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?

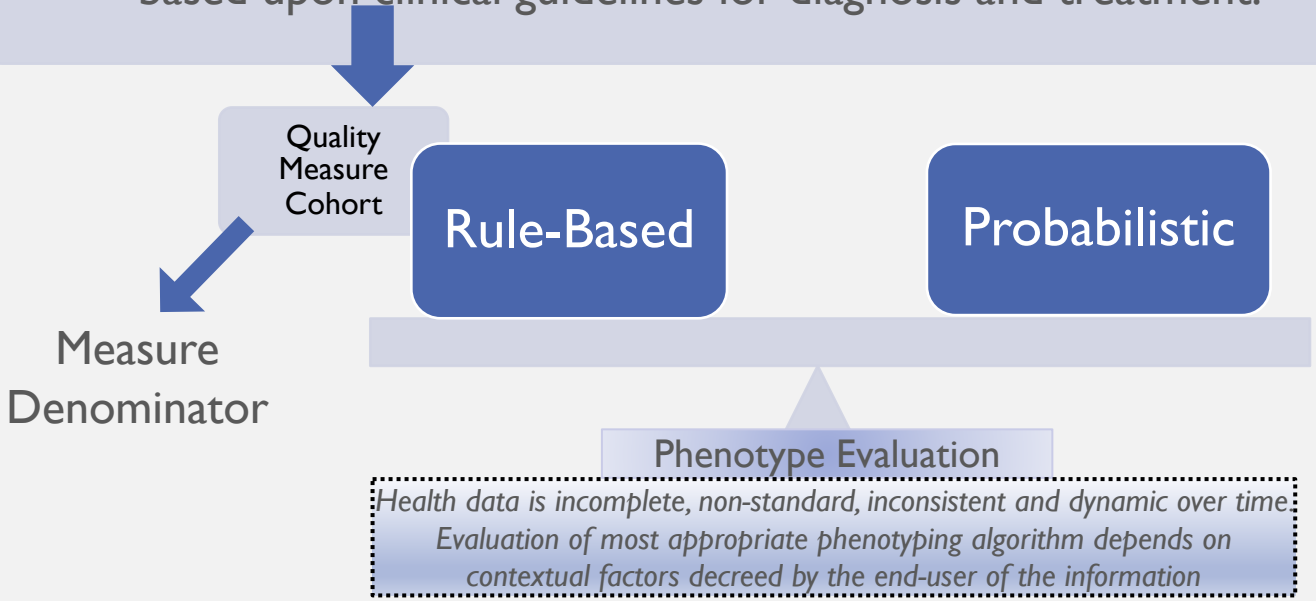
```
define "Numerator 2":
  exists "Follow Up Care on or 30 Days after First Positive Screen"
    or "Has Positive Brief Screen Same Day as Negative Full Length Screen"

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 Condit
          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 Manag
        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 Behavior
      hasDepressionCaseManagementEncounterWithSymptom: exists ( ( Status."Finished Encounter" ( [Encounter: "Depression Case
        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 FHIRBa
      hasBehavioralHealthEncounter: exists ( ( Status."Finished Encounter" ( [Encounter: "Behavioral Health Encounter"] ) ) B
          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, FollowUpCar
        else null ) 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

J Biomed Inform. 2019 Sep;97:103258. doi: 10.1016/j.jbi.2019.103258. Epub 2019 Jul 29.

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

Comparative Study J Am Med Inform Assoc. 2013 Dec;20(e2):e319-26. doi: 10.1136/amiajnl-2013-001952. Epub 2013 Sep 11.

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

J Am Med Inform Assoc. 2013 Jun;20(e1):e147-54. doi: 10.1136/amiajnl-2012-000896. Epub 2013 Mar 26.

