• House rules, intro, agenda (5’)

• 1: Indicators and Data Analysis (15’)

• 2: Data Extraction (20’)
  • Measure / MeasureReport
  • ETL
    • fhir2es
    • parquet

• 3: Q&A
  • Your context / challenges / ideas?

• 4: Data Visualization (20’)
  • Data Analysis
  • Data Visualizations

• 5: Q&A
  • Your context / challenges / ideas?
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Part 1
Indicators and Data Analysis
Data Analysis
Analytics

Different types of use cases for “analytics”:

● Producing standard reports
● Track data patterns for surveillance / alerts
● Exploring and visualizing the data freely to find patterns, infer information
● ...

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Standard reports

- Used for standard indicators
  - E.g. TX_CURR [https://indicatorregistry.unaids.org/export-to-pdf/1171](https://indicatorregistry.unaids.org/export-to-pdf/1171)

- Require a fixed, **well managed** set of data
  - “death from COVID” vs “death by COVID”

- Some governance is expected
Exploratory analytics

- Ad-hoc exploration of the data
  - ...or visual depiction of the reports

- May start with or without a specific /strict data set

- Great for discovery, pattern finding
  - ...actually a good way to validate the reports, the data itself, and define new reports
# Data exploration and analytics

<table>
<thead>
<tr>
<th></th>
<th>Standard reports</th>
<th>Data exploration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Managing analytics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indicator definition</td>
<td>Indicator definitions are precisely defined</td>
<td>Indicators and dashboards can start with a initial draft / conceptual goal and defined / refined in exploration</td>
</tr>
<tr>
<td></td>
<td>Indicator definitions are managed from their first definition - and are documented accordingly</td>
<td>Indicators and dashboards are documented when they become “official”</td>
</tr>
<tr>
<td><strong>Extracting data</strong></td>
<td></td>
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<tr>
<td>Data set required</td>
<td>Data set typically defined before even getting the data</td>
<td>Usually “needs more data” (mind your privacy requirements)</td>
</tr>
<tr>
<td>Data extraction pipeline</td>
<td>Extraction process should be managed and monitored for all the data that is required.</td>
<td>Extraction process should be managed and monitored.</td>
</tr>
<tr>
<td><strong>Producing / saving results</strong></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Reports are usually persisted, and should be traced</td>
<td>Reports are point-in-time observation, but may be persisted</td>
</tr>
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</table>
Indicator and Data definitions

- “Data Definitions” - can be technical or semantic.
  - Semantic definitions: data meaning, cardinality, value sets, constraints
    - we have logical models (as discussed in our webinars)
  - Technical definitions: technical format (inheriting the semantic definitions)

- Indicator definitions should be clear at least semantically, ideally technically too

- Analytics reports should be traced to definitions
Part 2
Data Extraction
Main topics

• Indicator/Aggregate Data
  • Measure and MeasureReport
  • $evaluate-measure
  • Mobile Aggregate Data Exchange (mADX)

• Extract, Transform, and Load
  • fhir2es - Node.JS module
  • Parquet
  • DHIS2 (non-FHIR / ADX)
Indicator or aggregate data can be retrieved from a FHIR server using MeasureReports that are based on defined Measures. Clinical Quality Language (CQL) can be used to process the FHIR resources on a server using the $evaluate-measure operation. MeasureReports can be also be stored once calculated and then retrieved when needed.
The Measure resource represents a structured, computable definition of a health-related measure such as a clinical quality measure, public health indicator, or population analytics measure.

- [https://www.hl7.org/fhir/clinicalreasoning-quality-reporting.html](https://www.hl7.org/fhir/clinicalreasoning-quality-reporting.html)
- Logic is contained in a Library resource containing CQL or Expression Logical Model (ELM)
Measure Resource

A Measure can include multiple population groups that include populations and stratifiers and supplemental data.

**Populations** include a specific component of the calculated measure, such as numerator, denominator, and initial population.

