FHIR Masterclass

Mark Braunstein, MD
Professor of the Practice
School of Interactive Computing
Georgia Institute of Technology
About Me
1963 ...
1965...
1969...
A typical flip-chip module, the R111, had three 2-input nand gates -- $14
Core Memory ...

12 33 x 33 planes = approximately 1630 bytes of memory -- $4680
Removable Disks ...

Removable pack hard drive 30 MB -- $30,000
### Patient Summary

**Problem List**

<table>
<thead>
<tr>
<th>Date of Def</th>
<th>Date of Res</th>
<th>Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/9/76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BRAUNSTEIN, MARK</td>
<td>PATIENT: DOE, JOHN</td>
<td>OPD #1</td>
</tr>
<tr>
<td>UNIT #1</td>
<td>9/9/76</td>
<td>9/9/76</td>
</tr>
<tr>
<td>AGE: 41</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Permanent Problems**

<table>
<thead>
<tr>
<th>Date of Def</th>
<th>Date of Res</th>
<th>Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 6/30/75</td>
<td></td>
<td>MEDICAL EXAM, NO DISEASE DETECTED</td>
</tr>
<tr>
<td></td>
<td>1 VISIT</td>
<td>ICMPPC = 900</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TORACCO ABUSE</td>
</tr>
<tr>
<td></td>
<td>1 VISIT</td>
<td>ICMPPC = 3049</td>
</tr>
<tr>
<td>B 6/30/75</td>
<td></td>
<td>EMMHYSEMA, BRONCHIECTASIS, &amp; COPD</td>
</tr>
<tr>
<td></td>
<td>1 VISIT</td>
<td>ICMPPC = 492</td>
</tr>
</tbody>
</table>

**Temporary Problems**

<table>
<thead>
<tr>
<th>Date of Def</th>
<th>Date of Res</th>
<th>Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 7/10/75</td>
<td>7/17/75</td>
<td>ACUTE UPPER RESPIR TRACT INFECTION</td>
</tr>
<tr>
<td>10/27/75</td>
<td></td>
<td>3 VISITS ICMPPC = 460</td>
</tr>
</tbody>
</table>
Early “PopHealth” …
Today ...

**Collect**

**Goal 1:** Expand adoption of Health IT

**Share**

**Goal 2:** Advance secure and interoperable health information

**Use**

**Goal 3:** Strengthen health care delivery

**Goal 4:** Advance the health and well-being of individuals and communities

**Goal 5:** Advance research, scientific knowledge, and innovation
Interoperability
**Traditional:** possessing the technical means to share diverse data among digital systems and tools

**Open:** ensuring that the data stored in digital health systems is freely available to end users and software developers rather than being restricted only to the vendor companies that created those systems
Contemporary Interoperability Spectrum

Traditional Interoperability Use Cases
“... while the average Medicare beneficiary sees between six and seven different physicians, **beneficiaries with five or more chronic conditions see almost 14 different physicians in a year** and average 37 physician visits annually. People with five or more chronic conditions fill almost 50 prescriptions in a year.”

Transitions of Care Medication Reconciliation

“an estimated 80% of serious medical errors involve miscommunication between caregivers during the transfer of patients.”

http://www.jointcommission.org/assets/1/6/tst_hoc_persp_08_12.pdf

Read a Joint Commission Publication on Medication Reconciliation
Public Health Surveillance
Population Health Quality Measures

The Triple Aim (IHI):

- Improving the patient experience of care (including quality and satisfaction)
- Improving the health of populations
- Reducing the per capita cost of health care


https://www.osehra.org/popHealth
Typical “Retrospective” Architectures
Population Health popHealth

https://github.com/pophealth/popHealth/wiki
Regional Health Information Exchange IHIE
National EHR **My Health Record**

Read About CMS’ Blue Button on FHIR Program
Global Research OHDSI

http://www.ohdsi.org/

Federated OMOP
Potential FHIR “Active” Architectures
“Active”

HSPC and SMART Client Libraries

HSPC Compliant Platform

FHIR enabled proprietary EHR systems using FHIR Resources and FHIR API

“Public” Applications using HTML5, Javascript, etc

“Confidential” Applications using JSP, PHP, etc.

“Backend Services” using Java, etc.

FHIR Resources and Profiles with Medical Encoding for Semantic Data Modeling

Authentication, Authorization, and Identity

JSON Web Tokens for Credentials

http://www.hspconsortium.org/
FHIR BACKGROUND
HL7 Standards Evolution

Messaging -> Documents/Modeling -> Workable Interoperability

- V2: 1987
- Start V3: 1995
- V3 CDA: 2005
- Fresh FHIR: Look DSTU 2011 2014

- 10 years
- 3 years

http://www.hl7.org/
HL7 101
HL7 V2 Message

LOINC 1554-5  Glucose [Mass/volume] in Serum or Plasma --12 hours fasting

HL7 V3 Domain Content

<observationEvent>
    <id root="2.16.840.1.113883.19.1122.4" extension="1045813"
        assigningAuthorityName="GHH LAB Filler Orders"/>
    <code code="1554-5" codeSystemName="LN">
        codeSystem="2.16.840.1.113883.6.1"
        displayName="GLUCOSE^POST 12H CFST:MCNC:PT:SER/PLAS:QN"/>
    <statusCode code="completed"/>
    <effectiveTime value="200202150730"/>
    <priorityCode code="R"/>
    <confidentialityCode code="N" codeSystem="2.16.840.1.113883.5.25"/>
    <value xsi:type="PQ" value="182" unit="mg/dL"/>
    <interpretationCode code="H"/>
    <referenceRange>
        <interpretationRange>
            <value xsi:type="IVL_PQ">
                <low value="70" unit="mg/dL"/>
                <high value="105" unit="mg/dL"/>
            </value>
            <interpretationCode code="N"/>
        </interpretationRange>
    </referenceRange>
</observationEvent>

