Denominator 3 for the practice**.
- d. If either SERVICE CODE or DATE OF SERVICE is not met, or there are missing or invalid field codes (e.g., date of service), then STOP processing. This subject is not included in denominator 3.

NOTE: The dental service in 2018 can be with any practice. It does not need to be with the practice that provided the index restoration in 2016.

2. **For each clinician**, select subjects in Denominator 1 who also have any dental service in 2018 (where the dental service in 2018 is not restricted to the same clinician):
 - a. If subject is in Denominator 1 **AND**
 - b. If [SERVICE CODE] = [D0100 – D9999] **with any clinician** AND
 - c. If [DATE OF SERVICE] >= January 1, 2018 AND <= December 31, 2018, then include in **Denominator 3 for the clinician**.
 - d. If either SERVICE CODE or DATE OF SERVICE is not met, or there are missing or invalid field codes (e.g., date of service), then STOP processing. This subject is not included in denominator 3.

NOTE: The dental service in 2018 can be with any clinician. It does not need to be with the clinician that provided the index restoration in 2016.

YOU NOW HAVE THE PRACTICE-SPECIFIC AND CLINICIAN-SPECIFIC DENOMINATOR 3 (DEN3)

NUMERATOR 3: CROWN/ENDO/PARTIAL/EXTRACTION WITHIN 24 MONTHS OF RESTORATION

For each practice and clinician: Among the subjects in Denominator 3, **for each restoration placed in 2016**, check if subject received any crown, endodontic, partial denture, or extraction service in the same tooth as the restoration within 24 months of the restoration placement with any practice/clinician:

3. Select subjects in the practice-specific or clinician-specific Denominator 3.
4. For **each restoration placed in 2016**, check if subject has any crown, endodontic, partial denture, or extraction service **in the same tooth within 24 months** (can be placed by any practice/clinician):
 - a. Crowns:
 - i. If any [CROWN CODE] = [D2710 through D2794]; AND
 - ii. [CROWN TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. $0 < [CROWN DATE OF SERVICE] - [RESTORATION DATE OF SERVICE] \leq 730$ days

OR

- b. Endodontic services:
- i. If any [ENDODONTIC CODE] = [D3110 through D3999]; AND
 - ii. [ENDO TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. [ENDO DATE OF SERVICE] – [RESTORATION DATE OF SERVICE] <= 730 days

OR

- c. Partial denture services:
- i. If any [PARTIAL DENTURE CODE] = [D5211 through D5286]; AND
 - ii. [PARTIAL TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. 0 < [PARTIAL DATE OF SERVICE] – [RESTORATION DATE OF SERVICE] <= 730 days

OR

- d. Extraction services:
- i. If any [EXTRACTION CODE] = [D7111 through D7999]; AND
 - ii. [EXTRACTION TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. 0 < [EXTRACTION DATE OF SERVICE] – [RESTORATION DATE OF SERVICE] <= 730 days
- e. If subject had ANY follow-up procedure contained in (a) – (d) within 730 days, then **include in practice-specific or clinician-specific numerator 3**.
- f. If subject did not have any follow-up procedure contained in (a) – (d) within 730 days, then STOP processing; this subject is included in denominator 3, but will not be included in numerator 3.

NOTES:

- The crown/endo/partial/extraction procedure can be with any practice or clinician. It does not need to be with the practice/clinician that provided the restoration in 2016.
- If either SERVICE CODE or DATE OF SERVICE criteria are not met, or there are missing or invalid field codes (e.g., TOOTH NUMBER), then STOP processing. This subject is included in denominator 3, but is not included in numerator 3.

