CENTERS FOR MEDICARE & MEDICAID SERVICES

Clinical Quality Language (CQL) Basics
Thursday September 1, 2016
4:00 PM EDT

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Centers for Medicare & Medicaid Services

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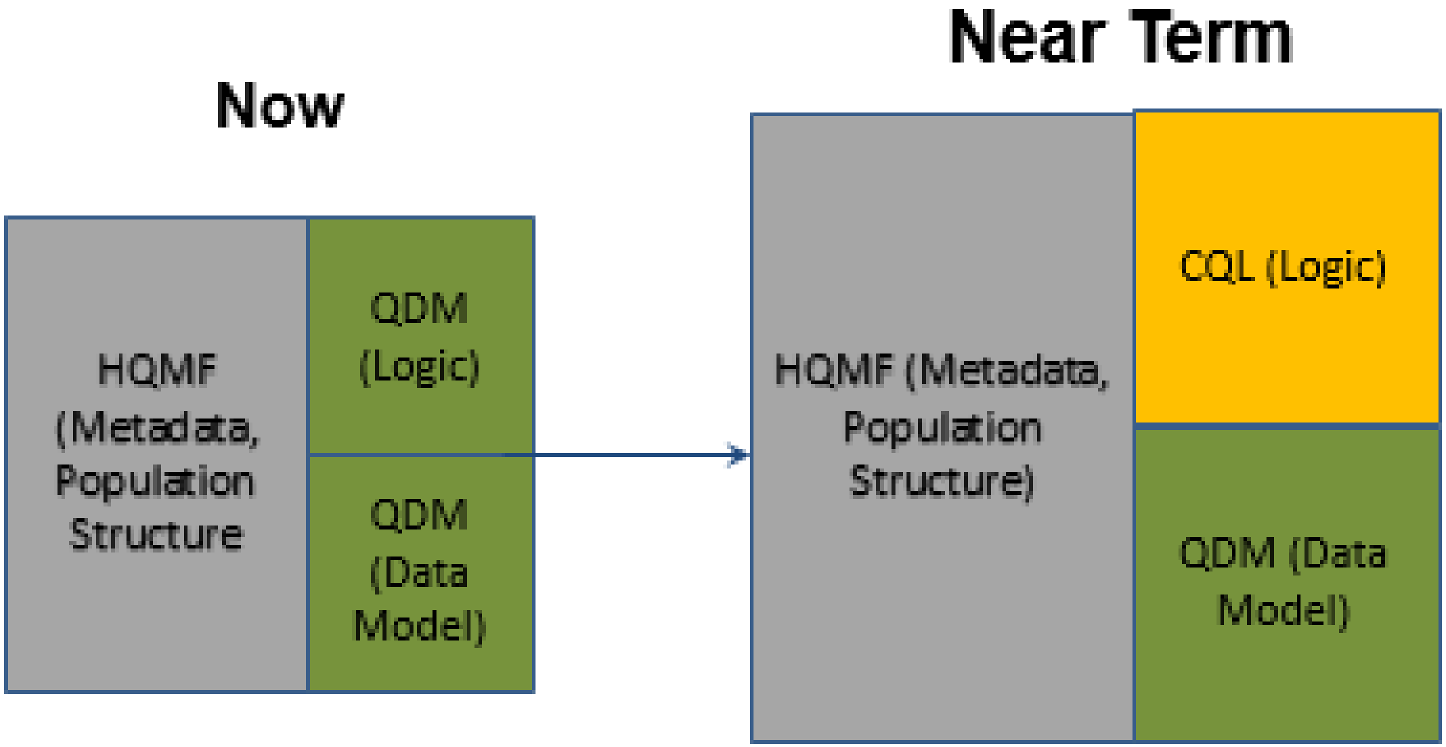
ESAC, Inc.

Agenda

- Welcome and Background
- CQL Language Tour
    - Accessing Clinical Data
    - Using Queries
    - Computation
    - Date/Times, Intervals, and Timing Phrases
    - Combining Queries
    - Aggregate Computation

Evolving eCQM Standards


Now
HQMF (Metadata, Population Structure
QDM (Logic)
QDM (Data Model)
Near Term
HQMF (Metadata, Population Structure)
CQL (Logic)
QDM (Data Model)

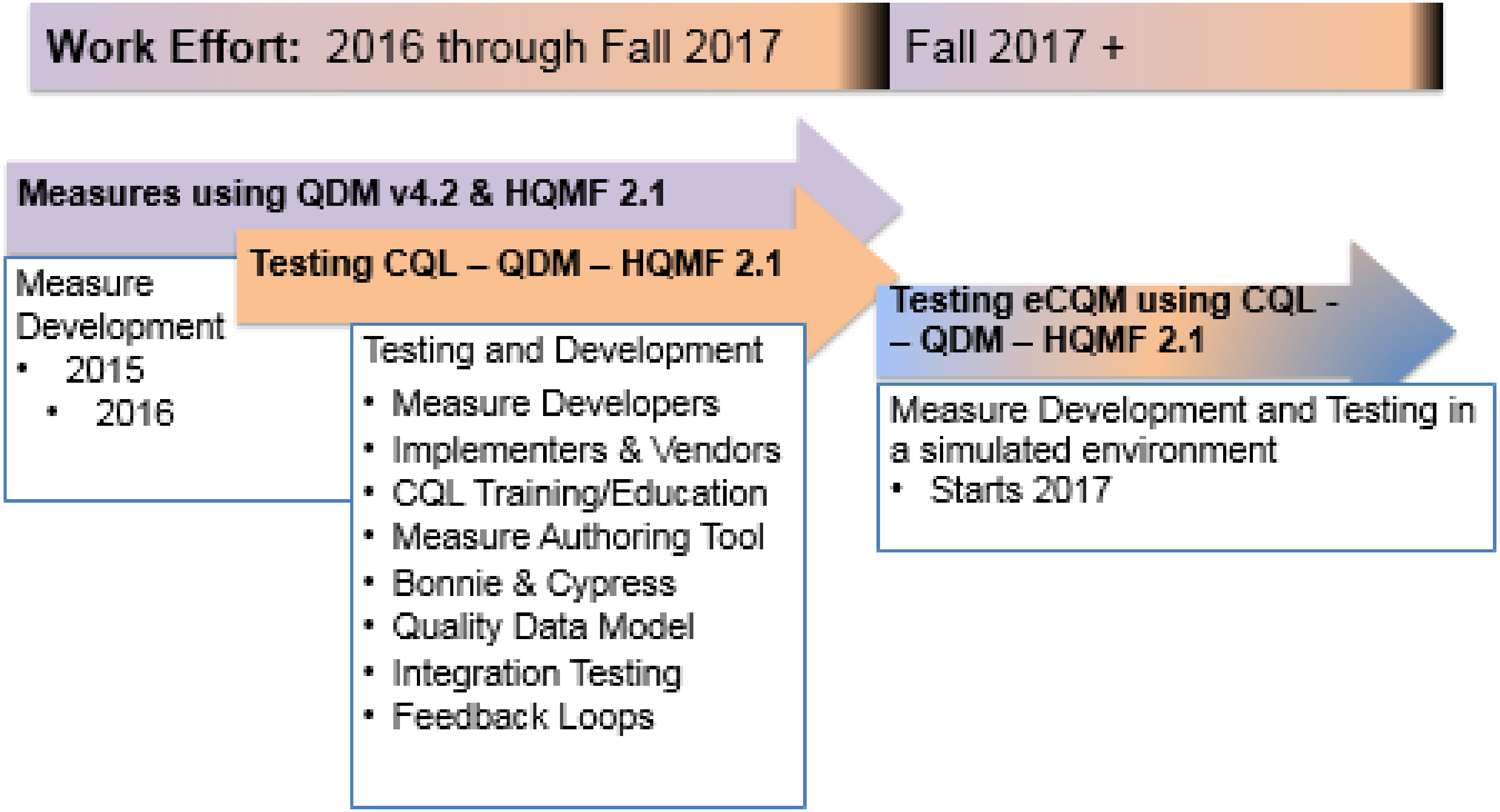
Definitions:

HQMF – Health Quality Measure Format

CQL – Clinical Quality Language

QDM – Quality Data Model

Proposed Timeline For Updating Standards



Work Effort: 2016 through Fall 2017

Fall 2017 +

Measures using QDM v4.2 & HQMF 2.1

Measure Development

- 2015
  - 2016

Testing CQL – QDM – HQMF 2.1

Testing and Development

- Measure Developers
- Implementers & Vendors
- CQL Training/Education
- Measure Authoring Tool
- Bonnie & Cypress
- Quality Data Model
- Integration Testing
- Feedback Loops

Testing eCQM using CQL -– QDM – HQMF 2.1

Measure Development and Testing in a simulated environment

- Starts 2017

CQL LANGUAGE TOUR

Clinical Quality Language (CQL)

- Health Level 7(HL7) standard designed to:
  - Enable automated point-to-point sharing of executable clinical knowledge
  - Provide a clinically focused, author-friendly, and human-readable language
- Currently a Draft Standard for Trial Use (DSTU) publication
  - http://www.hl7.org/implement/standards/product_brief.cfm?product_id=400

Accessing Clinical Data

- Clinical data models contain “statements” of clinical data, e.g.,
  - Patient had a routine check-up on April 3rd
  - Patient was administered an antibiotic
  - Patient had an appendectomy
  - Patient was diagnosed with Type II Diabetes

Accessing Clinical Data (cont.)

- Statements can be organized into different *types, e.g.,*

Patient had a routine check-up on April 3rd	Encounter
Patient was administered an antibiotic	Medication, Administered
Patient had an appendectomy	Procedure, Performed
Patient was diagnosed with Type II Diabetes	Diagnosis

Accessing Clinical Data (cont.)

