

SESSION

06

FHIR TRAINING

CDC FOUNDATION
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Session 6

1. BLOCK 1
 1. FHIR RESTful Operations
 2. Transactions
 3. Extended Operations
 4. Assignment
2. BLOCK 2
 1. FHIR Search
 2. Assignment
3. BLOCK 3
 1. FHIR Technologies / The FHIR Toolbox

Block 1 – FHIR Operations

1. RESTful Operations

1. Actions: Create, Read, Update, Delete
2. Actions vs HTTP Methods
3. Live: Create, Read, Update
4. FHIR Transactions
5. Extended Operations
6. Assignment

REST: a URL based API



Note: This URL resolves to the current version of a resource
It's also specific to a server

REST actions

CRUD:

- Create – create a new instance of data
 - HTTP POST
- Read – get the content (state) of an instance of data
 - HTTP GET
- Update – change the content of an instance of data
 - HTTP PUT
- Delete – remove the instance of data
 - HTTP DELETE

Note: There is also PATCH. Not widely implemented but handy if someone wants to update specific fields without overwriting the entire resource.

FHIR reuses these

- Instance
 - **Read** **GET** [base]/Patient/100
 - **Update** **PUT** [base]/Patient/100
 - **Delete** **DELETE** [base]/Patient/100
 - History **GET** [base]/Patient/100/_history
 - Vread **GET** [base]/Patient/100/_history/{vid}
- Type
 - **Create** **POST** [base]/Patient
 - Search **GET** [base]/Patient?name=eve
 - History **GET** [base]/Patient/_history
 - Validate **POST** [base]/Patient/\$validate
- System
 - Conformance **GET** [base]/metadata
 - Transaction **POST** bundle to root
 - History **GET** [base]/_history

Details see:

<https://www.hl7.org/fhir/http.html>

Versioning

- Most recent version
 - `http://server.org/fhir/Patient/1`
 - Returns single resource
- Specific version
 - `http://server.org/fhir/Patient/1/_history/1`
 - Returns single resource
- All versions
 - `http://server.org/fhir/Patient/1/_history`
 - Returns *bundle* of versions (see later)

Version support is optional

What is ‘creating’ in FHIR? Which Server?

- **Which server?** You can use any test server
- The **full list of FHIR test servers** can be found here:

<https://confluence.hl7.org/spaces/FHIR/pages/35718859/Public+Test+Servers>

- **What is an endpoint in FHIR:** the URL you use to operate with the server FHIR resources.
- Here is one test server you can use:

<https://fhirserver.hl7fundamentals.org/fhir>

*This is called ‘the **base endpoint**’, common to all resources and server operations*

Create: What is ‘creating’ in FHIR?

- ‘Create’ means asking the server to **store the resource** and **assign a logical id**
- FHIR is based on a variant of the RESTful paradigm, which defines how to invoke operations on resources:

OPERATION	REST HTTP VERB
CREATE	POST
READ	GET (DIRECT)
UPDATE	PUT
DELETE	DELETE
SEARCH	GET (PARAMETERIZED)

- So ‘creating’ is basically storing a resource on a **FHIR Server endpoint** using a **POST** operation.

What is ‘creating’ in FHIR? Resource URL

- Resource specific URL - > where do we POST
 - When you want to perform a resource specific operation, you need to include the resource name in the URL.
[BaseEndpoint]/[ResourceName]
 - For example, if we want to do an operation with the ‘patient’ resource in our server:

<http://fhirserver.hl7fundamentals.org/fhir/Patient>

What is ‘creating’ in FHIR? What to POST?

- **Resource Content - What do we POST**

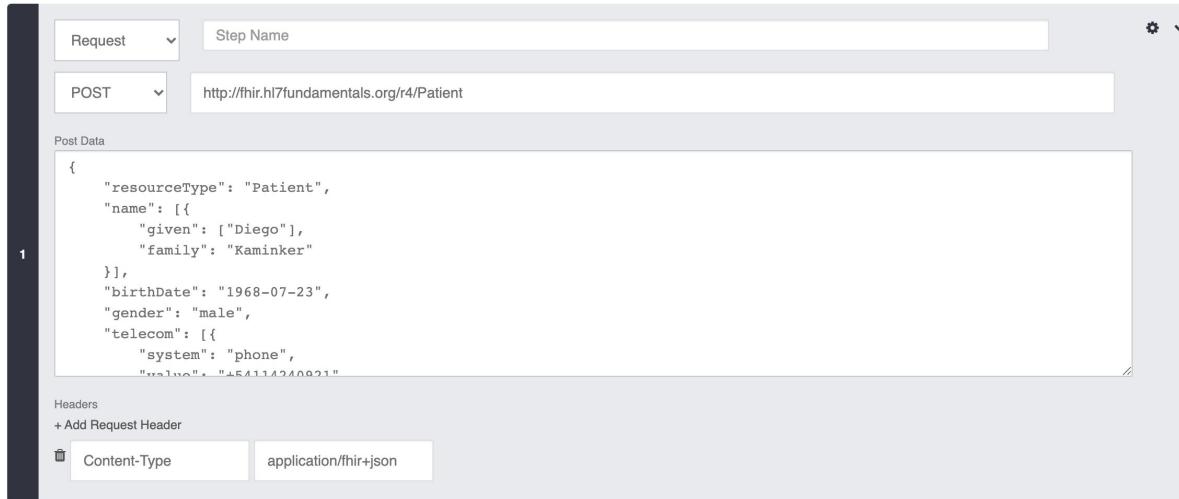
- When you want to create a resource, you need to include the content as the **request body**

- **Headers**

- The server needs to know if you are POSTing JSON or XML
 - We will include the **Content-Type** header with the value **application/fhir+json** or **application/fhir+xml** depending on the content we are sending.

Let's CREATE a resource...

We can use **Postman** – or just **Hopscotch**: <https://hopscotch.io/>
Combine **Request Method** (POST), **(Body)**: Your resource ,
Content-Type: application/json or xml

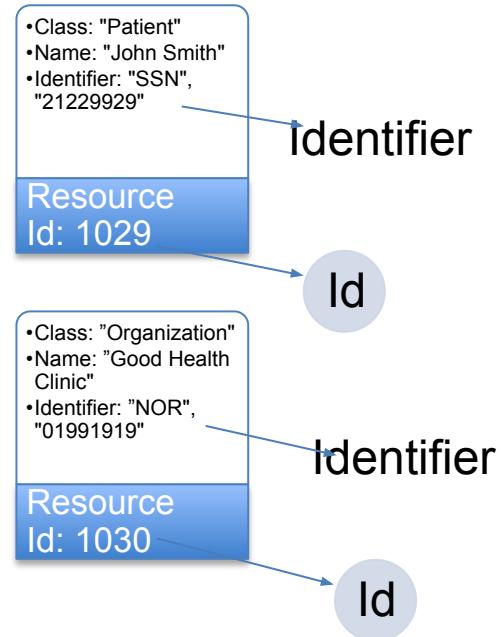


Read: a resource knowing its 'id'

What is a resource 'id'?

'id's are logical identifiers. They are assigned by the server where the resource is stored. Do not confuse them with 'identifier'.

- **id** -> logical server assigned identifier
- **Identifier** -> human readable, assigned identifier. Example: national identifier for a patient, order number for a lab order, etc.



Read: a resource knowing it's 'id'

If you know the resource id, it's as simple as

GET **[BaseEndpoint]/[ResourceName] /[ResourceId]**

Example: To get the info for the organization with the id: 2997 in our own server:

GET

<http://fhirserver.hl7fundamentals.org/fhir/Organization/2997>

Just paste this in the address bar using any browser
Or using a REST Client

Let's retrieve and update then...

1

GET ▾ http://fhir.hl7fundamentals.org/r4/Patient/210953

PUT ▾ http://fhir.hl7fundamentals.org/r4/Patient/210953

Post Data

1

```
{
  "resourceType": "Patient",
  "id": "210953",
  "meta": {
    "versionId": "1",
    "lastUpdated": "2020-10-05T16:15:58.883+00:00"
  },
  "text": {
    "status": "generated",
    "div": "<div xmlns=\"http://www.w3.org/1999/xhtml\"><div class=\"hapiHeaderText\">Diego <b>KAMINKER </b></div>
<table border=1><tr><td>name</td><td>KAMINKER, Diego</td></tr><tr><td>gender</td><td>male</td></tr><tr><td>date of birth</td><td>2020-10-05</td></tr><tr><td>telecom</td><td></td></tr></table>"
```

Headers

+ Add Request Header

Content-Type application/fhir+json

Assignment #5 – Part A

We will proceed to work in groups now, and solve Assignment #5 Part A – RESTful Operations

[Assignment #5 - FHIR Operations.pdf](#)



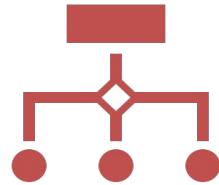
FHIR Bundles

- Set of resources
- Building block for all paradigms
- **Bundle.type** defines the kind
 - (and basic paradigm we are using)
 - type=“transaction”
 - type=“message”
 - type=“batch”
 - type=“document”
 - type=“searchset”

Bundle
type=“xx”

Entry 1..N

FHIR Transactions / Batches



Multiple operations at once

Return bundle with outcomes

Transaction

- Related resources - Referential integrity
(All OK or Nothing OK)

Batch

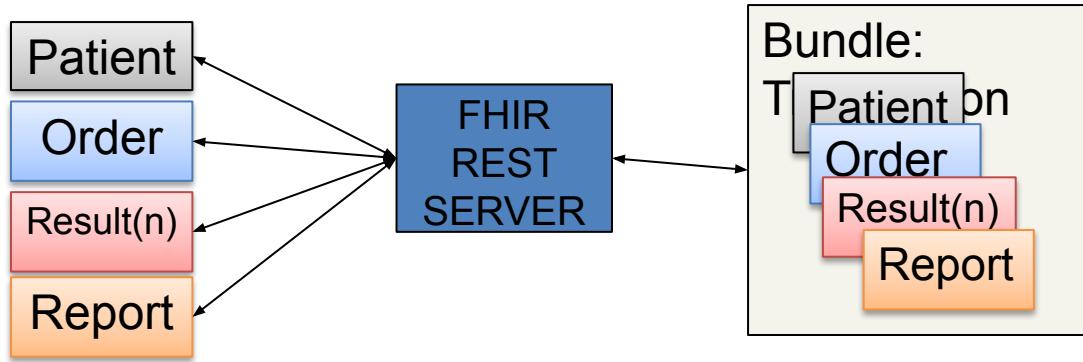
- Unrelated (Each operation has its own outcome)

FHIR Transactions

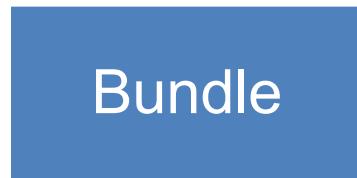
- Arbitrary resource bundle
- A transaction is a complex set of operations which can include conditional CRUD. Not supported by all servers.
- **Transaction:** The server will **process all the operations successfully, or none.**
- **Batch:** The server will process all the successful operations, **even when there are some in the transaction which could not be processed.**

FHIR Transactions

- The only way to perform operations without a lot of server traffic (request-response)
- Example: save the patient + the order + the results + the PDF report for a lab in only one trip to the server.



Transactions – Conceptual View



Advantages

1 Round Trip
Compared to
1 Round Trip per Resource

Patient

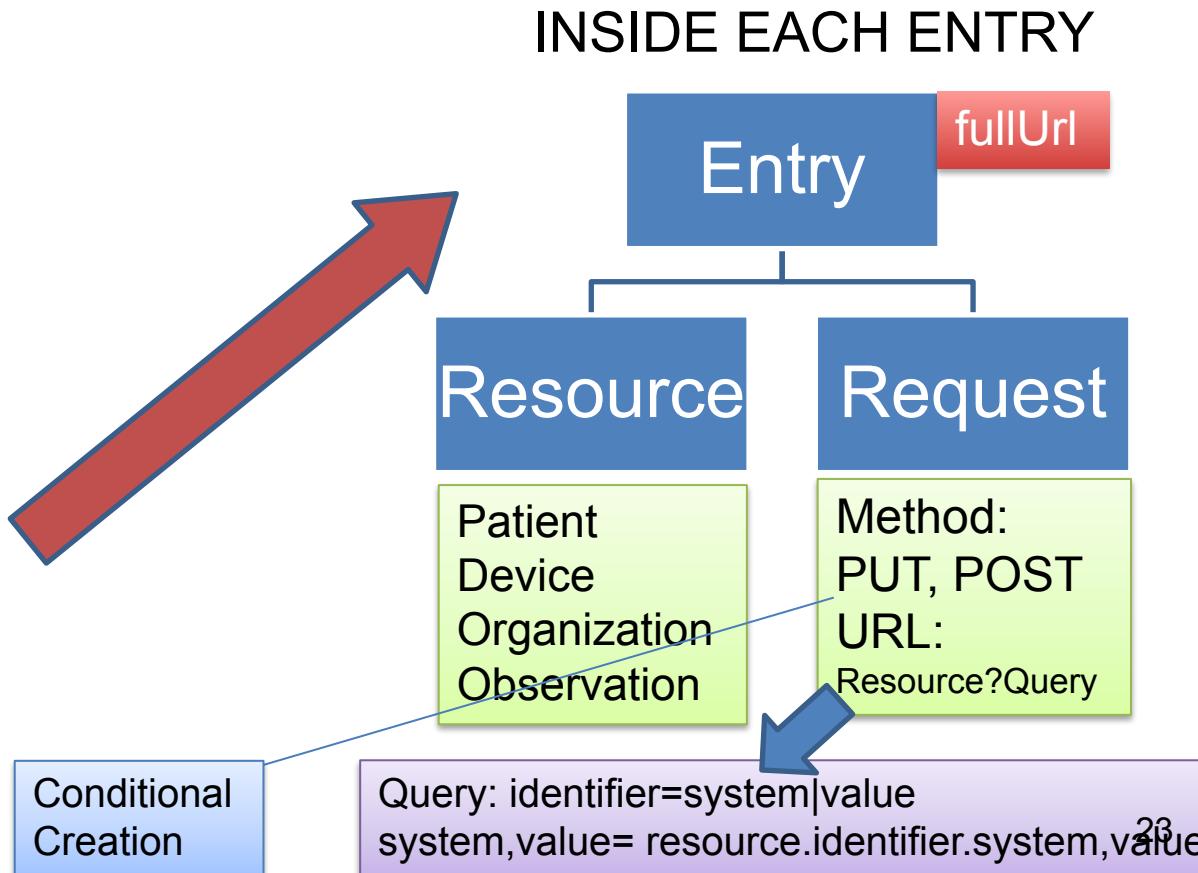
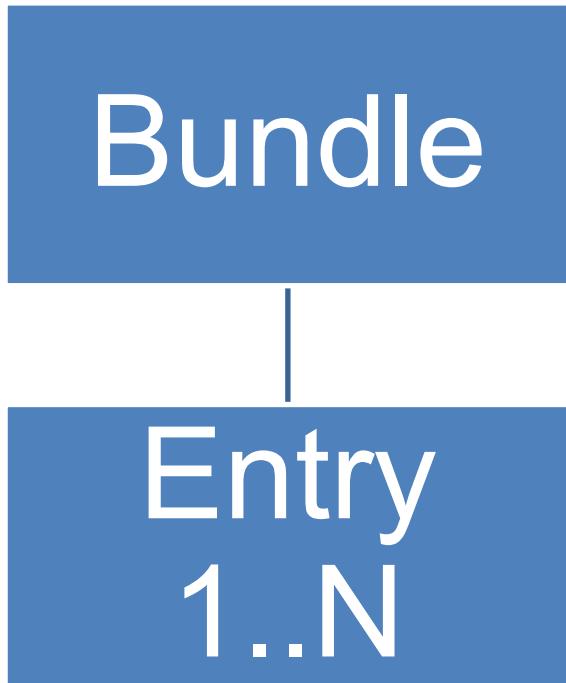
Organization