YOU NOW HAVE THE PRACTICE-SPECIFIC AND CLINICIAN-SPECIFIC NUMERATOR 3 (NUM 3)

5. Report ([using reporting template](#)):
- a. Number of patients in practice-specific or clinician-specific denominator, overall and by age stratification category
 - b. Number of patients in practice-specific or clinician-specific numerator, overall and by age stratification category

DENOMINATOR 4: RESTORATION IN 2016 AND ANY DENTAL SERVICE IN 2019

Among those subjects in **Denominator 1**, select those who also have any dental service in 2019. The dental service in 2019 is not restricted to the same practice or clinician. It is simply to establish that the patient is still active in the database.

1. **For each practice**, select subjects in Denominator 1 who also have any dental service in 2019 (where the dental service in 2019 does not need to be restricted to the same practice):
 - a. If subject is in Denominator 1 **AND**
 - b. If [SERVICE CODE] = [D0100 – D9999] **with any practice** AND
 - c. If [DATE OF SERVICE] >= January 1, 2019 AND <= December 31, 2019, then include in **Denominator 4 for the practice**.
 - d. If either SERVICE CODE or DATE OF SERVICE is not met, or there are missing or invalid field codes (e.g., date of service), then STOP processing. This subject is not included in denominator 4.

NOTE: The dental service in 2019 can be with any practice. It does not need to be with the practice that provided the index restoration in 2016.

2. **For each clinician**, select subjects in Denominator 1 who also have any dental service in 2019 (where the dental service in 2019 is not restricted to the same clinician):
 - a. If subject is in Denominator 1 **AND**
 - b. If [SERVICE CODE] = [D0100 – D9999] **with any clinician** AND
 - c. If [DATE OF SERVICE] >= January 1, 2019 AND <= December 31, 2019, then include in **Denominator 4 for the clinician**.
 - d. If either SERVICE CODE or DATE OF SERVICE is not met, or there are missing or invalid field codes (e.g., date of service), then STOP processing. This subject is not included in denominator 4.

NOTE: The dental service in 2019 can be with any clinician. It does not need to be with the clinician that provided the index restoration in 2016.

YOU NOW HAVE THE PRACTICE-SPECIFIC AND CLINICIAN-SPECIFIC DENOMINATOR 4 (DEN4)

NUMERATOR 4: CROWN/ENDO/PARTIAL/EXTRACTION WITHIN 36 MONTHS OF RESTORATION

For each practice and clinician: Among the subjects in Denominator 4, **for each restoration placed in 2016**, check if subject received any crown, endodontic, partial denture, or extraction service in the same tooth as the restoration within 36 months of the restoration placement with any practice/clinician:

3. Select subjects in the practice-specific or clinician-specific Denominator 4.

4. For **each restoration placed in 2016**, check if subject has any crown, endodontic, partial denture, or extraction service **in the same tooth within 36 months** (can be placed by any practice/clinician):
- a. Crowns:
 - i. If any [CROWN CODE] = [D2710 through D2794]; AND
 - ii. [CROWN TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. $0 < [\text{CROWN DATE OF SERVICE}] - [\text{RESTORATION DATE OF SERVICE}] \leq 1,095$ days
- OR**
- b. Endodontic services:
 - i. If any [ENDODONTIC CODE] = [D3110 through D3999]; AND
 - ii. [ENDO TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. $[\text{ENDO DATE OF SERVICE}] - [\text{RESTORATION DATE OF SERVICE}] \leq 1,095$ days
- OR**
- c. Partial denture services:
 - i. If any [PARTIAL DENTURE CODE] = [D5211 through D5286]; AND
 - ii. [PARTIAL TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. $0 < [\text{PARTIAL DATE OF SERVICE}] - [\text{RESTORATION DATE OF SERVICE}] \leq 1,095$ days
- OR**
- d. Extraction services:
 - i. If any [EXTRACTION CODE] = [D7111 through D7999]; AND
 - ii. [EXTRACTION TOOTH NUMBER] = [RESTORATION TOOTH NUMBER]; AND
 - iii. $0 < [\text{EXTRACTION DATE OF SERVICE}] - [\text{RESTORATION DATE OF SERVICE}] \leq 730$ days
 - e. If subject had ANY follow-up procedure contained in (a) – (d) within 1,095 days, then **include in practice-specific or clinician-specific numerator 4**.
 - f. If subject did not have any follow-up procedure contained in (a) – (d) within 1,095 days, then STOP processing; this subject is included in denominator 4, but will not be included in numerator 4.

