OMOP ON CQL ON FHIR: THE INTERSECTION OF INTEROPERABILITY STANDARDS AND DIGITAL QUALITY

Evaluating dQM Cohort definitions as OMOP Phenotypes
**INTERSECTING INTEROPERABILITY STANDARDS**

Reliability, Validity and Scientific Soundness

**Purpose:** To engineer a solution that will enable efficient and meaningful testing of digital measure cohort definitions in real world datasets to improve the validity of the quality measure results.

*dQM definitions identify a population for measurement in a consistent, reliable, uniform and objective manner, finding potentially eligible patients and including only those fitting the cohort definition for the specified quality use case.*

**define Positive Adolescent Depression Screen with result**

( ["Assessment, Performed": "Patient Health Questionnaire 9 Modified for Teens total score"] PHQ9M where PHQ9M.result >= 5 )

**code** "Patient Health Questionnaire 9: Modified for Teens **total score** [Reported.PHQ.Teen]": '89204-2' from "LOINC" display
THE DIGITAL QUALITY ECOSYSTEM

Digital Quality Measures are the Foundation

- Leverage more and better data into greater insight
- Foster patient-specific care
- Align with interoperability and value-based payment models
- Decrease measurement burden

THE IMPACT

- Gain more timely and relevant quality insights
- Support value-based contracting
- Reduce burden and cost
- Achieve alignment and transparency across stakeholders
- Improve Accuracy and Trust
What are Digital Quality Measures?

define "Numerator 2":
exists "Follow Up Care on or 30 Days after First Positive Screen"
or "Has Positive Brief Screen Same Day as Negative Full Length Screen"

define "Follow Up Care on or 30 Days after First Positive Screen":
( "First Positive Adolescent Depression Screen between January 1 and December 1"
union "First Positive Adult Depression Screen between January 1 and December 1" ) Screening
return ( Tuple {
  hasFollowUpVisit: exists ( Status."Finished Encounter" ( [Encounter: "Follow Up Visit"] ) ) FollowUpVisit
  where Encounters."Encounter Has Diagnosis" ( FollowUpVisit, [Condition: "Depression or Other Behavioral Health Condition" and date from start of FHIRBase."Normalize Interval" ( FollowUpVisit.period ) 30 days or less on or after date from
  hasDepressionCaseManagementEncounterWithDx: exists ( [Status."Finished Encounter" ( [Encounter: "Depression Case Management" where date from start of FHIRBase."Normalize Interval" ( dcmEnc.period ) 30 days or less on or after date from start
  where Encounters."Encounter Has Diagnosis" ( CaseManagementEncounterWithDx, [Condition: "Depression or Other Behavioral Health Condition" where date from start of FHIRBase."Normalize Interval" ( dcmEnc.period ) 30 days or less on or after date from start
  where exists [Observation: "Symptoms of depression (finding)"] DepressionSymptoms
  where date from start of FHIRBase."Normalize Interval" ( DepressionSymptoms.effective ) ~ date from start of FHIRBase.
  hasBehavioralHealthEncounter: exists ( [Status."Finished Encounter" ( [Encounter: "Behavioral Health Encounter"] ) ) BehavioralHealthEncounter
  where date from start of FHIRBase."Normalize Interval" ( BHEnc.period ) 30 days or less on or after date from start
  )
or ( exists ( Status."Active Condition" ( [Condition: "Exercise counseling"] ) ) ExerciseDiagnosis
  where date from start of FHIRBase."Prevalence Period" ( ExerciseDiagnosis ) 30 days or less on or after date from
  ),
  hasAntidepressantMedication: exists ( Status."Dispensed Medication" ( [MedicationDispense: "Antidepressant Medications" where date from ADMeds.whenHandedOver 30 days or less on or after date from start of FHIRBase."Normalize Interval" (
  ) ) FollowUpCare
return if AnyTrue({ FollowUpCare.hasFollowUpVisit, FollowUpCare.hasDepressionCaseManagementEncounterWithDx, FollowUpCare.hasBehavioralHealthEncounter, FollowUpCare.hasAntidepressantMedication }) screeningWithFollowUpCare
where screeningWithFollowUpCare is not null
**DQM Cohort Definitions and Phenotypes**

*Identifying patients with certain characteristics of interest through electronic phenotyping*

**Rule-Based Phenotype:** inclusion criteria based on standard data elements (i.e., diagnosis codes, medications, procedures, and lab values) based upon clinical guidelines for diagnosis and treatment.¹

¹ Banda et al. 2018. *Advances in Electronic Phenotyping: From Rule-Based Definitions to Machine Learning Models*
WHY OMOP?

