



DRAFT
HL7 FHIR Implementation Guide:
FHIR eCQM Profile
Release 1 - US Realm

October 2015

HL7 For-Comment Ballot

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Clinical Quality Information Work Group

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1 Introduction

The Clinical Quality Language (CQL)[1] standard aims to unify the expression of logic for electronic Clinical Quality Measures (eCQM) and Clinical Decision Support (CDS). This document defines an approach to using CQL with Fast Health Interoperability Resources (FHIR) DSTU2[2] for defining eCQMs.

This Implementation Guide (IG) specifies how the Clinical Quality Language (CQL) is used in conjunction with the Quality Improvement Core (QICore)[3] FHIR profiles to define and invoke clinical quality measures.

This approach supercedes previous approaches to representing eCQMs using the Health Quality Measure Format (HQMF)[4].

A sister HL7 initiative, FHIR-based CDS, will produce a complementary IG that covers the use of FHIR and CQL to define Clinical Decision Support (CDS) knowledge artifacts and invoke their use. [5]

1.1 Ballot Material

This Draft Standard for Trial Use (DSTU) ballot review material includes the following items:

- FHIR eCQM Profile (this implementation guide)
- CMS146.xml - a sample FHIR XML file that uses CQL expressions to define its population criteria
- CMS146.json - the alternative JSON representation of the CMS146.xml file
- CMS146.cql - a sample CQL file that contains the CQL expressions used by the sample FHIR files
- CMS146.elm.xml - a sample ELM file that contains the ELM version of the expressions used by the sample FHIR files

TODO: Update contents of ballot material to include MeasureArtifacts, MeasureRequests, MeasureResponses, OperationDefinition, sample operation request, and StructureDefinition profiles of the above.

The majority of the listings included in this implementation guide are extracted from the sample files listed above. When a listing is extracted from a sample file the source file is named in the listing caption and, for ease of reference, the line numbers shown in the listing match the line numbers in the named source file.

This implementation guide is expected to be read in conjunction with the specifications that it derives from, specifically:

- Clinical Quality Language (CQL)[1]
- Fast Health Interoperability Resources (FHIR DSTU2)[2]
- Quality Improvement Core (QICore) IG[3]
- FHIR-based CDS, sister HL7 For-Comment Ballot

Except where noted, material from the above specifications is not reproduced here.

1.2 Conventions

The keywords SHALL, SHOULD, MAY, NEED NOT, SHOULD NOT, and SHALL NOT in this document are to be interpreted as described in the HL7 Version 3 Publishing Facilitator's Guide.

- **SHALL**: an absolute requirement for the particular element. Where a SHALL constraint is applied to an XML element, that element must be present in an instance, but may have an exceptional value (i.e., may have a nullFlavor), unless explicitly precluded. Where a SHALL constraint is applied to an XML attribute, that attribute must be present, and must contain a conformant value.
- **SHALL NOT**: an absolute prohibition against inclusion
- **SHOULD/SHOULD NOT**: best practice or recommendation. There may be valid reasons to ignore an item, but the full implications must be understood and carefully weighed before choosing a different course
- **MAY/NEED NOT**: truly optional; can be included or omitted as the author decides with no implications

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1.4 Copyright

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2 FHIR eCQM and CDS

Figure 1 is a UML diagram for the shared model underlying both the CDS and eCQM implementation guides, plus eCQM specific resources.

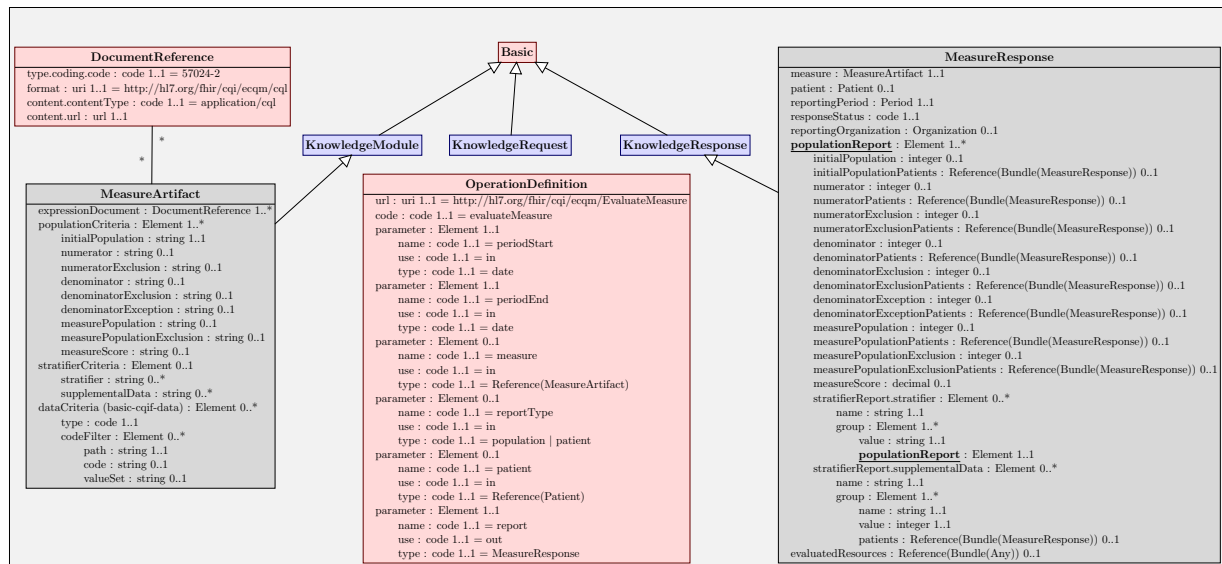


Figure 1: FHIR eCQM UML Diagram (Simplified)

In Figure 1, resources defined as part of FHIR Core are colored red, profiles defined as part of the FHIR-based CDS IG [5] are colored blue, and the profiles defined as part of this IG are colored grey.

Both this IG and the FHIR-based CDS IG are based on two profiled resources: KnowledgeModule and KnowledgeResponse. The KnowledgeRequest profile is not used by this IG. The FHIR-based CDS IG further profiles all three of those resources for the purposes of clinical decision support. Similarly, this IG further profiles KnowledgeModule and KnowledgeResponse for the purposes of clinical quality measures, the results of which are represented as MeasureArtifact and MeasureResponse.

The MeasureArtifact resource (see Section 3), in conjunction with one or more DocumentReference resources that reference CQL expression documents, is used to represent an eCQM.

The OperationDefinition (see Section 4.1) defines the FHIR operation used to calculate or execute a specific eCQM.

Finally, the MeasureResponse resource (see Section 5) represents a response or report that resulted from a specific request.

3 Measure Artifact

In this section we define an approach to defining eCQMs based on a profile of the FHIR Basic resource in conjunction with CQL.