NOTES:

- The crown/endo/partial/extraction procedure can be with any practice or clinician. It does not need to be with the practice/clinician that provided the restoration in 2016.

- If either SERVICE CODE or DATE OF SERVICE criteria are not met, or there are missing or invalid field codes (e.g., TOOTH NUMBER), then STOP processing. This subject is included in denominator 4, but is not included in numerator 4.

YOU NOW HAVE THE PRACTICE-SPECIFIC AND CLINICIAN-SPECIFIC NUMERATOR 4 (NUM 4)

5. Report ([using reporting template](#)):
 - a. Number of patients in practice-specific or clinician-specific denominator, overall and by age stratification category
 - b. Number of patients in practice-specific or clinician-specific numerator, overall and by age stratification category

Appendix 2: Advanced Procedure (crowns, partials, endodontic treatment, or extractions) after Restoration Placement Practice and Clinician Rates, Stratified by Age

Crowns/partial/endodontic/extractions following restoration placement: >=19 YEARS													
Practice													
		DEN1	NUM1	RATE1	DEN2	NUM2	RATE2	DEN3	NUM3	RATE3	DEN4	NUM4	RATE4
		#ptnts w/ Eval/Rest in 2016	#ptnts w/ Crown/etc. within 6 mos.		#ptnts w/ Eval/Rest in 2016 & Any Dental Service in 2017	#ptnts w/ Crown/etc. within 12 mos.		#ptnts w/ Eval/Rest in 2016 & Any Dental Service in 2018	#ptnts w/ Crown/etc. within 24 mos.		#ptnts w/ Eval/Rest in 2016 & Any Dental Service in 2019	#ptnts w/ Crown/etc. within 36 mos.	
>=19 Years (total, nonstratified)													
Data Partner 1 (n=2,069)	Median	195	3	1.52%	161	6	3.35%	145	11	7.19%	134	16	10.91%
Data Partner 2 (n=100)	Median	251	4	1.52%	184	7	3.33%	148	10	6.44%	128	12	8.80%
19-30 Years													
Data Partner 1	Median	37	0	0.00%	26	0	0.00%	21	1	3.85%	18	1	6.25%
Data Partner 2	Median	46	0	0.00%	29	0	0.00%	22	1	2.99%	17	1	2.77%
31-50 Years													
Data Partner 1	Median	77	1	1.39%	63	2	2.86%	58	4	5.71%	55	5	8.70%
Data Partner 2	Median	102	1	1.21%	1.21%	2	2.59%	64	3	4.84%	59	4	6.66%
51-64 Years													
Data Partner 1	Median	58	1	1.69%	51	2	3.77%	47	4	8.16%	44	6	12.73%
Data Partner 2	Median	64	1	1.85%	52	2	3.68%	46	3	7.23%	41	5	10.60%
>=65 Years													
Data Partner 1	Median	24	0	0.00%	21	1	4.00%	19	2	10.00%	17	3	15.63%
Data Partner 2	Median	27	0	0.00%	22	1	4.88%	20	2	9.88%	18	2	13.33%