Glucose level (normal ranges)

LOINC 1554-5
Glucose [Mass/volume] in Serum or Plasma --12 hours fasting

1. Open Alma Deleon CCD with Text Viewer Program
2. Copy and paste into XML Input Box
3. Click Tree View

https://www.linkedin.com/pulse/connecting-ios-your-emr-using-healthkit-cda-part-three-eric-whitley
Entry Relationship: One of several elements used to connect clinical act statements to each other.

Observation: An act that is intended to result in new information about a subject.
“a static model of health and healthcare information as viewed within the scope of HL7 standards development activities”
Innovative CDA Rendering
FHIR Links to V2 and V3

View the V3 Administrative Gender Value Set in JSON

This value set has an inline code system http://hl7.org/fhir/administrative-gender which defines the following codes:

<table>
<thead>
<tr>
<th>Code</th>
<th>Display</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>male</td>
<td>Male</td>
<td>M</td>
</tr>
<tr>
<td>female</td>
<td>Female</td>
<td>F</td>
</tr>
<tr>
<td>other</td>
<td>Other</td>
<td>UN</td>
</tr>
<tr>
<td>unknown</td>
<td>Unknown</td>
<td>UNK</td>
</tr>
</tbody>
</table>

Resources that have an <identification> element support searching by the identifier, so that records can be located by that method. So if an FHIR v2 message has the following OBR:

```
OBR | 1|185533|GH 801312755163-4128-0151240-0000000001|20180620120730|...
```

Then the DiagnosticReport it represents can be located using the following query:

```
OCT [base]/DiagnosticReport?identifier=16547013
```

Resource: Observation

This page contains various operations for interacting with the Observation resource.
CDA -> FHIR

Matt Spielman shreds a CCDA document into FHIR resources using InterSystems’ HealthShare

https://twitter.com/DocOnFHIR
FHIR Resources
Maturity

3: has been verified as meeting the DSTU Quality Guidelines and has been subject to a round of formal balloting with at least 10 implementer comments drawn from at least 3 organizations resulting in at least one substantive change.
FHIR Observation Resource

```
{
  "resourceType": "Observation",
  "id": "152896",
  "meta": {
    "versionId": "1",
    "lastUpdated": "2016-09-30T10:32:52.116-04:00"
  },
  "text": {
    "status": "generated",
    "div": "<div xmlns="http://www.w3.org/1999/xhtml">Heart Rate, 71 bpm</div>"
  },
  "status": "final",
  "code": {
    "coding": [
      {
        "system": "http://loinc.org",
        "code": "8867-4"
      }
    ],
    "text": "Heart Rate"
  },
  "subject": {
    "reference": "Patient/152860"
  },
  "encounter": {
    "reference": "Encounter/152862"
  },
  "effectiveDateTime": "2016-09-23T10:33:40-04:00",
  "valueQuantity": {
    "value": 71,
    "unit": "bpm"
  }
}
```
Try It

1) Open diana prince.txt
2) Copy and paste into the Open Resource box
3) Click Load JSON

Copy and paste me into SMART FRED V0.4

Note the Extensions for US Core Race, Ethnicity and Religion
<table>
<thead>
<tr>
<th>Resource Type</th>
<th>Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Id</td>
<td>1081177</td>
</tr>
</tbody>
</table>

**Meta**

| VersionId | 1 |
| LastUpdated | 2016-07-20 10:7:45 AM (GMT-04:00) |

**Text**

<table>
<thead>
<tr>
<th>Status</th>
<th>Generated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dn</td>
<td>Diana PRINCE</td>
</tr>
<tr>
<td></td>
<td>Identifier: 987654321</td>
</tr>
<tr>
<td></td>
<td>Address: 123 Main Street, New York NY</td>
</tr>
<tr>
<td></td>
<td>BirthDate: June 14, 1997</td>
</tr>
</tbody>
</table>

**Extension**

Uri:

http://hl7.org/fhir/StructureDefinition/us-core-race

Value (CodeableConcept)

<table>
<thead>
<tr>
<th>Coding</th>
<th>System: <a href="http://hl7.org/fhir/v3/Race">http://hl7.org/fhir/v3/Race</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>2106-3</td>
</tr>
<tr>
<td>Display</td>
<td>White</td>
</tr>
</tbody>
</table>