- Within these types, different kinds of statements can be represented with *codes* from *code systems*.
- Within Encounter, e.g.,

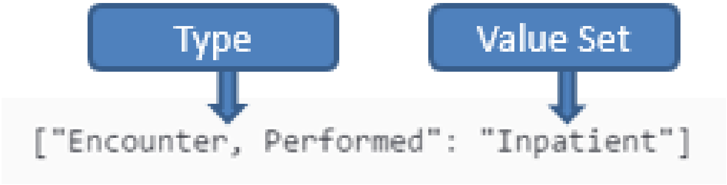
Patient had a routine check-up on April 3rd	SNOMEDCT|185349003
Patient was admitted to the ED	SNOMEDCT|4525004
Patient was admitted for elective surgery	SNOMEDCT|8715000

Accessing Clinical Data (cont.)

- The codes describing different kinds of statements are then grouped with *value sets*, allowing classes of specific kinds of statements to be referenced, e.g.,

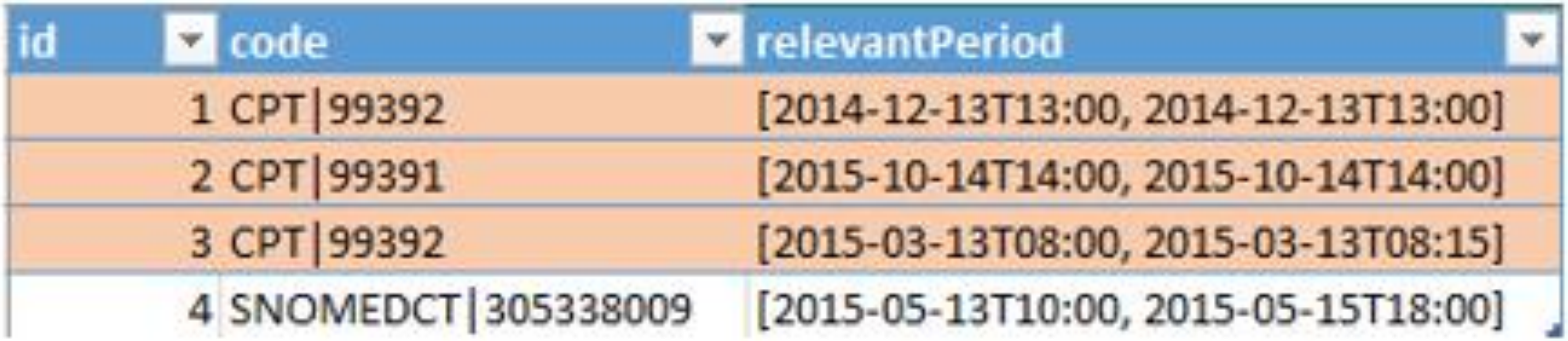
Patient had a routine check-up on April 3rd	Encounter Inpatient
Patient was admitted to the ED	Emergency Department Visit
Patient was admitted for elective surgery	Elective Encounter

CQL Retrieve



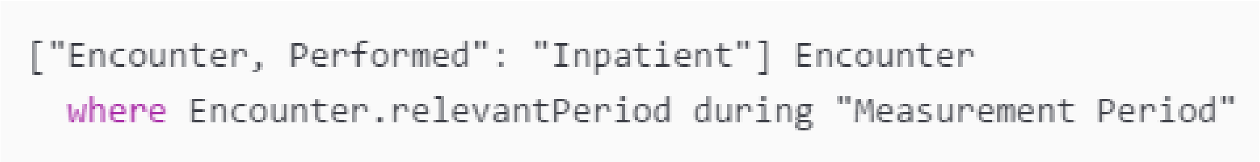
```
["Encounter, Performed": "Inpatient"]
```

This *retrieve* expression results in only the highlighted encounters, because they have codes that match the “Inpatient” value set.



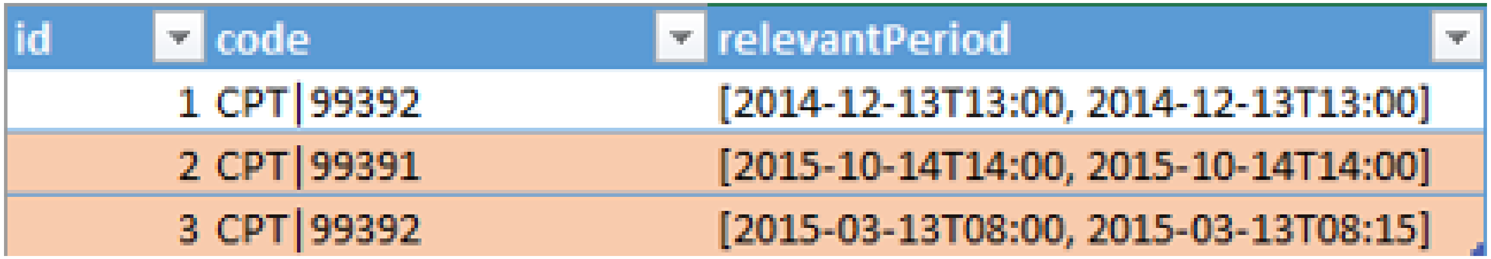
id	code	relevantPeriod
1	CPT|99392	[2014-12-13T13:00, 2014-12-13T13:00]
2	CPT|99391	[2015-10-14T14:00, 2015-10-14T14:00]
3	CPT|99392	[2015-03-13T08:00, 2015-03-13T08:15]
4	SNOMEDCT|305338009	[2015-05-13T10:00, 2015-05-15T18:00]

Filtering with Where



```
["Encounter, Performed": "Inpatient"] Encounter
  where Encounter.relevantPeriod during "Measurement Period"
```

Introducing an *alias*, **Encounter** in this case, allows you to reference elements of the statement for further filtering using a *where clause.* The above filter results in only the highlighted rows, because they are *during* the “Measurement Period” (2015 year).



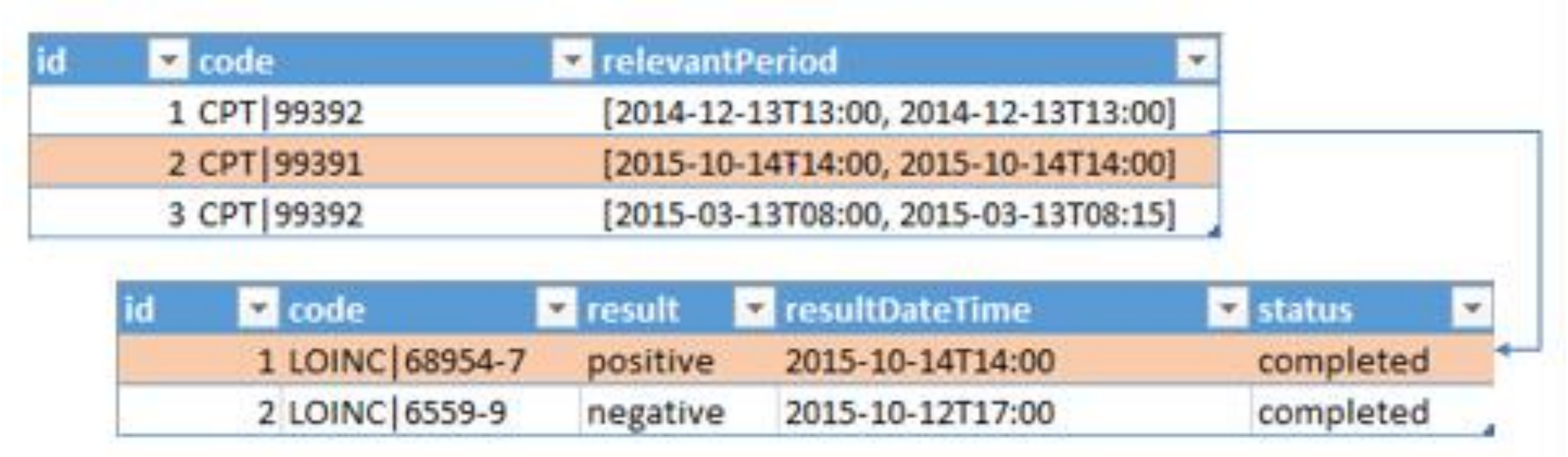
id	code	relevantPeriod
1	CPT|99392	[2014-12-13T13:00, 2014-12-13T13:00]
2	CPT|99391	[2015-10-14T14:00, 2015-10-14T14:00]
3	CPT|99392	[2015-03-13T08:00, 2015-03-13T08:15]

Relationships (with)

```
["Encounter, Performed": "Inpatient"] Encounter
  with ["Laboratory Test, Performed": "Streptococcus Test"] LabTest
    such that LabTest.resultDateTime during Encounter.relevantPeriod
```

The *with clause* allows you to define relationships with other data based on specific criteria.