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

Katherine M Newton [1], Peggy L Peissig, Abel Ngo Kho, Suzette J Bielinski, Richard L Berg, Vidhu Choudhary, Melissa Basford, Christopher G Chute, Iftikhar J Kullo, Rongling Li, Jennifer A Pacheco, Luke V Rasmussen, Leslie Spangler, Joshua C Denny

Affiliations + expand

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

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

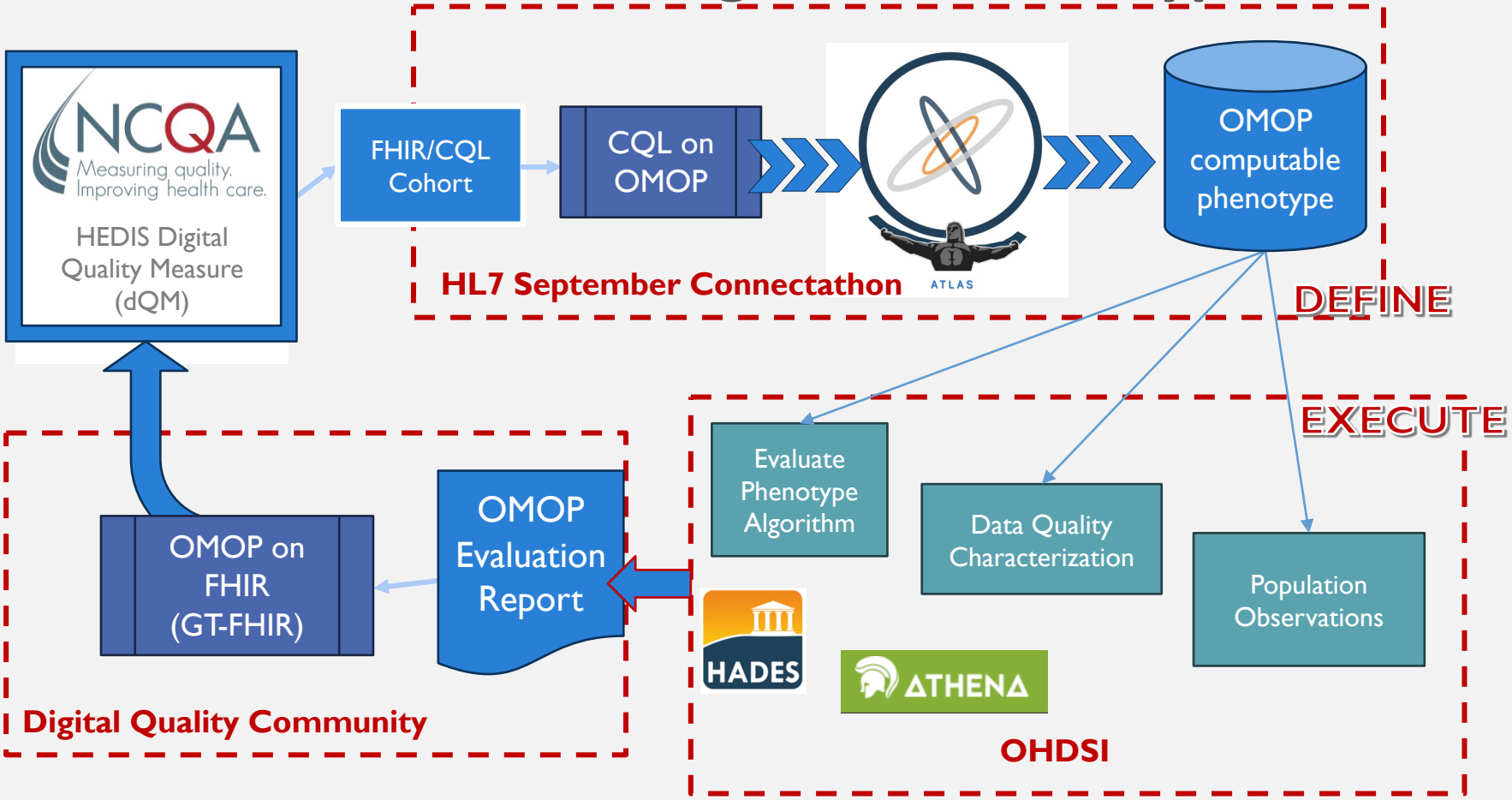
Cost is $565,217 per measure developed; $1.65 mil per measure in use

- 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)*

Wadhera RK, Figueroa JF, Joynt Maddox KE, Rosenbaum LS, Kazi DS, Yeh RW. Quality Measure Development and Associated Spending by the Centers for Medicare & Medicaid Services. *JAMA*. 2020;323(16):1614–1616. doi:10.1001/jama.2020.1816
https://jamanetwork.com/journals/jama/fullarticle/2764986

OMOP on FHIR: Evaluating dQM Phenotypes in RWD



HL7 Connectathon: Transforming FHIR to OMOP

Creating OMOP-CQL Phenotypes

```
library FHIRHelpers version '4.0.0'

using FHIR version '4.0.0'

define function ToInterval(period FHIR.Period):
    if period is null then
        null