**Extension**

Uri:

http://hl7.org/fhir/StructureDefinition/us-core-ethnicity
Composable

FHIRE - FHIR Adapter - OMOP Data Model - Synthetic Patient Data
Find Marla

Click here
Click on Patient Resource
Search for Family Name “Dixon”
Find “Marla”
Note her ID
### FHIR Bundle

**Request**

GET http://polaris.i3i.gatech.edu:8080/fhir-omopv5/base/Patient?family=Dixon

**Request Headers**

- User-Agent: MAPI-FHIR/1.0 (FHIR Client; FHIR 1.0.2/STU2; apache)
- Accept-Charset: utf-8
- Accept-Encoding: gzip
- Accept: application/xml+fhir; q=1.0, application/json+fhir; q=1.0

**Response**

- Status: HTTP/1.1 200 OK
- Server: Apache-Coyote/1.1
- X-Powered-By: MAPI FHIR 1.6 REST Server (FHIR Server; FHIR 1.0.2/STU2)
- Date: Tue, 04 Oct 2016 21:04:12 GMT
- Content-Type: application/json+fhir; charset=UTF-8
- Transfer-Encoding: chunked

**Response Headers**

- Last-Modified: Tue, 04 Oct 2016 21:04:22 GMT

**Result Body**

<table>
<thead>
<tr>
<th>ID</th>
<th>Title</th>
<th>Updated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient523050</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient238</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Raw Message**

```json
{
    "resourceType": "Bundle",
    "total": 2,
    "entry": [
        {
            "resourceType": "Patient",
            "id": "Patient523050",
            "meta": {
                "lastUpdated": "2016-10-04T17:04:22.138-04:00"
            }
        },
        {
            "resourceType": "Patient",
            "id": "Patient238",
            "meta": {
                "lastUpdated": "2016-10-04T17:04:22.138-04:00"
            }
        }
    ],
    "request": {
        "method": "GET",
        "url": "http://polaris.i3i.gatech.edu:8080/fhir-omopv5/base/Patient?family=Dixon"
    }
}
```
What’s Marla’s Body Weight (LOINC 3141-9)?

ID: 523050

Click Here
Compound Search

Search Parameters
- patient - The subject that the observation is about (if patient)
- patient - The resource identity
- code - The code of the observation type

Includes
- Observation:encounter
- Observation:patient
- Observation:subject

Sort Results
- Sort By: Default
- Direction: Default

Other Options
- Limit: max # returned

Search Parameters:
- 523050
- LOINC: 3141-9
Find Her Medical Problems

Weight: 185 lbs

Click Here

How many problems does Marla have?
Find Her Medication Orders

Problems: 4

Click Here

How many drugs should Marla be taking?
Who is her doctor?
### Observation Search Specification

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Paths</th>
</tr>
</thead>
<tbody>
<tr>
<td>category</td>
<td>token</td>
<td>The classification of the type of observation</td>
<td>Observation.category</td>
</tr>
<tr>
<td>code</td>
<td>token</td>
<td>The code of the observation type</td>
<td>Observation.code</td>
</tr>
<tr>
<td>code-value[]</td>
<td>composite</td>
<td>Both code and one of the value parameters</td>
<td>Observation.codeValue</td>
</tr>
<tr>
<td>component</td>
<td>token</td>
<td>The component code of the observation type</td>
<td>Observation.componentCode</td>
</tr>
<tr>
<td>component-value[]</td>
<td>composite</td>
<td>Both component code and one of the component value parameters</td>
<td>Observation.componentValue</td>
</tr>
<tr>
<td>component-data-absent-reason</td>
<td>token</td>
<td>The reason why the expected value in the element is missing.</td>
<td>Observation.componentDataAbsentReason</td>
</tr>
<tr>
<td>component-value-concept</td>
<td>token</td>
<td>The value of the component observation. If the value is a CodeableConcept,</td>
<td>Observation.componentValueCodeableConcept</td>
</tr>
<tr>
<td>component-quantity</td>
<td>token</td>
<td>The value of the component observation. If the value is a Quantity, or a SampledData (just search on the bounds of the values in sampled data)</td>
<td>Observation.componentValueQuantity</td>
</tr>
<tr>
<td>component-value-string</td>
<td>token</td>
<td>The value of the component observation. If the value is a string, and also searches in CodeableConcept text</td>
<td>Observation.componentValueString</td>
</tr>
<tr>
<td>data-absent-reason</td>
<td>token</td>
<td>The reason why the expected value in the element is missing.</td>
<td>Observation.dataAbsentReason</td>
</tr>
<tr>
<td>data</td>
<td>date</td>
<td>Obtained date/time. If the obtained element is a period, a date that falls in this period</td>
<td>Observation.effective[x]</td>
</tr>
<tr>
<td>device</td>
<td>reference</td>
<td>The Device that generated the observation data.</td>
<td>Observation.device (Device, DeviceProfile)</td>
</tr>
<tr>
<td>encounter</td>
<td>reference</td>
<td>Healthcare event related to the observation</td>
<td>Observation.encounter (Encounter)</td>
</tr>
<tr>
<td>identifier</td>
<td>token</td>
<td>The unique id for a particular observation</td>
<td>Observation.identifier</td>
</tr>
<tr>
<td>patient</td>
<td>reference</td>
<td>The subject that the observation is about (if patient)</td>
<td>Observation.patient (Patient)</td>
</tr>
<tr>
<td>performer</td>
<td>reference</td>
<td>Who performed the observation</td>
<td>Observation.performer (Patient, Organization, Practitioner, RelatedPerson)</td>
</tr>
<tr>
<td>related</td>
<td>composite</td>
<td>Related Observations - search on related-type and related-target together</td>
<td>Observation.relation (Observation, RelatedObservation, RelatedTarget)</td>
</tr>
<tr>
<td>related-target</td>
<td>reference</td>
<td>Resource that is related to this one</td>
<td>Observation.relationTarget (Observation, RelatedTarget)</td>
</tr>
<tr>
<td>related-type</td>
<td>token</td>
<td>has-member</td>
<td>derived-from</td>
</tr>
<tr>
<td>specimen</td>
<td>reference</td>
<td>Specimen used for this observation</td>
<td>Observation.specimen (Specimen)</td>
</tr>
<tr>
<td>status</td>
<td>token</td>
<td>The status of the observation</td>
<td>Observation.status</td>
</tr>
<tr>
<td>subject</td>
<td>reference</td>
<td>The subject that the observation is about (if patient)</td>
<td>Observation.subject (Device, Location, Patient, Group)</td>
</tr>
<tr>
<td>value-concept</td>
<td>token</td>
<td>The value of the observation. If the value is a CodeableConcept,</td>
<td>Observation.valueCodeableConcept</td>
</tr>
<tr>
<td>value-date</td>
<td>date</td>
<td>The value of the observation. If the value is a date or period of time.</td>
<td>Observation.valueDateTime, Observation.valuePeriod</td>
</tr>
<tr>
<td>value-quantity</td>
<td>token</td>
<td>The value of the observation. If the value is a Quantity, or a SampledData (just search on the bounds of the values in sampled data)</td>
<td>Observation.valueQuantity</td>
</tr>
<tr>
<td>value-string</td>
<td>string</td>
<td>The value of the observation. If the value is a string, and also searches in CodeableConcept text</td>
<td>Observation.valueString</td>
</tr>
</tbody>
</table>