PRACTICE- AND CLINICIAN-LEVEL DENTAL QUALITY MEASURE DEVELOPMENT REPORTS

Crowns/partials/endodontic/extractions following restoration placement: >=19 YEARS													
Clinician													
		DEN1	NUM1	RATE1	DEN2	NUM2	RATE2	DEN3	NUM3	RATE3	DEN4	NUM4	RATE4
		#ptnts w/ Eval/Rest in 2016	#ptnts w/ Crown/etc. within 6 mos.		#ptnts w/ Eval/Rest in 2016 & Any Dental Service in 2017	#ptnts w/ Crown/etc. within 12 mos.		#ptnts w/ Eval/Rest in 2016 & Any Dental Service in 2018	#ptnts w/ Crown/etc. within 24 mos.		#ptnts w/ Eval/Rest in 2016 & Any Dental Service in 2019	#ptnts w/ Crown/etc. within 36 mos.	
>=19 Years (total, nonstratified)													
Data Partner 1 (n=1744)	Median	184	3	1.40%	153	5	3.15%	139	10	6.67%	129	14	10.26%
Data Partner 2 (n=100)	Median	255	5	1.76%	184	7	3.29%	152	10	5.84%	132	13	8.21%
19-30 Years													
Data Partner 1	Median	35	0	0.00%	25	0	0.00%	21	1	3.23%	18	1	5.88%
Data Partner 2	Median	50	0	0.00%	33	0	0.00%	24	1	1.50%	19	1	3.65%
31-50 Years													
Data Partner 1	Median	71	1	1.27%	60	2	2.66%	55	3	5.26%	52	4	8.30%
Data Partner 2	Median	97	2	1.63%	73	3	3.26%	63	4	5.22%	54	4	6.74%
51-64 Years													
Data Partner 1	Median	54	1	1.54%	48	2	3.45%	45	3	7.55%	42	5	11.76%
Data Partner 2	Median	68	2	1.88%	56	2	3.58%	47	3	7.23%	43	4	10.35%
>=65 Years													
Data Partner 1	Median	23	0	0.00%	20	1	3.45%	19	2	9.52%	17	2	15.00%
Data Partner 2	Median	28	0	0.00%	22	1	1.95%	18	1	7.69%	17	2	12.50%

Appendix 3: Evidence Review by ADA Science and Research Institute

1. For posterior restorations (regardless of material) in general, what is the expected survival rate at 12/24 and 36 months?

After examining seven meta-analyses spanning from 2012 to 2022, it has been found that the survival rate for posterior restorations in both primary and permanent teeth, regardless of the material used, ranges from 61.6% to 97% for at least 48 months. The survival rates are affected by the type of teeth being evaluated (permanent or primary), the material used, and the number of restored surfaces.

Type of posterior restoration	Type of dentition	Follow-up periods	Survival Rate	Reference
Resin composite materials (hybrid, micro-hybrid, nanohybrid or bulk fill composite) and Glass- ionomers	Permanent	At least 2 years	After 4 years: 95–97% with no significant differences between the resin composite materials. After 10 years: 85–90% with no significant difference between hybrid, micro-hybrid, and non-hybrid resin materials. For compomer and GIC (Glass Ionomer Cement) restorations, the mean overall survival rate was about 80% after 6 years.	(Heintze, Loguercio et al. 2022)
Atraumatic Restorative Treatment (ART)	Primary and permanent teeth	12 to 36 months	For primary teeth: 71% in 12 months to 65% in 36 months. For permanent teeth: 96% in 12 months to 61% in 36 months.	(Garbim, Laux et al. 2021)
Amalgam and composite resin restorations	Permanent	At least 3 years	Amalgam: 92.5% Direct resin composite: 85.8%	(Worthington, Khangura et al. 2021)
Bulk-fill resin composites and conventional resin composites	Permanent	12-72 months	Bulk-fill: 94.43% Conventional: 96.68%	(Velo, Lemos et al. 2019)