    else
        if period."start" is null then
            Interval(period."start".value, period."end".value]
        else
            Interval[period."start".value, period."end".value]

define function ToCalendarUnit(unit System.String):
    case unit
        when 'ms' then 'millisecond'
        when 's' then 'second'
        when 'min' then 'minute'
        when 'h' then 'hour'
        when 'd' then 'day'
        when 'wk' then 'week'
        when 'mo' then 'month'
        when 'a' then 'year'
        else unit
    end
```

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

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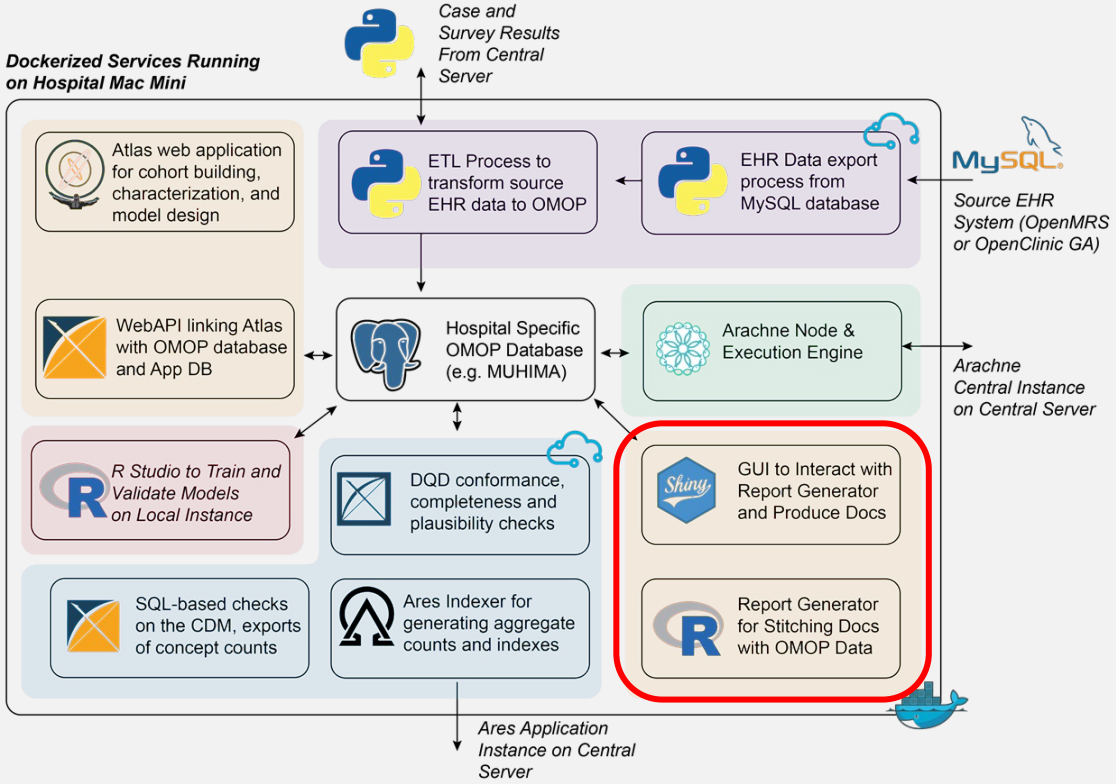

- 14 Hospitals/Clinics provided with pre-configured MacMini Machine
- Two additional national COVID sources to augment EHR data
- Deployment of services using Docker
- Orchestration of services using SimpleMDM
- Each site has local OHDSI environment to interact with OMOP data, and network integration tooling for federated participation

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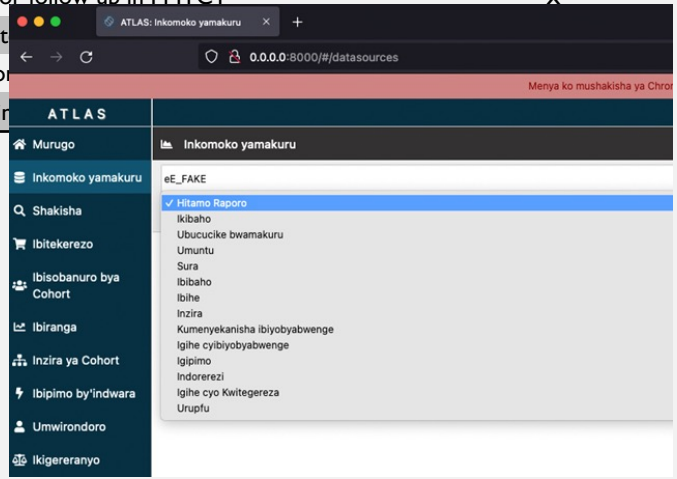
GUI to Interact with Report Generator and Produce Docs