Phenotype Evaluation Using OMOP RWD


PheValuator: Development and evaluation of a phenotype algorithm evaluator

Joel N Swerdel 1, George Hripcsak 2, Patrick B Ryan 3

Affiliations + expand
PMID: 31369862  PMCID: PMC7736922  DOI: 10.1016/j.jbi.2019.103258


Validation of electronic medical record-based phenotyping algorithms: results and lessons learned from the eMERGE network


Affiliations + expand
PMID: 23531748  PMCID: PMC3715338  DOI: 10.1136/amiajnl-2012-000896

A comparison of phenotype definitions for diabetes mellitus

Rachel L Richesson 1, Shelley A Rusincovitch, Douglas Wixted, Bryan C Batch, Mark N Feinglos, Marie Lynn Miranda, W Ed Hammond, Robert M Califf, Susan E Spratt

Affiliations + expand
PMID: 24026307  PMCID: PMC3861928  DOI: 10.1136/amiajnl-2013-001952

Measuring the Effect of EHR Data Quality in Identifying Type-2 Diabetes Population Across Common Phenotype Definitions of Diabetes

Priyanka Sood, MPH, Star Liu, BS, Hadi Kharrazi, MD PhD FACMI

Johns Hopkins Bloomberg School of Public Health, Baltimore MD
**WHY THIS IS IMPORTANT**

*Cost is $565,217 per measure developed; $1.65 mil per measure in use*

- Between 2008 and 2018, the CMS has invested more than $1.3 billion in quality measure development.
  - 2300 measures have been developed, of which 788 are being used
- CMS currently lacks a strategy to systematically evaluate whether their quality measures improve the delivery of care and health outcomes
  - Assessment: only 37% of its ambulatory medicine measures were valid

**Approx $4.45 mil per valid measure in use (n=292)**


https://jamanetwork.com/journals/jama/fullarticle/2764986
CQL is data model independent:
- libraries must specify the data that they are written for
- evaluation engine must ‘know’ the data model in order to evaluate to the library.

selection of HEDIS measures for connectathon intended to demonstrate the behavior of FHIR-CQL definitions in OMOP data.
DIGITAL QUALITY MEASURES (dQMs)

Statin treatment with Cardiovascular disease
Males 21–75 years of age and females 40–75 years of age with clinical atherosclerotic cardiovascular disease (ASCVD).

Prenatal depression with follow-up
Women with a live birth who were screened for clinical depression during pregnancy using a standardized instrument.

ADHD Meds with follow-up
Children between 6 and 12 years of age who were diagnosed with ADHD and had one follow-up visit with a practitioner with prescribing authority within 30 days of their first prescription of ADHD medication.

Domains covered
• Person
• Condition Occurrence
• Drug Exposure
• Episode
• Episode_Event
• Observation
• Visit Occurrence
• Visit Detail
• Provider
Clinical Quality Language (CQL)

Data model independent, programming language for computable phenotypes

- Mature domain specific language for expression of clinical logic
- Supports time resolution intervals with complete set of operators
- Supports interval arithmetic and collapsing (the Circe "magic")
- Supports concept set data type and operations
- Supports custom operators that could encapsulate methods
- Supports window expressions
  - e.g. Blood pressure increase of 5mm within a 20 minute interval

⇒ Must be combined with a data model, FHIR Base, Quality Data Model, ... or.. OMOP
CQL/OMOP as a Circe Alternative

Do we need our own domain specific language?