Device

Observation
(#1...#N)

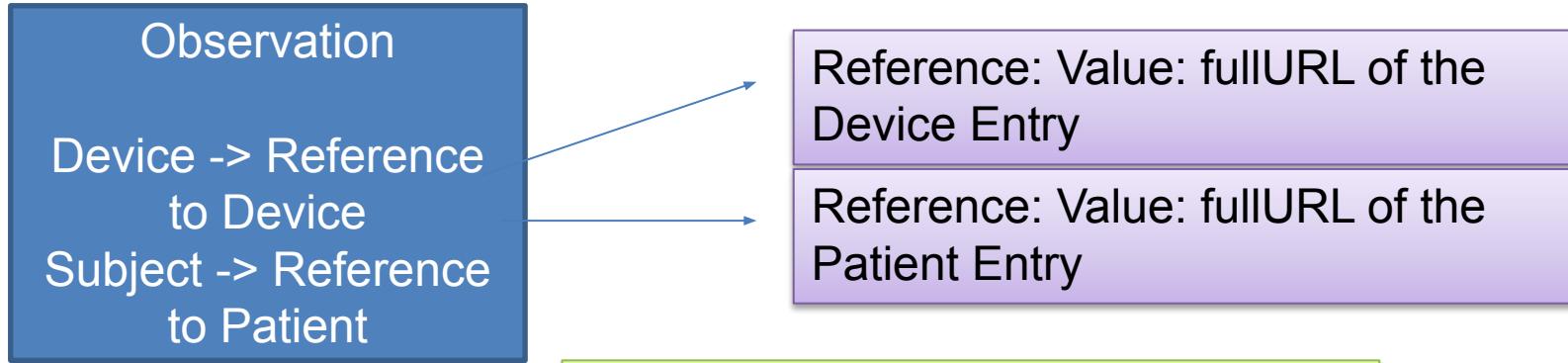
POST to base endpoint: {{endpoint}}
Remember to establish header
Content-Type : application/fhir+json

INSIDE THE BUNDLE



REFERENCES INSIDE THE BUNDLE

- Virtual References, resolved by the FHIR Server



Why?

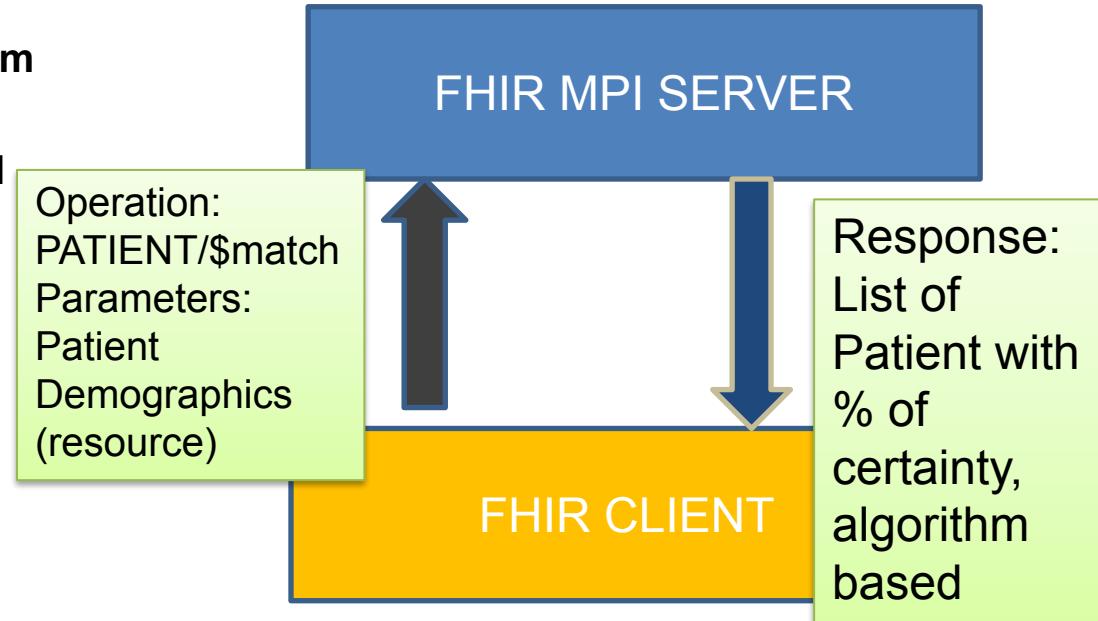
We don't know yet which logical identifier will be assigned by the server to the patient and device
We use a temporary placeholder

FHIR Extended Operations

WHEN

- You need the server **to perform an action involving a special algorithm or business rule**
- These sole action may affect several resources beyond the transaction capability: examples:
 - Patient/\$merge
 - Patient/\$match
 - Terminology Services

FHIR defined Operations



<http://hl7.org/fhir/operationslist.html>

Your own operations!

- You can define your own using the Parameters and OperationDefinition resources.
- **Question: How will the clients know that you support a specific operation?**

Operations: How?

- Example Operation: <https://www.hl7.org/fhir/patient-operation-everything.html>

Operations – How?

- Parameters resource - This special resource has no other use than for operation parameters.

The screenshot shows a web browser displaying the FHIR Parameters resource structure. The URL in the address bar is hl7.org/fhir/parameters.html. The page title is "2.45.3 Resource Content". Below the title, there is a navigation bar with tabs: Structure (highlighted in yellow), UML, XML, JSON, Turtle, R3 Diff, and All. The main content area is titled "Structure" and contains a table with columns: Name, Flags, Card., Type, and Description & Constraints. The table rows represent the structure of the Parameters resource:

Name	Flags	Card.	Type	Description & Constraints
Parameters	Σ N		Resource	Operation Request or Response Elements defined in Ancestors: <code>id</code> , <code>meta</code> , <code>implicitRules</code> , <code>language</code>
parameter	Σ I	0..*	BackboneElement	Operation Parameter + Rule: A parameter must have one and only one of (value, resource, part)
name	Σ	1..1	string	Name from the definition
value[x]	Σ I	0..1	*	If parameter is a data type
resource	Σ I	0..1	Resource	If parameter is a whole resource
part	Σ	0..*	see parameter	Named part of a multi-part parameter

At the bottom left, there is a link "Documentation for this format" with a question mark icon. The bottom right corner of the slide has the number 28.

FHIR Operations

2.2.0.2 FHIR defined Operations

This specification defines several operations:

Base Operations (All resource types)	
Validate a resource	[base]/[Resource]/\$validate [base]/[Resource]/[id]/\$validate
Access a list of profiles, tags, and security labels	[base]/\$meta [base]/[Resource]/\$meta [base]/[Resource]/[id]/\$meta
Add profiles, tags, and security labels to a resource	[base]/[Resource]/[id]/\$meta-add
Delete profiles, tags, and security labels for a resource	[base]/[Resource]/[id]/\$meta-delete
Operations Defined by Resource Types	
Generate a Document	[base]/Composition/\$document
Concept Translation	[base]/ConceptMap/\$translate [base]/ConceptMap/[id]/\$translate
Closure Table Maintenance	[base]/\$closure
Evaluate	[base]/DecisionSupportRule/[id]/\$evaluate
Evaluate	[base]/DecisionSupportServiceModule/[id]/\$evaluate
Fetch Encounter Record	[base]/Encounter/[id]/\$everything
Find a functional list	[base]/List/\$find
Process Message	[base]/\$process-message
Fetch Patient Record	[base]/Patient/\$everything [base]/Patient/[id]/\$everything
Populate Questionnaire	[base]/Questionnaire/\$populate [base]/Questionnaire/[id]/\$populate
Build Questionnaire	[base]/StructureDefinition/\$questionnaire [base]/StructureDefinition/[id]/\$questionnaire
Value Set Expansion	[base]/ValueSet/\$expand [base]/ValueSet/[id]/\$expand
Concept Look Up	[base]/ValueSet/\$lookup
Value Set based Validation	[base]/ValueSet/\$validate-code [base]/ValueSet/[id]/\$validate-code
Operations Defined by Implementation Guides	

BLOCK 2 – FHIR SEARCH

1. FHIR Search - Intro
2. Search parameters
3. Assignment

FHIR RESTful Search

- Works on pre-defined named parameters (only) (e.g. “name”)
 - Listed at the end of each resource

GET [base]/Patient?name=eve

GET [base]/Observation?code=3141-9

GET [base]/Patient/100

GET [base]/Patient?_id=100

GET [base]/Patient?identifier=MRN1234

Note that the 3rd one is actually the odd one out here – why?

Ok I get it...or not?

<code>http://server.org/fhir/Patient/</code>	406 hits
<code>http://server.org/fhir/Patient?gender=M</code>	234 hits
<code>http://server.org/fhir/Patient?gender=F</code>	167 hits

Total: 234 + 167 = 401

<code>http://server.org/fhir/Patient/</code>	406 hits
<code>http://server.org/fhir/Patient?gender=M</code>	234 hits
<code>http://server.org/fhir/Patient?gender=F</code>	167 hits
<code>http://server.org/fhir/Patient?gender:missing=true</code>	5 hits

Total: 234 + 167 + 5 = 406

Search (Patient)

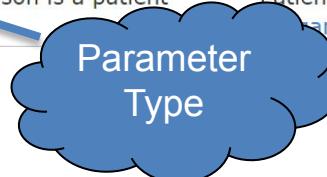
Each resource has a set of “standard” search operations, so **not every element can be searched!**:

family	string	A portion of the family name of the patient	Patient.name.family
gender	token	Gender of the patient	Patient.gender
given	string	A portion of the given name of the patient	Patient.name.given
identifier	token	A patient identifier	Patient.identifier
language	token	Language code (irrespective of use value)	Patient.communication.language
link	reference	All patients linked to the given patient	Patient.link.other (Patient)
name	string	A portion of either family or given name of the patient	Patient.name
organization	reference	The organization at which this person is a patient	Patient.managingOrganization (Organization)
phone	token	A value in a phone contact	Patient.telecom(system=phone)

Search (Patient)

- Each search parameter has a ‘type’

family	string	A portion of the family name of the patient	Patient.name.family
gender	token	Gender of the patient	Patient.gender
given	string	A portion of the given name of the patient	Patient.name.given
identifier	token	A patient identifier	Patient.identifier
language	token	Language code (irrespective of use value)	Patient.communication.language
link	reference	All patients linked to the given patient	Patient.link.other (Patient)
name	string	A portion or either family or given name of the patient	Patient.name
organization	reference	The organization at which this person is a patient	Patient.managingOrganization (Organization)
phone	token	A value in a phone contact	Patient.telecom(system=phone)



Combining parameters

- Can search by GET & POST – usually GET
- Always return a bundle
- Multiple parameters
 - Specifying multiple parameters finds resources matching all params ☐ “AND”
`http://fhir.hl7fundamentals.org/r4/Patient?name=jones&gender=female`
 - Parameters may list multiple values (comma) ☐ “OR”
`http://fhir.hl7fundamentals.org/r4/Patient?name=patel,jones`

Combining parameters

- Specifying multiple parameters finds resources matching all params ☐ “AND”
- Parameters may list multiple values ☐ “OR”
- `http://server.org/fhir/Patient/search?`
`birthdate=1972-11-30`
`&language=NL, FR`

Chained searches

- Patient has a search for “name”.
- Observation has a search for “subject” (the id of the Patient, Group or Device)
- How do I find Observations for a patient, searching using his name?

2 queries in 1

- You (as a client) don't need to do separate operations, just one:

```
http://server.com/fhir/Observation?patient  
    .name=jones
```

But note: this still only works on the predefined search parameters. You cannot just use any property of the resource.

More optimizations

- Say we do:
 - `http://fhir.com/fhir/Observation?date=2014-01-20`
 - We get back: a Bundle with 0..* “Observations”
- Now, usually, wouldn’t we want the Patient information too? => Need to do “N” queries for the Observation’s “subject”
- Quicker:

?_include=Observation:patient



Search
Param

Returns both Observations + Patients

Advanced search

- Common Parameters

- _id
- _lastUpdated
- _tag
- _profile
- _security
- _text
- _content
- _list
- _query

- Search Result Parameters

- sort
- count
- include
- revinclude
- summary
- elements
- contained
- containedType

Details
next...

FHIR RESTful Search

2.1.1.1 Summary Table

Search Parameter Types	Parameters for all resources	Search result parameters
Number	<code>_id</code>	<code>_sort</code>
Date/DateTime	<code>_lastUpdated</code>	<code>_count</code>
String	<code>_tag</code>	<code>_include</code>
Token	<code>_profile</code>	<code>_revinclude</code>
Reference	<code>_security</code>	<code>_summary</code>
Composite	<code>_text</code>	<code>_elements</code>
Quantity	<code>_content</code>	<code>_contained</code>
URI	<code>_list</code> <code>_query</code>	<code>_containedType</code>

Common parameters - I

- _id
 - Query by Id (string)
- _lastUpdated
 - When the resource was last updated (date)
- _tag
 - From the appropriate meta element (token)
- _profile
 - From the appropriate meta element (url)
- _security
 - From the appropriate meta element (token)

Common parameters - II

- _text
 - Search in text element (string)
- _content
 - Search for text across the entire resource (string)
- _list
 - Return resources referenced by a List resource
 - Can use ‘current lists’ and other query
 - <http://hl7.org/fhir/lifecycle.html#current>
- _query
 - Custom named query
 - Use OperationDefinition to define

Chained searches

- Search based on referenced properties
 - Observation has a search for “subject” (the id of the Patient, Group or Device)
 - Patient has a search for “name” and “identifier”.
 - ‘chained’ search:
 - [host]/Observation?subject.name={x}
 - [host]/Observation?subject.identifier={y}
- But note this still only works on the predefined search parameters. You cannot just use any property of the resource.

