Completeness, accuracy, and computability of National Quality Forum-specified eMeasures

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ABSTRACT

Objective To analyze the completeness, computability, and accuracy of specifications for five National Quality Forum-specified (NQF) eMeasures spanning ambulatory, post-discharge, and emergency care within a comprehensive, integrated electronic health record (EHR) environment.

Materials and methods To evaluate completeness, we assessed eMeasure logic, data elements, and value sets. To evaluate computability, we assessed the translation of eMeasure algorithms to programmable logic constructs and the availability of EHR data elements to implement specified data criteria, using a de-identified clinical data set from Kaiser Permanente Northwest. To assess accuracy, we compared eMeasure results with those obtained independently by existing audited chart abstraction methods used for external and internal reporting.

Results One measure specification was incomplete; missing applicable LOINC codes rendered it non-computable. For three of four computable measures, data availability issues occurred; the literal specification guidance for a data element differed from the physical implementation of the data element in the EHR. In two cases, cross-referencing specified data elements to EHR equivalents allowed variably accurate measure computation. Substantial data availability issues occurred for one of the four computable measures, producing highly inaccurate results.

Discussion Existing clinical workflows, documentation, and coding in the EHR were significant barriers to implementing eMeasures as specified. Implementation requires redesigning business or clinical practices and, for one measure, systemic EHR modifications, including clinical text search capabilities.

Conclusions Five NQF eMeasures fell short of being machine-consumable specifications. Both clinical domain and technological expertise are required to implement manually intensive steps from data mapping to text mining to EHR-specific eMeasure implementation.

Key words: Electronic Health Record; Meaningful Use; Healthcare Quality Indicators/Methods; Process Assessment (Health Care)

BACKGROUND AND SIGNIFICANCE

The Health Information Technology for Economic and Clinical Health (HITECH) Act, part of the American Recovery and Reinvestment Act of 2009, invested US$20 billion to advance the use of health information technology in the USA. HITECH’s objectives include establishing unified standards and certification to facilitate the collection and electronic exchange of healthcare information, building the infrastructure for health information technology, protecting the security of health information, and providing incentive payments for physicians, hospitals, and certain other providers to use certified electronic health records (EHRs) in meaningful ways.¹ ² Consequently, beginning in 2011 and continuing for 5 years, Medicare EHR incentive programs provide substantial payments to eligible professionals and hospitals demonstrating meaningful use of certified EHR technology. Similar payments under the Medicaid EHR incentive programs begin as individual states are ready to participate and continue until 2021.

‘Meaningful use’ of certified EHRs is evidenced by a range of functions, from creating a medical record to helping clinicians make better decisions and avoid preventable errors to engaging patients and families. HITECH also requires that providers demonstrate meaningful use through electronic quality reporting, reflecting a widespread belief in the potential of EHRs to advance quality measurement and reporting.³ ⁴ Stage 1 meaningful use requires eligible professionals to complete six clinical quality measures (CQMs) and eligible hospitals to complete 15 CQMs; stage 2 requirements expand this to nine CQMs for eligible professionals and 16 CQMs for eligible hospitals.⁵ ⁶ The Centers for Medicare and Medicaid Services

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of the US Department of Health and Human Services (HHS) selects CQMs from which providers may choose measures to complete electronically.

Before the advent of meaningful use, discrepancies were documented between automated and completely or partially manual quality reporting. Accessing the rich clinical data in EHRs requires specifying quality measures so that EHRs implement in a wide array of settings and across multiple provider groups can be used to completely and accurately extract required data and accurately compute performance results. In 2010, at the request of the HHS, the National Quality Forum (NQF) converted 113 NQF-endorsed CQMs from a paper-based format relying on chart abstraction to an electronic ‘eMeasure’ format. The resulting specifications for individual measures, submitted to HHS in December 2011, include the data elements, logic, and definitions in Health Level 7 Healthcare Quality Messaging Format (HL7 HQMF). Studies published in 2012 and later also documented discrepancies between automated and manual quality reporting, but analyses were conducted before the release of eMeasure specifications.

Following the release of eMeasure specifications, little has been published evaluating them within specific EHR environments. An analysis of the implementation of Meaningful Use Stage 1 eMeasure specifications among four hospitals identified program design, technology, clinical, and strategic challenges, described policy implications and provided recommendations, but supplied little detail about the nature of gaps. Our objective was to assess the completeness, computability, and accuracy of published specifications and describe gaps for selected NQF-specified eMeasures within a healthcare system using a well-established, comprehensive EHR integrated across all care settings.