In this case, only the October encounter is returned, because it has a LabTest that resulted during the encounter.



id	code	relevantPeriod
1	CPT|99392	[2014-12-13T13:00, 2014-12-13T13:00]
2	CPT|99391	[2015-10-14T14:00, 2015-10-14T14:00]
3	CPT|99392	[2015-03-13T08:00, 2015-03-13T08:15]

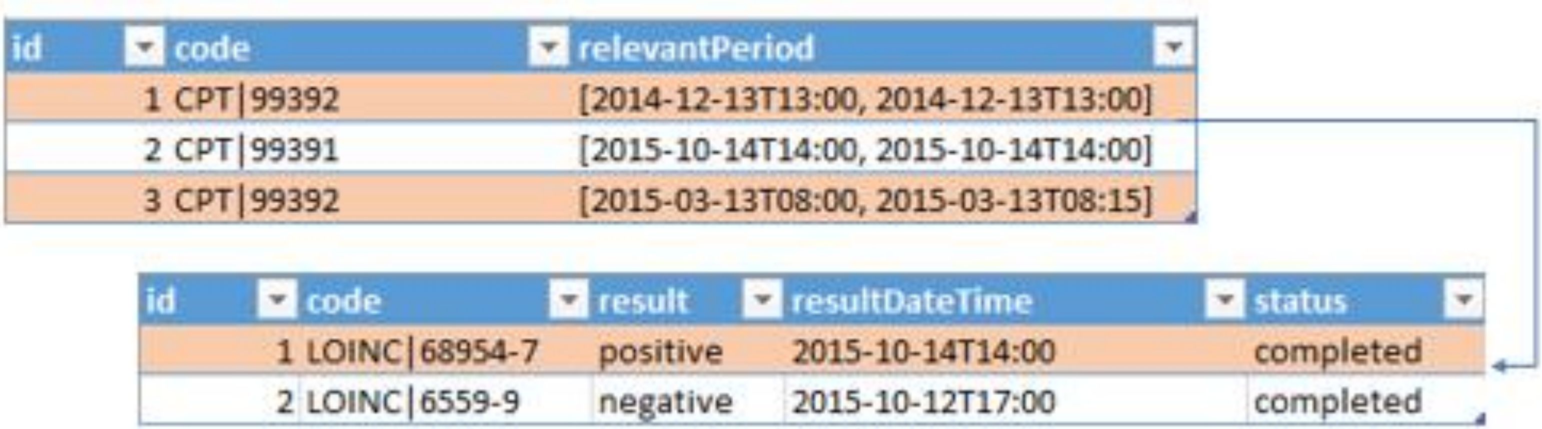
id	code	result	resultDateTime	status
1	LOINC|68954-7	positive	2015-10-14T14:00	completed
2	LOINC|6559-9	negative	2015-10-12T17:00	completed

Relationships (without)

```
["Encounter, Performed": "Inpatient"] Encounter
  without ["Laboratory Test, Performed": "Streptococcus Test"] LabTest
    such that LabTest.resultDateTime during Encounter.relevantPeriod
```

Statements can also be excluded based on relationships using the *without clause*.

In this case, the October encounter is excluded, because it has a LabTest that resulted during the encounter.



id	code	relevantPeriod
1	CPT|99392	[2014-12-13T13:00, 2014-12-13T13:00]
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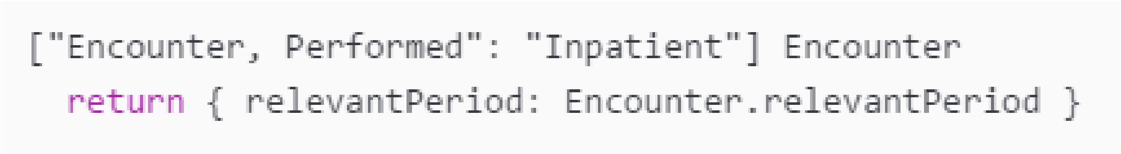
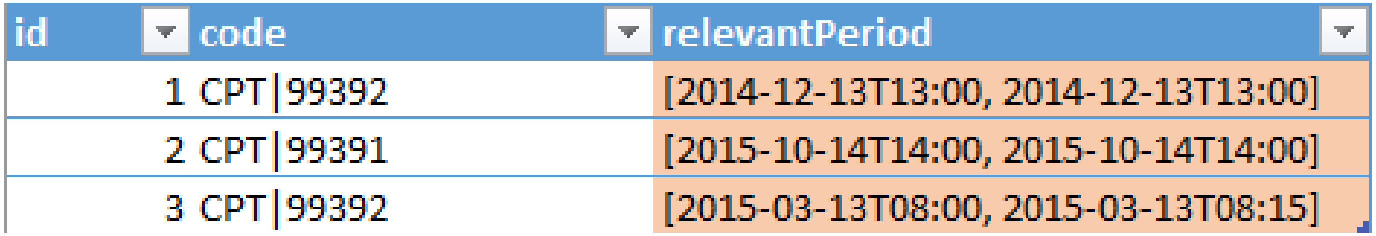
id	code	result	resultDateTime	status
1	LOINC|68954-7	positive	2015-10-14T14:00	completed
2	LOINC|6559-9	negative	2015-10-12T17:00	completed

Shaping Results with Return



```
["Encounter, Performed": "Inpatient"] Encounter
  return { relevantPeriod: Encounter.relevantPeriod }
```

You can return only a subset of the elements in a statement using the *return clause*.
In this case, only the relevantPeriod element is returned.



id	code	relevantPeriod
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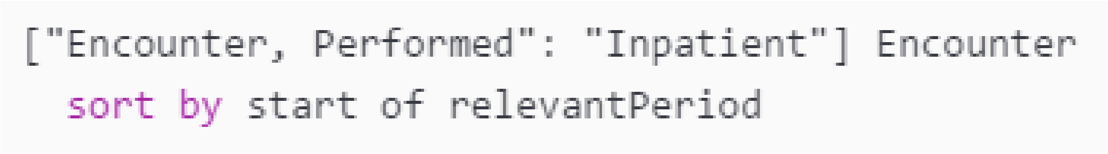
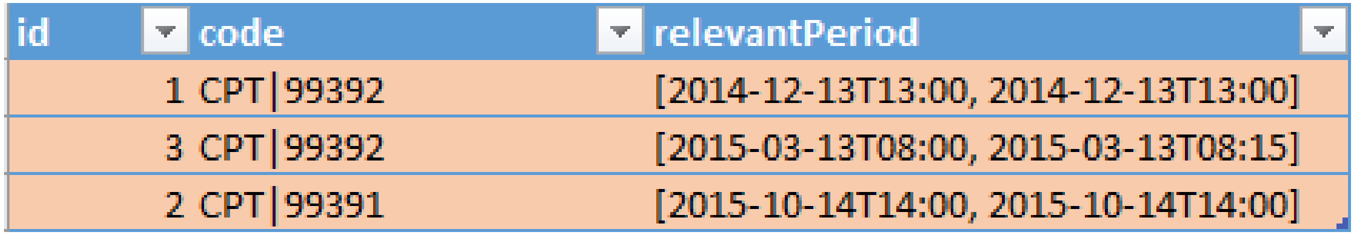
Ordering Results with Sort



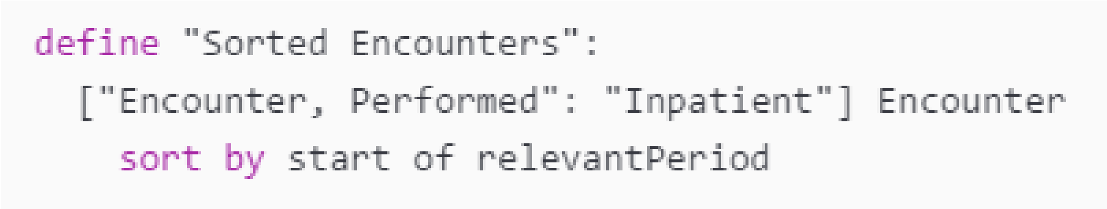
```
["Encounter, Performed": "Inpatient"] Encounter
  sort by start of relevantPeriod
```

You can order the results using the *sort clause*.
In this case, the result is sorted by the start of the relevantPeriod element, ascending.



id	code	relevantPeriod
1	CPT|99392	[2014-12-13T13:00, 2014-12-13T13:00]
3	CPT|99392	[2015-03-13T08:00, 2015-03-13T08:15]
2	CPT|99391	[2015-10-14T14:00, 2015-10-14T14:00]

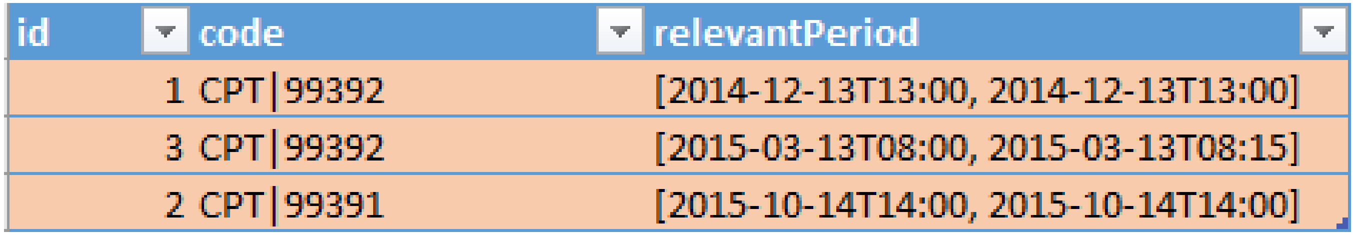
Naming Expressions



```
define "Sorted Encounters":
  ["Encounter, Performed": "Inpatient"] Encounter
    sort by start of relevantPeriod
```

You can name any expression so that it can be reused in subsequent expressions using the *define declaration*.