<http://fhirtest.uhn.ca/baseDstu3/Observation?subject.name=patel>

_include related resources

- Include related resources in the response
- Based on search parameters
- Server declares in conformance
- Format
 - [host]/`{type}`?_include=`{source type}:{search parameter}:{target type}`
- Eg
 - [host]/MedicationOrder?_include=MedicationOrder:patient&criteria...

http://fhirtest.uhn.ca/baseDstu3/Observation?_id=99267&_include=Observation:encounter

http://fhirtest.uhn.ca/baseDstu3/Observation?subject.name=patel&_include=Observation:patient

Getting “all” patients

- `http://server.org/fhir/Patient`
- Usually returns a paged feed
- Use `_count` to indicate number of results per page
- Special case of the “real” search operation:

`http://server.org/fhir/Patient/_search?name=eve`

`http://server.org/fhir/Patient?name=eve`

Query response

- Example:

```
<Bundle xmlns="http://hl7.org/fhir">
  <id value="urn:uuid:1d2de686-03d8-4451-afc0-193104c3464e" />
  <meta>
    <lastUpdated value="2015-04-26T20:25:15.6271425Z" />
  </meta>
  <type value="searchset" />
  <total value="2" />
  <link>
    <relation value="self" />
    <url value="http://fhir-dstu2-nprogram.azurewebsites.net/Patient?name=smith" />
  </link>
  <entry>
    <resource>
      <Patient xmlns="http://hl7.org/fhir">
        ...
      </Patient>
    </resource>
  </entry>
  <entry>
    <resource>
      <Patient xmlns="http://hl7.org/fhir">
        ...
      </Patient>
    </resource>
  </entry>
</Bundle>
```

Assignment #5

We will proceed to work in groups now, and solve Assignment #5

[Assignment #5 - FHIR Operations.pdf](#)

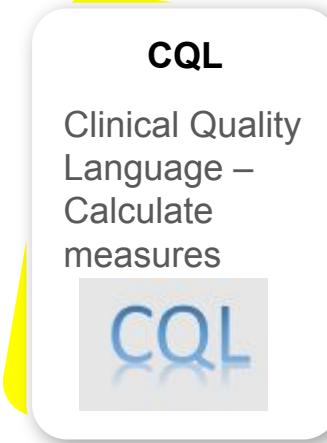
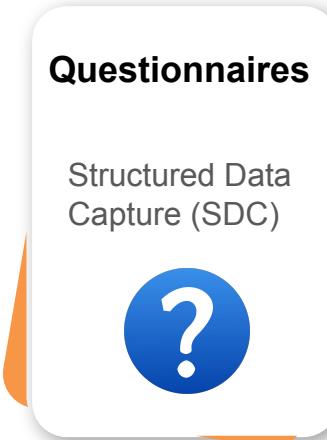
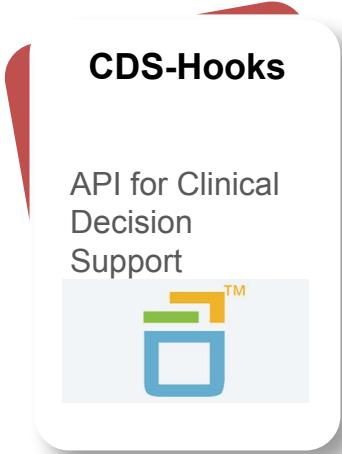


BLOCK 3 – FHIR Technologies / Toolbox

1. SMART on FHIR,
2. CDS Hooks
3. CQL
4. Bulk FHIR
5. Questionnaires - LHC Tools

6 QUESTIONS FOR THIS BLOCK

FHIR Technologies



Not just one standard (FHIR). A standard family, with several technologies

SMART-on-FHIR

Smart-On-FHIR
Security, roles,
launching



What is it? (in one sentence!):
**Secure launching and data exchange
of Patient/Clinician oriented apps with
EHRs**

Spec:

<https://hl7.org/fhir/smart-app-launch/>

An example, please!

<https://tinyurl.com/CDC24-SmartOnFHIR>

Scenarios

When do we want to apply knowledge?

Individual Patient

We are attending a patient, or the patient is using a patient portal)

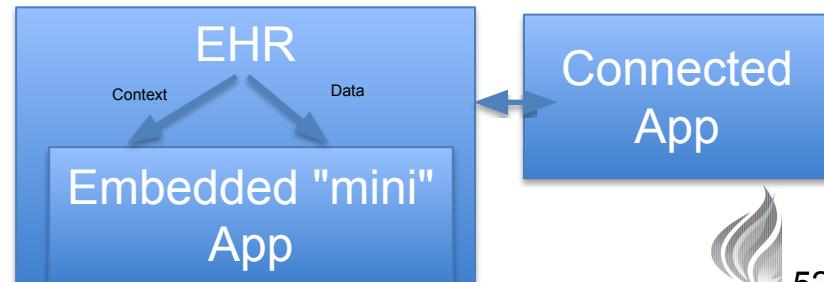
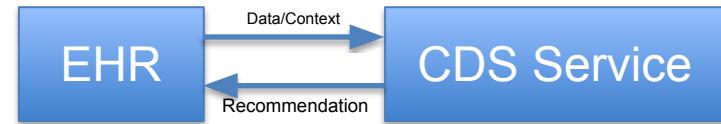
→ Independent Knowledge (CDS) Service

We want to provide any EHR with a service given context and data, apply knowledge and recommend an action course

→ Embedded/Shared User Interface

We want to show information in a different way, integrated with the EHR/Patient Portal

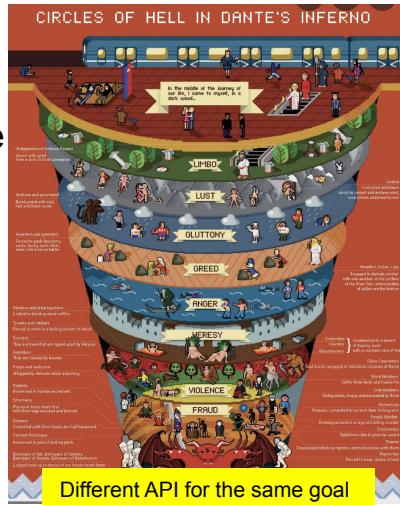
CDS HOOKS™



Visual Integration Embedded/Integrated Mini App

Problems?

- How to authenticate/authorize
- Application substitution
- Visual integration with the EHR
- One API for each EHR to extract data



Who is interested?

- EHR/LIS/RIS providers
- Independent App Vendors

EHR 1:"Easy!: Call my server with <http://myehr.com/api1>

EHR 2:"Simple!: Call my server data

EHR 3:Easy: Call my service with this API :
<http://myehr/ProprietaryAPI/GetData?PatientId=200> and you
can get the patient information!

APP 1:"Call my App with these parameters

APP 2:Easy: Invoke my App like this:

APP 3: Simple!: Invoke my app and then feed these
parameters: ...

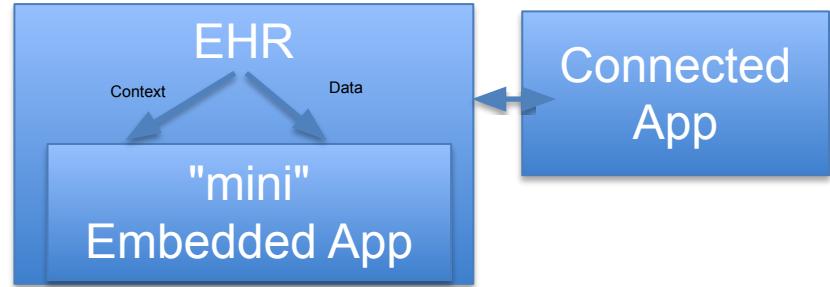
Visual Integration

Embedded/Integrated App

What do we need? **ONLY ONE API!**

Remember that FHIR...defines Standardized APIs!

- One way of **registering** apps in EHRs
- One way of **launching** apps
- A framework for **authorization/authentication**
- A way of **providing context** (user, patient, encounter)
- A way of **exchanging clinical data** about the patient (meds, vital signs, labs, etc.)



Note: it doesn't matter which EHR or what your mini app does:
This specs allow us to connect and launch any application!

SMART on FHIR

Substitutable
Medical
Applications &
Reusable
Technologies

STU1 (2018)
R2.1.0 (2021)



Register/Launch Apps

SMART Application Launch IG

<http://hl7.org/fhir/smart-app-launch/index.html>

Authenticate/Authorize

oAuth2 + OpenID Connect +
SMART Scopes

<http://hl7.org/fhir/smart-app-launch/scopes-and-launch-context/index.html>

Provide Context

SMART Launch Context

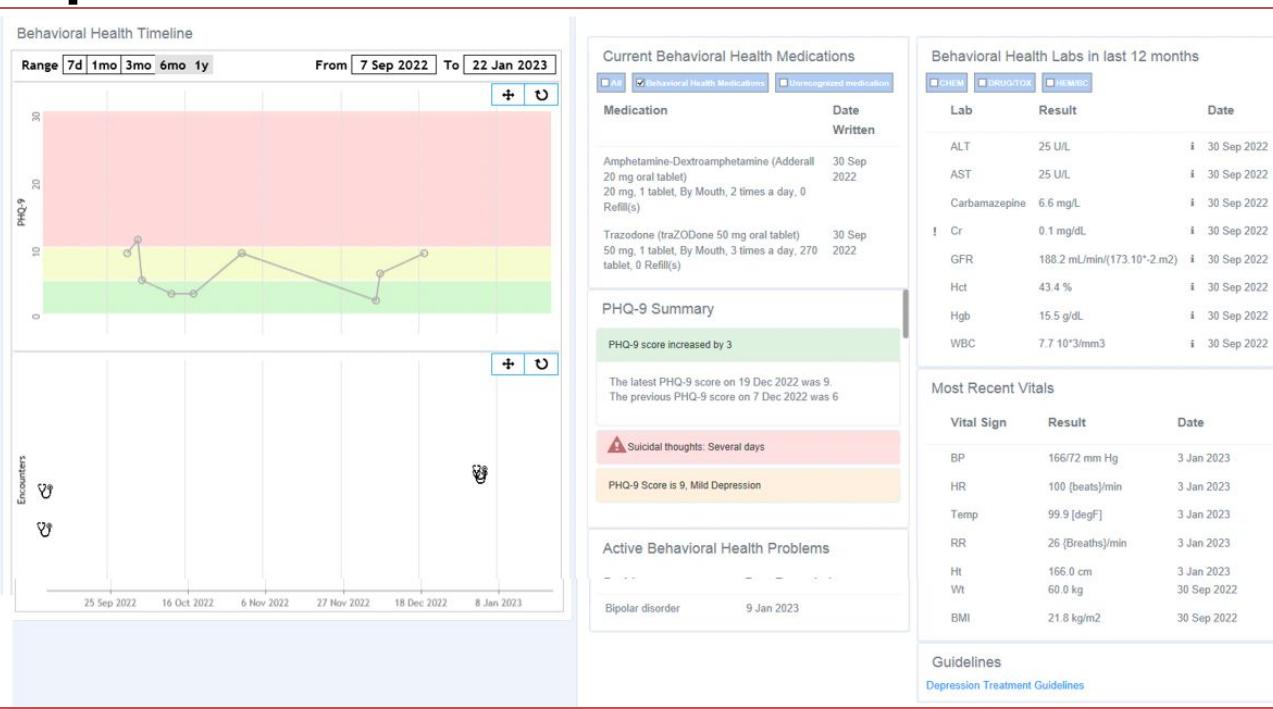
Clinical Data Exchange

FHIR Resources + IG

Some Smart-on-FHIR Real Life Examples

- Examples courtesy of Aziz Boxwala, MD, PhD, FACMI
(Elimu Informatics)
 - <https://github.com/elimuinformati...>
 - aziz.boxwala@elimu.io
- Perioperative Opioid MME Tracking Smart App
- Behavioral Health Smart App
- Hypertension Smart App
- Pre-Diabetes Smart App

Example: Behavioral Health Smart App



- Unified display of data relevant to behavioral health
CDS for PHQ-9 scores
Labs for therapeutic drug monitoring
- PHQ-9 data obtained from 3rd party app (patient-reported)
EHR (clinic intake)

Example: Prediabetes Risk Assessment

Name: Tangelo, Marmot Date of Birth: 15 Feb 1975

Diabetes Risk Factors

	Risk factor value	EHR data
Age *	49 years	Birth date is 15 Feb 1975
Sex *	Female	Gender in EHR is Female
Race	White	Race in EHR is White
Smoking status	Never	Smoking status in EHR is New
Hypertension Dx *	Yes	Problem Hypertension
Most Recent SBP	138 mm[Hg]	BP measured on 14 Aug 2024
BMI	30.9 kg/m ²	BMI recorded on 14 Aug 2024
HbA1c	6 %	Lab result from 20 Jul 2024
Fasting Plasma Glucose	105 mg/dL	Lab result from 20 Jul 2024
HDL	64 mg/dL	Lab result from 20 Jul 2024
Triglycerides	180 mg/dL	Lab result from 20 Jul 2024

Risk Summary

Intermediate

	Usual Care	DPP Lifestyle	Metformin
3 years diabetes risk	10.2%	4.3%	9.6%
Relative risk reduction	reference	58.0%	5.6%
Number need to treat	reference	17.0	241

Source: Elimu Informatics

Lab Results Timeline

Encounters

Ambulatory

Current Medications

All Prediabetes Medications

Medication	Date Written
amlODIPine 2.5 MG Oral Tablet	15 Jul 2024
lisinopril 10 MG Oral Tablet	14 Aug 2024

Labs In Last 12 Months

All CHEM

Lab	Result	Date
BUN	18.2 mg/dL	20 Jul 2024
Fasting Glu	105 mg/dL	20 Jul 2024
Glu	114 mg/dL	18 Sep 2024
HbA1c	6 mg/dL	20 Jul 2024
HDL	64 mg/dL	20 Jul 2024
LDL	163 mg/dL	20 Jul 2024
Trig	180 mg/dL	20 Jul 2024

Conditions

All Prediabetes Problems

Condition	Date Recorded
Body mass index 30+ - obesity (finding)	15 Jul 2024
Hyperlipidemia	15 Jul 2024
Hypertension	15 Jul 2024

Most Recent Vitals

Vital Sign	Result	Date
BP	138/85 mm[Hg]	14 Aug 2024
HR	81 /min	14 Aug 2024
Temp	36.6 °C	14 Aug 2024
RR	16 /min	14 Aug 2024
O2 Sat	95 %	14 Aug 2024
Ht	178 cm	14 Aug 2024
Wt	98 kg	14 Aug 2024
BMI	30.9 kg/m ²	14 Aug 2024

All data has finished loading

- Assesses 3-year risk for patients with prediabetes progressing to diabetes
- FHIR Questionnaire using SDC profile
- Auto-populates risk assessment form from FHIR data
- CDS Hooks shows risk summary (uses custom hook)

Support from Major EHR Vendors

- Smart-on-FHIR Support is in US
Regulation is mandatory from 2022
- Athenahealth:
<https://docs.athenahealth.com/api/docs/all-apis>
- Allscripts/Veradigm:
<https://developer.veradigm.com/Fhir/Introduction>

Stand-alone application launch for a patient

The endpoint for the product's Veradigm FHIR server is available from the Veradigm Endpoint Directory or Altera Endpoint Directory. Typically endpoints that include /open are for patient applications. These patient application endpoints can also be tagged with a Patient badge on the Endpoint Directory.