MATERIALS AND METHODS

Kaiser Permanente is the largest not-for-profit integrated healthcare delivery system in the USA. Its EHR, KP HealthConnect, is based on software from Epic Systems Corporation and was deployed beginning in 2003. KP HealthConnect is implemented programwide, allowing clinicians and employees to manage the healthcare and administrative needs of 9 million members across seven geographic regions.

Measure selection

Our goal was to select a group of measures that collectively addressed evidence-based interventions: (1) related to quality, patient safety, and utilization for acute and chronic conditions; (2) among obstetric (OB), adult, and geriatric patients; (3) occurring in inpatient, emergency, and ambulatory settings and transitions between settings; and (4) reflecting activities of healthcare providers in multiple departments, including laboratory services, pharmacy, and imaging, as well as diagnoses and procedures. We also focused on industry-standard accredited or regulatory measures or metrics routinely collected and reported to support internal Kaiser Permanente strategic goals because audited comparable performance data were available, independently obtained through existing chart abstraction methods.

A substantial proportion of available eMeasures fit our selection criteria; after considering alignment with organizational performance improvement goals, we narrowed the list of candidate measures to 10. Resource availability constrained our final analysis to five NQF–specified measures: NQF 0012, prenatal screening for HIV; NQF 0052, use of imaging studies in low back pain; NQF 0097, medication reconciliation; NQF 0137, ACE inhibitor (ACE-I) or angiotensin II receptor blocker (ARB) at discharge for left ventricular systolic dysfunction (LVSD) among patients with acute myocardial infarction (AMI); and NQF 0148, blood cultures in the emergency department before initial antibiotic in the hospital.

Analysis

We assessed each eMeasure specification for completeness, computability, and accuracy. Completeness was a characteristic inherent in the specification and not a function of its deployment in a given EHR environment. We defined an eMeasure specification as complete if the measure algorithm and HQMF specification included all necessary data elements or evidence concepts and the enumerated value sets represented all specified data elements. The selected eMeasures included 3–30 data elements. For each Quality Data Model (QDM) data element, specifications enumerated value sets consisting of clinical, billing, and coding data.

Computability and accuracy were functions of eMeasure deployment within the EHR environment at Kaiser Permanente. Computability comprised two aspects: (1) the extent to which an eMeasure specification algorithm could be translated to programmable logic constructs; and (2) the availability of EHR data elements to implement the eMeasure-specified QDM data criteria. We defined a specification as computable if it could be translated to programmable logic constructs and if all discrete data domains, data elements, and initial patient population criteria were available for extraction within KP HealthConnect. Although eMeasure specifications may have described value sets for QDM data elements using International Classification of Diseases, Tenth Revision (ICD-10) and SNOMED Clinical Terms (SNOMED-CT), we adhered to standard code sets implemented in KP HealthConnect: International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM), Current Procedural Terminology (CPT-4), Logical Observation Identifiers Names and Codes (LOINC), and RxNorm.

When an eMeasure specification suggested the value set of a QDM data element was enumerated only through SNOMED-CT, we expected to see a distinct data element in the EHR for that clinical observation (e.g., for NQF 0012, a documented clinical observation as a reason for HIV screening exclusion). For measures that were not computable as specified, we identified any discrepancies between the specification’s literal guidance on an eMeasure’s data element and the physical implementation of the data element in the EHR; we also identified any transformations required for eMeasure computation.

We defined accuracy as concordance between the results obtained by implementing the eMeasure specifications and
by existing audited chart abstraction methods. For measures we assessed as complete and computable, we extracted clinical data and computed the eMeasure, using PluralSoft’s CareQuotient software. We identified and computed submeasures, the building blocks for computing the denominator and one or more numerators. Submeasures included:

- **Initial patient population**: the eMeasure-specified initial population, representing the population eligible for the CQM.
- **Initial denominator**: some eMeasures specify a subset of the initial patient population as a starter set for the final measure denominator.
- **Denominator exclusions**: the subset of the initial patient population or initial denominator that is excluded to arrive at the measure. Multiple sets of denominator exclusions may be specified.
- **Measure denominator**: the eMeasure-specified reportable denominator population subset with all denominator exclusion subsets removed.
- **Intermediate numerator**: although not required to be reported under NQF specifications, the calculation of intermediate numerators is helpful when an eMeasure specifies a population defined by more than one characteristic. Intermediate numerators facilitate computation auditing and provide insight into population characteristics.
- **Compliant numerator**: the eMeasure-specified reportable subset of the measure denominator.