[https://www.hl7.org/](https://www.hl7.org/)
Population Search

Patients who live in Detroit

Exercise:
Try New York
How many patients?

https://demo.bbonfhir.com/
## Complexity Goldilocks Problem

<table>
<thead>
<tr>
<th>Examples</th>
<th>Non-examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative</td>
<td>Gender</td>
</tr>
<tr>
<td>- Patient</td>
<td>- Too small</td>
</tr>
<tr>
<td>- Organization</td>
<td></td>
</tr>
<tr>
<td>- Location</td>
<td></td>
</tr>
<tr>
<td>Clinical</td>
<td>Electronic Health Record</td>
</tr>
<tr>
<td>- Allergy</td>
<td>- Too big</td>
</tr>
<tr>
<td>- Family History</td>
<td></td>
</tr>
<tr>
<td>- Care Plan</td>
<td></td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Blood Pressure</td>
</tr>
<tr>
<td>- Document</td>
<td>- Too specific</td>
</tr>
<tr>
<td>- Message Profile</td>
<td></td>
</tr>
<tr>
<td>- Conformance</td>
<td></td>
</tr>
</tbody>
</table>

### How Many? How Detailed?

https://www.hl7.org/
Other Challenging Resource Sub-domains

Media

Imaging
Native FHIR output?
What data?
Mean/max/min?
Result Interpretation?

Duke Maps CCD to Apple’s HealthKit

Human API
Try it as homework!
<table>
<thead>
<tr>
<th>ResourceType</th>
<th>Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>_uuid</td>
<td>Unknown Elements</td>
</tr>
<tr>
<td>Id</td>
<td>f001</td>
</tr>
</tbody>
</table>

**Identifier**

| System | http://goodhealthhospital/identifier/devices |
| Value | 12345 |

**Type**

| System | http://snomed.info/sct |
| Code | 26862003 |
| Display | Feeding tube, device |

**Status**

| Available |

**ManufactureDate**

| Aug 8th, 2015 |

**Expiry**

| Aug 5th, 2020 |

**Udi**

| (01)00000123000017(10)ABC123(17)120415 |

**Owner**

| Reference | Organization: 2.16.840.1.113883.19.5 |

**Location**

| Display | Central Supply |
Codes, Value Sets, Profiles
1) **CODE SET**: The terminology (SNOMED, LOINC)

2) **VALUE SET**: Subset for a specific purpose (ED visit)

3) **ELEMENT DEFINITION**: Binds an element of the resource to a Value Set in a specific Profile

4) **SPECIFIC RESOURCE INSTANCE**: Has a value from the terminology and claims to be conformant to the profile (via the element definition)

Remember LOINC?