1. The application requests the Capability Statement from Veradigm FHIR server.
2. The Veradigm and Altera FHIR server returns the Capability Statement which includes the authorize endpoint for the Veradigm Authorization server and the token endpoint.
3. The application sends credentials to the Veradigm Authorization server. These credentials include the application's client ID and client secret. (On the FHIR App page on the Veradigm Connect Portal.)
4. If the application credentials are recognized by the Veradigm Authorization server (meaning the client has authorized the application), the server verifies that the patient is valid.

SMART launch

1. A Veradigm or Altera product user launches a SMART application from the product. The product sends any relevant context with the launch command to the application.
2. Application sends credentials to the Veradigm Authorization server. These credentials include the application's client ID and client secret. (On the FHIR App page on the Veradigm Connect Portal.)
3. If the application credentials are recognized by the Veradigm Authorization server (meaning the client has authorized the application in the Veradigm and Altera License Management Portal), the product's log in screen displays. The user can enter their user credentials (user ID and password) in the product. If the application credentials are not recognized by the Veradigm Authorization server, the server returns an error.
4. OAuth sends the user's product credentials to the Veradigm Authorization server. If the credentials are valid, the server returns a temporary token to the application's Callback URL (as defined in the Veradigm Connect Portal for the application).
5. The application sends the temporary token to the token endpoint, and the Veradigm Authorization server returns a regular token. The length of time during which the token is valid is defined in the Veradigm and Altera License Management Portal.
6. If you are testing the authentication in Postman, you can manually copy the access token and paste it into Authorization tab > Current Token section > Token. Enter the URL for the request, and then click Send.

CDS-HOOKS

CDS-Hooks

API for Clinical
Decision
Support



What is it? (in one sentence!):
Standard FHIR API for asking for CDS knowledge and receiving answers

Spec:

<https://cds-hooks.hl7.org/2.0/>

An example, please!

<https://sandbox.cds-hooks.org/>

Scenarios

When do we want to apply knowledge?

Individual Patient

(We are attending a patient, or the patient is using a patient portal)

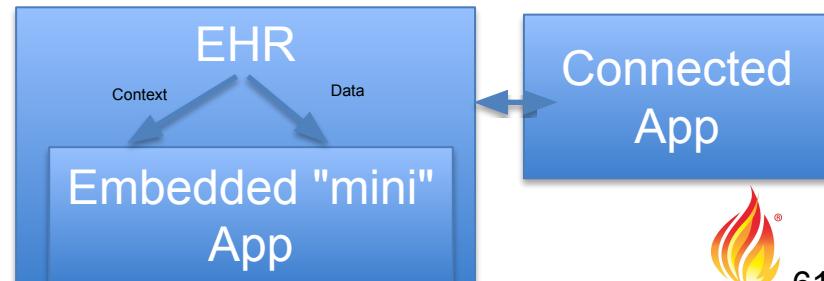
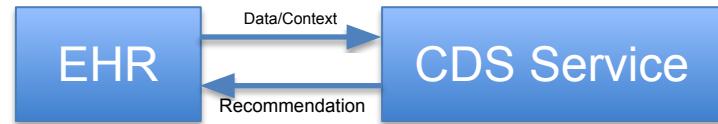
→ Independent Knowledge (CDS) Service

We want to provide any EHR with a service: given context and data, apply knowledge and recommend an action course

→ Embedded/Shared User Interface

We want to show information in a different way, integrated with the EHR/Patient Portal

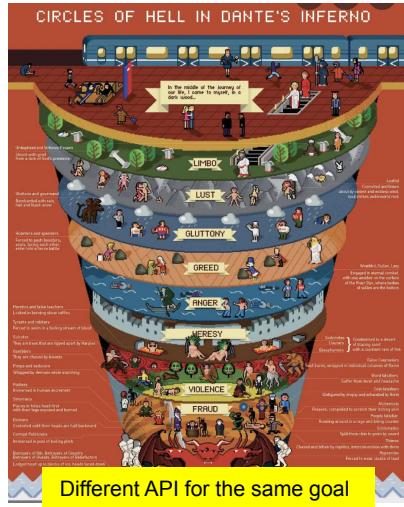
CDS HOOKS™



What do we need?

Problem?

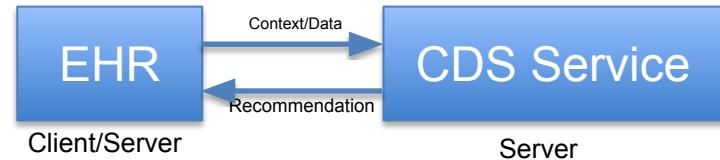
- Different API for each CDS service
- A different API to access data for each EHR



Different API for the same goal

Who is interested?

- EHR/LIS/RIS Vendors involving CDS
- CDS Providers



Service 1:"Easy call my API: <http://mycds.com/api1> you will return the recommendation

Service 2:"Piece of cake: <http://miothercds.com/api2>

Service 3:"1-2-3: Call my service with this API <http://miotherothercds.com/api3method> and it will return the recommendation

EHR 1:"Easy!: Call my server with <http://myehr.com/api1> you will return the recommendation

EHR 2:"Simple!: Call my server data

EHR 3:Easy: Call my service with this API : <http://myehr/ProprietaryAPI/GetData?PatientId=200> and you can get the patient information!

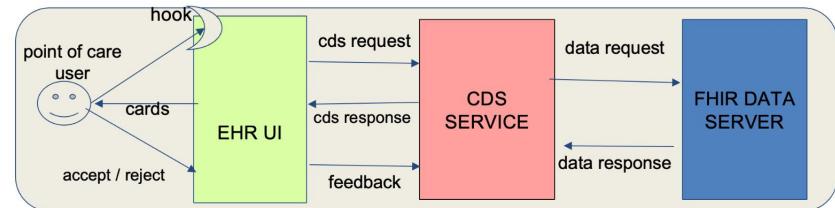
"REMOTE" CDS

Independent CDS Service

What do we need: **The same API!**

Remember that FHIR is leveraged to create...Standardized APIs!

- A way to **discover/register services**
- A framework for **authorization/authentication**
- A way to **describe the context** (What I am doing in my EHR that requires this service?)
- A way to **exchange clinical patient data** (medication, labs, vital signs, etc.)
- A way to **call the services**
- A way to **return the recommendations**



hook

What is the user doing in the EHR
cds request
Which user, which patient
Which service
Additional clinical or demographic data
FHIR data server and authentication parameters

cds response : Set of cards

cards: source, information, recommendation (actions), smart app link
data request / response
FHIR resources required for service
feedback
whether actions were accepted by user
reasons for override



Note: it does not matter how the service implements 'knowledge'/'algorithms'
This API connects us to any service and allow us to leverage it

CDS HOOKS



HL7 Standard 1.0 (2019)

STU2 (08-23-2022)

<https://cds-hooks.hl7.org/2.0/>

Register/Discover Services

{cds_endpoint}/cds-services

Describe the context

hook ("Which part of the clinical workflow?) patientId userId

Authenticate/Authorize

1- TLS cds_endpoint / 2- Signed JWT 3- Data Access Token

Clinical Data Exchange

Access to FHIR Resources + "Prefetch"

Return Recommendations

cards

Healthwise helps people make better health decisions with CDS Hooks

Review patient education at the moment in care

Patient Education

Source: Healthwise

The following patient education resources were found.

Conditions

Dementia associated with another disease(2008-08-08)

Essential hypertension(2008-04-20)

Other persistent mental disorders due to conditions classified elsewhere(2007-09-15)

- Medical History and Physical Exam for Dementia or Alzheimer's Disease,
- Memory Problems: Wandering,
- Memory Problems: Tips for Helping the Person With Daily Tasks

Prevent medication interactions at the time of prescription

Drug Interactions

Source: Healthwise

The following drug interactions were found.

Interactions

ACE INHIBITORS; ARBS; ALISKIREN/POTASSIUM PREPARATIONS (moderate)

lisinopril (bulk) and potassium acetate may interact based on the potential interaction between ACE INHIBITORS; ARBS; ALISKIREN and POTASSIUM PREPARATIONS.

KEEP VITAMIN K CONTENT OF DIET CONSISTENT. (serious)

The use of warfarin (bulk) may interact with food in that FOOD HIGH IN VITAMIN K MAY DECREASE EFFECT.



Medication Management for Adherence (CDS Hooks)

Real-time medication adherence insights

delivered directly into workflow during patient visits

Patient View
Daniel X. Adams
Birthdate: 1925-12-23
Hello Daniel!
Source: Patient greeting service

Medication Management for Adherence
Source: Powered by Surescripts
The PDC (Proportion of Days Covered) is calculated by the Pharmacy Benefit Management (PBM) or Health Plan based on claims data. The PDC score is used to communicate the patient's overall adherence.
Lowest PDC score 47% Diabetes as of 10/13/2016 12:17:38 AM

Medication Adherence Profile

Medication	Filled	Supply
METFORMIN HCL - 30.0 MG NDC: 68382075810	9/25/2016	30 days
LOVASTATIN - 90.0 MG NDC: 68180046803	9/25/2016	90 days

Bi-directional communication

to enable users to provide real-time feedback

Medication Adherence
Adams, Daniel - DOB: 12/23/1925
Received: 10/25/2016

Health plan records show this patient may not be taking their diabetes medication as instructed. Please talk to your patient about adherence.

Please respond:

Is adherence a confirmed issue?

Yes

Why is adherence an issue?

Patient has been educated on importance of adherence and plans to resume therapy

Patient refuses drug due to cost

Patient refuses drug due to side effects

Patient refuses drug due to other reasons

An unlisted reason

Stanson Health's CDS Hooks service

Clinical Advisory

A Choosing Wisely® recommendation from the American Geriatrics Society states:

Don't use benzodiazepines or other sedative-hypnotics in older adults as first choice for insomnia, agitation or delirium. [more...](#)

lorazepam 1 mg tablet [orderId: 117278]

[remove order](#)

EDUCATION

1 2 3 4 5 6

[OVERRIDE](#)

[DISMISS](#)

A Choosing Wisely® recommendation from the American College of Cardiology states:

Don't perform annual stress cardiac imaging or advanced non-invasive imaging as part of routine follow-up in asymptomatic patients. [more...](#)

you are able to narrow this down when accepting

[select order to remove](#)

- a. Computed tomography angiography of coronary arteries [orderId: 1234]
- b. Positron emission tomography myocardial stress imaging using rubidium 81 [orderId: 1235]

EDUCATION

1 2 3 4

[OVERRIDE](#)

[DISMISS](#)

Real time, workflow integrated, patient specific, evidence based

Reduces low-value and unnecessary care

Who supports CDS Hooks? EHRs (client)

- Next slide for who created services...



Example - Epic Documentation:

<https://fhir.epic.com/Documentation?docId=cds-hooks>



covermymeds



fdb
First Databank



INTEROPION

HIN
consulting, llc



**MAYO
CLINIC**



HSPC
the healthcare services platform consortium™

QVΣRA

zynxhealth

PREMIER



**NORTHROP
GRUMMAN**

ONA

ORION
HEALTH

surescripts

OSEHRA

visualDx
arpage



Epic

healthwise®
for every health decision®



EBSCO Health

**Intermountain
Healthcare**

Cerner

Allscripts™ **athenahealth**

eClinicalWorks

THE **IT SYSTEM**

IMO
Intelligent Medical Objects

Lantana
CONSULTING GROUP



mcg

firely

RxREVU
Wolters Kluwer
Health

PHILIPS
Healthcare

perspecta

ENVISION
TECHNOLOGY PARTNERS

**HEALTH
SAMURAI**

U
HEALTH
UNIVERSITY OF UTAH

Lush
Group Inc.

stanson○health
Clinical Cloud Solutions

MedImpact

MITRE
HI7
polyglot™
International
Health Through Understanding™

syapse

Cigna

accenture
mModal

TABULARASA
HEALTHCARE®

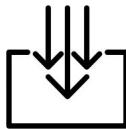
medical-objects
CLINICAL APPLICATIONS, MESSAGING AND INTEGRATION

**MERCK
MANUALS**

Bulk FHIR

Bulk Data Access

Obtaining big loads of data asynchronously



What is it? (in one sentence!):
Standard FHIR API for "big data" exchange (100000s of records)

Spec:

<https://hl7.org/fhir/uv/bulkdata/>

An example, please!

<https://tinyurl.com/cdc24-bulkfhir>

Scenarios

When do we want to apply knowledge?

Population Health

We want to analyze data from a (big) set of patients

→ Data Extraction

We want to extract data from the EHR for research, or apply discovery algorithms, or to calculate quality / clinical / epidemiological measures

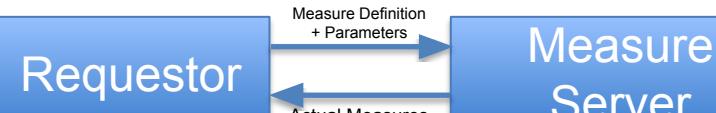
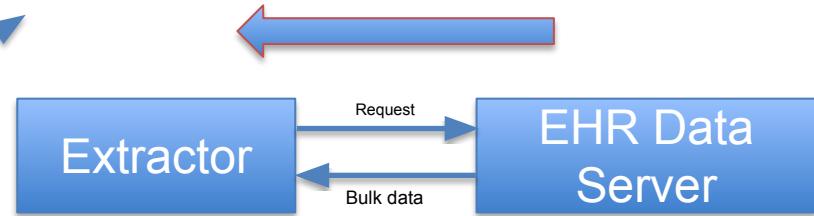
Also, for initial load of a native FHIR server

→ Population Health Measures

We want to use a service to calculate measures on a given population -> (numerator / denominator)

FHIR BULK

I ask for the data, and then process it



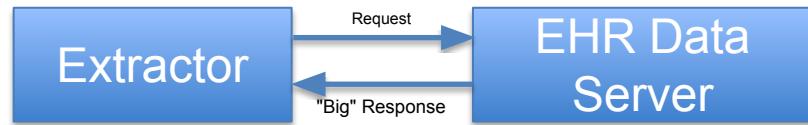
Data Extraction

"Big" Data Extraction

We need **clinical/financial data about patients**, to do some kind of analysis: **quality measures, public health reporting, data mining, ML training, etc.**

- **Extractor:** requesting some data / parameters for extraction (which data?)
- **Data Server:** prepares the data and alert when the data is available (the process is asynchronous)

We are talking about SEVERAL (HUNDRED) THOUSANDS of records



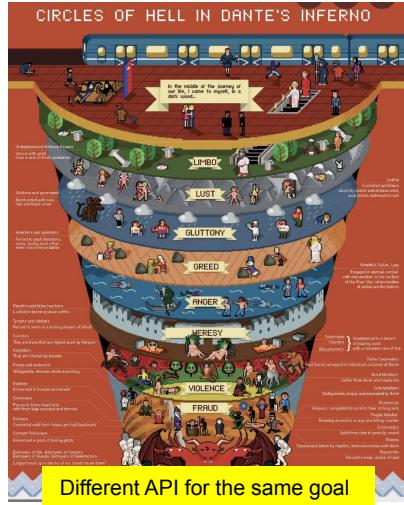
"Big" Data / "Extraction" examples

- "Recover vitals, demographics, labs of all patients with 'diabetes' in the last 2 years"
- "Recover all procedures for patient covered by XYZ network in the last 3 months"
- "Recover all medication, clinical notes and demographic data for all COVID19 patients"

Data Extraction

Problems?