Listing 1 shows an example FHIR Basic resource that defines an eCQM in a manner similar to previous approaches that used HQMF, except using FHIR conventions. This FHIR Basic resource conforms to the MeasureArtifact profile which contains a list of extension elements, each of which defines aspects

of the eCQM. Using extension elements, the `MeasureArtifact` lists expression documents (1..*) used in this eCQM in lines 37–58. Because extension elements of the same type (represented by the `extension.url` attribute) are allowed in FHIR, as many expression documents that are needed can be included. Each expression document is included as a FHIR `DocumentReference` (here a contained resource for example purposes, but it can also be an external reference). Additional extension elements are used to define the population criteria (lines 62–75), stratifier criteria (lines 76–92), and data criteria (lines 93–118). Each type of extension is defined in [Section 3.2–Section 3.7](#).

```

1 <?xml version="1.0" encoding="UTF-8"?>
2 <Basic xmlns="http://hl7.org/fhir">
3   <meta>
4     <profile value="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact"/>
5   </meta>
6   <id value="CMS146"/>
7   <text>
8     <status value="generated"/>
9     <div xmlns="http://www.w3.org/1999/xhtml">
10      Percentage of children 2-18 years of age who were diagnosed with
11      pharyngitis, ordered an antibiotic and received a group A streptococcus
12      (strep) test for the episode.
13    </div>
14  </text>

```

```

37 <contained>
38   <DocumentReference>
39     <id value="expressions"/>

```

```

53     <content>
54       <contentType value="application/x-cql"/>
55       <url value="CMS146.cql"/>
56     </content>
57   </DocumentReference>
58 </contained>
59 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.expressionDocument">
60   <valueReference value="#expressions"/>
61 </extension>
62 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria">

```

```

75 </extension>
76 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.stratifierCriteria">

```

```

92 </extension>
93 <extension url="http://hl7.org/fhir/StructureDefinition/basic-cqif-data">

```

```

118 <extension url="codeFilter">
119   <extension url="path">

```

Listing 1: Example FHIR eCQM (abridged from `MeasureArtifact.xml`)

3.1 Measure Metadata

The KnowledgeModule profile of the Basic resource adds a set of common metadata that is shared between eMeasures and CDS artifacts. Table 1 defines the mapping between the existing metadata defined for eMeasures and the properties of the KnowledgeModule profile.

eMeasure	Cardinality	KnowledgeModule Field/Extension	Notes
Title	0..1	http://hl7.org/fhir/StructureDefinition/basic-cqif-title	
Identifier	0..1	identifier	Inherited from Basic resource, identifier type code as http://hl7.org/fhir/cqi/ecqm/MeasureArtifact/Identifier/cms
Version Number	0..1	http://hl7.org/fhir/StructureDefinition/basic-cqif-moduleVersion	
NQF Number	0..1	identifier	Inherited from Basic resource, identifier type code as http://hl7.org/fhir/cqi/ecqm/MeasureArtifact/Identifier/nqf
GUID	0..1	identifier	Inherited from Basic resource, identifier type code as http://hl7.org/fhir/cqi/ecqm/MeasureArtifact/Identifier/guid
Measure Steward	0..1	http://hl7.org/fhir/StructureDefinition/basic-cqif-steward	
Measure Developer	0..1	http://hl7.org/fhir/StructureDefinition/basic-cqif-contributor	type.code of author
Endorser	0..1	http://hl7.org/fhir/StructureDefinition/basic-cqif-contributor	type.code of endorser
Description	0..1	http://hl7.org/fhir/StructureDefinition/basic-cqif-description	
Copyright	0..1	http://hl7.org/fhir/StructureDefinition/basic-cqif-rightsDeclaration	
Reference	0..*	http://hl7.org/fhir/StructureDefinition/basic-cqif-relatedResource	type.code of citation

Table 1: Mapping from eMeasure metadata to KnowledgeModule properties

The MeasureArtifact profile adds additional metadata to the set provided by the KnowledgeModule, Table 2 describes each property and its mapping from existing eMeasure metadata.

eMeasure	Cardinality	MeasureArtifact Extension	Notes
Disclaimer	0..1	http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.disclaimer	String (containing Markdown)
Measure Scoring	0..1	http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.scoring	Code, e.g. proportion, CV
Measure Type	0..1	http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.type	Code, e.g. process, outcome
Risk Adjustment	0..1	http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.risk-adjustment	String
Rate Aggregation	0..1	http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.rate-aggregation	String
Rationale	0..1	http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.rationale	String (containing Markdown)
Clinical Recommendation Statement	0..1	http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.clinical-recommendation-statement	String (containing Markdown)
Improvement Notation	0..1	http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.improvement-notation	String, e.g. Higher score indicates better quality
Definition	0..1	http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.definition	String (containing Markdown)
Guidance	0..1	http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.guidance	String (containing Markdown)
Measure Set	0..1	http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.set	String, e.g. Preventive Care and Screening

Table 2: Mapping from eMeasure metadata to MeasureArtifact properties

3.2 Including Expression Documents

A MeasureArtifact can include one or more CQL expression documents, using an extension for each. An example is shown in Listing 2.

The url in line 59 specifies that this extension is an expression document. By definition, this type of extension contains a reference to a DocumentReference. The DocumentReference can be an external resource, or it can be contained (lines 37–58). The code on line 43 specifies that this is a health quality measure document, and the format (line 47) and contentType (line 54) specify that it is a CQL document, in particular. The exact location of the CQL document is provided by the url on line 55.

Conformance *shall* requirements for including CQL expression documents are included in Table 3.

```

37 <contained>
38   <DocumentReference>
39     <id value="expressions" />
40     <type>
41       <coding>
42         <system value="http://hl7.org/fhir/vs/c80-doc-typecodes" />
43         <code value="57024-2" />
44         <display value="Health Quality Measure document" />
45       </coding>
46     </type>
47     <format value="http://hl7.org/fhir/cqi/ecqm/cql" />
48     <author>
49       <reference value="#author" />
50     </author>
51     <indexed value="2015-06-12T10:05:48-04:00" />
52     <status value="current" />
53     <content>
54       <contentType value="application/x-cql" />
55       <url value="CMS146.cql" />
56     </content>
57   </DocumentReference>
58 </contained>
59 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.expressionDocument">
60   <valueReference value="#expressions" />
61 </extension>

```

Listing 2: Including a CQL Expression Document (from MeasureArtifact.xml)

Requirement	Path	Cardinality	Description
1	extension	1..*	Extension to include an expression document.
2	extension.url	1..1	(Fixed Value) http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.expressionDocument
3	extension.valueReference	1..1	Reference to a DocumentReference resource.
4	DocumentReference	1..*	Specifies an external CQL expression document.
5	DocumentReference.type.coding.system	1..1	(Fixed Value) http://hl7.org/fhir/vs/c80-doc-typecodes
6	DocumentReference.type.coding.code	1..1	(Fixed Value) 57024-2
7	DocumentReference.format	1..1	(Fixed Value) http://hl7.org/fhir/cqi/ecqm/cql
8	DocumentReference.content.contentType	1..1	(Fixed Value) application/cql
9	DocumentReference.content.url	1..1	References the location of a CQL file.