In this case, the result of “Sorted Encounters” is now the same as the result of the defined expression.



id	code	relevantPeriod
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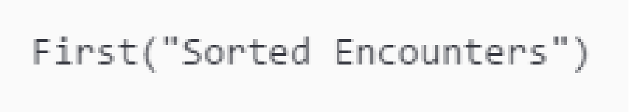
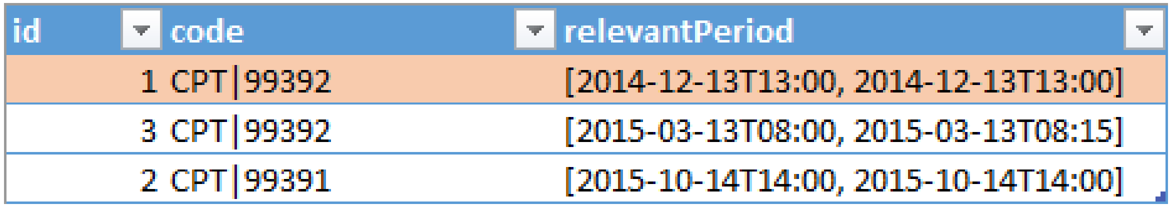
3	CPT|99392	[2015-03-13T08:00, 2015-03-13T08:15]
2	CPT|99391	[2015-10-14T14:00, 2015-10-14T14:00]

Picking Items from Results



```
First("Sorted Encounters")
```



id	code	relevantPeriod
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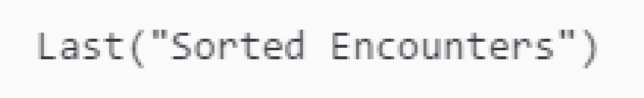
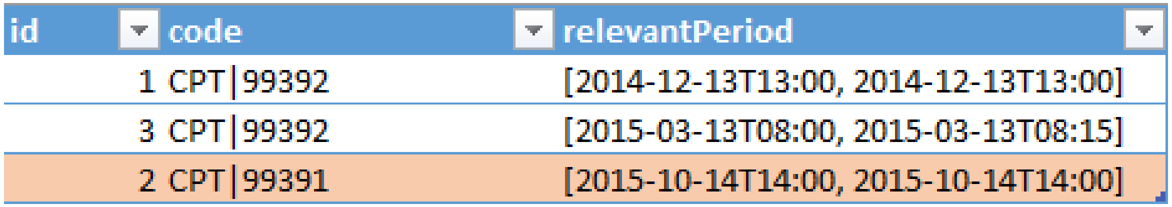


```
Last("Sorted Encounters")
```

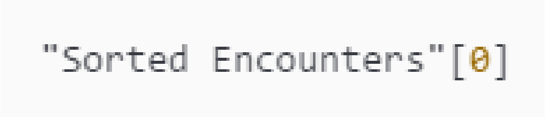


id	code	relevantPeriod
1	CPT|99392	[2014-12-13T13:00, 2014-12-13T13:00]
3	CPT|99392	[2015-03-13T08:00, 2015-03-13T08:15]
2	CPT|99391	[2015-10-14T14:00, 2015-10-14T14:00]

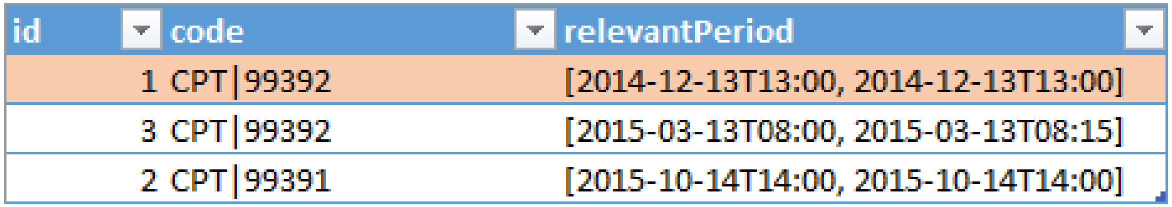
The results of retrieves and queries are lists, so you can pick items based on order using *First()* and *Last().*

Because “Sorted Encounters” is ordered by the start of the relevantPeriod, *First()* returns the oldest encounter, while *Last()* returns the most recent.

Picking Items (cont.)



```
"Sorted Encounters"[0]
```



id	code	relevantPeriod
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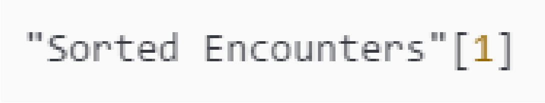
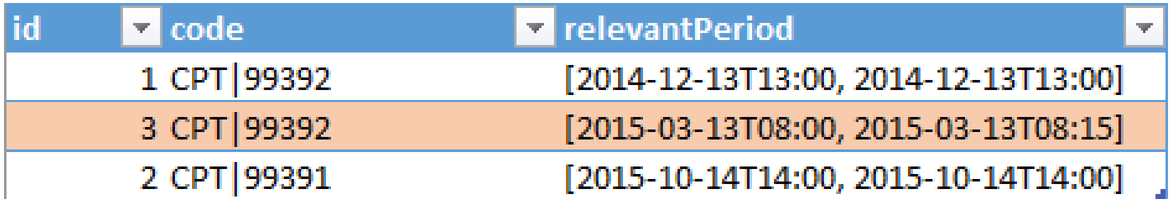


```
"Sorted Encounters"[1]
```



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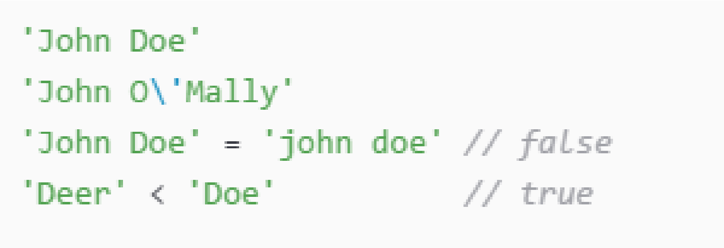
3	CPT|99392	[2015-03-13T08:00, 2015-03-13T08:15]
2	CPT|99391	[2015-10-14T14:00, 2015-10-14T14:00]

You can also use the *indexer* (**[ ]**) to pick out any item by its index in the list.

Indexes in CQL are 0-based, so the first item is index 0, the second item is index 1, and so on.

Note that whenever you're performing operations that rely on the order of elements in the list, be sure to use a *sort clause* to get the appropriate ordering.

Strings



```
'John Doe'
'John O\'Mally'
'John Doe' = 'john doe' // false
'Deer' < 'Doe'          // true
```

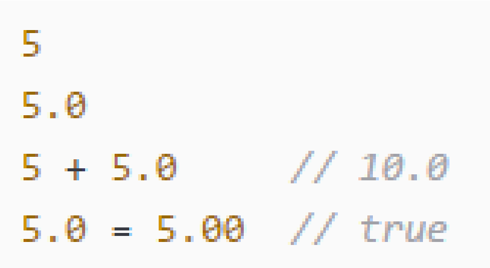
CQL supports strings using single-quotes (').

You can *escape* characters (such as single-quotes, tabs, carriage returns, and line feeds, using standard escape characters.

CQL supports string comparison for all the comparison operators (=, !=, <=, >=, <, and >).

String comparison is case-sensitive, and based on the Unicode value of each character.

Numbers and Calculation

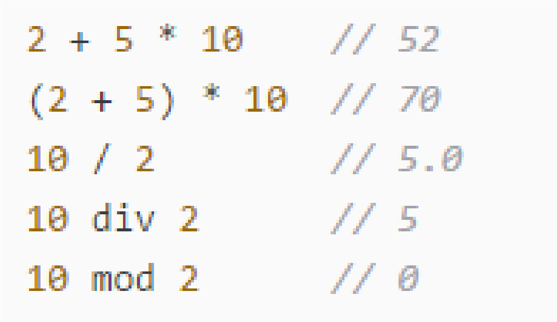


```
5
5.0
5 + 5.0      // 10.0
5.0 = 5.00   // true
```

CQL supports *Integers* (whole numbers), and *Decimals*.

In calculations and comparisons, integers are implicitly converted to decimals when necessary.

Comparison of decimals ignores precision.



```
2 + 5 * 10     // 52
(2 + 5) * 10   // 70
10 / 2         // 5.0
10 div 2       // 5
10 mod 2       // 0
```

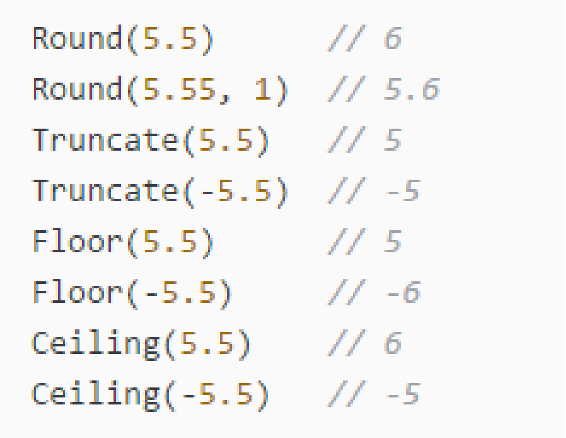
CQL uses standard mathematical operator precedence.

Use parentheses to force precedence.

Division in CQL always returns a decimal, use *div* to perform integer division.

The *mod* operator returns the remainder of an integer division.

Rounding and Exponents

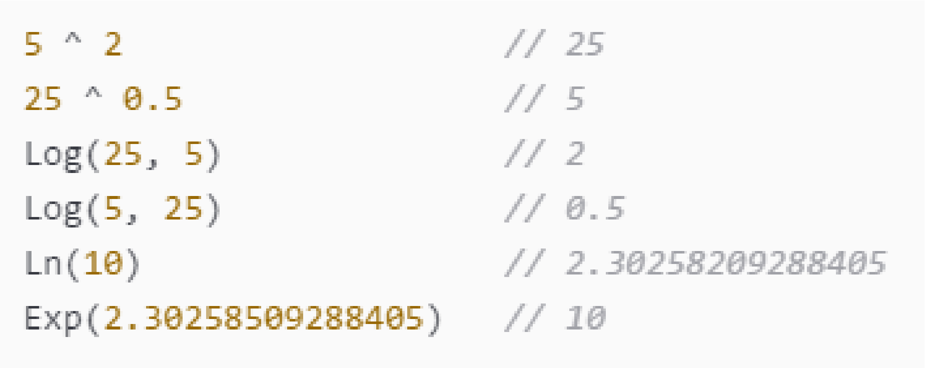


```
Round(5.5)         // 6
Round(5.55, 1)     // 5.6
Truncate(5.5)      // 5
Truncate(-5.5)     // -5
Floor(5.5)         // 5
Floor(-5.5)        // -6
Ceiling(5.5)       // 6
Ceiling(-5.5)      // -5
```

CQL supports standard rounding, 0.5 and above rounds up, 0.4 and below rounds down. The second argument, if supplied, specifies the precision of the result.