- How to guarantee security
- Async Processing
- Efficient format
- One API for each EHR?
- Different format for each extraction?



Who is interested?

- EHR Vendors / Data Exporters
- Public Health/Payors/Researchers (EXT: Extractors)

EHR 1:Easy! Call this API

EHR 2:We cannot do that!

EHR 3: Give us 4 months

EXT 1:Please provide with a CSV file with these fields

EXT 2:Create an XLS file with these columns

EXT 3: Call this service with this XML for each case

FHIR BULK DATA

<https://hl7.org/fhir/uv/bulkdata/>

STU 1 12/2020

STU 2 11/2021



Efficient Data Exchange

ND-JSON

Security Model

Smart Back-End Services Authorization

<http://docs.smarthealthit.org/authorization/back-end-services/>

Asynchronous Data Exchange

FHIR \$export API

Clinical Data Exchange

FHIR Resources (+Appropriate data model:IG)

Kick-off request

- Standardized Operation (**\$export**)
- Which kind of resources we want
- Asynchronous : **Prefer: respond-async**
- Export all patients, a group of patients, or all the resources.
 - *[FHIR Server Base]/Patient/\$export*
 - *[FHIR Server Base]/Group/[group id]/\$export*
 - *[FHIR Server Base]/\$export*

Groups are arbitrary and can be pre-negotiated

Kick-off Operation Parameters

`_outputFormat` The format for the generated bulk data files
Currently, only **ndjson** is supported

`_since` Filter results by FHIR resource modified date
FHIR instant timestamp
(required for servers to support)



`_type` Filter results by comma delimited list of FHIR resource types
(optional for servers to support)

`_typeFilter` Filter using FHIR REST queries
(optional and experimental)

Kick-off Operation Parameters



_elements	FHIR resource elements to return e.g., Patient.id, Patient.identifier <i>(optional and experimental)</i>
Patient	FHIR Patient References to limit data returned <i>(optional, not valid for GET requests or system level requests)</i>
includeAssociatedData	Metadata resources to include with response e.g., LatestProvenanceResources or RelevantProvenanceResources <i>(optional and experimental)</i>

Historical Group Data

- Server side with revised guidance on the “_since” parameter

“In the case of a Group level export, servers MAY return additional resources modified prior to the supplied time if the resources belong to the patient compartment of a patient added to the Group after the supplied time (this behavior should be clearly documented by the server).”



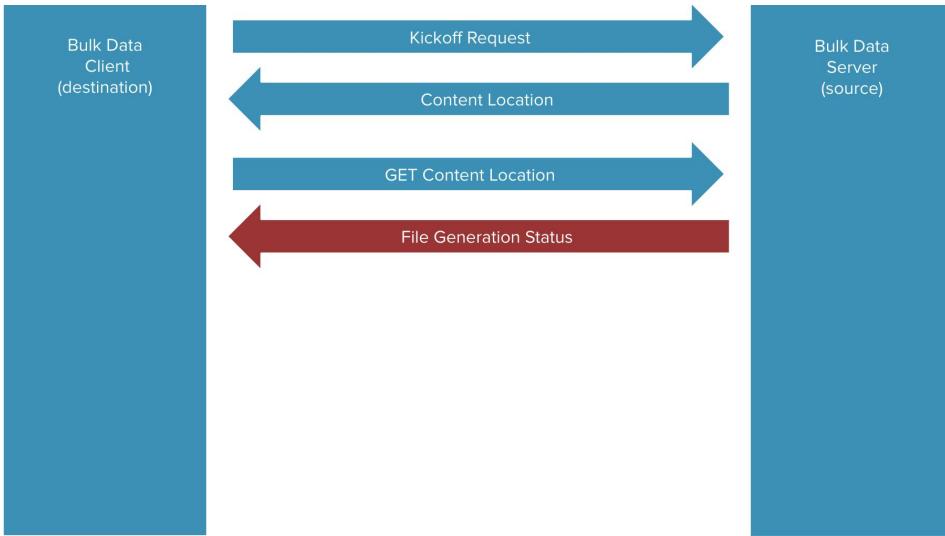
- Client side with the “patients” and “_elements” parameters

- Make a request to get just the ids of patients in the group with “_elements”
- Use the “patients” parameter to get data for patients not previously retrieved
- Use the “patients” parameter and the “_since” parameter to get new data for remaining patients



Polling

We ask in Content-Location until we get a 200 instead of 202



Status: 202 Accepted
X-Progress: “50% complete”
Retry-After: 120

Status Complete Response Body

```
1 "transactionTime" : "2020-07-13T13:28:17.239Z",
2 "request" : "https://example.com/Patient/$export?_type=Patient,Observation",
3 "requiresAccessToken" : true,
4 "output" : [{
    "type" : "Patient",
    "url" : "https://example.com/files/patient_file_1.ndjson"
}, {
    "type" : "Patient",
    "url" : "https://example.com/files/patient_file_2.ndjson"
}, {
    "type" : "Observation",
    "url" : "https://example.com/files/observation_file_1.ndjson"
}],
5 "deleted" : [{
    "type" : "Bundle",
    "url" : "https://example.com/output/del_file_1.ndjson"
}],
6 "error" : [{
    "type" : "OperationOutcome",
    "url" : "https://example.com/files/error_file_1.ndjson"
}]
```

New in v2

5

6

Updated in v2

NDJSON

- Several JSON instances in the same file, streamable

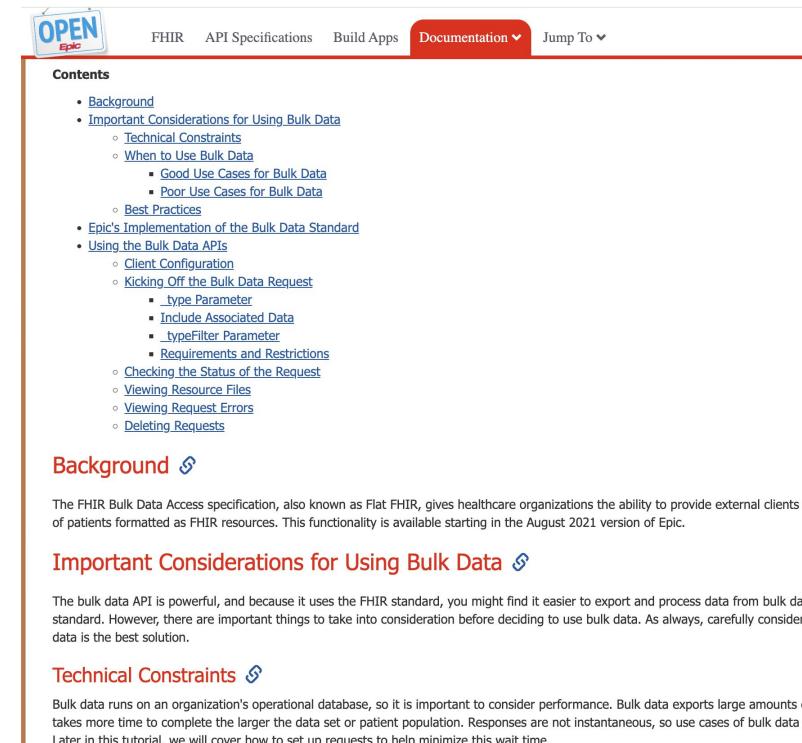


```
{"id": "06eb35fc-09e6-48 ... "given": ["Lucille"], "family": "Bluth"}]}  
{"id": "cf53f382-6eb6-4f ... "given": ["George", "Oscar"], "family": "Bluth", "suffix": ["Senior"]]}]}  
 {"id": "406a9c3e-50f9-4c ... "given": ["Michael"], "family": "Bluth"}]}
```



Support from Major EHR Vendors

- Bulk FHIR Support is in US Regulation as mandatory from 2022
- Epic:
https://fhir.epic.com/Documentation?doctId=fhir_bulk_data
- Cerner/Oracle:
https://docs.oracle.com/en/industries/health/millennium-platform-apis/mfbda/bulk_data_access.html



The screenshot shows a navigation bar with links for OPEN, FHIR, API Specifications, Build Apps, Documentation (which is highlighted in red), and Jump To. Below the navigation bar is a "Contents" section with a hierarchical list of topics:

- Background
- Important Considerations for Using Bulk Data
 - Technical Constraints
 - When to Use Bulk Data
 - Good Use Cases for Bulk Data
 - Poor Use Cases for Bulk Data
 - Best Practices
- Epic's Implementation of the Bulk Data Standard
- Using the Bulk Data API
 - Client Configuration
 - Kicking Off the Bulk Data Request
 - _type Parameter
 - Include Associated Data
 - _typeFilter Parameter
 - Requirements and Restrictions
 - Checking the Status of the Request
 - Viewing Resource Files
 - Viewing Request Errors
 - Deleting Requests

Background 

The FHIR Bulk Data Access specification, also known as Flat FHIR, gives healthcare organizations the ability to provide external clients of patients formatted as FHIR resources. This functionality is available starting in the August 2021 version of Epic.

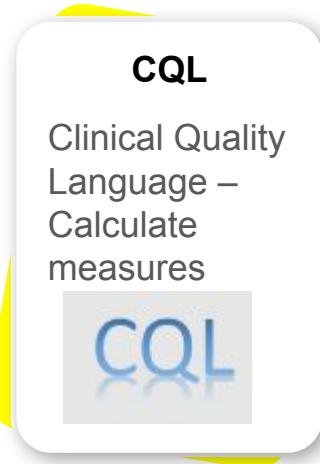
Important Considerations for Using Bulk Data 

The bulk data API is powerful, and because it uses the FHIR standard, you might find it easier to export and process data from bulk data standard. However, there are important things to take into consideration before deciding to use bulk data. As always, carefully consider data is the best solution.

Technical Constraints 

Bulk data runs on an organization's operational database, so it is important to consider performance. Bulk data exports large amounts of data, so it takes more time to complete the larger the data set or patient population. Responses are not instantaneous, so use cases of bulk data. Later in this tutorial, we will cover how to set up requests to help minimize this wait time.

CQL - Clinical Quality Language



What is it? (in one sentence!):
Syntax and structure to extract information from FHIR servers for clinical measures

Spec:
<https://cql.hl7.org/index.html>

An example, please!
<https://tinyurl.com/cqldiabetes>

Current status and features

- Normative ANSI standard v1.5.2, based on FHIR R4

<https://cql.hl7.org/>

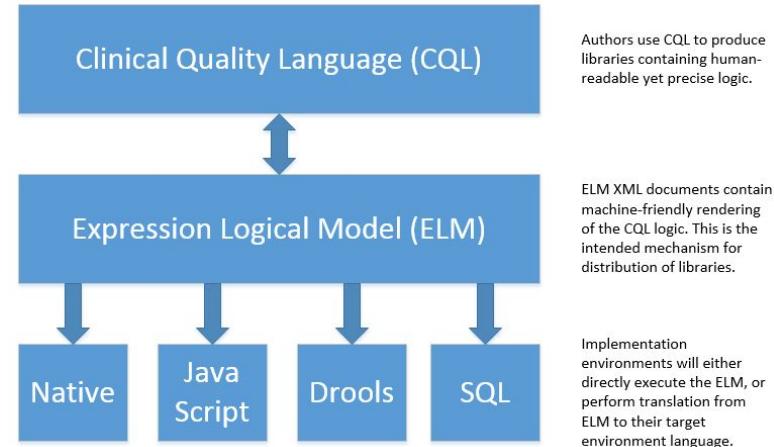
- What is it? "**high-level, domain-specific language focused on clinical quality** and targeted at **measure and decision support** artifact authors"
- **Goals:** To enable creation, distribution, execution, and maintenance of computable clinical knowledge
- **Audience:** Clinician/domain-expert friendly / Clinically focused / Unambiguous
- **Features:** Platform & technology independent / Sufficiently expressive

Use Cases

- In general,... "Apply Logic to FHIR"
- **Quality Measures:** Development and Execution
 - example: Da Vinci Data Exchange for Quality Measures
<https://hl7.org/fhir/us/davinci-deqm/>
- **Decision Support:** Computable Clinical Guidelines
 - Example: WHO Antenatal Smart Guides
 - <https://build.fhir.org/ig/WorldHealthOrganization/smart-anc/>
- **Rules and pre-population for Prior Authorization**

Perspectives (from the conceptual level)

- Author
 - **communicating and interpreting the semantics defined at the conceptual level, from a human perspective (CQL)**
- Logical
 - *representing the semantics of expressions in the simplest complete way (ELM)*
- Physical
 - *Interpreting the semantics defined at the logical level, from a machine perspective (XML)*



Language

- declarative (not imperative)
- functional (no side-effects)
- clinical domain-specific language (DSL)
- physical independence • platform
- data model and location
- complete: algebraic, temporal, relational

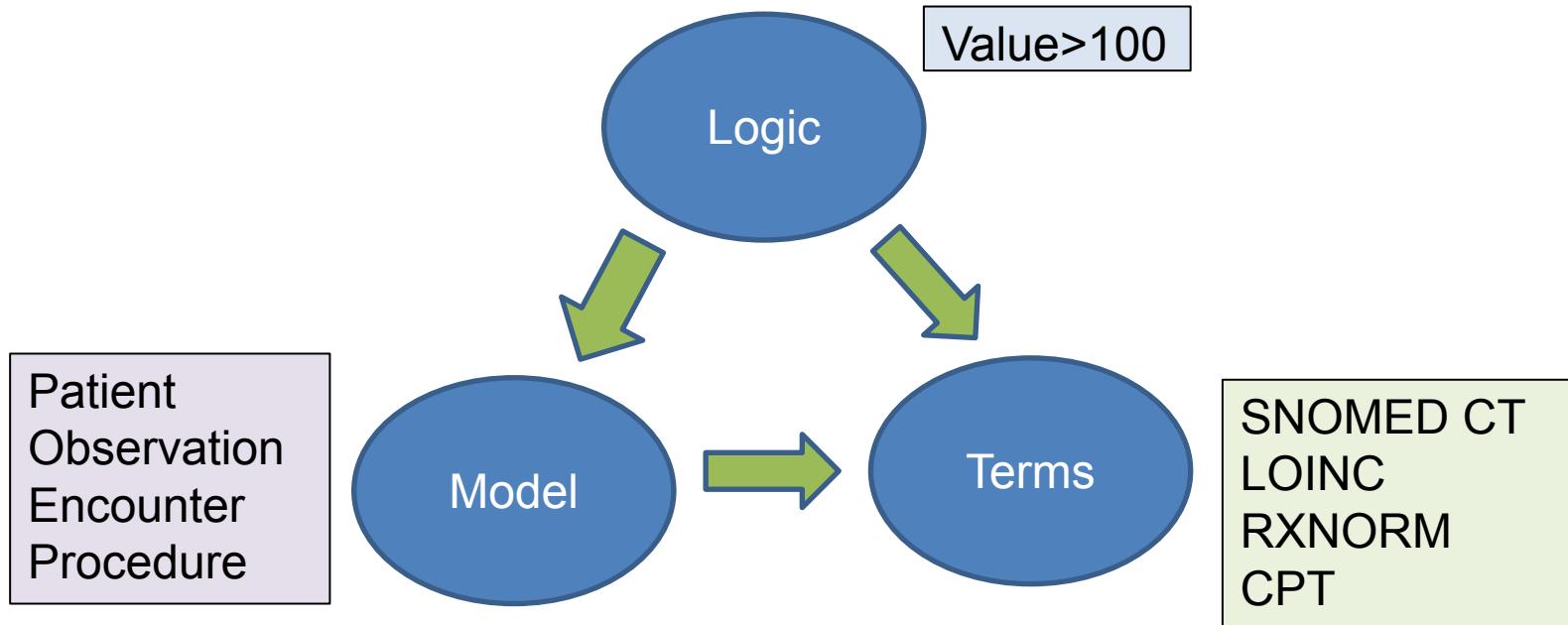
CQL has the notion of a "context"

- Implicit filter
- Allows authors to write from a particular perspective

- Good for representing the data needed from the EHR, and the logic to apply, to calculate numerator and denominator for population quality measures.