Table 3: Conformance *Shall* Requirements for Including Expression Documents

3.3 Specifying Population Criteria

A `MeasureArtifact` can specify various types of populations, depending on the type of measure scoring being used. Table 4 shows which population groups are required (R), optional (O), or not permitted (NP) for proportion, ratio, and continuous variable measures. Table 4 is adapted from Table 1 from the HQMF DSTU Release 2 specification[4] and Table 2.1 from the QDM-based HQMF IG[6].

Measure Type	Initial Population	Denominator	Denominator Exclusion	Denominator Exception	Numerator	Numerator Exclusion	Measure Population	Measure Population Exclusion	Measure Score
Proportion	R	R	O	O	R	O	NP	NP	O
Ratio	R	R	O	NP	R	O	NP	NP	O
Continuous Variable	R	NP	NP	NP	NP	NP	R	O	O

Table 4: Measure Populations based on Types of Measure Scoring

A `MeasureArtifact` can define one or more populations, using an `extension` for each. An example is shown in Listing 3.

```

62 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria">
63   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.initialPopulation">
64     <valueString value="CMS146.InInitialPopulation"/>
65   </extension>
66   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.numerator">
67     <valueString value="CMS146.InNumerator"/>
68   </extension>
69   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.denominator">
70     <valueString value="CMS146.InDenominator"/>
71   </extension>
72   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.denominatorExclusion">
73     <valueString value="CMS146.InDenominatorExclusions"/>
74   </extension>
75 </extension>

```

Listing 3: Defining a Population (from `MeasureArtifact.xml`)

The `url` in line 62 specifies that this `extension` defines a set of populations. By definition, this type of `extension` contains one or more population criteria (see Table 4 for the rules). Each population criteria `extension` references a CQL expression by name (lines 64, 67, 70, 73). The named CQL expressions may use an optional namespace (“CMS146” in our example). The namespaces and CQL expressions must be defined in the CQL expression documents associated with this `MeasureArtifact` (see Section 3.2).

Conformance *shall* requirements for defining population criteria are included in Table 5.

The types and definitions of population criteria that are listed in Table 4 and Table 5 (for example, “initial population” and “numerator”) are unchanged from previous definitions provided in [4], where they are defined in Section 2.3.1.1 Table 2, Section 2.3.1.2 Table 3, and Section 2.3.1.3 Table 4. However, this IG introduces an additional population criteria, `measureScore`, which provides a final fully-calculated score. See Section 3.5 for an abridged example measure using `measureScore`.

Requirement	Path	Cardinality	Description
10	extension	1..*	Extension to define a population.
11	extension.url	1..1	(Fixed Value) http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria
12	extension.extension	0..1	Optional extension to name this population.
13	extension.extension.url	1..1	(Fixed Value) http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.name
14	extension.extension.valueString	1..1	Optional name or short description of this population.
15	extension.extension	1..*	Extensions to define each population criteria.
16	extension.extension.url	1..1	Choose one of the following URL identifiers to specify a type of population criteria: http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.initialPopulation http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.numerator http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.numeratorExclusion http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.denominator http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.denominatorExclusion http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.denominatorException http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.measurePopulation http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.measurePopulationExclusion http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.measureScore
17			The presence or absence of population group extensions (see Shall 16) shall conform to Table 4
18	extension.extension.valueString	1..1	The name of a CQL expression (may be namespaced) that defines this population criteria.
19	extension.extension	0..*	Optional extensions to provide a human readable description for each population criteria.
20	extension.extension.url	1..1	Choose one of the following URL identifiers to specify a type of population criteria: http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.initialPopulation-description http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.numerator-description http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.numeratorExclusion-description http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.denominator-description http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.denominatorExclusion-description http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.measurePopulation-description http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.measurePopulationExclusion-description http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.measureScore-description
21	extension.extension.valueString	1..1	The human readable description of this population criteria.

Table 5: Conformance *Shall* Requirements for Defining Populations

3.4 Measures with Multiple Populations

Some eCQMs include multiple populations of the same type. For example, CMS172v4, specifies eight different initial populations, eight different denominators and numerators.

To represent that in a `MeasureArtifact`, we merely need to create multiple `extension` elements with the `url` set to `http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria` and defined according the rules defined in [Section 3.3](#). Because `extension` elements of the same type (represented by the `extension.url` attribute) are allowed in FHIR, as many populations that are needed can be included. An abridged example is shown in [Listing 4](#).

On the reporting side (defined in [Section 5](#)), the multiple populations can be differentiated by the population name (see Shall 12-14 in [Table 5](#)), which the report will be expected to include.

3.5 Continuous Variable Measures

According to CMS definition, continuous variable measures may include a measure observation section. This section defines variables (for example, time from check-in to time of antibiotic administration) used to score particular aspects of performance. Measure observations are not population criteria in that they do not determine whether or not a patient is to be counted in a measure. Rather, measure observations are data elements to be collected on patients meeting the population criteria within a continuous variable measure.¹

[Listing 5](#) gives an example of the measure observation section from the hospital measure CMS55/NQF0495 (median time from arrival to departure for admitted emergency room patients), and [Listing 6](#) shows the related CQL expressions that define the continuous variable.

Similar to the FHIR examples in [Listing 1](#) and [Listing 4](#), the measure in [Listing 5](#) would reference an external CQL document as defined in [Section 3.3](#) (not shown in this example). However, instead of defining each

¹ CMS Guide for Reading Eligible Professional (EP) and Eligible Hospital (EH) eMeasures, Version 4, May 2013

```

1 <?xml version="1.0" encoding="UTF-8"?>
2 <Basic xmlns="http://hl7.org/fhir">
3   <meta>
4     <profile value="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact"/>
5   </meta>
6   <id value="CMS172"/>
7   <text>
8     <status value="generated"/>
9     <div xmlns="http://www.w3.org/1999/xhtml">
10      Surgical patients who received prophylactic antibiotics consistent
11      with current guidelines (specific to each type of surgical procedure).
12    </div>
13  </text>
14  <!-- abridged for clarity -->
15  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria">
16    <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.name">
17      <valueString value="Population 1"/>
18    </extension>
19    <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.initialPopulation">
20      <valueString value="CMS172.InInitialPopulation1"/>
21    </extension>
22    <!-- abridged for clarity -->
23  </extension>
24  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria">
25    <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.name">
26      <valueString value="Population 2"/>
27    </extension>
28    <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.initialPopulation">
29      <valueString value="CMS172.InInitialPopulation2"/>
30    </extension>
31    <!-- abridged for clarity -->
32  </extension>
33  <!-- as many additional populationCriteria extensions as required can go here -->
34 </Basic>

```

Listing 4: Defining a Measure with Multiple Populations

population criteria, the population only defines the measure observation as `measureScore` (lines 16–18), and the namespaced expression `CMS55.MeasureScore` is referenced in line 17.