Ceramic, Hybrid and Composite Onlays	Permanent	12 months or more	The estimated restoration survival rate was 94.2%	(Bustamante-Hernández, Montiel-Company et al. 2020)
Atraumatic restorative treatment (ART) sealants and restorations	Primary and permanent teeth	At least 1 year	Survival rates of single-surface ART restorations over the first 2 years in primary teeth: 93% Survival rates of multiple-surface ART restorations in primary teeth over the first 2 years in primary teeth: 62%. Survival rates of single-surface ART restorations over the first 3 years: 85% Survival rates for single-surface ART restorations in permanent teeth over the first 3 years: 85% Survival rates for multiple-surface ART restorations in permanent teeth over 1 year: 86%. The mean annual dentine lesion incidence rate, in pits and fissures previously sealed using ART, over the first 3 years was 1%.	(de Amorim, Leal et al. 2012)
Resin composites, compomers, amalgams and glass-ionomer	Permanent (Class II restorations)	Average 4.6 years	61.6%	(Kopperud, Tveit et al. 2012)

2. Are patient factors more predominant or technical quality of the provider more predominant when it comes to survival?

Clinical retrospective and practice-based studies published that patient-related factors, such as caries risk and bruxism (Laske et al. 2019, Opdam et al. 2007; Opdam et al. 2010; van de Sande et al. 2013) as well as socioeconomic status (Correa et al. 2013; Collares et al. 2018), are **variables of main importance in restoration survival**. Systematic reviews including patient-related risk factors showed that their influence on restoration performance is significant and relevant (Opdam et al. 2014; van de Sande et al. 2016). Besides patient-related factors, dentist factors, such as personal skills and treatment decisions (Laegreid et al. 2014; Laske et al. 2016a; Collares et al. 2017) and health insurance policies (Khalaf et al. 2014), may play a significant role in the survival of restorations placed in general practice as well.

Studies identified several of these risk factors, such as socioeconomic status (Correa et al. 2013), general health, periodontal status (Adolphi et al. 2007), oral hygiene (Kopperud et al. 2012), high caries risk (Kopperud et al. 2012; van de Sande et al. 2013), and parafunctional habits (van de Sande et al. 2013; Pallesen and van Dijken 2015). Moreover, restoration size (Lucarotti et al. 2014; Laske et al. 2016b) and the presence of an endodontic treatment (Laske et al. 2016b) were found as risk factors for survival.

According to Laske et al. (2019), a wide range in operator AFR (Annual Failure Risk) was found, varying between 3.6% and 11.7%. This is remarkable in that all included dentists are motivated above average to provide high-quality care. As indicated in another study (Laske et al. 2016b), the observed differences may be related to operator skills, clinical experience, sex, and age, but it could also be related to practice organization, intervention choices by the dentists, and different patient needs and demands.

Demarco et al. (2012; 2023) showed that **tooth/restoration-level factors were the most prevalent risk factors** when compared to patient-level and dentist-level factors, especially the type of tooth restored, number of restored surfaces, position of the tooth in the mouth, and type of resin composite used. The most frequent patient-level factors investigated were their gender, age, and presence of caries and/or occlusal stress risks. **Dentist-level factors were far less prevalent than the other types**, the most frequently found types were the effect of different operators and the operator's experience.

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Appendix 4: Related Concept Data

Measure: Percentage of Total Crowns Placed Requiring Root Canal Treatment Subsequent to Placement (data provided by Data Partner 2)