Truncate() returns the integer component of a decimal.

Floor() returns the greatest integer less than a decimal.
Ceiling() returns the least integer greater than a decimal.



```
5 ^ 2                        // 25
25 ^ 0.5                     // 5
Log(25, 5)                   // 2
Log(5, 25)                   // 0.5
Ln(10)                       // 2.30258209288405
Exp(2.30258509288405)        // 10
```

CQL supports exponents and roots with ^.

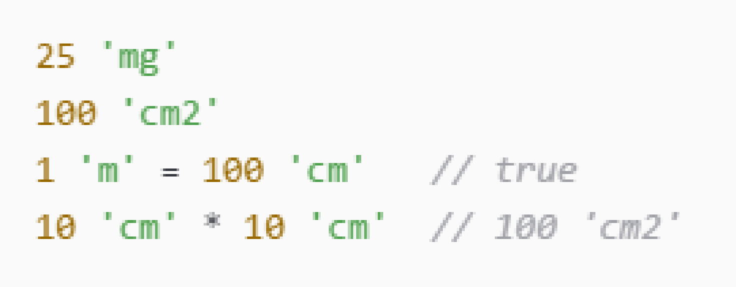
Logarithms to a given base use *Log()*.

Natural logarithms use *Ln()* and *Exp()*.

Quantities

Quantities in CQL are a number followed by a UCUM unit.

CQL supports arithmetic and comparison operators for quantities.



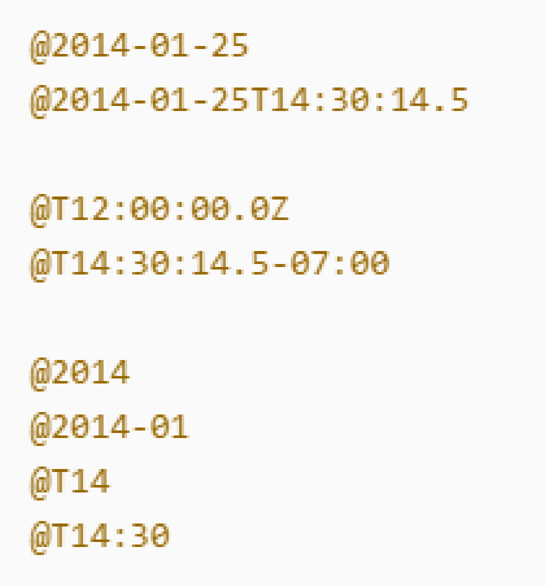
```
25 'mg'
100 'cm2'
1 'm' = 100 'cm'    // true
10 'cm' * 10 'cm'   // 100 'cm2'
```

Implementations are required to respect units, but not necessarily conversions between units.

Arithmetic operators, in particular, must return quantities with appropriate units, but not necessarily converted.

An implementation may throw a run-time error for an unsupported unit conversion operation.

DateTime and Time



```
@2014-01-25
@2014-01-25T14:30:14.5

@T12:00:00.0Z
@T14:30:14.5-07:00

@2014
@2014-01
@T14
@T14:30
```

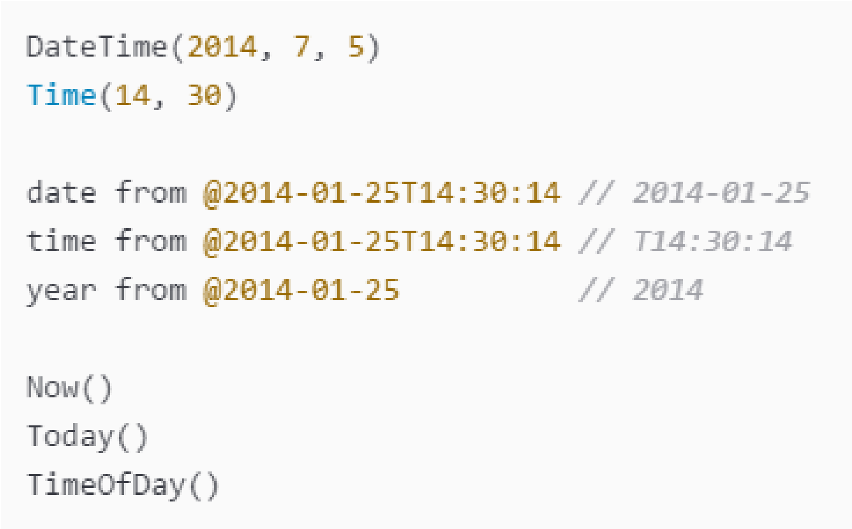
CQL supports dateTime, a point-in-time on the Western calendar, specified with integers for year, month, day, hour, minute, second, and millisecond, plus a timezone.

CQL also supports Time, a point-in-time in a 24-hour period, specified with integers for hour, minute, second, and millisecond, plus timezone.

Both dateTime and Time support partial values, but only for trailing precisions (i.e., if you specify a day, you must also specify a year and month.

If not supplied, timezone is assumed based on the evaluation context.

DateTime and Time (cont.)



```
DateTime(2014, 7, 5)
Time(14, 30)

date from @2014-01-25T14:30:14 // 2014-01-25
time from @2014-01-25T14:30:14 // T14:30:14
year from @2014-01-25          // 2014

Now()
Today()
TimeOfDay()
```

CQL also supports construction of dateTime and Time values as expressions.

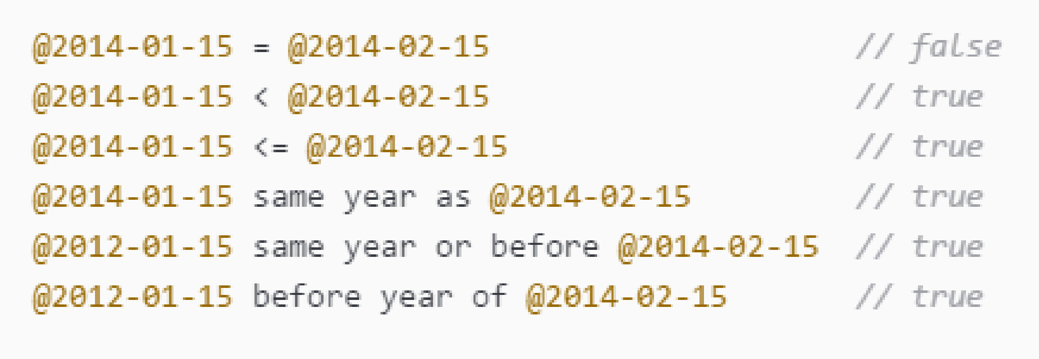
You can use *date from* to extract the date (with no time components) from a dateTime value.

You can use *time from* to extract the time from a dateTime value.

You can use the name of a component to extract it from a dateTime or Time value.

Now(), *Today()*, and *TimeOfDay()* return the dateTime, Date, and Time, respectively, of the evaluation context.

Date Comparison

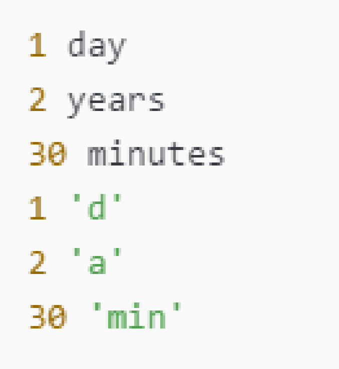


```
@2014-01-15 = @2014-02-15                           // false
@2014-01-15 < @2014-02-15                           // true
@2014-01-15 <= @2014-02-15                          // true
@2014-01-15 same year as @2014-02-15                // true
@2012-01-15 same year or before @2014-02-15         // true
@2012-01-15 before year of @2014-02-15              // true
```

You can compare dateTime and Time values using the standard comparison operators: =, !=, <=, >=, <, and >.

You can also perform precision-based comparisons using *same as*, *before/after of*, and *same or before/after*.

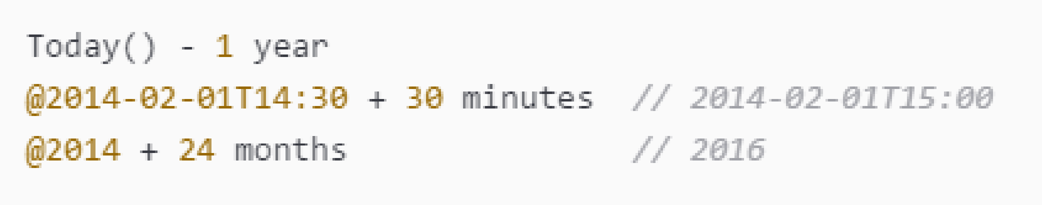
Date Arithmetic



```
1 day
2 years
30 minutes
1 'd'
2 'a'
30 'min'
```

CQL supports time-valued quantities with the name (singular or plural) of the precision as the unit.