The expression `CMS55.MeasureScore` is declared in line 28 of the CQL document (it appears in the code listing without the namespace) shown in [Listing 6](#). That expression in turn references other expressions (for example, `MeasureObservation` in lines 20–24).

```

1 <?xml version="1.0" encoding="UTF-8"?>
2 <Basic xmlns="http://hl7.org/fhir">
3   <meta>
4     <profile value="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact"/>
5   </meta>
6   <id value="CMS55"/>
7   <text>
8     <status value="generated"/>
9     <div xmlns="http://www.w3.org/1999/xhtml">
10      Median time from emergency department arrival to time of departure from the
11      emergency room for patients admitted to the facility from the emergency department.
12    </div>
13  </text>
14  <!-- abridged for clarity -->
15  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria">
16    <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.measureScore">
17      <valueString value="CMS55.MeasureScore"/>
18    </extension>
19  </extension>
20 </Basic>

```

Listing 5: Continuous Variable Measure Observation Example

```

1 library CMS55 version '1'
2
3 using QDM
4
5 valueset "Inpatient" = ValueSet('2.16.840.1.113883.3.666.5.307')
6 valueset "Emergency Department Visit" = ValueSet('2.16.840.1.113883.3.117.1.7.1.293')
7
8 context Patient
9
10 define InpatientEncounters :
11   ["Encounter, Performed": "Inpatient"] E
12   where E.lengthOfStay <= 120 days
13   and E.dischargeDateTime during MeasurementPeriod
14
15 define EDEncounters =
16   ["Encounter, Performed": "Emergency Department Visit"] ED
17   with InpatientEncounters E such that ED.effectiveTime
18   ends at most 1 hour before start of E.effectiveTime
19
20 define MeasureObservation : EDEncounters E
21   where E.facilityLocationArrivalDateTime is not null
22   and E.facilityLocationDepartureDateTime is not null
23   return minutes between E.facilityLocationArrivalDateTime
24     and E.facilityLocationDepartureDateTime
25
26 context Population
27
28 define MeasureScore : Median(MeasureObservation)

```

Listing 6: CQL Defining the Measure Observation (CMS55v1.NQF0495.cql in Listing 5)

3.6 Stratification and Supplemental Data

Stratifiers and supplemental data are specified as shown in [Listing 7](#). Stratification criteria (lines 77–85) are supplied as a `extensions` specifying CQL expressions (notice the explicit library or namespace, such as `CMS146.AgesUpToNine`) and FHIR resource attributes (in our example, `Patient.gender`). When the stratification criteria is an expression, that expression defines as many stratification groups as the number of values that the expression returns. For example, if the expression returns a boolean, then there would be two stratification groups: `true` and `false`. When the stratification criteria is a FHIR resource attribute, there will be as many stratification groups as values. For example, specifying `Patient.gender` will yield four stratification groups since FHIR has four gender codes (in the DSTU2 branch): `male`, `female`, `other`, and `unknown`.

```

76 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.stratifierCriteria">
77 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.stratifierCriteria.stratifier">
78 <valueString value="CMS146.AgesUpToNine"/>
79 </extension>
80 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.stratifierCriteria.stratifier">
81 <valueString value="CMS146.AgesTenPlus"/>
82 </extension>
83 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.stratifierCriteria.stratifier">
84 <valueString value="Patient.gender"/>
85 </extension>
86 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.stratifierCriteria.supplementalData">
87 <valueString value="Patient.gender"/>
88 </extension>
89 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.stratifierCriteria.supplementalData">
90 <valueString value="Patient.deceasedBoolean"/>
91 </extension>
92 </extension>

```

Listing 7: Specifying Stratifiers and Supplemental Data (from `MeasureArtifact.xml`)

Supplemental data elements (line 86–91 in [Listing 7](#)) are also specified using `extensions`, where we can specify additional FHIR data attributes or elements to be included in the results. In this example the measure requests patient gender and whether or not they are still alive.

Conformance *shall* requirements for defining stratification and supplemental data are included in [Table 6](#).

Requirement	Path	Cardinality	Description
22	<code>extension</code>	0..*	Extension to define stratification and supplemental data.
23	<code>extension.url</code>	1..1	(Fixed Value) <code>http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.stratifierCriteria</code>
24	<code>extension.extension</code>	0..*	Extensions to define stratification data.
25	<code>extension.extension.url</code>	1..1	(Fixed Value) <code>http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.stratifierCriteria.stratifier</code>
26	<code>extension.extension.valueString</code>	1..1	The name of a valid referenced CQL expression or valid FHIR Resource Path.
27	<code>extension.extension</code>	0..*	Extensions to define supplemental data.
28	<code>extension.extension.url</code>	1..1	(Fixed Value) <code>http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.stratifierCriteria.supplementalData</code>
29	<code>extension.extension.valueString</code>	1..1	A valid FHIR Resource Path.
30			Stratification and supplemental data defined within an eCQM are applicable to all defined <code>populationCriteria</code> sections.

Table 6: Conformance *Shall* Requirements for Defining Stratification and Supplemental Data

On the reporting side (defined in [Section 5](#)), the stratification groups and supplemental data are reported by expression name or FHIR path (see [Shall 26](#) and [29](#)).

3.7 Data Criteria

The data criteria section of the `MeasureArtifact` defines the patient data of interest in the measure as a set of entries. Each entry identifies specific types of data along with constraints that the data must meet. [Listing 8](#) shows an example data criteria for the FHIR `Condition` resources that represent confirmed di-

agnoses of acute pharyngitis. The sample file `MeasureArtifact.xml` contains additional data criteria for Encounter, DiagnosticReport, and other FHIR Resources.

Note that CQL defines its own method for referencing data and that there is no direct link between the data criteria included in the FHIR representation and the data used by the CQL expressions. The FHIR data criteria are used in this implementation guide to promote limited backwards compatibility with existing implementations of previous eCQM IGs for the following use cases:

- Determining the set of data used by a particular eCQM.
- Limited “scoop-and-filter” for creation of population reports. However, the lack of temporal bounds on data criteria may result in the inclusion of more data than actually required. Implementations desiring more fine-grained filtering can examine the CQL to determine additional data constraints.