\{
    "system": "http://loinc.org",
    "code": "8867-4"
\}

\begin{center}
\begin{tikzpicture}
\node (alpha) {Alpha 1 globulin:MCnc:Pt:Ser/Plas:Qn:Electrophoresis};
\node[below left=of alpha] {component/analyte};
\node[below right=of alpha] {kind of property of observation or measurement};
\node[below=of alpha] {time aspect};
\node[below=of alpha] {system (sample) type};
\node[below=of alpha] {scale};
\node[below=of alpha] {method};
\end{tikzpicture}
\end{center}
Display ValueSet: observation-codes

- ID: observation-codes
- URL: http://hl7.org/fhir/ValueSet/observation-codes
- Version: 1.7.0
- Name: LOINC Codes
- Publisher: FHIR Project team
- Description: This value set includes all LOINC codes
- Status: draft
- Date: 2016-09-18T23:10:50+10:00

Observation Resource Specification

https://www.hl7.org/
## Profiles

### Value Set

<table>
<thead>
<tr>
<th>Level</th>
<th>Code</th>
<th>Display</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1004-1</td>
<td>American Indian or Alaska Native</td>
<td>American Indian or Alaska Native</td>
</tr>
<tr>
<td>2</td>
<td>1005-6</td>
<td>Alaskan</td>
<td>Alaskan</td>
</tr>
<tr>
<td>3</td>
<td>1006-3</td>
<td>Apache</td>
<td>Apache</td>
</tr>
<tr>
<td>4</td>
<td>1011-8</td>
<td>Chiricahua</td>
<td>Chiricahua</td>
</tr>
<tr>
<td>5</td>
<td>1012-4</td>
<td>Fort Sill Apache</td>
<td>Fort Sill Apache</td>
</tr>
<tr>
<td>6</td>
<td>1013-2</td>
<td>Jicarilla Apache</td>
<td>Jicarilla Apache</td>
</tr>
<tr>
<td>7</td>
<td>1014-0</td>
<td>Lipan Apache</td>
<td>Lipan Apache</td>
</tr>
<tr>
<td>8</td>
<td>1015-6</td>
<td>Mescalero Apache</td>
<td>Mescalero Apache</td>
</tr>
<tr>
<td>9</td>
<td>1016-5</td>
<td>Oklahoma Apache</td>
<td>Oklahoma Apache</td>
</tr>
<tr>
<td>10</td>
<td>1017-3</td>
<td>Payson Apache</td>
<td>Payson Apache</td>
</tr>
<tr>
<td>11</td>
<td>1018-1</td>
<td>San Carlos Apache</td>
<td>San Carlos Apache</td>
</tr>
<tr>
<td>12</td>
<td>1019-9</td>
<td>White Mountain Apache</td>
<td>White Mountain Apache</td>
</tr>
<tr>
<td>13</td>
<td>1021-5</td>
<td>Apache</td>
<td>Apache</td>
</tr>
<tr>
<td>14</td>
<td>1022-3</td>
<td>Northern Arapaho</td>
<td>Northern Arapaho</td>
</tr>
<tr>
<td>15</td>
<td>1023-1</td>
<td>Southern Arapaho</td>
<td>Southern Arapaho</td>
</tr>
<tr>
<td>16</td>
<td>1024-9</td>
<td>Wind River Arapaho</td>
<td>Wind River Arapaho</td>
</tr>
<tr>
<td>17</td>
<td>1026-4</td>
<td>Arnavut</td>
<td>Arnavut</td>
</tr>
<tr>
<td>18</td>
<td>1028-0</td>
<td>Assiniboine Sioux</td>
<td>Assiniboine Sioux</td>
</tr>
<tr>
<td>19</td>
<td>1030-6</td>
<td>Assiniboine Sioux</td>
<td>Assiniboine Sioux</td>
</tr>
<tr>
<td>20</td>
<td>1031-4</td>
<td>Fort Peck Assiniboine Sioux</td>
<td>Fort Peck Assiniboine Sioux</td>
</tr>
<tr>
<td>21</td>
<td>1033-0</td>
<td>Bannock</td>
<td>Bannock</td>
</tr>
<tr>
<td>22</td>
<td>1035-5</td>
<td>Blackfeet</td>
<td>Blackfeet</td>
</tr>
<tr>
<td>23</td>
<td>1037-1</td>
<td>Brotherton</td>
<td>Brotherton</td>
</tr>
<tr>
<td>24</td>
<td>1038-7</td>
<td>Burt Lake Band</td>
<td>Burt Lake Band</td>
</tr>
<tr>
<td>25</td>
<td>1041-3</td>
<td>Cañon</td>
<td>Cañon</td>
</tr>
</tbody>
</table>

#### United States Realm FHIR Profile

**Scope and Usage**

This profile defines several extensions relevant to the US realm.

**Extensions to Patient**

- `race` (0..1): A CodeableConcept bound to the v3 value set for Race
- `ethnicity` (0..1): A CodeableConcept bound to the v3 value set for Ethnicity

**Extensions to Address**

- `county` (0..1): A coding containing the name of the county.

**Extensions to ContactPoint**

- `direct` (0..1): A boolean flag indicating that a particular email address can be used with the Direct Protocol. An example Patient showing these extensions can be found here.