After computing submeasures, we computed aggregate eMeasure results and compared them to results independently obtained from existing audited chart abstraction methods used for internal and external reporting as part of ongoing operations.

**Dataset**

All data used in the analyses were de-identified and came from two sources: the enterprise-level data warehouse for KP HealthConnect in Kaiser Permanente Northwest and KP HealthConnect data stored in data tables in Epic’s Clarity. Data for ambulatory care eMeasures were representative of the region’s entire membership; data for inpatient and emergency department care and associated care transitions were limited to the single Kaiser Permanente hospital then operating in the Northwest region. The measurement period for all measures was October 1, 2011 through September 30, 2012. We included specific domains of historical data over a longer period of time because they provided data points for determining an eMeasure’s initial patient population and denominator inclusion and exclusion criteria. For all patients in an eMeasure’s initial patient population, we also included encounter or visit data for the 24 months before the measurement period and all available patient-level historical problem lists and allergy data.

The Kaiser Permanente Southern California Institutional Review Board determined that this project was not human subjects research and not subject to oversight.

**RESULTS**

**Completeness of HQMF specification**

For four of the five measures we assessed, HQMF specifications were complete. The exception was NQF 0148, blood cultures in the emergency department before initial antibiotic in the hospital. In this case, the HQMF specification identified that the data element ‘Hospital Measures-Blood Culture’ is expected to be enumerated through value sets comprising either SNOMED-CT codes or LOINC codes. However, the specification does not provide a detailed list of applicable LOINC codes. As a result, we could not compute this eMeasure as specified, but it can be computed if an alternative identification of blood culture collection exists and is used for documentation in the EHR.

**Computability**

NQF 0012, Prenatal care: screening for HIV

Seven submeasures were required: initial patient population, four denominator exclusions, measure denominator, and compliant numerator (table 1). Data availability issues arose for three QDM data elements.

Specification for the initial patient population enumerated CPT or ICD-9 codes identifying patient encounters/visits in which a delivery of live birth procedure was performed or a diagnosis was made. In lieu of using procedure or diagnostic codes, Kaiser Permanente identifies the delivery of live births using data captured in Epic Clarity’s OB History table. We completed the required data transformation, using data from Clarity to create a new patient encounter/visit for the recorded delivery date with a default CPT code to signify the data element for the delivery of live birth procedure. A denominator exclusion required a documented clinical observation (in lieu of the specified SNOMED-CT code) for a laboratory test not performed for patient reasons. No specific clinical observation data element in KP HealthConnect identifies if a HIV screening test was not performed because of patient reasons (e.g., refusal). No data were available for this denominator exclusion, and no transformation occurred.

The compliant numerator required a LOINC or procedure code or clinical observation (in lieu of the specified SNOMED-CT code) to identify that a laboratory test was performed. Clinical or business practices at Kaiser Permanente Northwest do not consistently capture in the EHR a CPT or LOINC code or a specific clinical observation stored as a structured data element for HIV screening. Rather, HIV screening is recorded in the progress notes (a text field) of the patient encounter/visit in the Clarity Medical Reason table. We completed the required data transformation, creating a new Patient Clinical Observation by doing a full-text search in the progress note for evidence of HIV screening. We used the date of the progress note as the date of the clinical observation documentation, which is essential for eMeasure computation.

NQF 0052, Use of imaging studies in low back pain

Eight submeasures were required: the initial patient population, five denominator exclusions, the measure denominator, and
the compliant numerator. No data availability issues were identified and no data transformations occurred (table 2).

NQF 0097, Medication reconciliation
Three submeasures were required: initial patient population, measure denominator, and compliant numerator. Data availability issues arose for two QDM data elements (table 3).

The initial patient population specification required a procedure code for a discharge day management encounter. Current clinical and business processes do not consistently capture a specific CPT code identifying an inpatient discharge. Kaiser Permanente instead identifies inpatient discharge events using data captured in Epic Clarity’s Discharges table. We completed the required data transformation, using Clarity data to create a new patient encounter with a default CPT code to signify the QDM data element for the recorded discharge day.