The population criteria sub-components (initial population criteria, denominator criteria, etc.) define the rules that govern whether a particular patient or episode of care qualifies to be a part of that population.

```
98 <extension url="http://hl7.org/fhir/StructureDefinition/basic-cqif-data">
99   <extension url="type">
100     <valueCode value="Condition"/>
101   </extension>
102   <extension url="codeFilter">
103     <extension url="path">
104       <valueString value="category"/>
105     </extension>
106     <extension url="code">
107       <valueString value="diagnosis"/>
108     </extension>
109   </extension>
110   <extension url="codeFilter">
111     <extension url="path">
112       <valueString value="clinicalStatus"/>
113     </extension>
114     <extension url="code">
115       <valueString value="confirmed"/>
116     </extension>
117   </extension>
118   <extension url="codeFilter">
119     <extension url="path">
120       <valueString value="code"/>
121     </extension>
122     <extension url="valueSet">
123       <valueString value="2.16.840.1.113883.3.464.1003.102.12.1011"/>
124     </extension>
125   </extension>
126 </extension>
```

Listing 8: Specifying Optional Data Criteria (from `MeasureArtifact.xml`)

Conformance *shall* requirements for defining data criteria are included in [Table 7](#).

Requirement	Path	Cardinality	Description
31	extension	0..*	Extension to define data criteria.
32	extension.url	1..1	(Fixed Value) http://hl7.org/fhir/StructureDefinition/basic-cqif-data
33	extension.extension	1..1	Extension to define data criteria type.
34	extension.extension.url	1..1	(Fixed Value) http://hl7.org/fhir/StructureDefinition/basic-cqif-data#type
35	extension.extension.valueCode	1..1	A valid FHIR Resource type.
36	extension.extension	1..*	Extensions to define data criteria code filters.
37	extension.extension.url	1..1	(Fixed Value) http://hl7.org/fhir/StructureDefinition/basic-cqif-data#codeFilter
38	extension.extension.extension	1..1	Extension to define code filter path.
39	extension.extension.extension.url	1..1	(Fixed Value) http://hl7.org/fhir/StructureDefinition/basic-cqif-data#codeFilter#path
40	extension.extension.extension.valueString	1..1	The path to the code being filtered.
41	extension.extension.extension	0..1	Extension to define code filter value.
42	extension.extension.extension.url	1..1	(Fixed Value) http://hl7.org/fhir/StructureDefinition/basic-cqif-data#codeFilter#code
43	extension.extension.extension.valueString	1..1	The code to select.
44	extension.extension.extension	0..1	Extension to define code filter value set.
45	extension.extension.extension.url	1..1	(Fixed Value) http://hl7.org/fhir/StructureDefinition/basic-cqif-data#codeFilter#valueSet
46	extension.extension.extension.valueString	1..1	The URL of the ValueSet to select.

Table 7: Conformance *Shall* Requirements for Defining Data Criteria

4 Invoking Measures

The Health Quality Measure Format (HQMF) defines the electronic representation of an eMeasure but does not define a mechanism for invoking an eMeasure. FHIR defines both the representation of resources and a general mechanism for interacting with them via the `OperationDefinition` resource. Prior sections of this specification described the `MeasureArtifact` representation of an eMeasure, this section describes the `evaluateMeasure` operation that is used to invoke an eMeasure and obtain the results.

4.1 Operation Definition

FHIR defines a standard set of common interactions that include read, update, delete and search. In addition, FHIR defines a standard set of extended *operations* that can be performed on resources, resource types and system wide. The standard operations include profile validation, concept translation and value set expansion. FHIR also supports custom operations via the FHIR `OperationDefinition` resource. This resource offers a means to create a formal definition of a custom operation that can be performed on a FHIR server. For the purposes of measure evaluation we define a new custom operation with a code of `evaluateMeasure`.

The `evaluateMeasure` operation has the following properties:

Idempotent The operation may be invoked multiple times without side effects. Note that the result of invoking the operation may vary over time if patient data used in the eMeasure changes between invocations. Note also that the parameters supplied with the operation invocation can affect the results.

Invocation Target The operation can be invoked on instances of the `MeasureArtifact` resource that represent a particular eMeasure or on the type of the resource with a parameter that specifies the eMeasure to calculate.

[Listing 9](#) shows the formal definition of the `evaluateMeasure` operation properties.

The effect of invoking the `evaluateMeasure` operation is to calculate the quality measure according to the supplied parameters and to return a `MeasureResponse` resource through which the results will be made available. As described below in [Section 5](#), measure calculation may not be instantaneous and the `MeasureResponse` resource provides a mechanism to handle long running calculations.

```

126 <kind value="operation"/>
127 <idempotent value="true"/>
128 <code value="evaluateMeasure"/>
129 <system value="false"/>
130 <type value="Basic"/>
131 <instance value="true"/>

```

Listing 9: Definition of the evaluateMeasure properties (from MeasureEvalOperationDefn.xml)

4.2 Parameters

The evaluateMeasure operation defines several input parameters and one output parameter as follows (formal definitions extracted from MeasureEvalOperationDefn.xml):

periodStart [input, required] the start of the measurement period. In keeping with the semantics of the date parameter used in the FHIR search operation, the period will start at the beginning of the period implied by the supplied timestamp. E.g. a value of 2014 would set the period start to be 2014-01-01T00:00:00 inclusive.

```

132 <parameter>
133   <name value="periodStart"/>
134   <use value="in"/>
135   <min value="1"/>
136   <max value="1"/>
137   <documentation value="The start of the measurement period"/>
138   <type value="date"/>
139 </parameter>

```

periodEnd [input, required] the end of the measurement period. The period will end at the end of the period implied by the supplied timestamp. E.g. a value of 2014 would set the period end to be 2014-12-31T23:59:59 inclusive.

```

140 <parameter>
141   <name value="periodEnd"/>
142   <use value="in"/>
143   <min value="1"/>
144   <max value="1"/>
145   <documentation value="The end of the measurement period"/>
146   <type value="date"/>
147 </parameter>

```

measure [input, optional] a reference to the measure to evaluate. This parameter is only required when the operation is invoked on the resource type, it is not used when invoking the operation on a MeasureArtifact instance.

```

148 <parameter>
149   <name value="measure"/>
150   <use value="in"/>
151   <min value="0"/>
152   <max value="1"/>
153   <documentation value="The measure to evaluate"/>
154   <type value="Reference(Basic)"/>
155   <profile>
156     <reference value="http://hl7.org/fhir/cqi/ecqm/MeasureArtifact"/>
157   </profile>
158 </parameter>

```

reportType [input, optional] the type of report desired, allowed values are population or patient. If not specified, a default value of patient will be used if the patient parameter is supplied, population otherwise.

```

159 <parameter>
160   <name value="reportType"/>
161   <use value="in"/>
162   <min value="0"/>
163   <max value="1"/>
164   <documentation value="The type of measure report"/>
165   <type value="code"/>
166 </parameter>

```

patient [input, optional] a reference to a patient to evaluate the measure against. If not specified the measure will be evaluated for all patients that meet the requirements of the eMeasure, if specified only the referenced patient will be evaluated.

```

167 <parameter>
168   <name value="patient"/>
169   <use value="in"/>
170   <min value="0"/>
171   <max value="1"/>
172   <documentation value="The patient to evaluate the measure against"/>
173   <type value="Reference(Patient)"/>
174 </parameter>