**Content**

- **Extensions**
  - `us-core-race`: A category of humans sharing history, origin or nationality.
  - `us-core-ethnicity`: A category of human sharing heritage.
  - `us-core-county`: Name of county.
  - `us-core-religion`: Patient’s preferred religious affiliation.
  - `us-core-direct`: Email is a “direct” email.
  - `us-core-conceptStatus`: The status of a Concern associated with a condition.

**Search Parameters**

Search parameters defined by this package. See Searching for more information about searching in REST, messaging, and services.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Path</th>
<th>Source</th>
<th>JSON</th>
</tr>
</thead>
<tbody>
<tr>
<td>ethnicity tolerant</td>
<td>Concept</td>
<td>Returns patients with an ethnicity extension matching the specified code.</td>
<td>@search/extension[0=</td>
<td><a href="https://fhir">https://fhir</a>.</td>
<td>JSON</td>
</tr>
<tr>
<td>race tolerant</td>
<td>CodeableConcept</td>
<td>Returns patients with a race extension matching the specified code.</td>
<td>@search/extension[race-</td>
<td><a href="https://fhir">https://fhir</a>.</td>
<td>JSON</td>
</tr>
</tbody>
</table>
US DAF Profile

The DAF Initiative tries to leverage the HL7 FHIR, C-CDA and existing IHE standards to standardize access to Meaningful Use Stage 2 structured information both within the organization and from external organizations.

<table>
<thead>
<tr>
<th>Data Access Framework</th>
<th>Data Access Framework using FHIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Model to support queries</td>
<td>Meaningful Use Stage 2 Data Elements mapped to FHIR Resources</td>
</tr>
<tr>
<td>Query Results</td>
<td>Meaningsful Use Stage 2 Vocabularies and Value sets</td>
</tr>
<tr>
<td>Query Structure</td>
<td>Meaningsful Use Stage 2 Vocabularies and Value sets</td>
</tr>
<tr>
<td>Security Layer</td>
<td>FHIR Resource profiles</td>
</tr>
<tr>
<td>Transport Layer</td>
<td>FHIR Resource Profiles</td>
</tr>
</tbody>
</table>

https://www.hl7.org/
Conformance

Provides for a degree of automatic configuration and adaptation

Automation connects to all the detailed statements of functionality, such as StructureDefinitions (Profiles) and ValueSets

Human-readable content that can minimize the need for direct communication between the operators of the systems being configured to interoperate
FHIR Paradigms
**REST** Small, light-weight exchanges with low coupling between systems

**Messages** Communicate multiple resources in a single exchange

**Documents** Focus is on persistence when data spans multiple resources

**Services** Use a custom service when capabilities of other paradigms don’t fit requirement

https://www.hl7.org/
FHIR REST API

Create
Read
Update
Delete

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Path</th>
<th>Request</th>
<th>Content-Type</th>
<th>Body</th>
<th>Prefer</th>
<th>Conditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>read</td>
<td>/{type}/{id}</td>
<td>GET</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>O: If-Match, If-None-Match</td>
</tr>
<tr>
<td>vread</td>
<td>/{type}/{id}/_history/{vid}</td>
<td>GET</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>update</td>
<td>/{type}/{id}</td>
<td>PUT</td>
<td>R</td>
<td>Resource</td>
<td>O</td>
<td>If-Match</td>
</tr>
<tr>
<td>delete</td>
<td>/{type}/{id}</td>
<td>DELETE</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>create</td>
<td>/{type}</td>
<td>POST</td>
<td>R</td>
<td>Resource</td>
<td>O</td>
<td>If-None-Exist</td>
</tr>
<tr>
<td>search</td>
<td>/{type}</td>
<td>GET</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>search-all</td>
<td>_/search?</td>
<td>POST</td>
<td>application/x-www-form-urlencoded</td>
<td>form data</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>conformance</td>
<td>/ or /metadata</td>
<td>OPTIONS or GET</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>transaction</td>
<td>/</td>
<td>POST</td>
<td>R</td>
<td>Bundle</td>
<td>O</td>
<td>N/A</td>
</tr>
<tr>
<td>history</td>
<td>/{type}/{id}/_history</td>
<td>GET</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>history-type</td>
<td>/{type}/_history</td>
<td>GET</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>history-all</td>
<td>_/History</td>
<td>GET</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>(operation)</td>
<td>/{type}/$[name]</td>
<td>POST</td>
<td>R</td>
<td>Parameters</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>or /{type}/id/$[name]</td>
<td>GET</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>
FHIR Document