The compliant numerator required specification of a clinical observation (in lieu of SNOMED-CT codes) for a medication reconciliation intervention. This observation is recorded in specific flow sheets/template in KP HealthConnect, and no transformation was done. However, these data drove the transformation for another missing QDM data element.

The measurement denominator specified a procedure code for an outpatient office encounter. Even though the data included all patient encounters/visits for patients in the initial patient population, the outpatient encounter procedure code was missing for dates when a clinical observation for medication reconciliation was recorded. We thus performed the computation in two ways and compared the results. The first computation conformed to the eMeasure specification for the existence of an outpatient encounter; the second assumed that the clinical observation data for medication reconciliation was performed during an outpatient encounter occurring on the same date, even though the data did not reflect the existence of an associated outpatient encounter. The results varied substantially (table 3).

NQF 0137, ACE-I or ARB at discharge for LVSD among patients with AMI
Twenty-nine submeasures were required: the initial patient population, the initial denominator, 23 denominator exclusions, the measure denominator, two intermediate numerators, and the compliant numerator. Data availability issues arose for 10 QDM data elements.

The initial patient population specification required a clinical observation for an inpatient stay (in lieu of SNOMED-CT code for ‘Hospital Measures-Encounter Inpatient’). No discrete element identifying an inpatient stay was captured in KP HealthConnect in the data set. We investigated potential alternate methods to identify evidence of inpatient stays using billing data. They included checking for use of Place of Service codes for hospital inpatient stay (e.g., 21) and/or use of CPT Evaluation and Management (E&M) codes for physician services rendered within a hospital inpatient setting. No Place of Service code or CPT codes reliably identified inpatient stays. However, admission and discharge dates of an inpatient stay were captured in Epic Clarity’s Discharges table. We completed the required transformation, using Clarity data to determine the clinical observation for an inpatient stay.

The initial denominator specification required clinical observations (in lieu of SNOMED-CT and ICD-9 codes) for an active diagnosis of LVSD, diagnostic study (ejection fraction) results,
### Table 2: Data availability for NQF 0052, use of imaging in low back pain

<table>
<thead>
<tr>
<th>Submeasure, measure number</th>
<th>Description</th>
<th>Numerator value</th>
<th>Denominator value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial patient population, 052-001</strong></td>
<td>Number of patients 18–49 years old with low back pain</td>
<td>8267</td>
<td>8267</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Denominator exclusions, 052-002</strong></td>
<td>Number of patients in 052-001 with cancer</td>
<td>232</td>
<td>8267</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Denominator exclusions, 052-003</strong></td>
<td>Number of patients in 052-001 with trauma</td>
<td>408</td>
<td>8267</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Denominator exclusions, 052-004</strong></td>
<td>Number of patients in 052-001 who abuse IV drugs</td>
<td>110</td>
<td>8267</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Denominator exclusions, 052-005</strong></td>
<td>Number of patients in 052-001 with neurologic impairment</td>
<td>67</td>
<td>8267</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Denominator exclusions, 052-006</strong></td>
<td>Number of patients in 052-001 who are excluded from imaging studies</td>
<td>793</td>
<td>8267</td>
<td>10%</td>
</tr>
<tr>
<td><strong>Measure denominator, 052-007</strong></td>
<td>Number of patients in 052-001 who are eligible for imaging studies</td>
<td>7474</td>
<td>8267</td>
<td>90%</td>
</tr>
<tr>
<td><strong>Compliant numerator, 052-008</strong></td>
<td>Number of patients in 052-001 without imaging studies</td>
<td>6003</td>
<td>7474</td>
<td>80%</td>
</tr>
</tbody>
</table>

IV, intravenous; NQF, National Quality Forum.