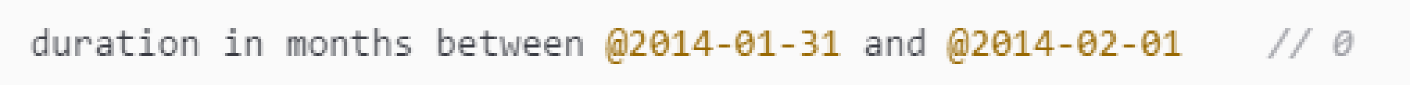
UCUM units can also be used (with quotes).



```
Today() - 1 year
@2014-02-01T14:30 + 30 minutes  // 2014-02-01T15:00
@2014 + 24 months               // 2016
```

Durations can then be added to or subtracted from dateTime and Time values, with the expected semantics for durations with variable days such as years and months.

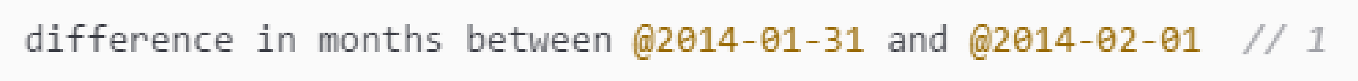
Computing Duration and Difference



```
duration in months between @2014-01-31 and @2014-02-01    // 0
```

The *duration in..between* operator determines the number of whole periods between two dateTime or Time values.

This expression returns 0 because there are no whole months between the two dates.

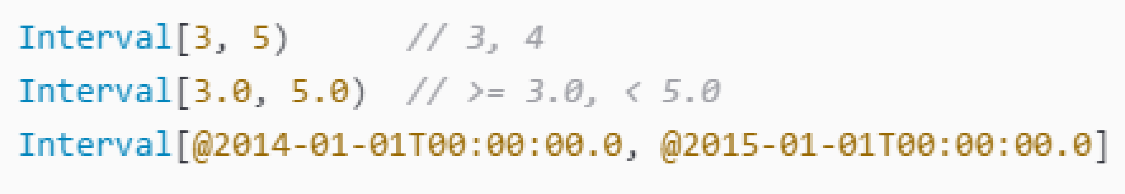


```
difference in months between @2014-01-31 and @2014-02-01  // 1
```

The *difference in..between* operator determines the number of boundaries crossed between two dateTime and Time values.

This expression returns 1 because 1 month boundary was crossed between the two dates.

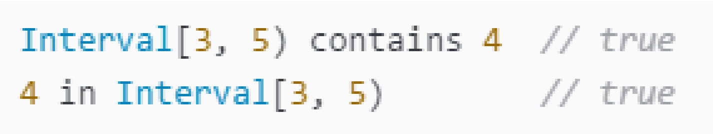
Intervals



```
Interval[3, 5)        // 3, 4
Interval[3.0, 5.0)  // >= 3.0, < 5.0
Interval[@2014-01-01T00:00:00.0, @2015-01-01T00:00:00.0]
```

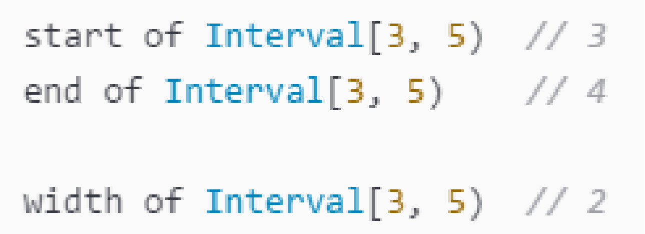
CQL supports Intervals for numbers and date/time values.

Intervals use standard mathematical notation to indicate open and closed (i.e., whether the endpoint is included in (closed) or excluded from (open) the interval).



```
Interval[3, 5) contains 4   // true
4 in Interval[3, 5)         // true
```

You can test for membership with *contains* and *in*, and you can determine the boundaries of an interval using *start of* and *end of.*

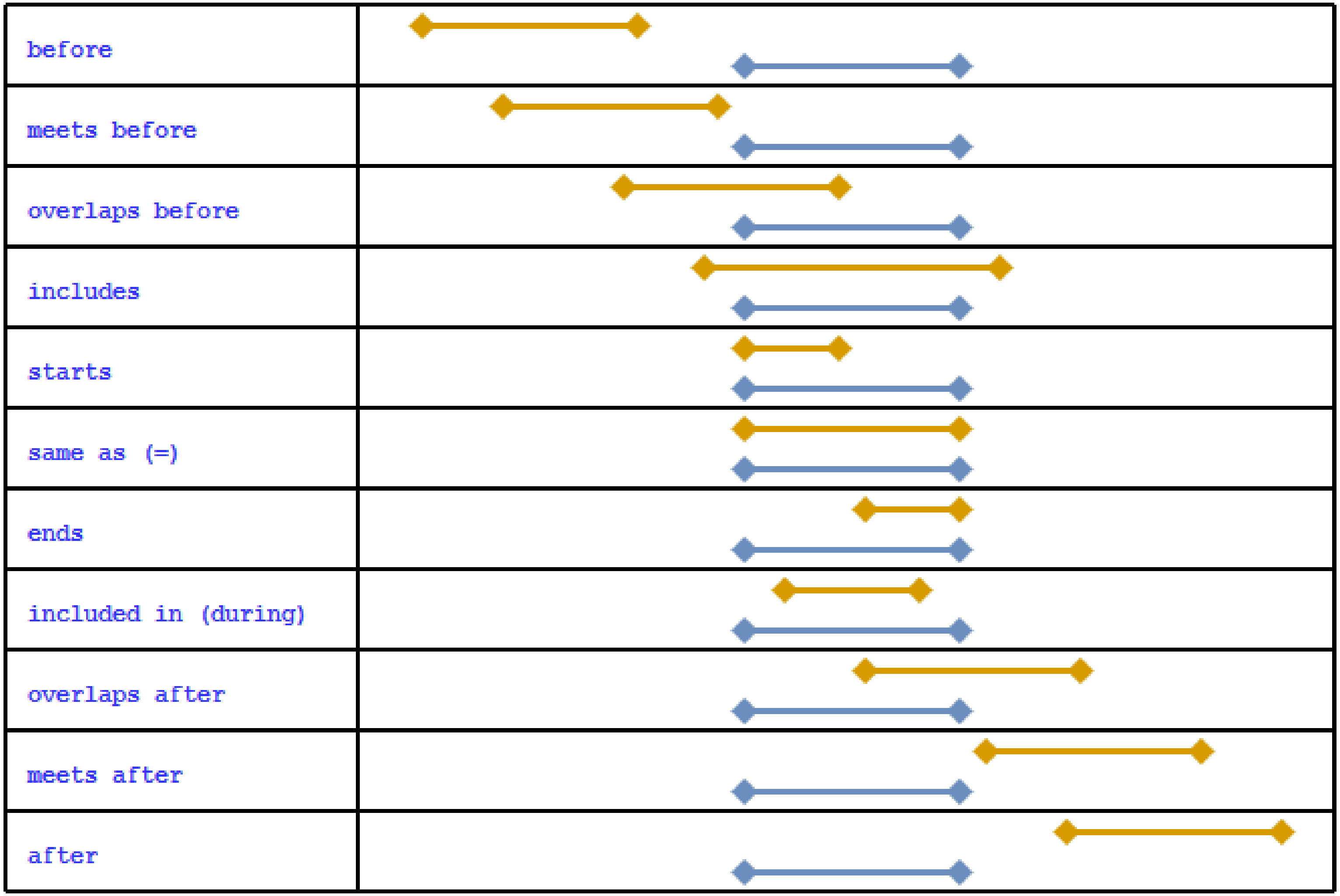


```
start of Interval[3, 5)  // 3
end of Interval[3, 5)    // 4

width of Interval[3, 5)  // 2
```

You can determine the width of an interval using *width of*.

Comparing Intervals



before

meets before

overlaps before

includes

starts

same as (=)

ends

included in (during)

overlaps after

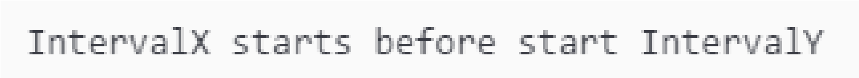
meets after

after

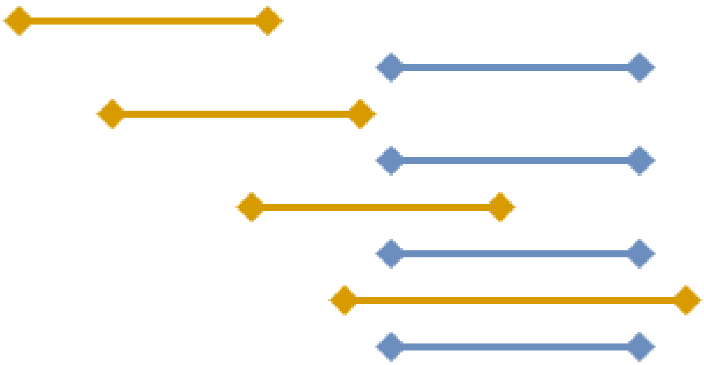
Timing Phrases

CQL also supports timing phrases that make it easier to express precise relationships between intervals using natural language.