Report Generator for Stitching Docs with OMOP Data

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



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

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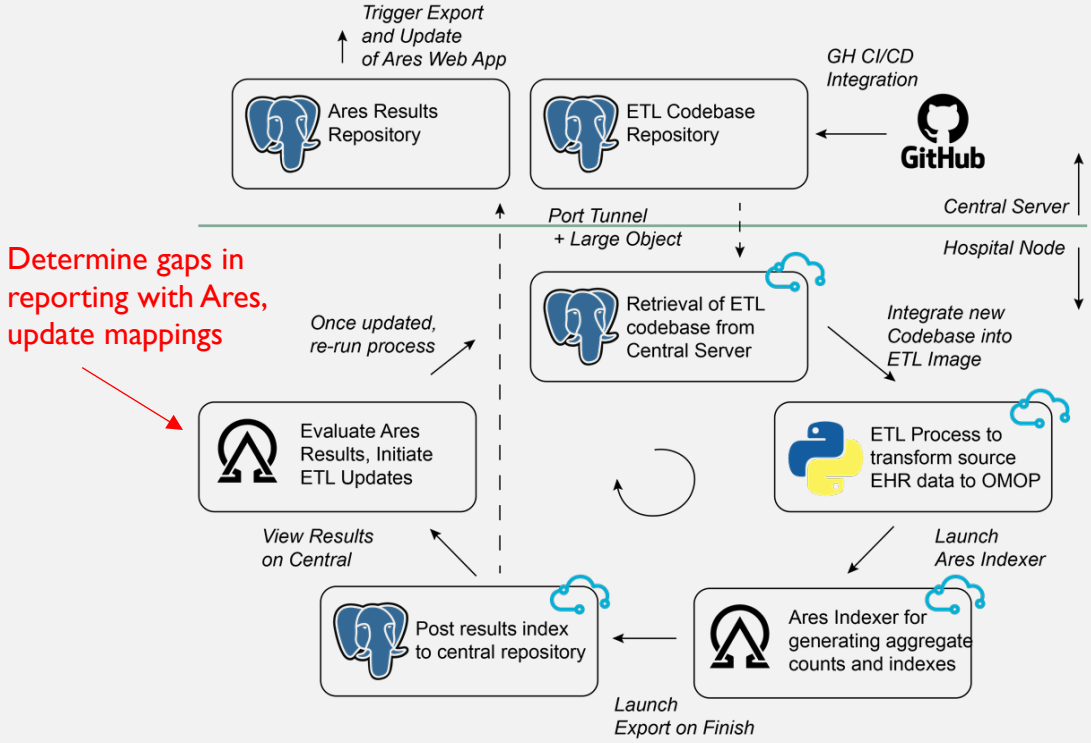
		<18 years		18-24 years		25-34 years		35-44 years		45-54 years		55 +	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1	Total number of HIV Index clients registered in care & Treatment this month	X	X	X	X	X	X	X	X	X	X	X	X
2	Total number of patients already on ART proposed Partner Notification Service (PNS) this month	X	X	X	X	X	X	X	X	X	X	X	X
3	Total number of patients already on ART proposed and accepted Partner Notification Service (PNS) this month	X	X	X	X	X	X	X	X	X	X	X	X
4	Total number of new clients initiated on ART this month	X	X	X	X	X	X	X	X	X	X	X	X
5	Total number of new clients initiated on ART and accepted PNS this month	X	X	X	X	X	X	X	X	X	X	X	X
6	Total number of sexual partners disclosed this month	X	X	X	X	X	X	X	X	X	X	X	X

dQMs In Practice – LAISDAR Project

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



DQMs In Practice – LAISDAR Project

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