- Identify individual conditions or gaps in care.

Components of Sharing Knowledge



Questionnaires – and SDC



What is it? (in one sentence!):
FHIR Resources and Specific IG to define, collect and store structured questions and answers

Spec:
<https://hl7.org/fhir/uv/sdc/>

An example, please!
<https://hcforms.nlm.nih.gov/>

FHIR Questionnaires

- Features / Use Cases
- Artifacts for Questionnaires : Questionnaire and QuestionnaireResponse
- SDC
- Workflow : search , load , present , validate , store
- Tools to test and build Questionnaires
- Projects based in FHIR Questionnaire

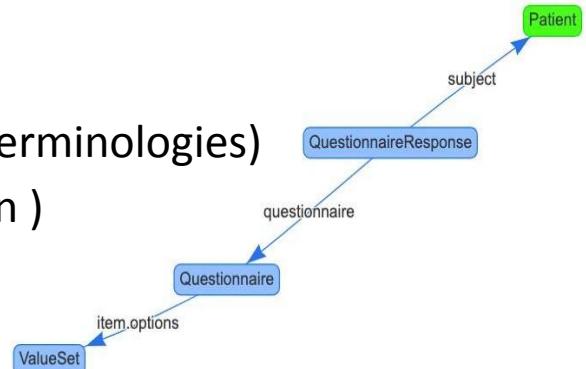
Credit for original English presentation
Brian Postlethwaite / 2020-2022

Use Cases

- Assessment (Primary care or triage)
- Surveys
- Governmental Forms
- Admission
- Patient consent
- Primary Care
- Research
- Oncology
- Pathology
- Report to Public Health
- Payments / Insurance

FHIR artifacts for Questionnaires

- **Questionnaire** resource
 - Conformance Resource: defines the questionnaire **items (questions)**
 - Similar to StructureDefinition
 - Can include ValueSet (embedded or referenced terminologies)
 - Usually NOT further restricted (it IS the restriction)
- **QuestionnaireResponse** resource
 - Record of **answers**
 - the structure is given by the items of the Questionnaire
- **Others**
 - Extensions , Operations , Profiles , Implementation Guides (including SDC)



Resource Definition

Questionnaire

- metadata
- Item (can be nested)
 - LinkId (KEY!)
 - Text (TITLE)
 - Item type (datatype)
 - repeats (repetitive)
 - Data rules (validation)

QuestionnaireResponse

- Context (author , patient)
- Item (1...n)
 - LinkId
 - answer value (response value)

The LinkId matches the answer
with your definition
Has to coincide verbatim
including nesting

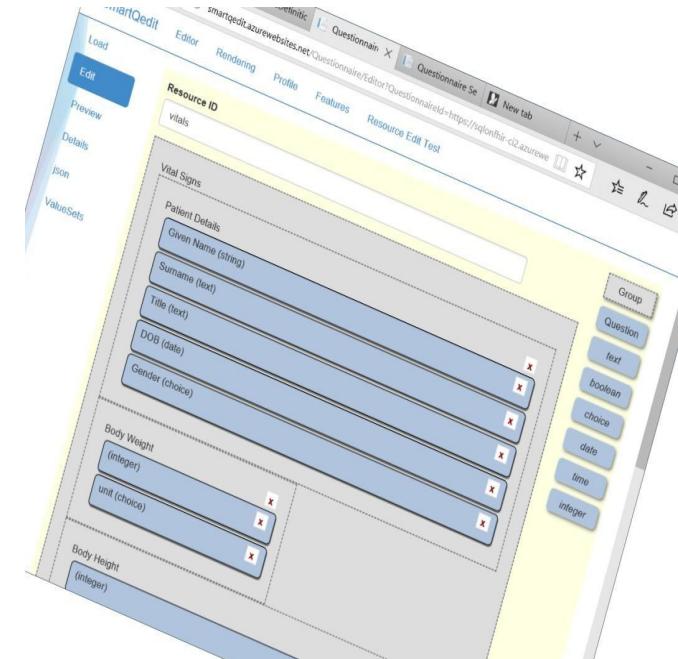
Tools to Test/Build Generic Questionnaires

- The most complete / interesting (NIH)

- <https://hcforms.nlm.nih.gov/sdc>

- All the tools (registered / known)

- <https://confluence.hl7.org/display/FHIR/SDC+Implementations>



It is simple...

- Putting together a **QuestionnaireResponse** is one of the simpler tasks in the FHIR world
- *NOTE: All the rest of the possible complications remain the same*

[QUESTIONNAIRE HEADING]

```
{" resourceType ":" QuestionnaireResponse "," questionnaire ":"http:// url_of_my.project.gov / Questionnaire /{{questionnaire}}","status":" completed "," authored ":" {{ completed_date }} "," author ":"{{ identifier ":" system ":"http:// url_de_my.project.gov /authors", " value ":" {{ author_ident }} "}}, [RESPONSE FOR EACH ITEM]  
" item "[  
{" linkId ":"{{id_question_1}}"," text ":"{{text_question_1}}",  
" answer "[{" valueString ":" {{ value_string_question_1}} "}]},  
{" linkId ":"{{id_question_2}}"," text ":"{{text_question_2}}",  
" answer "[{" valueDateTime ":" {{ value_date_time_question_2}} "}]},  
{" linkId ":"{{id_question_3}}"," text ":"{{text_question_3}}",  
" answer "[{" valueCoding ":"  
{" system ":" http://url_de_my.project.gov/CodeSystem/OptionsQuestion3 ",  
" code ":" {{question_answer_code_3}} ",  
" display ":" {{meaning_answer_question_3}} "}]}}]
```

Strictly the ONLY thing that changes in each answer to the same questionnaire it is what you see as **bold_and_brackets**

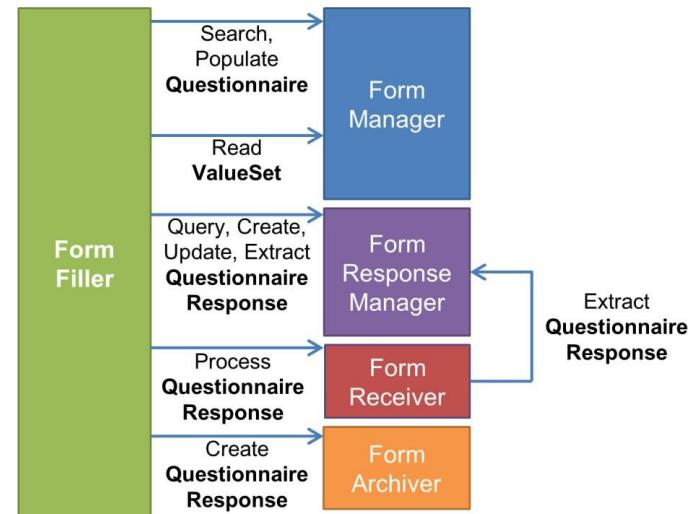
But powerful!

That is the MINIMUM that can be specified , but there are tools available to specify :

- *Workflow*
- *Simple validation*
- *Complex validation*
- *Details of how to fill the form*

Implementation Guide : Structured Data Capture

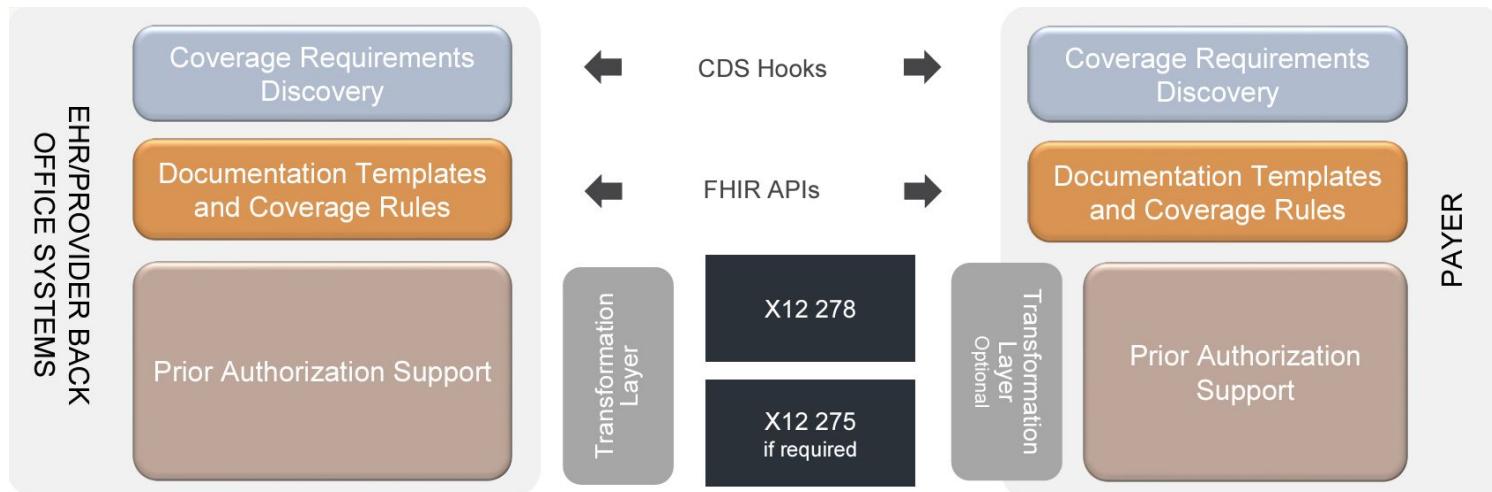
- Eight areas of improvement to the base spec
 - 1) Workflow : system roles , request to ' complete form '
 - 2) How to find questionnaires ?
 - 3) Presentation Considerations (colors , formatting , order of the controls)
 - 4) Behavior Improvements (rules , relationships between questions , maximums and minimums , calculations)
 - 5) Autocomplete on startup (with the data that can be extracted from the EHR using the FHIR API)
 - 6) Data extraction (from the questionnaire to other FHIR resources)
 - 7) Modules (Share questionnaire fragments)
 - 8) Adaptive (build forms dynamically via an API)



<http://hl7.org/fhir/uv/sdc/>
Version : 3.0.0 FMM:3

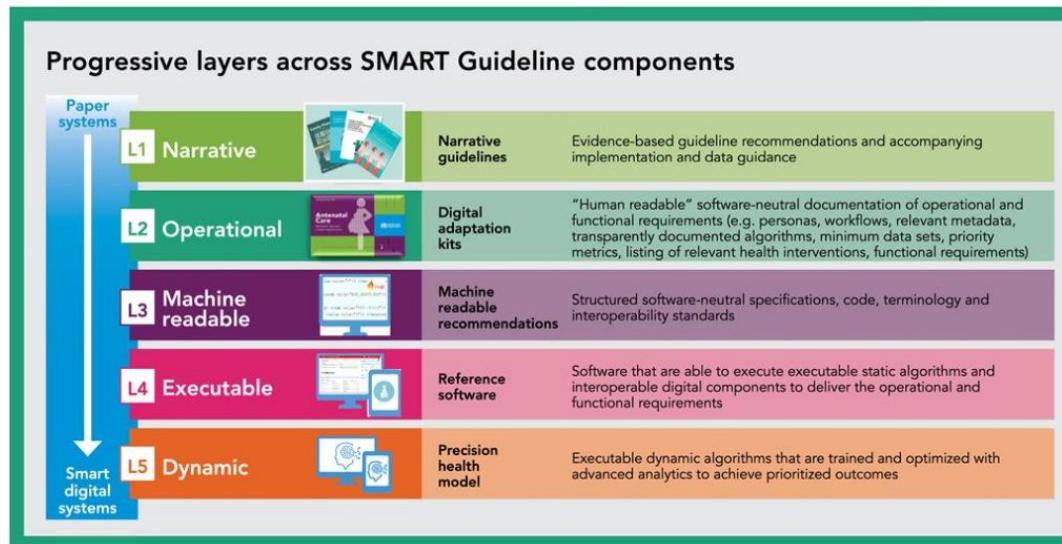
Example Scenario: Prior Authorization

- Uses all the FHIR Product Family: FHIR, US Core, CDS Hooks, Smart-on-FHIR, CQL!



Example Scenario: WHO SMART Guidelines

- Computable version of the paper-based guidelines for HIV, ANC Immunization, TB, etc. Uses: Questionnaires, CQL, CDS-Hooks



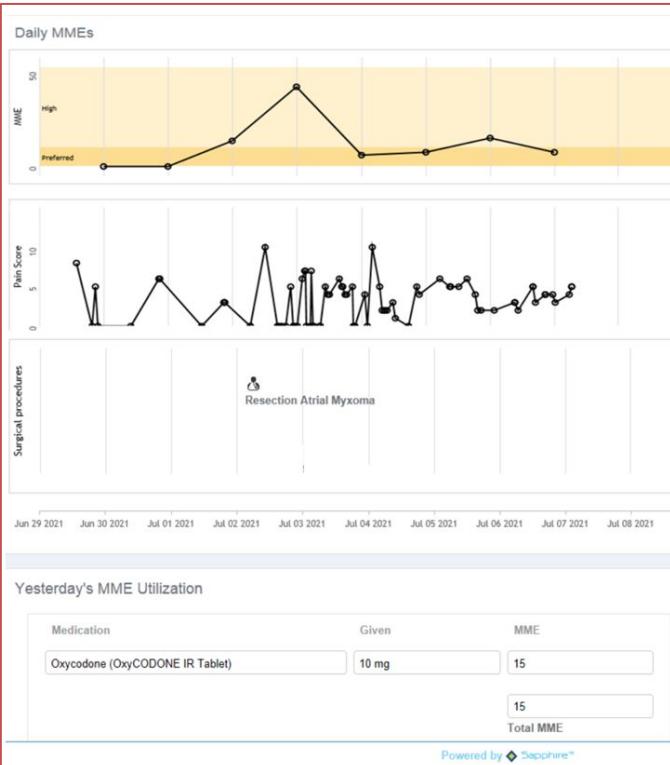
Questions for Session #6

Which technology should we use to...