### Table 3: Data availability for NQF 0097, medication reconciliation

<table>
<thead>
<tr>
<th>Submeasure, measure number</th>
<th>Description</th>
<th>Numerator value</th>
<th>Denominator value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assuming recorded medication reconciliation clinical observations occurred during outpatient encounters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Initial patient population, 097-001</strong></td>
<td>Number of patients aged 65 years or older who have been discharged 60 days prior to the measurement period end date</td>
<td>945</td>
<td>945</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Measure denominator, 097-002</strong></td>
<td>Number of patients in 097-001 who had an outpatient encounter 60 days after the discharge</td>
<td>945</td>
<td>945</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Compliant numerator, 097-003</strong></td>
<td>Number of patients in 097-002 for whom medication reconciliation has been performed</td>
<td>796</td>
<td>945</td>
<td>84%</td>
</tr>
<tr>
<td><strong>Conforming to the eMeasure specification for the existence of an outpatient encounter</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Initial patient population, 097-001</strong></td>
<td>Number of patients aged 65 years or older who have been discharged 60 days prior to the measurement period end date</td>
<td>945</td>
<td>945</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Measure denominator, 097-002</strong></td>
<td>Number of patients in 097-001 who had an outpatient encounter 60 days after the discharge</td>
<td>8</td>
<td>945</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Compliant numerator, 097-003</strong></td>
<td>Number of patients in 097-002 for whom medication reconciliation has been performed</td>
<td>8</td>
<td>8</td>
<td>100%</td>
</tr>
</tbody>
</table>

NQF, National Quality Forum.
and an active diagnosis of moderate or severe LVSD. Kaiser Permanente does not use separate EHR-captured discrete data elements to identify an active diagnosis of LVSD and the results of ejection fraction diagnostic studies. Prevailing clinical practices note LVSD diagnosis, severity, and ejection fraction measurement in progress notes attached to a patient encounter. These data primarily occurred in the form of textual notes, although there were infrequent instances of the ICD-9 code for ‘Diagnosis, Active: LVSD moderate or severe.’ The latter enabled us to calculate the submeasure as specified, although accuracy was very low. The transformation required to increase accuracy would create discrete clinical observations accounting for textual notes reflecting an active diagnosis of LVSD and the results of ejection fraction studies. A significant barrier was the need for sophisticated full text search and retrieval; we did not complete this transformation, and the accuracy of the eMeasure initial denominator remained very low.

Multiple data availability issues occurred for denominator exclusions. Clinical observation data elements (in lieu of the HL7 value set and SNOMED-CT codes) for medical, system, and patient reasons for not prescribing ACE-I or ARB were not captured in the EHR. We were unable to transform data, and these denominator exclusions were not checked during computation. Similarly, discrete clinical observation data elements (in lieu of the HL7 value set and SNOMED-CT codes) were absent for multiple denominator exclusions: inpatient comfort care, inpatient hospice care, clinical trial participation, discharge against medical advice, and expiration.

**Accuracy**

Table 4 summarizes the results of the accuracy analyses for the five NQF-specified measures we assessed, compared to the results we expected on the basis of existing audited chart abstraction methods used in ongoing internal and external quality reporting.

**DISCUSSION**

All eMeasure specifications were complete and computable except NQF 0148, for which LOINC codes were missing. However, specifications make assumptions about clinical, billing, and coding data capture practices that may not be implemented by the EHR or billing systems or by Kaiser Permanente. Specifications also relied on codes that did not exist in the EHR.

Literal implementation of specifications was not feasible in four instances. Transformation using available data elements in the EHR produced results that substantially varied from those expected for two measures. Our results indicate that customizations will be required in KP HealthConnect to adopt practices and workflows that align with QDM data element capture prescribed by eMeasure specifications.

Strengths of our report include detailed information on gaps between eMeasure specifications and their literal implementation in an established EHR based on a widely used platform. Our analysis of measures spanning care settings and needs is also a strength.

Several limitations deserve mention. We analyzed a small number of measures, and the generalizability of our findings to other measures is unknown. In addition, our analysis relied on a datamart extracted from an EHR, not the real-time operating EHR. Although we did not identify any data elements missing from our analysis that would have been included in the live EHR, it is possible that our results might have varied slightly.