```

report [output, required] an instance of the MeasureResponse resource described below that provides the results of the measure calculation

```

175 <parameter>
176   <name value="report"/>
177   <use value="out"/>
178   <min value="1"/>
179   <max value="1"/>
180   <documentation value="The measure report"/>
181   <type value="Basic"/>
182   <profile>
183     <reference value="http://hl7.org/fhir/cqi/ecqm/MeasureResponse"/>
184   </profile>
185 </parameter>

```

4.3 Examples

```
GET [base]/Basic/$evaluateMeasure?measure=CMS146&periodStart=2014&periodEnd=2014
```

```
GET [base]/Basic/CMS146/$evaluateMeasure?periodStart=2014&periodEnd=2014
```

Listing 10: Evaluating a measure for all patients

The examples in [Listing 10](#) show how to obtain the results of evaluating the eMeasure with identifier “CMS146” for all patients over a measurement period that consists of all of 2014. Some items of note:

- the first variant evaluates the operation on `[base]/Basic` which is the type of resource and specifies the eMeasure to evaluate using a parameter
- the second variant evaluates the operation on `[base]/Basic/CMS146` which is the `MeasureArtifact` instance that represents that measure so there’s no need to also include a reference to the eMeasure in the operation parameters
- the HTTP `GET` method is used since the `evaluateMeasure` operation is idempotent
- `[base]` is used as a shortcut for the base URI of the FHIR server
- the type of the resource is `Basic` in the URI since FHIR does not allow use of alternate paths for profiles of resources
- the period start and end values are both specified to a granularity of a year, the description of the parameters above explains why this results in a measure period that spans the entire year

```
GET [base]/Basic/CMS146/$evaluateMeasure?patient=124&periodStart=2014-01&periodEnd=2014-03
```

Listing 11: Evaluating a measure for a single patient

The example in [Listing 11](#) demonstrates how to obtain the results of evaluating the eMeasure with identifier “CMS146” for the patient with identifier “124” over a measurement period that consists of the first three months of 2014.

5 Measure Response

When eCQMs are represented with the Health Quality Measure Format (HQMF), a single HQMF document represents both the measure itself and the request. Meanwhile, the responses are represented as Quality Reporting Document Architecture (QRDA) documents. QRDA documents come in three flavors: Category I for individual patients reports, Category II for patient list reports, and Category III for population reports.

When eCQMs are represented with FHIR resources, the measure is represented as a `MeasureArtifact` and the request is an HTTP `GET` conforming to the `OperationDefinition` described in [Section 4](#). Meanwhile,

the responses are represented as MeasureResponse resources. Like QRDA, the MeasureResponse allows for Category I (individual), Category II (patient list) and Category III (population) reports. Each type is described in [Section 5.3–Section 5.5](#).

MeasureResponse is a profile of KnowledgeResponse and KnowledgeResponse is a profile of the Basic resource, see [Figure 1](#) in [Section 2](#).

[Listing 12](#) gives an example of a basic population report MeasureResponse, and conformance *shall* requirements are defined in [Table 8](#).

```

1  <?xml version="1.0" encoding="UTF-8"?>
2  <Basic xmlns="http://hl7.org/fhir">
3    <meta>
4      <profile value="http://hl7.org/fhir/cqi/ecqm/MeasureResponse"/>
5    </meta>
6    <id value="Response"/>
7    <text>
8      <status value="generated"/>
9      <div xmlns="http://www.w3.org/1999/xhtml">
10     QRDA Calculated Summary Report for CMS146:
11     Percentage of children 2-18 years of age who were diagnosed with
12     pharyngitis, ordered an antibiotic and received a group A streptococcus
13     (strep) test for the episode.
14   </div>
15 </text>
16 <code>
17   <coding>
18     <system value="http://hl7.org/fhir/ValueSet/c80-doc-typecodes" />
19     <code value="55184-6" />
20   </coding>
21 </code>

28   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.measure">
29     <valueReference value="Basic/CMS146"/>
30   </extension>
31   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.period">
32     <valuePeriod>
33       <start value="2014-01-01" />
34       <end value="2014-03-31" />
35     </valuePeriod>
36   </extension>
37   <extension url="http://hl7.org/fhir/StructureDefinition/basic-cqif-responseStatus">
38     <valueCode value="complete"/>
39   </extension>
40   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.organization">
41     <valueReference value="#reporter"/>
42   </extension>
43   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport">

56   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.stratifier">

94   </extension>

244  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData">

262  </extension>
263  </extension>
264 </Basic>

```

Listing 12: Sample MeasureResponse (Abridged from MeasureResponse.cat3.xml)

Requirement	Path	Cardinality	Description
47	code.coding.system	1..1	(Fixed Value) http://hl7.org/fhir/ValueSet/c80-doc-typecodes
48	code.coding.value	1..1	(Fixed Value) 55184-6
49	extension	1..1	Extension to define the measure this response was calculated for.
50	extension.url	1..1	(Fixed Value) http://hl7.org/fhir/cqi/ecqm/MeasureResponse.measure
51	extension.valueReference	1..1	Reference to a MeasureArtifact.
52	extension	1..1	Extension to define the measurement reporting period.
53	extension.url	1..1	(Fixed Value) http://hl7.org/fhir/cqi/ecqm/MeasureResponse.period
54	extension.valuePeriod	1..1	Measurement reporting period.
55	extension	1..1	Extension to define the response status.
56	extension.url	1..1	(Fixed Value) http://hl7.org/fhir/StructureDefinition/basic-cqif-responseStatus
57	extension.valueCode	1..1	complete pending error
58	extension	0..1	Extension to define the reporting Organization.
59	extension.url	1..1	(Fixed Value) http://hl7.org/cqi/ecqm/MeasureResponse.organization
60	extension.valueReference	1..1	Reference to a Organization.
61	extension	1..*	Extension to report population results (see Table 9).

Table 8: Conformance *Shall* Requirements for Measure Responses

5.1 Reporting Population Data

A `MeasureReport` will contain one set of population data for each set of population criteria specified in the corresponding `MeasureArtifact`. Each population set will contain one or more data elements, each corresponding to a defined criteria (e.g. initial population, numerator, et cetera) and CQL expression that was defined in the `MeasureArtifact`. If the population set in the `MeasureArtifact` defined a name, the name will be included in the results (so that multiple populations can be aligned with the appropriate results).

For example, [Listing 3](#) shows an example `MeasureArtifact` defining population criteria. [Listing 13](#) shows an example `MeasureResponse` reporting those results.

```

43 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport">
44   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.initialPopulation">
45     <valueInteger value="500"/>
46   </extension>
47   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.numerator">
48     <valueInteger value="200"/>
49   </extension>
50   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.denominator">
51     <valueInteger value="500"/>
52   </extension>
53   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.denominatorExclusion">
54     <valueInteger value="100"/>
55   </extension>

```

```

263 </extension>

```

Listing 13: Reporting Population Data (from `MeasureResponse.cat3.xml`)

Conformance *shall* requirements for reporting population data are included in [Table 9](#).