1. ...call a clinical decision support system for immunization from my EHR?
2. ...retrieve 1MM patient records from a big hospital network EHR?
3. ...calculate the numerator and denominator for a quality measure?
4. ...assess gaps in healthcare for a specific patient?
5. ...distribute a standard survey to all my providers to assess patients outreach preferences?
6. ...visually integrate a new app to any EHR in a standardized way?

Archive

Example: Perioperative Opioid Morphine Tracking Smart App



Active Opioid Analgesics		
Medication	Date Written	Status
Oxycodone (OxyCODONE IR Tablet) 5 mg, By Mouth, Every 4 hours, PRN: Pain , Moderate, Oral route (qualifier value),	2021-07-02 10:26 AM	Active
Active Non-Opioid Analgesics		
Medication	Date Written	Status
Acetaminophen (Acetaminophen Tablet) 975 mg, By Mouth, Every 6 hours, Oral route (qualifier value),	2021-07-02 02:03 PM	Active
Gabapentin (gabapentin 300 mg oral capsule) 300 mg, By Mouth, Daily at bedtime, Oral route (qualifier value),	2021-07-03 09:36 AM	Active
Aspirin (Aspirin Tablet) 81 mg, By Mouth, Daily, Oral route (qualifier value),	2021-07-02 10:26 AM	Active

- Perioperative opioid Rx is a risk factor for opioid use disorder
- Assessing daily periop opioid use is difficult because of different opioid products, multiple administrations, PRN & PCA
- Morphine milligram equivalent (MME)t normalizes potency of different opioid products, but is tedious to calculate

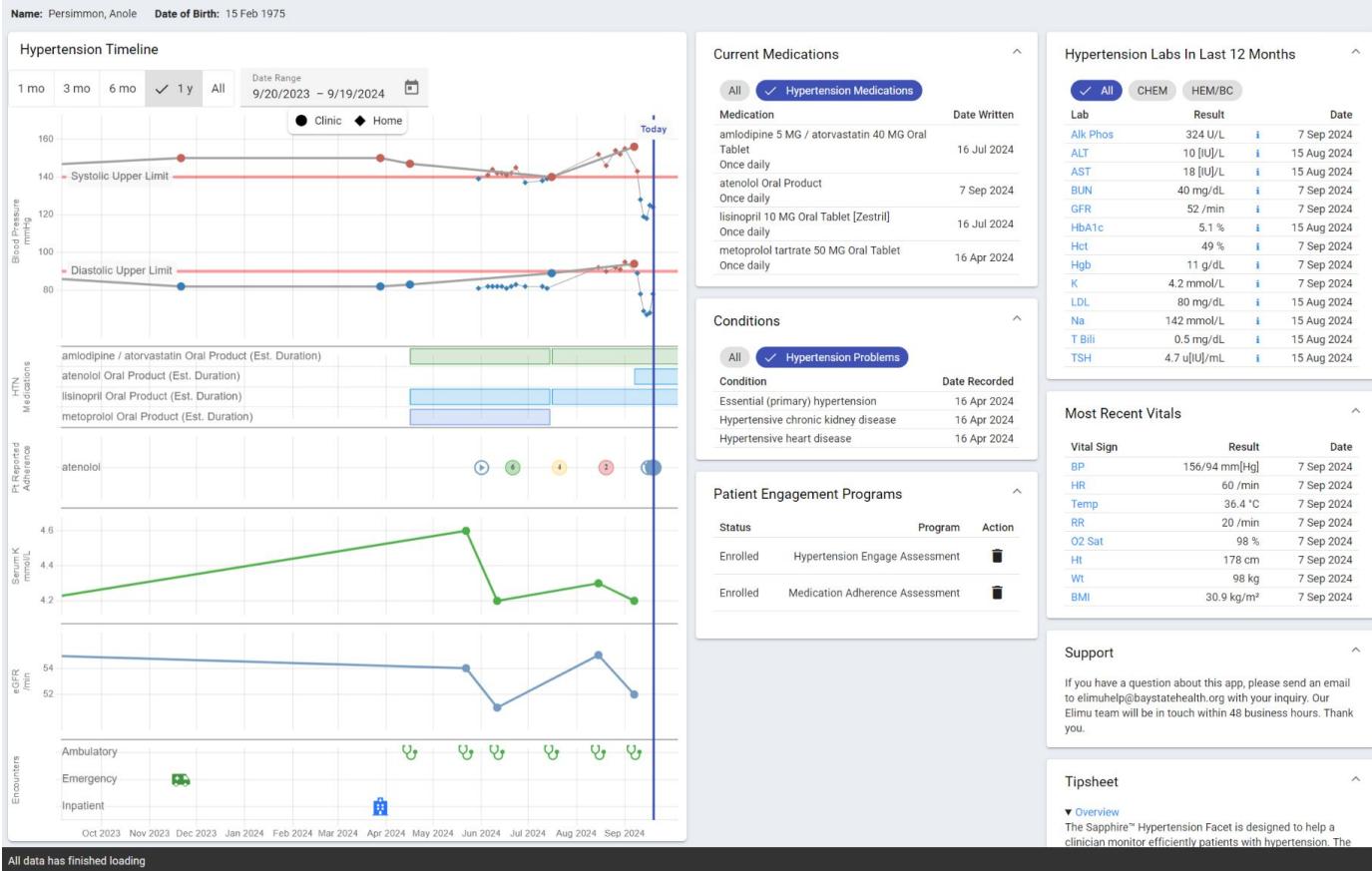
Despite comparable clinical characteristics, we found notable changes in opioid utilization patterns comparing January–February 2020 to January–February 2021 after we implemented the multimodal approach. Mean total intraoperative administration of MME—exclusively in the form of intravenous fentanyl—dropped by nearly 70% (mean [SD] of 374.0 [119.1] mcg/d vs 113.5 [60.4] mcg/d). There was a 92% reduction in mean tramadol MME at discharge (47.9 [75.5] mg vs 3.6 [18.0] mg). The total MME's prescribed on discharge dropped by 62% (221.3 [221.7] mg vs 85.1 [142.2] mg).

MiniApp working in any EHR

Impact:

102

Example: Hypertension Smart App



- Timeline view of home and clinic BPs, med Rx, med adherence, labs, visits
- Snapshots of current meds, labs, problems, vitals
- Enroll patients in BP monitoring and medication adherence monitoring
- Goal is to help monitor BP control and adjust treatment

Example: Pharmacogenomics App

- CDS Hooks service that externalizes from EHR complex and rapidly evolving genomic knowledge
- Use FHIR Genomic operations
 - Simplify use of genomic data in clinical decision-support
 - Provide APIs for variant, genotype, and phenotype queries of genomic data for individuals and populations
- We used a GACS that implements FHIR Genomic Operations
 - CDS based on whole genome/exome sequences

WARNING: Clopidogrel interactions

Decreased drug efficacy. Avoid if possible. Use prasugrel or ticagrelor at standard dose if no contraindication

Category	Interaction	Effects	Details
drug-drug	isoniazid 100 MG Oral Tablet	⬇️	Concurrent use of isoniazid and clopidogrel may reduce clopidogrel efficacy.
drug-gene	CYP2C19 *1/*2 (CYP2C19 Intermediate Metabolizer)	⬇️	Reduced clopidogrel active metabolite formation; increased on-treatment platelet reactivity; increased risk for adverse cardiac and cerebrovascular events. Recommend: Avoid standard dose (75 mg) clopidogrel if possible. Use prasugrel or ticagrelor at standard dose if no contraindication.
drug-drug	rifAMPin 150 MG Oral Capsule	⬆️	Concurrent use of strong CYP2C19 inducers with clopidogrel may increase the effects and toxicity of clopidogrel, including bleeding.(1,2)

[Hide info rows](#)

[Change drug](#) [Change dose](#) [No change](#) [Cancel order](#) [Pharmacy Consult](#)

PerfectChoice™

Helping physicians make the perfect antibiotic choices.

IDENTIFY.

PerfectChoice Notification: Based on new culture information and facility antibiogram, the following antinefectives have the highest likelihood (% susceptible) of effectively treating the infection.

Source:
Launch Premier TheraDoc for more details.

Know the priority patients with new microbiology results with automated surveillance that notifies clinicians in their workflow.

DECIDE.

PerfectChoice – ID: New Organism Identified

STEVENSON, LAURA
Age: 4 years CrCl: >100mL/min
Allergies: No Known Allergies SCR: 0.9gm/dL
Previous Admit: 01/18/13

NEW CULTURE INFORMATION
1/22/14 08:45
Specimen ID: 00564783
Status: Prelim
Culture: Blood
Result: *E.Coli*

ID SUMMARY
Microbiology
01/20/14 Urine Culture: *E.coli*
Antibiotic Medications:
01/24/13 – 01/26/13 Amoxicillin-clavulanate 150mg PO q8h

Community-acquired infection
Isolation
NHSN Documentation:
None

PerfectChoice OPTIONS
Premier Memorial Hospital – Last 12 mos.

***E.Coli* - Specimen Source Blood**

Antibiotic Medications (% Susceptible)
Amoxicillin Subdarm (93%)*
Levofloxacin (88%)*
Cefazolin (79%)*
SMX-TMP (76%)*
Gentamicin (73%)*

Dismiss **Change Orders**

View the best antibiotic options based on facility antibiogram in context of the patient's relevant clinical data to reach the right decision.

ACT.

PerfectChoice – ID: New Organism Identified

STEVENSON, LAURA
Age: 4 years CrCl: >100mL/min
Allergies: No Known Allergies SCR: 0.9gm/dL
Previous Admit: 01/18/13

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Microbiology
01/20/14 Urine Culture: *E.coli*
Antibiotic Medications:
01/24/13 – 01/25/13 Amoxicillin-clavulanate 150mg PO q8h

Flags:
Community-acquired infection
Isolation
NHSN Documentation:
None

PerfectChoice OPTIONS
Premier Memorial Hospital – Last 12 mos.

***E.Coli* - Specimen Source Blood**

Antibiotic Medications (% Susceptible)
Amoxicillin Subdarm (93%)*
Levofloxacin (88%)*
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SMX-TMP (76%)*
Gentamicin (73%)*

Dismiss **Change Orders**

Access the EMR to make the appropriate medication order decisions.



A Premier Solution

Build custom differentials from patient information

Daniel X. Adams

Birthdate: 1925-12-23

Recently viewed Diagnoses from VisualDx

Add new Conditions to the problem list

Urticaria Creutzfeldt-Jakob Disease Lead Poisoning

DDx of Medication Reactions in VisualDx

Lisinopril Hydrochlorothiazide

Build a Custom Differential in VisualDx

Select a finding to be the Chief Complaint:

Hypertension

Diagnosis Summaries and Images in VisualDx

Primary Hypertension Osteoarthritis Dementia Alzheimer Disease

Find diagnosis summaries and textbook differentials

Differential Diagnosis & Pitfalls

- Drug toxicity
- Chronic ethanol consumption (ie, **alcohol use disorder**)
- **Lead poisoning**
- Carbon monoxide poisoning
- Multi-infarct dementia
- Depression
- Complex partial seizures
- Autoimmune encephalopathy
- **Creutzfeldt-Jakob disease**

Differential Diagnosis of a 80+ year old Male

with Lisinopril

Rash

Reaction 0 to 5 Days After Drug

Smooth Plaque

ADD OR REMOVE FINDINGS



Urticaria

VERY COMMON OR IMPORTANT DIAGNOSIS

Raised, erythematous wheals caused by the release of histamine and other vasoactive substances from mast cells. Urticaria can be triggered by a variety of mechanisms, both allergic and nonallergic. Pruritus, prickling and stinging sensations, or pain may occur with urticaria. Usually resolve within 24 hours without skin sequelae.

View Diagnosis Details



Other Resources:

UpToDate PubMed

Matches 4 of 4 findings: [Edit findings](#)

Lisinopril Rash Reaction 0 to 5 Days After Drug Smooth Plaque

Update record with new diagnoses and findings

Recently viewed Diagnoses from VisualDx

Add new Conditions to the problem list

Urticaria Creutzfeldt-Jakob Disease Lead Poisoning

Find patient handouts

Diagnoses with Patient Handouts in VisualDx

Urticaria

CDS Hooks Dose Calculator

Prevent ADEs with system-calculated, safe, patient-specific doses



Med ordering workflow: pediatric patient. sulfamethoxazole(trimethoprim)

Baby Girl

DOB:	05/01/2016	E-mail:	mommy.girl@hotmail.com
Age:	5	Phone:	855-293-0593
Height:	25.00 inches	Fax:	309-637-4622
Weight:	13.63 kgs	Address:	42 Richmond Terrace, known, IA, 10301
Gender:	Female		

Common Signs

FDB OrderKnowledge Signs

Common ambulatory signs for sulfamethoxazole 200 mg-trimethoprim 40 mg/5 mL oral suspension

[5 mg/kg] 9 mL by mouth every 12 hours

[150 mg/m²] 6 mL by mouth every day; administer 3 consecutive days per week

Source: First Databank
[First Databank Dose Calculator](#)

Dosage Calculation: sulfamethoxazole 200 mg-trimethoprim 40 mg/5 mL oral suspen

Calculated Dosage Amount: Dosage (5 mg/kg) x Patient Weight (13.63 kgs)	68 mg
Rounded Dosage Amount: Not to Exceed:	72.0 mg 160.00 mg
Variance Amount Low: Low variance (0.9 mg) x Calculated Dosage Amount (68 mg)	61.34 mg
Variance Amount High: High variance (1.1 mg) x Calculated Dosage Amount (68 mg)	74.96 mg
Dosing Rounding Increment:	1 mL

Leverages FDB Cloud Connector web services

Calculations happen in real-time using current knowledge base

- See common orders for this patient based on their age and the ordered drug
- Smart logic knows this order should be dosed as trimethoprim
- Select from safe rounded admin amounts

meducation® (CDS Hooks)

Meducation Personalized Medication Information meducation®

Meducation® provides patient-specific medication instructions & regimen summaries at 5-8 grade reading level & 21 languages to reduce errors & improve adherence.

 [Interact with Meducation PMI Viewer](#)

Meducation Regimen Summary meducation®

Meducation® provides patient-specific medication instructions & regimen summaries at 5-8 grade reading level & 21 languages to reduce errors & improve adherence.

 [Interact with MeducationRS](#)

University Medical Center
123 Main Street, Anytown, NC 12345
212-555-2121
ID: FHR7WKJ

EVERY DAY: Medicine you need to use every day.

	Morning	Noon	Evening	Bedtime	
Aspirin Enteric Coated Tablet 81 mg	1				Take by MOUTH. For heart.
Accupril Tablet 10mg	1				Take by MOUTH. For high blood pressure.
Humalog Insulin Solution 100 IU/mL	12 units	14 units	16 units		INJECTION medicine. For diabetes.
Biaxin Oral Suspension 125mg/5 mL	10 mL		10 mL		Take by MOUTH. For infection. Use for 10 days.
Lipitor Tablet 40 mg				1	Take by MOUTH. For high cholesterol.