The generalizability of our results to other care delivery systems and EHRs is unknown. However, two instances of data availability seem particularly likely to occur in other systems. Hospitals may use an EHR system relying on proprietary codes that do not conform to standard industry codes, in lieu of or in addition to SNOMED-CT, CPT, or Place of Service codes. However, the hospital may also use a billing system that captures both Place of Service and CPT codes to support revenue cycle management. Combining inpatient clinical encounter data

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
<th>Expected result</th>
<th>Result without transformation</th>
<th>Result with transformation</th>
</tr>
</thead>
<tbody>
<tr>
<td>NQF 0148</td>
<td>Blood cultures in the emergency department before initial antibiotic in the hospital</td>
<td>93.6–100%</td>
<td>Not accurate</td>
<td>Not performed</td>
</tr>
<tr>
<td>NQF 0012</td>
<td>Prenatal screening for HIV</td>
<td>88.3%</td>
<td>Insufficient data</td>
<td>62.9%</td>
</tr>
<tr>
<td>NQF 0052</td>
<td>Use of imaging in low back pain</td>
<td>84.1%</td>
<td>80.3%</td>
<td>Not performed</td>
</tr>
<tr>
<td>NQF 0097</td>
<td>Medication reconciliation</td>
<td>83.3%</td>
<td>Insufficient data</td>
<td>84.2%</td>
</tr>
<tr>
<td>NQF 0137</td>
<td>ACE-I or ARB at discharge for LVSD among patients with AMI</td>
<td>100%</td>
<td>Insufficient data</td>
<td>0%</td>
</tr>
</tbody>
</table>

ACE-I, ACE inhibitor; AMI, acute myocardial infarction; ARB, angiotensin II receptor blocker; LVSD, left ventricular systolic dysfunction; NQF, National Quality Forum.
in the EHR with the charges or claims data may help construct a more complete data set to implement an NQF eMeasure specification. The second instance related to data availability pertains to eMeasure specifications for structured clinical observations that are otherwise found within unstructured narratives in, for example, progress notes and text-based pathology and diagnostic imaging reports. This issue occurred for two of the eMeasures we assessed: NQF 0012, Prenatal care: screening for HIV, and NQF 0137, ACE-I or ARB at discharge for LVSD among patients with AMI. Text-based observations did not meet specifications for either measure. Both data availability issues could potentially be addressed through customized programming: combining EHR data with charges or claims data in the first example, and text mining in the second.

A previous report from Kaiser Permanente also indicates that customized programming is required to automate quality reporting.23 Although NQF eMeasure specifications in HQMF are intended to be machine-computable, they fall short of that objective.24 Instead, they are an evolving technical framework requiring a combination of clinical domain and technology expertise to implement manually intensive steps from data mapping to text mining to EHR-specific eMeasure implementation. EHRs such as KP HealthConnect need to simultaneously extend and standardize data capture capabilities to align with eMeasure-prescribed QDM data elements and their associated value sets. Alternatives are limited. Either an expensive effort to transform data from a native EHR implementation to a QDM specification will result or non-conformance with eMeasure specifications will lead to financial penalties in the form of missed incentive opportunities and regulatory repercussions.

One of the goals of eMeasurement is a reduced reporting burden and increased efficiency through less use of manual abstraction methods.25 Increased efficiency could occur if specifications were ‘plug and play,’ that is, able to be implemented without transformation. The burden of reporting falls on providers, and lessening it would allow the diversion of resources from the reporting infrastructure to clinical care. However, our findings indicate that a substantial infrastructure of analytic and programming resources will likely be required on a continuing basis, at least for the foreseeable future. When plug and play is missing, as it was in four of the measures we analyzed, quality reporting suffers in terms of efficiency, accuracy, and feasibility. Our analysis points out the shortcomings that currently exist when considering the use of eMeasures for performance measurement for accountability and public reporting purposes.

Our findings regarding the discrepancies between eMeasures specifications and business and clinical workflows at Kaiser Permanente suggest that tools successfully allowing plug and play will be specific to both the EHR platform (i.e., the vendor) and the organization implementing it. Local customization, essential to supporting well-established workflows, further increases the specificity required to create plug and play eMeasures.

CONCLUSIONS
The NQF-specified eMeasures we evaluated fell short of being machine-consumable specifications. A combination of clinical domain and technological expertise is required to implement manually intensive steps from data mapping to text mining to EHR-specific eMeasure implementation. The burden of reporting for providers is unlikely to be significantly reduced unless and until eMeasures require minimal or no transformation.

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CONTRIBUTORS
AA designed the study, analyzed and interpreted the data, and drafted and revised the paper. He is guarantor. JJ designed the study, interpreted the data, and drafted and revised the paper. HP designed data analysis tools, analyzed the data, and revised the paper. KGS designed data analysis tools, analyzed the data, and revised the paper.

COMPETING INTERESTS
None.

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REFERENCES

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