**Stratifiers** define ways to break up the population group such as age or gender.

**Supplemental data** is any additional information that should be included with the results.
$evaluate-measure Operation

The $evaluate-measure operation can be called to calculate a given measure and return a MeasureReport.

```
GET fhir/Measure/<MeasureId>/evaluate-measure?periodStart=2019-01-01&periodEnd=2019-12-31
```

This operation will process the measure based on the logic in the Library associated with the Measure and return the MeasureReport based on the given criteria for the start and end dates.

This is supported in the HAPI FHIR server.

The MeasureReport resource contains the results of the calculation of a measure; and optionally a reference to the resources involved in that calculation.

A MeasureReport is for a given time period.

The MeasureReport includes the population groups defined in the associated Measure resource with all the stratifiers.
Using Measure/MeasureReport in your Architecture

- Usage patterns can differ.
- Behavior patterns have been defined in Mobile Aggregate Data Exchange (mADX).
  - Using profiling like mADX improves interoperability.
The Mobile Aggregate Data Exchange (mADX) is an IHE Profile from the Quality, Reporting, and Public Health (QRPH) committee that supports interoperable public health reporting of aggregate health data. These most typically take the form of routine reports (weekly, monthly, quarterly etc.) from a health facility to some administrative jurisdiction such as a health district, though there are numerous other use cases such as international reporting and community health worker reporting. As the motivating context and use cases for this profile is the same as the Aggregate Data Exchange (ADX) profile, they are not repeated here. The mADX and ADX file are intended to be functionally equivalent.

https://wiki.ihe.net/index.php/Mobile_Aggregate_Data_Exchange_(mADX)
mADX Actors

- Content Data Structure Creator
- Content Data Structure Consumer
- Content Creator
- Content Consumer

mADX works together with Mobile Care Services Discovery (mCSD) and Sharing Valuesets, Codes, and Maps (SVCM) to retrieve supported data for Measures.
mADX Transactions

QRPH-58: Send Aggregate Report
- A Content Creator sends a MeasureReport resource to the Content Consumer.
  - Multiple MeasureReports can be sent in a Collection Bundle.

QRPH-59: Retrieve Aggregate Report Definition
- A Content Data Structure Consumer requests a Measure resource from the Content Data Structure Data Creator.
mADX Actors
FHIRE resources contain multiple levels of data. Some fields can be arrays or complex (objects).

Traditional data analysis usually works with flat data such as in a CSV file or a relational database.

- FHIRE Bulk Data Export with custom script
- fhir2es - Node.JS module
  - Configuration based
- Column-oriented data - parquet
- StructureMaps
- Other custom scripts/tools (e.g. logstash)
FHIR Data Export

- Export FHIR from server
  Export FHIR data using FHIR Bulk Data Export (NDJSON)
  - High Performance Computing on Flat FHIR Files Created with the New SMART/HL7 Bulk Data Access Standard

  History interaction
  - [https://www.hl7.org/fhir/http.html#history](https://www.hl7.org/fhir/http.html#history)

  Search interaction
  - [https://www.hl7.org/fhir/http.html#search](https://www.hl7.org/fhir/http.html#search)

- Write custom script to combine and flatten needed data
  You should not try to access the data directly from the database you use for your FHIR server
  - Data structure can change
  - You could corrupt the data
fhir2es

- NPM module for Node.JS
- [https://github.com/intrahealth/fhir2es](https://github.com/intrahealth/fhir2es)
- Uses Basic FHIR resource with extensions
  - Configures relationship between FHIR resources with fields to include
- Indexes to ElasticSearch or OpenSearch
- Can use Kibana or OpenSearch Dashboards for visualizations
  - With OpenSearch (or paid ElasticSearch) you can also expose data using an ODBC driver to use other visualization platforms.
Parquet