AS NEEDED: Medicine you should use as needed.

ProAir HFA Inhaler 90 mcg/inh	Use the medicine every 3 to 4 hours. Inhale one to two (1-2) puffs each time.	BREATHING medicine. For asthma attack. Use the medicine as needed for your symptoms.
-------------------------------	--	---

If you take any medication that is not on this list, please tell your healthcare provider.



ProAir HFA Inhaler 90 mcg/inh

meducation®

Biaxin Oral Suspension 125 mg/5 mL.
The medicine is used to treat infection.

How to take medicine:
Take the medicine by mouth twice a day.
Drink 10 mL each time.

Morning	Noon	Evening	Bedtime
10 mL		10 mL	

Use the medicine for a total of 10 days.

Instructions:
Take the medicine with food.
Keep this medicine at room temperature.
After using the medicine for the total number of days, throw away any left over medicine.
It is important that you keep taking each dose of this medicine on time even if you are feeling well.
If you forget to take a dose on time, take it as soon as you remember. If it is almost time for the next dose, do not take the missed dose. Return to your normal dosing schedule. Do not take 2 doses of this medicine at one time.
Please tell your doctor and pharmacist about all the medicines you take. Include both prescription and over-the-counter medicines. Also tell them about any vitamins, herbal medicines, or anything else you take for your health.

Ref#: FHR7WKJ-369785
English
Biaxin Oral Suspension 125 mg/5 mL



Disease Guideline

RxCheck

Hypertension

Medication Options

Medication Alert

RxCheck

lisinopril 5 mg tablet

- This medication is not recommended for Black or African American patients.

Switch to amiloride 5 mg-hydrochlorothiazide 50 mg tablet

Optimize pharmacy spend using **actionable recommendations**.

Hypertension	Est. Cost	Actual Adherence
acetebutolol 200 mg capsule • CMS Triple Weighted	\$55	98%
Alternatives	Fill Rates	
Seasonal Affective Disorder	Est. Cost	Actual Adherence
Wellbutrin XL (bupropion HCl) 150 mg tablet extended release 24 hr	\$1,081	73%
Alternatives	Fill Rates	

Improve outcomes through **consistent prescribing**.

Name	Patients	GDR	Prescribing Compliance	Prescriptions	High-risk Meds	Total Spend	Potential Savings	Action Buttons
Jamil Miller	52	94%	87%	310	22	\$2,467	\$713	
Darron Durgan	24	98%	76%	279	14	\$3,322	\$616	

Drive performance metrics (e.g., adherence) through **prescribing behavior surveillance**.

Precision Link at Boston Children's: PGx Recommendations via CDS Hooks

Adjusting medication order based upon genomic data

An **azathioprine** prescription
based upon a patient's
expression of **TPMT** enzyme



Normal metabolizer

PGx Recommendation

Start with normal starting dose (e.g., 2-3 mg/kg/d) and adjust doses of azathioprine based on disease-specific guidelines. Allow 2 weeks to reach steady state after each dose adjustment.

Intermediate metabolizer

PGx Recommendation

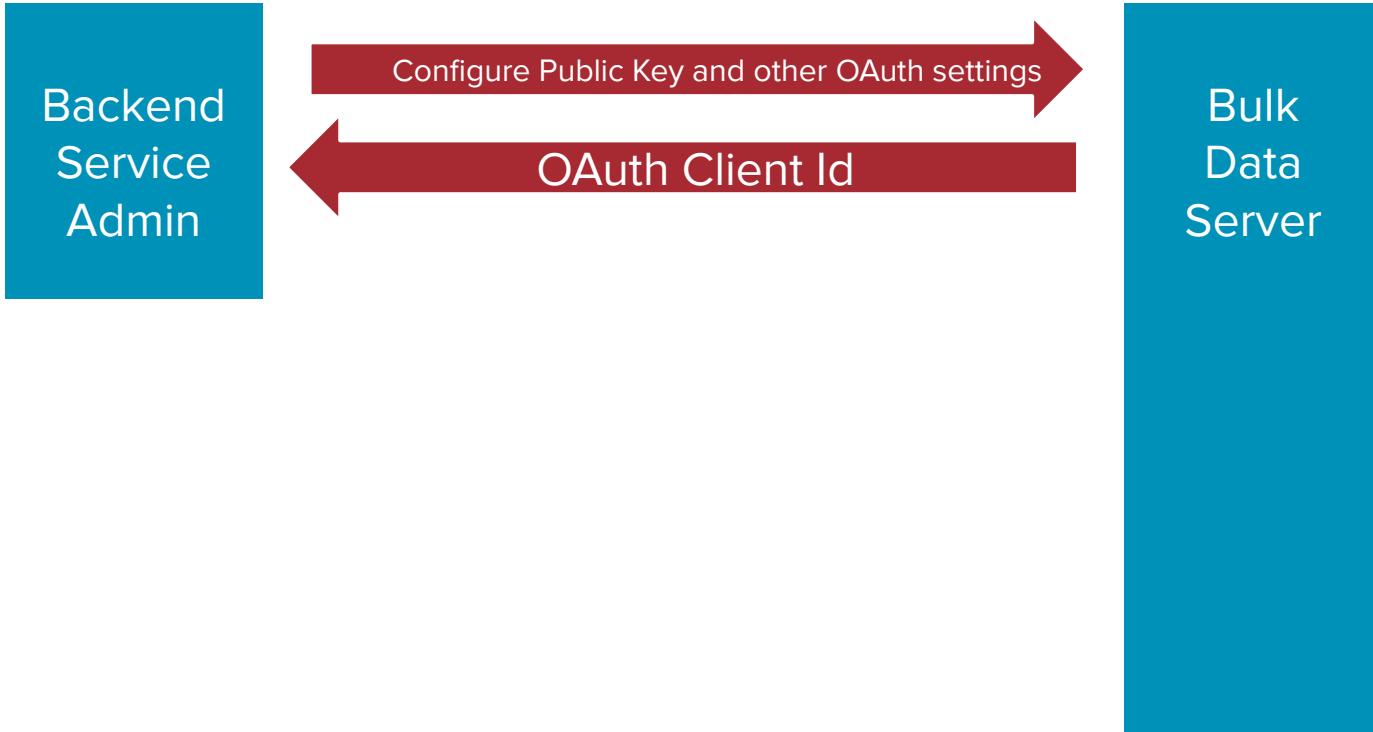
If disease treatment normally starts at the "full dose", consider starting at 30-70% of target dose (e.g., 1-1.5 mg/kg/d), and titrate based on tolerance. Allow 2-4 weeks to reach steady state after each dose adjustment.

Poor metabolizer

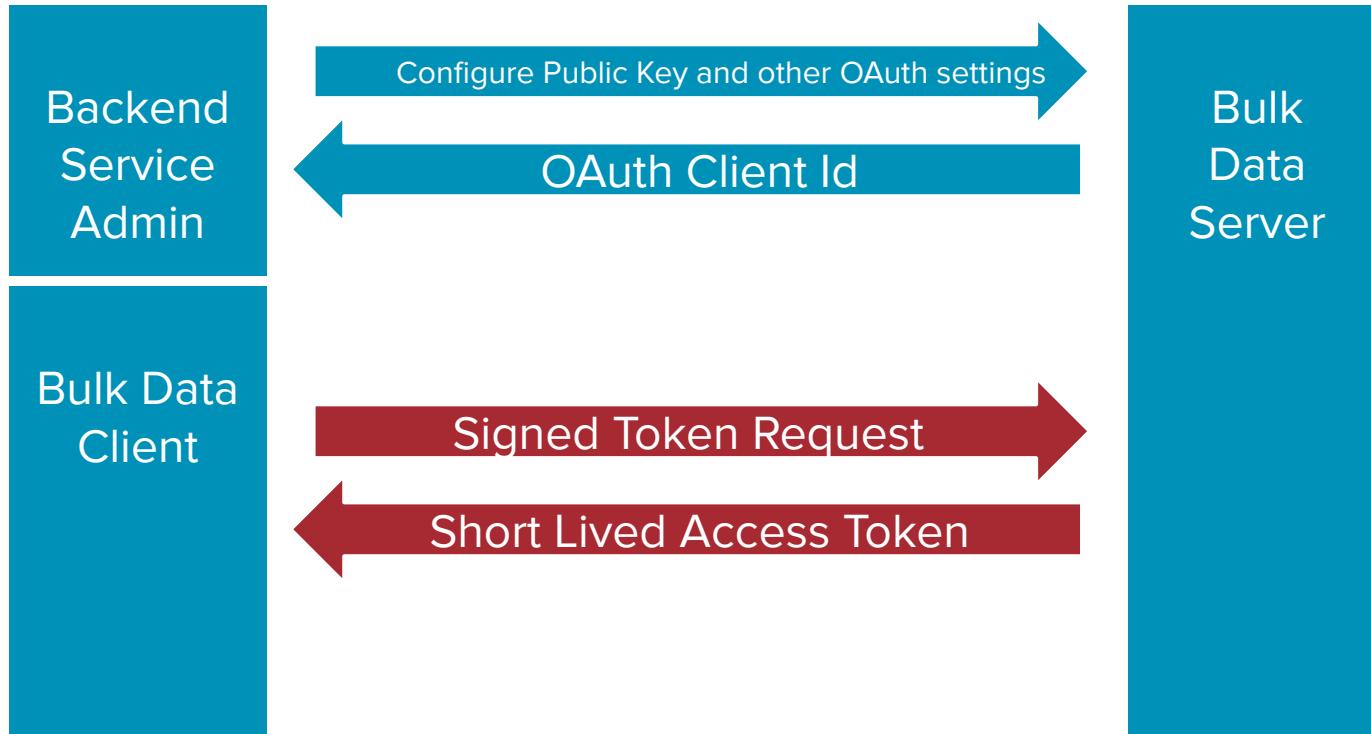
PGx Recommendation

Consider alternative agents. If using azathioprine start with drastically reduced doses (reduce daily dose by 10-fold and dose thrice weekly instead of daily) and adjust doses of azathioprine based on degree of myelosuppression and disease-specific guidelines. Allow 4-6 weeks to reach steady state after each dose adjustment. Azathioprine is the likely cause of myelosuppression.

Registration Flow (once)



Authorization Flow (min. once per request)



Authorization

- Create a JWT with iss/sub = client_id, aud = url de auth, digitally signed with our private key
- The 'scope' is 'what I want to access'. Pretty open. But must be as small as possible (remember BOLA)

) Conexión con el endpoint de autorización

(SMART Backend Services OAuth Profile)

```
❶ # Armo el jwt con el claim utilizando el client id y la clave privada
jwt_claims = {
    "iss": client_id,
    "sub": client_id,
    "aud": token_endpoint,
    "exp": datetime.datetime.utcnow() + datetime.timedelta(minutes=5),
    "jti": str(uuid.uuid4())
}

client_assertion = jose.jwt.encode(
    jwt_claims,
    signing_key,
    algorithm="RS256",
    headers={"kid": signing_key["kid"]}
)

token_request = {
    "scope": "system/*:read",
    "grant_type": "client_credentials",
    "client_assertion_type": "urn:ietf:params:oauth:client-assertion-type:jwt-bearer",
    "client_assertion": client_assertion
}

[18] ## Solicito el token de acceso
token_response = requests.post(token_endpoint, data=token_request)
```

Scope:What I
am requesting?

Attachments



Resource elements of type Attachment must contain:

data element with a Base64 encoded version of the file

OR

url element with an absolute URL for the file accessible using the same authentication as the ndjson files

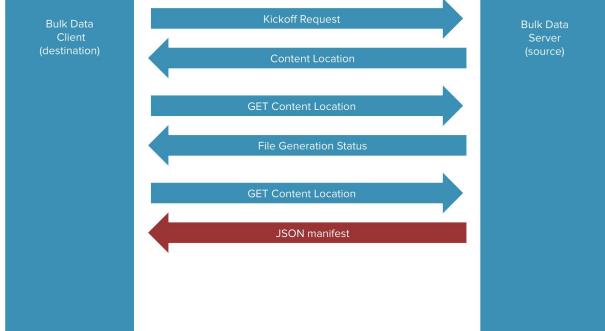
Kick-off response

It will return **202 (Accepted)** and an URL where we can ask when our 300,000,000 records will be ready for download...

```
{ 'Server': 'Cowboy', 'Connection': 'keep-alive', 'X-Powered-By':  
'Express', 'Content-Location':  
'https://bulk-data.smarthealthit.org/fhir/bulkstatus/cfe81d727b7f2e08e3  
5ad77efdefe6ad', 'Content-Type': 'application/json; charset=utf-8',  
'Content-Length': '644', 'Etag': 'W/"284-F3AUTGqq00JHYRvr+vui14KUsQE"',  
'Date': 'Sun, 14 Nov 2021 23:03:33 GMT', 'Via': '1.1 vegur'}
```

Polling

And when we get 200...



```
Response code: 202...
Response code: 200
Response body: { "transactionTime": "2021-11-14T23:03:33.337Z",
  "request": "https://bulk-data.smarthealthit.org/eyJlcnljOiiLCJwYWdlIjoxMDAwMCwiZHVVij...
SI6MSwic3R1Ijo0LCJkZWwiOjb9/fhir/Patient/\$export?\_type=Observation%2CCondition%2CPatient\_
  , "requiresAccessToken": true,
  "output": [
    { "type": "Condition", "count": 639,
      "url": "https://bulk-data.smarthealthit.org/eyJpZCI6ImNmZTgxZDcyN2I3Zj1MDhlMzVhZD...
2Zmc2V0IjowLCJsaW1pdCI6NjM5LCJzZWN1cmUiOnRydWV9/fhir/bulkfiles/1.Condition.ndjson } ... ] }
```

The manifest tells us how many resources per file and the url for the files

Data Access

FHIR resources

(But not just ANY FHIR resource : constrained!)

Structure: FHIR Resources

Specific profile so we know what to expect
on content/terminology

Efficient: ndjson

n resources in the same
file. No Spaces or CR/LF
<http://ndjson.org/>

FHIR core

Patient.identifier: 0..*
Patient.name 0..*
Patient.gender:0..1

'Our' FHIR

Patient.identifier: 1..*
Patient.name: 1..*
Patient.gender: 1..*
Observation.code.system
=LOINC

Search Result Parameters - I

- _sort
 - The order of returned results (format changing in STU-3)
- _count
 - Specify a number of resources to include
- _include
 - Include other resources referenced by this one (more detail soon)
- _revinclude
 - Include resources that reference this one (reverse include)
 - Eg provenance

Search Result Parameters - II

- _summary
 - Return a subset
 - true, false, text, data, count
 - Resources marked as 'SUBSETTED'
- _elements
 - Specify elements to return (+mandatory)
 - Resources marked as 'SUBSETTED'
- _contained
 - Whether search should include contained resources
 - False (default), true, both
- _containedType
 - With _contained – whether to return the container