https://www.hl7.org/
FHIR Message
Content/Resource Format Always the Same

Receive a lab result in a message…

Lab System → FHIR Message

FHIR Repository → FHIR Document

Package it in a discharge summary document

REST → National Exchange

https://www.hl7.org/
Resource References

Classic coding system issue

https://www.hl7.org/
Optional HTML representation of resource content - clinical safety issue, fall back option

```
<DiagnosticReport xmlns="http://hl7.org/fhir">
  <text>
    <status value="generated"/>
    <div xmlns="http://www.w3.org/1999/xhtml">
      <h3>CBC Report for Wile. E. COYOTE (MRN: 23453) issued 3-Mar 2011 11:45</h3>
      <pre>
        | Test               | Units | Value | Reference Range |
        |-------------------|-------|-------|-----------------|
        | Haemoglobin       | g/L   | 176   | 135 - 180       |
        | Red Cell Count    | x10*12/L | 5.9  | 4.2 - 6.0       |
        | Haematocrit        |       | 0.55+ | 0.38 - 0.52     |
        | Mean Cell Volume  | fL    | 99+   | 80 - 98         |
        | Mean Cell Haemoglobin | pg | 36+   | 27 - 35         |
        | Platelet Count    | x10*9/L | 444  | 150 - 450       |
        | White Cell Count  | x10*9/L | 4.6  | 4.0 - 11.0      |
      </pre>
    </div>
    <p>Acme Laboratory, Inc signed: Dr Pete Pathologist</p>
  </text>
  <status value="final"/> <!-- all this report is final -->
  <issued value="2011-03-04T11:45:33+11:00"/>
</DiagnosticReport>
```
Useable at Many Levels

**Personal**: Social media and mobile applications

**Provider**: Clinical workflow/process, decision support applications

**Institutional**: Data exchange between systems

**Regional**: Health information organizations (HIEs)

**National**: Health hubs or EHRs (e.g. My Health Record)
Open Health Apps **SMART on FHIR**

- Developed by Anyone
- Work with Any EHR
- Provider facing
- Patient facing

[Authorization, authentication, clinical data, UX]

---

http://jamia.oxfordjournals.org/content/early/2016/02/16/jamia.ocv189

https://gallery.smarthealthit.org/
Two Key Clinical Use Cases
Clinical Decision Support

More accurate diagnosis, more appropriate treatment, personalized/precision medicine

EHR Enhancement

Improved data collection, visualization, workflow/process
Clinical Decision Support (CDS)
Tight-App EHR Integration

Courtesy: Cerner
Solves the “Curly Braces” Problem

Arden Syntax

1.0 ASTM 1992
2.0 HL7 1999
2.10 HL7 2013 (XML)
3.0 Under Development

creatine := read {'dam'="PDQRES2"};
last_creat := read last {select "OBSRV_VALUE" from "LCR" where qualifier in ("CREATININE", "QUERY_OBSRV_ALL")};

“FHIR element and extension identifiers would provide one mechanism for identifying the relevant data elements.”

https://www.hl7.org/fhir/comparison-other.html

I’ll demonstrate this later on!
CDS Hooks

Synchronous, workflow-triggered CDS calls returning information and suggestions

Launching a user-facing SMART app when CDS requires deeper interaction

Long-running, non-modal CDS sessions that observe EHR activity in progress

Try it! Treat Daniel Adams’ Osteoarthritis with Voltaren
Patient View

Hello Daniel!
Source: Patient greeting service

**information card**: text for the user

**suggestion card**: specific suggestion with an EHR button to accept it. Clicking populates the EHR.

**app link card**: a SMART app, return to the EHR that re-triggers the **CDS hook**. This may result in different cards that may include **decisions**

*For example, a user might launch a hypertension management app, and upon returning to the EHR’s prescription page the new blood pressure prescription is there.*
## Rx View

**Treating:**
- Osteoarthritis

**Medication:**
- Search for a drug...

**Diclofenac Sodium 75 MG Delayed Release Oral Tablet [Voltaren]**

### Dosing Information

- **Dose Quantity:**
  - Value: 1
  - System: [Units of Measure](http://unitsofmeasure.org)
  - Code: "pill"

- **Timing:**
  - Frequency: 1
  - Period: 1
  - PeriodUnits: "d"
  - Boundaries:
    - Start: 2016-09-29
    - End: 2016-10-29

### Cost:
- $126. Save $99 with a generic.

Source: CMS Public Use File

**Change to generic**
Explore the FHIR Resources (Homework)
Medication Coding

```
{
  "resourceType": "MedicationOrder",
  "dateWritten": "2016-09-29",
  "status": "draft",
  "patient": {
    "reference": "Patient/1288992"
  },
  "dosageInstruction": [
    {
      "doseQuantity": {
        "value": 1,
        "system": "http://unitsofmeasure.org",
        "code": "{pill}\"
      },
      "timing": {
        "repeat": {
          "frequency": 1,
          "period": 1,
          "periodUnits": "d",
          "boundsPeriod": {
            "start": "2016-09-29",
            "end": "2016-10-29"
          }
        }
      }
    }
  ],
  "medicationCodeableConcept": {
    "text": "Diclofenac Sodium 75 MG Delayed Release Oral Tablet [Voltaren]",
    "coding": [
      {
        "display": "Diclofenac Sodium 75 MG Delayed Release Oral Tablet [Voltaren]",
        "code": "855928"
      }
    ],
    "reasonCodeableConcept": {
      "coding": [
        {
          "system": "http://snomed.info/sct",
          "code": "396275006",
          "display": "Osteoarthritis"
        }
      ],
      "text": "Osteoarthritis"
    }
  }
}
```

SMART Health IT — About CDS Hooks — Rx Demo source code

RxNorm CUI (Concept Unique Identifier)  
RxNorm has a REST api
What *Else* Can You Do With 855928?