The *before* and *after* operators can have a prefix of *starts* or *ends*, and a suffix of *start* or *end*. For example,



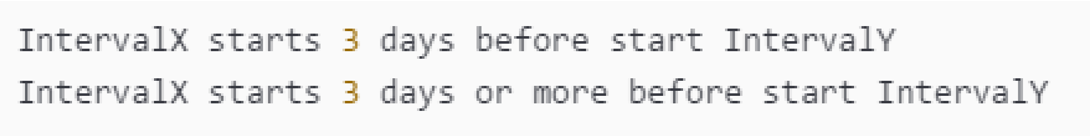
```
IntervalX starts before start IntervalY
```



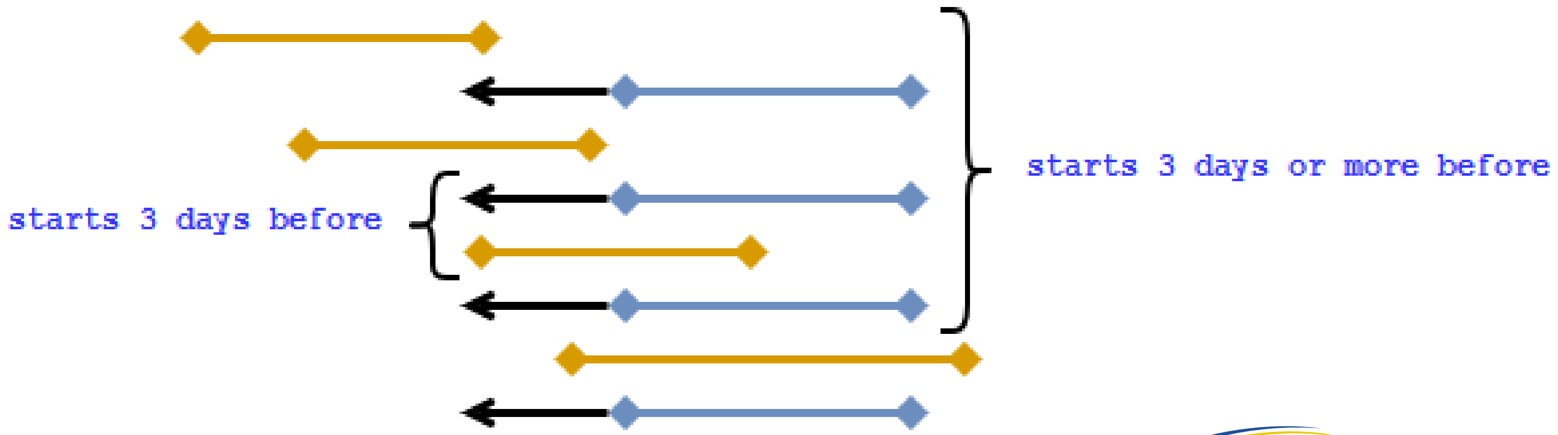
Timing Phrases (cont.)

The *before* and *after* operators can also take an offset that indicates how far away a given relationship should be.

This offset can be absolute, indicating that the boundary of the interval must be on the offset, or it can be relative, indicating that the boundary must be at least on the offset.

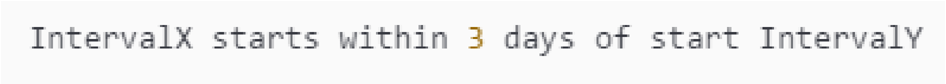


```
IntervalX starts 3 days before start IntervalY
IntervalX starts 3 days or more before start IntervalY
```

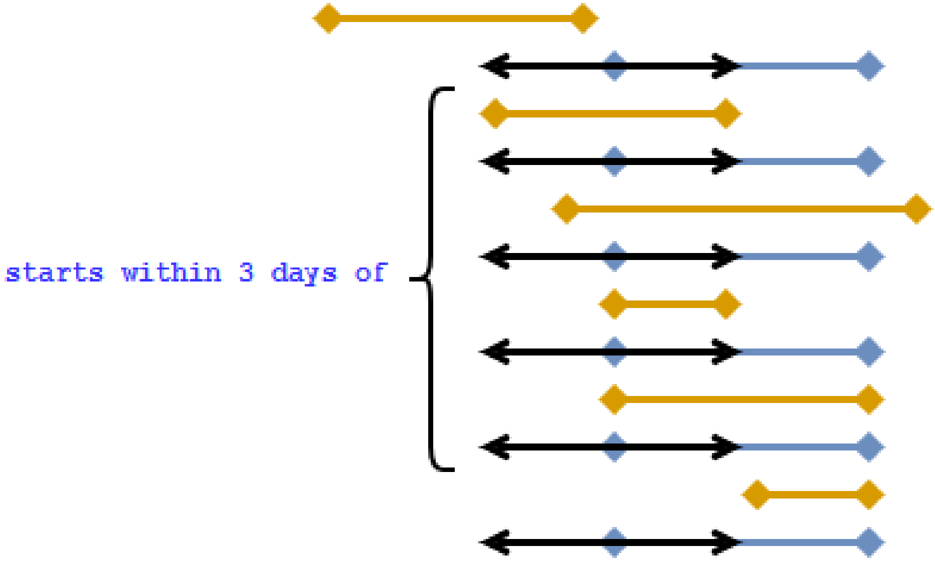


Timing Phrases (cont.)

You can also specify a range for the boundary relationship using the *within..of* operator.



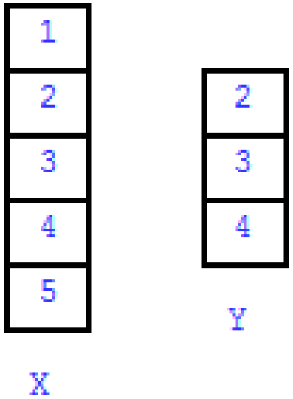
```
IntervalX starts within 3 days of start IntervalY
```

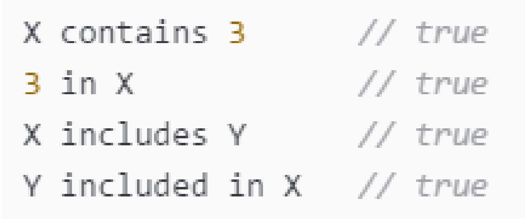


List Operations

You can test for membership of items in a list using the *contains* and *in* operators.

You can compare lists using equality (=), and the *includes* and *included in* operators.

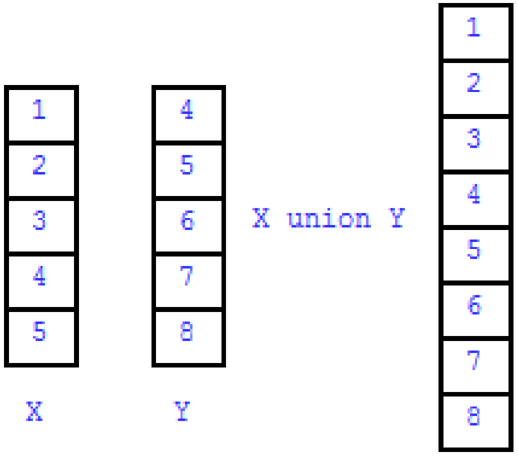




```
X contains 3      // true
3 in X            // true
X includes Y      // true
Y included in X   // true
```

Union

The *union* operator combines two lists, eliminating duplicates.



NOTE: In the current specification (CQL 1.1), union does not eliminate duplicates, so a distinct must be used. However, this is a DSTU comment to change this behavior to support the more intuitive duplicate elimination semantics.

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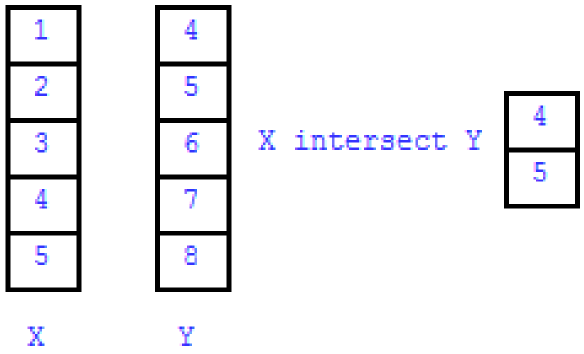
Intersect

The *intersect* operator results in a list containing only the elements that appear in both lists.



1
2
3
4
5

4
5
6
7
8

X intersect Y

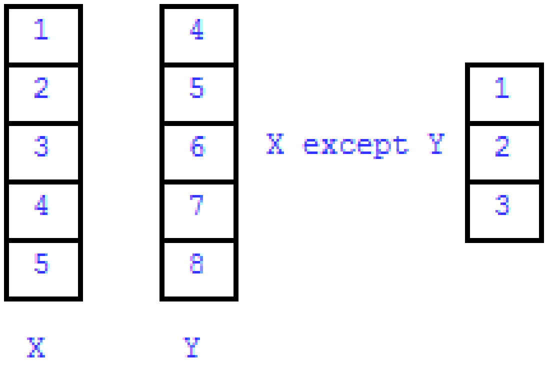
4
5

X

Y

Except

The *except* operator results in a list containing only the elements of the first list that are not present in the second list.