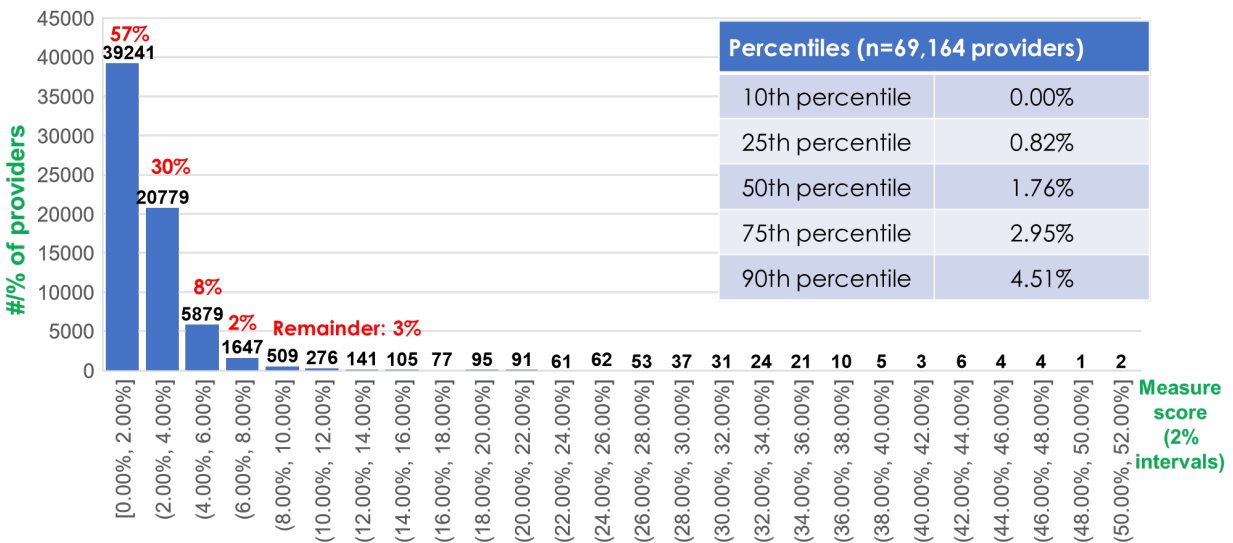
Numerator:

Count of unique patient/tooth combinations with D27xx (excluding D2799) with subsequent D3310, D3320, or D3330

Denominator:

Count of unique patient/tooth combinations with D27xx (excluding D2799)

**% crowns placed with subsequent root canal treatment
Histogram: #/% of Providers in Measure Score Range**



Measure: Percentage of Treated Teeth Subsequently Extracted (data provided by Data Partner 2)

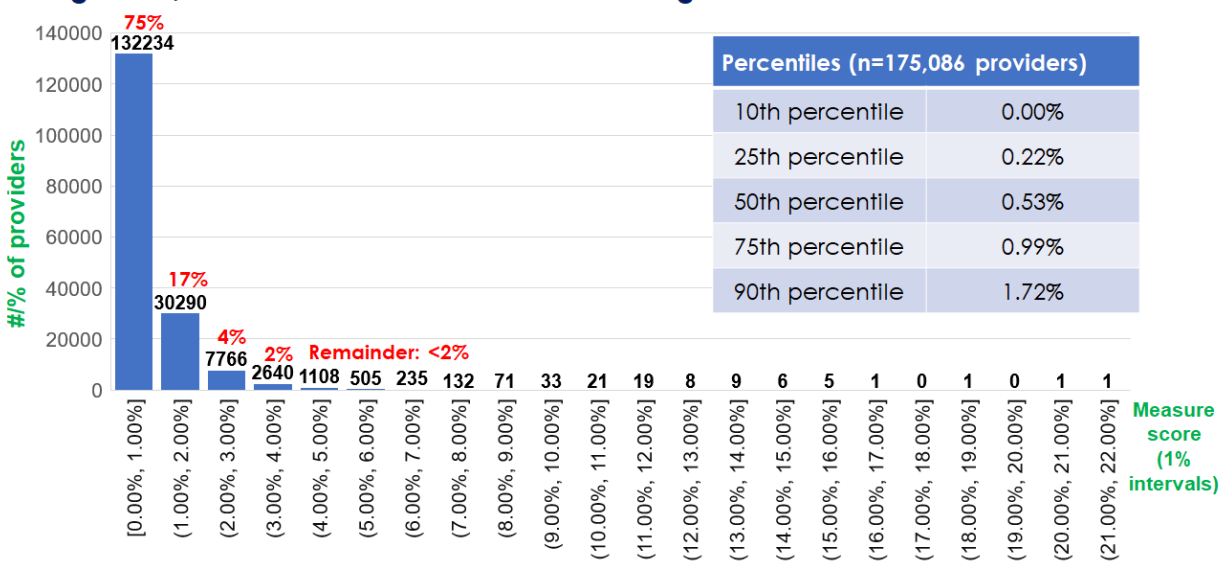
Numerator:

Count of unique patient/tooth combinations with D135x, D15xx, D2xxx, D3xxx, or D4xxx with subsequent D7140, D7210, or D7250 (primary teeth excluded)

Denominator:

Count of unique patient/tooth combinations with D135x, D15xx, D2xxx, D3xxx, or D4xxx (primary teeth excluded)

% of treated teeth subsequently extracted
Histogram: #/% of Providers in Measure Score Range



Measure: Percentage of Total Crowns Requiring Extraction of the Tooth Subsequent to Placement (data provided by Data Partner 2)

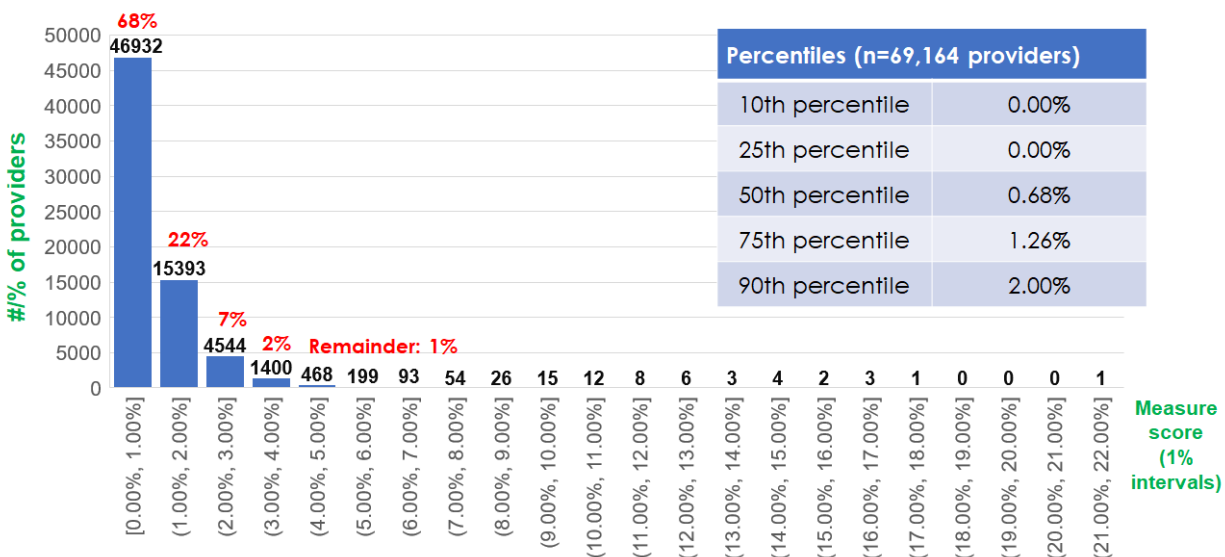
Numerator:

Count of unique patient/tooth combinations with D27xx (excluding D2799) with subsequent D7140, D7210, or D7250

Denominator:

Count of unique patient/tooth combinations with D27xx (excluding D2799)

% crowns placed with subsequent extraction
Histogram: #/% of Providers in Measure Score Range



Measure: Percentage of Implants Requiring Repair or Removal (data provided by Data Partner 2)

Numerator:

Count of unique patient/tooth combinations with D6010, D6013, D6040, D6050 with subsequent D6090, D6092, D6093, D6095, D6096, D6100, or D6105

Denominator:

Count of unique patient/tooth combinations with D6010, D6013, D6040, D6050

**% implants requiring repair or removal
Histogram: #/% of Providers in Measure Score Range**