- Apache Parquet is a compressed column-oriented format.
  - [https://parquet.apache.org/](https://parquet.apache.org/)
- Can be loaded into various tools
  - Can be used with Apache Spark and Hive
  - Can be used with Splink, python, or R for data analysis
- Examples
  - OpenMRS FHIR to Parquet
DHIS2

- Can convert mADX resources into ADX files to load into DHIS2
- Can create custom scripts to convert FHIR resources into ADX files
Q&A, ideas
Part 3
Data Analysis and Visualization
Main topics

- Data Analysis
  - Splink for record linkage
    - https://github.com/moj-analytical-services/splink
    - https://github.com/moj-analytical-services/splink_demos
  - Python and R
  - SQL on FHIR

- Data Visualization
  - OpenSearch Dashboards / Kibana
  - Apache Superset
  - Tableau / Power BI
  - Custom
Data Analysis

- Splink is an implementation of the Feligi-Sunter probabilistic matching algorithm
- Written in python
- Works with Apache Spark
- Can use jupyter notebooks to analyze data
Splink Data Analysis

**Distribution of counts of values in column YOB**

- In this col, 117 values (0.1%) are null and there are 98 distinct values.

**Top 20 values by value count**

- Year count
  - 1991: 5,000
  - 1992: 4,500
  - 1993: 4,000
  - 1994: 3,500
  - 1995: 3,000
  - 1996: 2,500
  - 1997: 2,000
  - 1998: 1,500
  - 1999: 1,000
  - 2000: 500
  - 2001: 0
  - 2002: 0
  - 2003: 0
  - 2004: 0
  - 2005: 0
  - 2006: 0
  - 2007: 0
  - 2008: 0
  - 2009: 0
  - 2010: 0
  - 2011: 0
  - 2012: 0
  - 2013: 0
  - 2014: 0
  - 2015: 0
  - 2016: 0
  - 2017: 0
  - 2018: 0
  - 2019: 0
  - 2020: 0
Python and R

- Can use python and R tools to analyze data
- Splink is based on python and uses jupyter notebooks where you can work with and analyze your data.
- Can query data in Apache Spark or similar tools
SQL on FHIR proposal

- https://github.com/FHIR/sql-on-fhir/blob/master/sql-on-fhir.md
- Ability to query FHIR resources in a known/standard way.
OpenSearch Dashboards

- OpenSearch is based off an older open-source version of ElasticSearch
- Steeper learning curve, but development is improving things quickly
- Can create maps
- Can use Vega
ElasticSearch / Kibana

- Kibana Lens is easier to use to create visualizations
- Can use older Aggregation based library that OpenSearch is based on
- Can create maps
- Can use Vega
Supported Databases

- Amazon Redshift
- Druid
- Google BigQuery
- ClickHouse
- Dremio
- Exasol
- Firebird
- Greenplum
- IBM DB2
- MySQL
- SQL Server
- MonetDB
- Oracle Database
- PostgreSQL
- Presto
- Snowflake
- SQLite
- Trino
- Rockset
- Vertica
- YugabyteDB

... and many other compatible databases

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Apache Superset

- Large visualization library
- Plugin support for custom visualizations
- Can create maps
- New visualizations are under development
Tableau and Power BI

- Can read from parquet files
- Can read from CSV files
- Can connect to traditional SQL servers or with an ODBC driver
- Licensing fees
- Large feature set
- Can do analysis and visualizations
Custom Solutions

- You can custom build using many available libraries

Pros
- Can build any visualization
- Can produce any layout

Cons
- Must maintain all libraries and code
- Requires coding to produce new reports
- Must add in any needed additional features (security, access controls, exporting, different formats)
Q&A, ideas
Get in touch, be active

• Check with others (at chat.fhir.org or community.fhir.org)
• Create (or ask someone to create) a change request
• Join a FHIR® event like DevDays (devdays.com), discuss
• Join a FHIR® connectathon, test and provide feedback
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