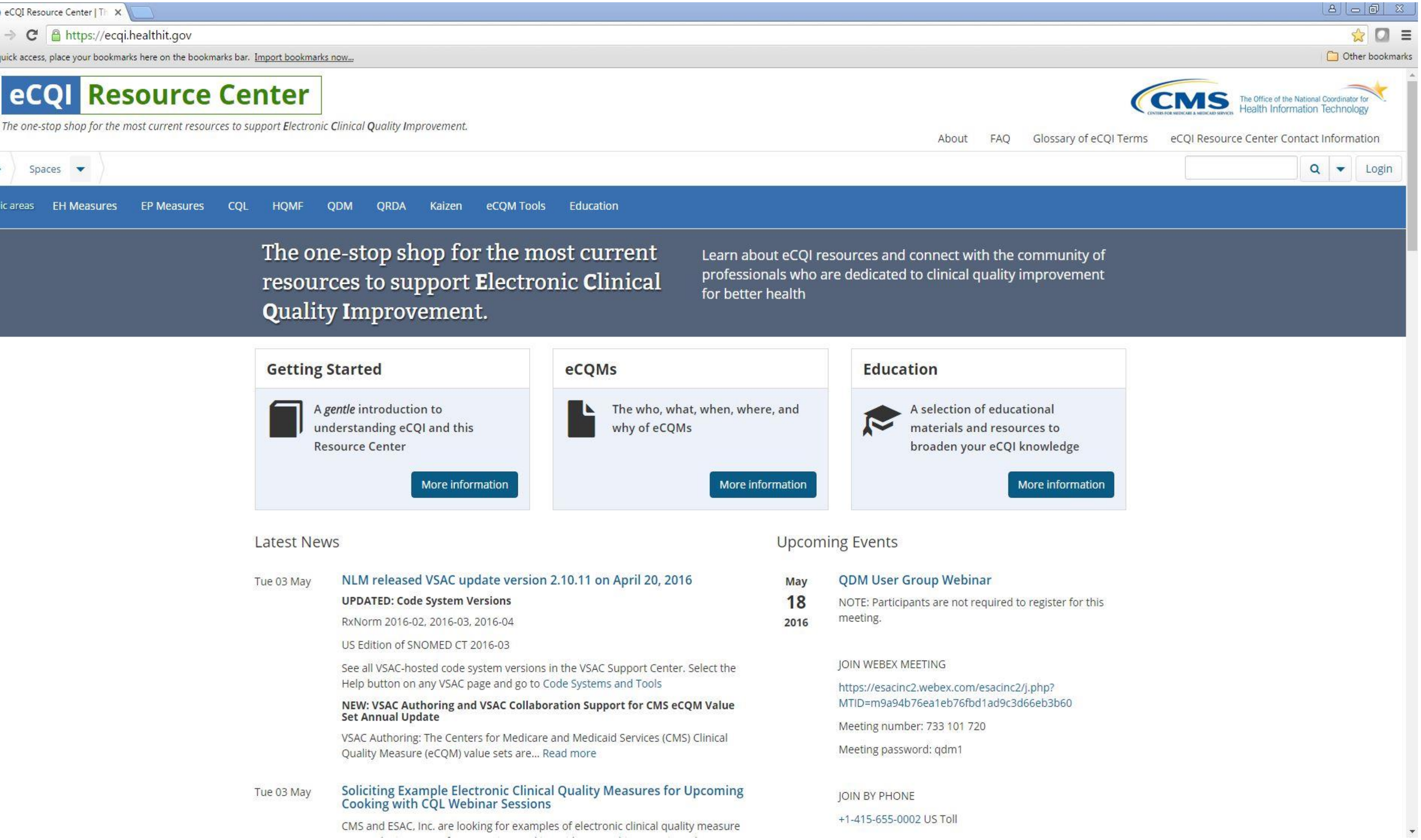
Questions?

Resources

- HL7 Cross-Paradigm Specification: Clinical Quality Language, Release 1 DSTU1.1
  - http://www.hl7.org/implement/standards/product_brief.cfm?product_id=400
- HL7 CDS Workgroup Project Homepage
  - http://wiki.hl7.org/index.php?title=Clinical_Quality_Language
- GitHub Tools Repository
  - https://github.com/cqframework/clinical_quality_language
- CQL JIRA site
  - https://oncprojectracking.healthit.gov/support/browse/CQLIT

eCQI Resource Center

- eCQI Resource Center
  - https://ecqi.healthit.gov
- CQL Space
  - https://ecqi.healthit.gov/cql



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https://ecqi.healthit.gov
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Latest News

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NLM released VSAC update version 2.10.11 on April 20, 2016

UPDATED: Code System Versions

RxNorm 2016-02, 2016-03, 2016-04

US Edition of SNOMED CT 2016-03

See all VSAC-hosted code system versions in the VSAC Support Center. Select the Help button on any VSAC page and go to Code Systems and Tools

NEW: VSAC Authoring and VSAC Collaboration Support for CMS eCQM Value Set Annual Update

VSAC Authoring: The Centers for Medicare and Medicaid Services (CMS) Clinical Quality Measure (eCQM) value sets are... Read more

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Soliciting Example Electronic Clinical Quality Measures for Upcoming Cooking with CQL Webinar Sessions

CMS and ESAC, Inc. are looking for examples of electronic clinical quality measure

Upcoming Events

May
18
2016

QDM User Group Webinar

NOTE: Participants are not required to register for this meeting.

JOIN WEBEX MEETING

https://esacinc2.webex.com/esacinc2/j.php?MTID=m9a94b76ea1eb76fbd1ad9c3d66eb3b60

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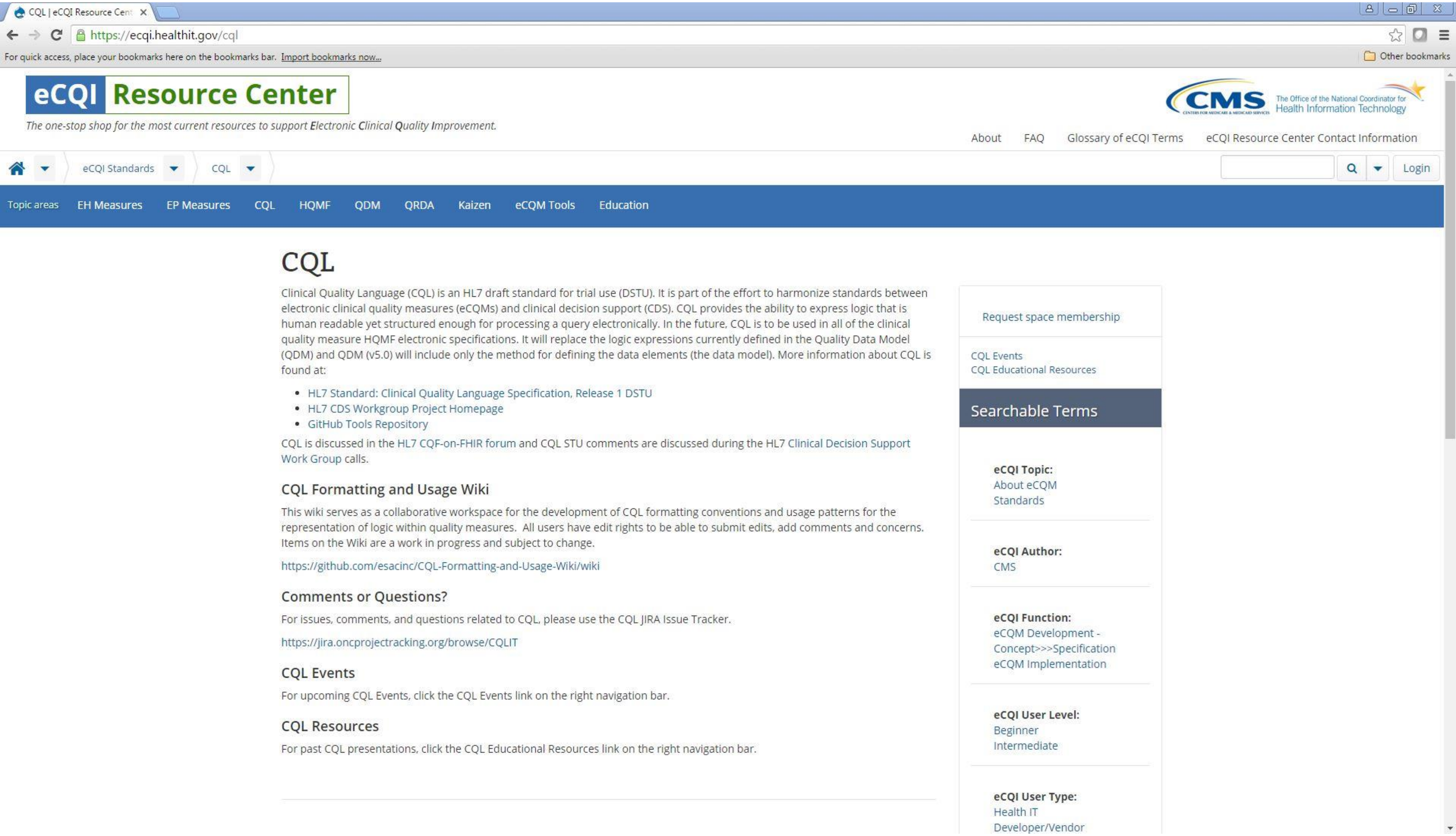
CQL Basics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CQL

Clinical Quality Language (CQL) is an HL7 draft standard for trial use (DSTU). It is part of the effort to harmonize standards between electronic clinical quality measures (eCQMs) and clinical decision support (CDS). CQL provides the ability to express logic that is human readable yet structured enough for processing a query electronically. In the future, CQL is to be used in all of the clinical quality measure HQMF electronic specifications. It will replace the logic expressions currently defined in the Quality Data Model (QDM) and QDM (v5.0) will include only the method for defining the data elements (the data model). More information about CQL is found at:

- HL7 Standard: Clinical Quality Language Specification, Release 1 DSTU
- HL7 CDS Workgroup Project Homepage
- GitHub Tools Repository

CQL is discussed in the HL7 CQF-on-FHIR forum and CQL STU comments are discussed during the HL7 Clinical Decision Support Work Group calls.

CQL Formatting and Usage Wiki

This wiki serves as a collaborative workspace for the development of CQL formatting conventions and usage patterns for the representation of logic within quality measures. All users have edit rights to be able to submit edits, add comments and concerns. Items on the Wiki are a work in progress and subject to change.

https://github.com/esacinc/CQL-Formatting-and-Usage-Wiki/wiki

Comments or Questions?

For issues, comments, and questions related to CQL, please use the CQL JIRA Issue Tracker.

https://jira.oncprojectracking.org/browse/CQLIT

CQL Events

For upcoming CQL Events, click the CQL Events link on the right navigation bar.

CQL Resources

For past CQL presentations, click the CQL Educational Resources link on the right navigation bar.

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