- CQL is an existing standard, usable on OMOP model, CQL/OMOP
  - No need to build/support our own standard documentation, training
- CQL supports all Circe functionality out of the box
  - Circe definitions can be converted to CQL/OMOP
  - Smooth deprecation of Circe via parallel implementations
- CQL has human readable/writable syntax (instead of JSON)
  - Better supports revision control
  - Inline comments for better documentation of logic
- CQL addresses many Circe deficiencies (time resolution, window functions)
- CQL logic definitions could be "pushed-down" into SQL
  - FunSQL could be used to write such an implementation
  - Could be some, but only a limited errata
CQL/OMOP IS NOT A PANACEA

Existing "CQL" measures would need to be ported

- Existing CQL uses FHIRBase or the Quality Data Model, not OMOP
  - Cannot use existing CQL/QDM or CQL/FHIR measures
  - Non-trivial conversion of FHIR objects into OMOP tables
- Existing CQL doesn't use OMOP Standard Vocabularies
  - Some work converting "Value Sets" (e.g. Concept Sets in our nomenclature)
- Difficulty Porting Quality Measures
  - CQL/QDM measures use Negated Events
  - QI-Core FHIR profile adds Negated Events
  - OMOP doesn't have Negated Events
- Support of OHDSI Methods requires Cleverness
  - CQL Syntax supports "extensions"; could they support OHDSI methods?
  - SQL translation needed for performance/compatibility
  - Creating a gateway to invoke "R" methods is non-trivial
DQMs In Practice – LAISDAR Project

Project Underway in 2021

Collaboration Between:
Univ. Ghent (BE)
Univ. Rwanda
Rwanda Biomed. Centre
Rwanda MOH
edenceHealth (BE)

Initial Aim:
Tracking public health response to COVID across Rwanda
Has since expanded to other pressing clinical areas like maternal/child health, HIV, and malaria
DQMs In Practice – LAISDAR Project

14 Hospitals/Clinics provided with pre-configured MacMini Machine

Two additional national COVID sources to augment EHR data

Deployment of services using Docker

Orchestration of services using SimpleMDM

Each site has local OHDSI environment to interact with OMOP data, and network integration tooling for federated participation
## DQMs In Practice – LAISDAR Project

**GUI to Interact with Report Generator and Produce Docs**

**Report Generator for Stitching Docs with OMOP Data**

**Used sample MOH reports to generate cohort definitions in Atlas for patient selection**

**Built reporting R package, based on EHDEN’s CDMInspection, to stitch Word documents with tables/plots from SQL queries**

<table>
<thead>
<tr>
<th>II. HIV exposed Infants outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. HIV exposed infants were followed at this Health Facility last month</td>
</tr>
<tr>
<td>2. HIV exposed infants newly enrolled in PMTCT at birth (up to six weeks)</td>
</tr>
<tr>
<td>3. HIV exposed infants newly enrolled in PMTCT after six weeks</td>
</tr>
<tr>
<td>4. HIV exposed infants transferred in the facility this month</td>
</tr>
<tr>
<td>5. HIV exposed infants who were lost and are retraced this month</td>
</tr>
<tr>
<td>6. HIV exposed infants who are confirmed HIV positive this month (at 9, 18 and 24 Months)</td>
</tr>
<tr>
<td>7. Children who confirmed HIV positive and enrolled to Care and Treatment this month</td>
</tr>
<tr>
<td>8. HIV exposed infants who are transferred out for follow up in PMTCT</td>
</tr>
<tr>
<td>9. HIV exposed infants who are reported as lost to follow up after 3 months follow up</td>
</tr>
<tr>
<td>10. HIV exposed infants who are deceased this month</td>
</tr>
<tr>
<td>11. HIV exposed infants who exited HIV negative in PMTCT</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
<th>&lt;18 years</th>
<th>18-24 years</th>
<th>25-34 years</th>
<th>35-44 years</th>
<th>45-54 years</th>
<th>55 +</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>1</td>
<td>Total number of HIV Index clients registered in care &amp; Treatment this month</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>Total number of patients already on ART proposed Partner Notification Service (PNS) this month</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>Total number of patients already on ART proposed and accepted Partner Notification Service (PNS) this month</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>Total number of new clients initiated on ART this month</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>Total number of new clients initiated on ART and accepted PNS this month</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>Total number of sexual partners disclosed this month</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
**Preliminary Results:**
- Four sites have reporting tooling deployed and in use
- Utility of OMOP reports has motivated participation in (1) semantic and structural mapping efforts, and (2) data quality assessments and associated updates
- OMOP Data, in combination with Atlas cohort definitions, can cover a large majority of reporting obligations imposed by the Rwandan Ministry of Health
Key Takeaways:

- OMOP has potential to serve DQM purposes, especially in LMI countries

- Potential for fulfilling reporting obligations was the biggest motivating factor for sites to participate in the mapping and quality control processes

- The LAISDAR team is actively seeking ways to sustain progress and plans to make existing development available to the OHDSI community