Requirement	Path	Cardinality	Description
62	extension	1..*	Extension to report population results.
63	extension.url	1..1	(Fixed Value) http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport
64	extension.extension	0..1	Optional extension to name this population. This extension is required if the name was defined in the <code>MeasureArtifact.populationCriteria</code> .
65	extension.extension.url	1..1	(Fixed Value) http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.name
66	extension.extension.valueString	1..1	Name or short description of this population.
67	extension.extension	1..*	Extensions to report each population criteria.
68	extension.extension.url	1..1	Choose one of the following URL identifiers to specify a type of population criteria: http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.initialPopulation http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.numerator http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.numeratorExclusion http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.denominator http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.denominatorExclusion http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.denominatorException http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.measurePopulation http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.measurePopulationExclusion http://hl7.org/fhir/cqi/ecqm/MeasureResposne.populationReport.measureScore
69	extension.extension.valueInteger extension.extension.valueDecimal	1..1	The numeric value reported for the population criteria. (Decimal for <code>measureScore</code> only).
70	extension.extension	0..*	Extensions to report stratification and supplemental data (see Table 10).
71	extension.extension	0..*	Extensions to report patient data (see Table 11).

Table 9: Conformance *Shall* Requirements for Reporting Population Data

5.2 Reporting Stratification and Supplemental Data

As detailed in the previous section, a `MeasureReport` will contain one set of population data for each set of population criteria specified in the corresponding `MeasureArtifact`. If stratification or supplemental data are specified in the `MeasureArtifact`, then each of those population sets in the `MeasureReport` will also contain a breakdown for each stratification and supplemental data element.

For example, [Listing 7](#) shows an example `MeasureArtifact` defining stratification and supplemental data. [Listing 14](#) shows an example `MeasureResponse` reporting one subset of that data – the `male` results of the `Patient.gender` stratifications. The other gender results (female, etc), and the other stratification groups are not shown but are contained within the example file.

```
134 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.stratifier">
135 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.stratifier.name">
136 <valueString value="Patient.gender"/>
137 </extension>
138 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.stratifier.group">
139 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.stratifier.value">
140 <valueString value="male"/>
141 </extension>
142 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport.initialPopulation">
143 <valueInteger value="250"/>
144 </extension>
145 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport.numerator">
146 <valueInteger value="100"/>
147 </extension>
148 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport.denominator">
149 <valueInteger value="250"/>
150 </extension>
151 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport.denominatorExclusion">
152 <valueInteger value="50"/>
153 </extension>
154 </extension>

206 </extension>
```

Listing 14: Reporting Stratification Data (from `MeasureResponse.cat3.xml`)

[Listing 15](#) shows the same example `MeasureResponse` reporting the `Patient.gender` supplemental data. The other supplemental groups are not shown but are contained within the example file.

```
207 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData">
208 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData.name">
209 <valueString value="Patient.gender"/>
210 </extension>
211 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData.group">
212 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData.group.name">
213 <valueString value="male"/>
214 </extension>
215 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData.group.value">
216 <valueInteger value="250"/>
217 </extension>
218 </extension>
219 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData.group">
220 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData.group.name">
221 <valueString value="female"/>
222 </extension>
223 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData.group.value">
224 <valueInteger value="250"/>
225 </extension>
226 </extension>
227 <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData.group">

243 </extension>
```

Listing 15: Reporting Supplemental Data (from `MeasureResponse.cat3.xml`)

Conformance *shall* requirements for reporting stratification and supplemental data are included in [Table 10](#).

Requirement	Path	Cardinality	Description
72	extension	1..*	Extension to report population results.
73	extension.url	1..1	<i>(Fixed Value)</i> http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport
74	extension.extension	0..*	Extension to report each set of stratification data.
75	extension.extension.url	1..1	<i>(Fixed Value)</i> http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.stratifier
76	extension.extension.extension	1..1	Extension to define the name of the stratification set.
77	extension.extension.extension.url	1..1	<i>(Fixed Value)</i> http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.stratifier.name
78	extension.extension.extension.valueString	1..1	The name of the stratification set. Must match the name of a stratifier in the MeasureArtifact, which must be a valid referenced CQL expression or valid FHIR Resource Path.
79	extension.extension.extension.extension	1..*	Extension to define a group – a particular stratification within the set.
80	extension.extension.extension.extension.url	1..1	<i>(Fixed Value)</i> http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.stratifier.group
81	extension.extension.extension.extension.extension	1..1	Extension to define the stratification value of this group.
82	extension.extension.extension.extension.extension.url	1..1	<i>(Fixed Value)</i> http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.stratifier.value
83	extension.extension.extension.extension.extension.valueString	1..1	The value of the stratification.
84	extension.extension.extension.extension.extension	1..*	Extensions to report each population criteria.
85	extension.extension.extension.extension.extension.url	1..1	Choose one of the following URL identifiers to specify a type of population criteria: http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport.initialPopulation http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport.numerator http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport.numeratorExclusion http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport.denominator http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport.denominatorExclusion http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport.measurePopulation http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport.measurePopulationExclusion http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport.measureScore
86	extension.extension.extension.extension.extension.valueInteger	1..1	The numeric value reported for the population criteria.
	extension.extension.extension.extension.extension.valueDecimal		<i>(Decimal for measureScore only).</i>
87	extension.extension	0..*	Extension to report each set of supplemental data.
88	extension.extension.url	1..1	<i>(Fixed Value)</i> http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData
89	extension.extension.extension	1..1	Extension to define the name of the supplemental data set.
90	extension.extension.extension.url	1..1	<i>(Fixed Value)</i> http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData.name
91	extension.extension.extension.valueString	1..1	The name of the supplemental data set. Must match the name of a supplemental data in the MeasureArtifact, which must be a valid FHIR Resource Path.
92	extension.extension.extension.extension	1..*	Extension to define a group – a particular supplemental data value within the set.
93	extension.extension.extension.extension.url	1..1	<i>(Fixed Value)</i> http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData.group
94	extension.extension.extension.extension.extension	1..1	Extension to define the supplemental data group name.
95	extension.extension.extension.extension.extension.url	1..1	<i>(Fixed Value)</i> http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData.group.name
96	extension.extension.extension.extension.extension.valueString	1..1	The name of the supplemental data group.
97	extension.extension.extension.extension.extension	1..1	Extension to define the supplemental data group value.
98	extension.extension.extension.extension.extension.url	1..1	<i>(Fixed Value)</i> http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData.group.value
99	extension.extension.extension.extension.extension.valueInteger	1..1	The value of the supplemental data group.

Table 10: Conformance *Shall* Requirements for Reporting Stratification and Supplemental Data

5.3 Category I (Individual) Reports

Category I (Individual) reports can be represented as a MeasureResponse according to the rules defined in Table 8 and Table 11. An abridged example is shown in Listing 17.

```
GET [base]/Basic/CMS146/$evaluateMeasure?patient=124&periodStart=2014-01&periodEnd=2014-03
```

Listing 16: Requesting a Category I (Individual) Report

Requirement	Path	Cardinality	Description
100	extension	1..1	The response contains an Extension to reference the Patient.
101	extension.url	1..1	(Fixed Value) http://hl7.org/fhir/cqi/ecqm/MeasureResponse.patient
102	extension.valueReference	1..1	Reference to a Patient.
103	extension	0..1	The response contains an Extension to reference resources used in calculating the results.
104	extension.url	1..1	(Fixed Value) http://hl7.org/fhir/cqi/ecqm/MeasureResponse.evaluatedResources
105	extension.valueReference	1..1	Reference to a Bundle.

Table 11: Conformance *Shall* Requirements for Category I (Individual) Measure Responses

```
1 <?xml version="1.0" encoding="UTF-8"?>
2 <Basic xmlns="http://hl7.org/fhir">
3   <!-- abridged -->
4   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.measure">
5     <valueReference value="Basic/CMS146"/>
6   </extension>
7   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.patient">
8     <valueReference value="Patient/124"/>
9   </extension>
10  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.period">
11    <valuePeriod>
12      <start value="2014-01-01" />
13      <end value="2014-03-31" />
14    </valuePeriod>
15  </extension>
16  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport">
17    <!-- Overall population reporting goes here, see Listing 13 for an example. -->
18  </extension>
19  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.evaluatedResources">
20    <!-- Bundle/789 contains the resources that were evaluated for Patient/124
21      during the execution and evaluation of this measure. -->
22    <valueReference value="Bundle/789"/>
23  </extension>
24 </Basic>
```

Listing 17: Example Category I (Individual) Report (Abridged for Clarity)

5.4 Category II (Patient List) Reports

Category II (Patient List) reports can be represented as a `MeasureResponse` according to the rules defined in [Table 8](#), and [Table 12](#). An abridged example is shown in [Listing 19](#).

```
GET [base]/Basic/CMS146/$evaluateMeasure?reportType=patient&periodStart=2014-01&periodEnd=2014-03
```

Listing 18: Requesting a Category II (Patient List) Report

Requirement	Path	Cardinality	Description
106	extension.extension	0..*	The populationReport extension contains Extensions to reference MeasureResponses conforming to Section 5.3 .
107	extension.extension.url	1..1	Choose one of the following URL identifiers to specify a type of patient list: http://hl7.org/fhir/cqi/ecqm/MeasureReponse.populationCriteria.initialPopulationPatients http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.numeratorPatients http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.numeratorExclusionPatients http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.denominatorPatients http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.denominatorExclusionPatients http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.denominatorExceptionPatients http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.measurePopulationPatients http://hl7.org/fhir/cqi/ecqm/MeasureArtifact.populationCriteria.measurePopulationExclusionPatients
108	extension.extension.valueReference	1..1	Reference to a Bundle of MeasureResponses conforming to Section 5.3 .

Table 12: Conformance *Shall* Requirements for Category II (Patient List) Measure Responses

```

1 <?xml version="1.0" encoding="UTF-8"?>
2 <Basic xmlns="http://hl7.org/fhir">
3   <!-- abridged -->
4   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.measure">
5     <valueReference value="Basic/CMS146"/>
6   </extension>
7   <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.period">
8     <valuePeriod>
9       <start value="2014-01-01" />
10      <end value="2014-03-31" />
11    </valuePeriod>
12  </extension>
13  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport">
14    <!-- Overall population reporting goes here -->
15    <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.initialPopulationPatients">
16      <!-- Bundle containing Category I (Patient) MeasureResponses -->
17      <!-- See Listing 17 for an example of a single patient -->
18      <valueReference value="Bundle/345"/>
19    </extension>
20    <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.numeratorPatients">
21      <!-- Bundle containing Category I (Patient) MeasureResponses -->
22      <!-- See Listing 17 for an example of a single patient -->
23      <valueReference value="Bundle/346"/>
24    </extension>
25    <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.denominatorPatients">
26      <!-- Bundle containing Category I (Patient) MeasureResponses -->
27      <!-- See Listing 17 for an example of a single patient -->
28      <valueReference value="Bundle/346"/>
29    </extension>
30  </extension>
31 </Basic>

```

Listing 19: Example Category II (Patient List) Report (Abridged for Clarity)

5.5 Category III (Population) Reports

Category III (Population) reports can be represented as a MeasureResponse according to the rules defined in Table 8. An abridged example is shown in Listing 21, and a complete example is included in this ballot package (MeasureResponse.cat3.xml).

```
GET [base]/Basic/CMS146/$evaluateMeasure?periodStart=2014-01&periodEnd=2014-03
```

Listing 20: Requesting a Category III (Population) Report

```
1 <?xml version="1.0" encoding="UTF-8"?>
2 <Basic xmlns="http://hl7.org/fhir">
3   <meta>
4     <profile value="http://hl7.org/fhir/cqi/ecqm/MeasureResponse"/>
5   </meta>
6   <id value="Response"/>
7   <text>
8     <status value="generated"/>
9     <div xmlns="http://www.w3.org/1999/xhtml">
10      QRDA Calculated Summary Report for CMS146:
11      Percentage of children 2-18 years of age who were diagnosed with
12      pharyngitis, ordered an antibiotic and received a group A streptococcus
13      (strep) test for the episode.
14    </div>
15  </text>
16  <code>
17    <coding>
18      <system value="http://hl7.org/fhir/ValueSet/c80-doc-typecodes" />
19      <code value="55184-6" /> <!-- Quality Reporting Document... -->
20    </coding>
21  </code>
22  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.measure">
23    <valueReference value="Basic/CMS146"/>
24  </extension>
25  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.period">
26    <valuePeriod>
27      <start value="2014-01-01" />
28      <end value="2014-03-31" />
29    </valuePeriod>
30  </extension>
31  <extension url="http://hl7.org/fhir/StructureDefinition/basic-cqif-responseStatus">
32    <valueCode value="complete"/>
33  </extension>
34  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.organization">
35    <valueReference value="Organization/example"/>
36  </extension>
37  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.populationReport">
38    <!-- Overall population reporting goes here -->
39  </extension>
40  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.stratifier">
41    <!-- Stratification reporting goes here -->
42  </extension>
43  <extension url="http://hl7.org/fhir/cqi/ecqm/MeasureResponse.stratifierReport.supplementalData">
44    <!-- Supplemental data goes here -->
45  </extension>
46 </Basic>
```

Listing 21: Example Category III (Population) Report (Abridged for Clarity)

References

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http://www.healthit.gov/sites/default/files/qdm_4_1_2.pdf
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