Is it safe in this patient? To find out, [try this](#).

```
<properties>
  <rxcui>855928</rxcui>
  <name>
    Diclofenac Sodium 75 MG Delayed Release Oral Tablet [Voltaren]
  </name>
  <synonym>
    Voltaren 75 MG Delayed Release Oral Tablet
  </synonym>
  <tty>SBD</tty>
  <language>ENG</language>
  <suppress>N</suppress>
  <umls cui>C0709155</umls cui>
</properties>

UMLS CUI
```
May Depend on What Else They’re Taking

What does this drug do?

{"rxcui":"83929","name":"abciximab","tty":"IN"},{"sourceConceptItem":{"id":"DB00054,BTD00041,BIOD00041","name":"Abciximab","url":"http://www.drugbank.ca/drugs/DB00054#interactions"}},"severity":"N/A","description":"Diclofenac may increase the anticoagulant activities of Abciximab."}
What is Abciximab?

Wikipedia:

“a platelet aggregation inhibitor mainly used during and after coronary artery procedures like angioplasty to prevent platelets from sticking together and causing thrombus (blood clot) formation within the coronary artery.”
{ "resourceType": "MedicationOrder", "dateWritten": "2016-09-29", "status": "draft", "patient": { "reference": "Patient/1288992" }, "dosageInstruction": [ { "doseQuantity": { "value": 1, "system": "http://unitofmeasure.org", "code": "{pill}" }, "timing": { "repeat": { "frequency": 1, "period": 1, "periodUnits": "d", "boundsPeriod": { "start": "2016-09-29", "end": "2016-10-29" } } } ], "medicationCodeableConcept": { "text": "Diclofenac Sodium 75 MG Delayed Release Oral Tablet [Voltaren]", "coding": [ { "display": "Diclofenac Sodium 75 MG Delayed Release Oral Tablet [Voltaren]", "system": "http://www.nlm.nih.gov/research/umls/rxnorm", "code": "855928" } ] }, "reasonCodeableConcept": { "coding": [ { "system": "http://snomed.info/sct", "code": "396275006", "display": "Osteoarthritis" } ], "text": "Osteoarthritis" } } SMART Health IT — About CDS Hooks — Rx Demo source code

A SNOMED-CT Clinical Concept
IHTDSO has a browser
SNOMED CT is the ontological basis of the upcoming ICD-11.
{
    "resourceType": "MedicationOrder",
    "dateWritten": "2016-09-29",
    "status": "draft",
    "patient": {
        "reference": "Patient/1288992"
    },
    "dosageInstruction": [
        {
            "doseQuantity": {
                "value": 1,
                "system": "http://unitofmeasure.org",
                "code": "{pill}"
            },
            "timing": {
                "repeat": {
                    "frequency": 1,
                    "period": 1,
                    "periodUnits": "d",
                    "boundsPeriod": {
                        "start": "2016-09-29",
                        "end": "2016-10-29"
                    }
                }
            }
        }
    ],
    "medicationCodeableConcept": {
        "text": "Diclofenac Sodium 75 MG Delayed Release Oral Tablet [Voltaren]",
        "coding": [
            {
                "display": "Diclofenac Sodium 75 MG Delayed Release Oral Tablet [Voltaren]",
                "code": "855928"
            }
        ]
    },
    "reasonCodeableConcept": {
        "coding": [
            {
                "system": "http://snomed.info/sct",
                "code": "396275006",
                "display": "Osteoarthritis"
            }
        ],
        "text": "Osteoarthritis"
    }
}

A SNOMED-CT Clinical Concept
IHTSDO has a REST api

SMART Health IT — About CDS Hooks — Rx Demo source code
Australian Medications
Therapeutic Clinical Decision Support

Experience with Prior Patients

Machine Learning

SMART on FHIR App Container

AED Predictive Analysis has been performed for Sarah Berger.
Filter out the following selection(s):

- Carbamazepine
- Lamotrigine
- Primidone
- Oxcarbazepine
- Topiramate

The probability of patient outcome improvement for modified treatment protocols listed in the app are intended to be one additional reference point to be used in making decisions regarding treatment protocol changes. Physicians and those recommending and prescribing treatment regimen changes for epilepsy patients are advised to weight this predictive analysis in concert with their own first-hand knowledge and other available information on the patient’s comprehensive health in reaching any clinical decision or prescribed treatment.
Hospital Discharge Decision Support

Model of Prior Patients
Public Health Decision Support

Experience with Prior Patients

Machine Learning

Cardiac Arrhythmia

10 min

Complete Heart Block

3.3 hr

Giant cell arteritis with polymyalgia rheumatica

14 days

ICD-9: Cardiac arrhythmia, unspecified

Description: arrhythmia

Time: 1/5/16 02:05

Time to death: D=10m
Genomics/Precision Medicine
CDS FHIR App Using Innovative Visualization
Let’s take a look!
EHR Usability, Workflow, Patient Engagement

http://isalushealthcare.com/

Courtesy Geisinger Health System
Key Patient Use Cases

Engagement
Targeted education
Support for compliance
Continuous care
Compliance
Compliance

Surescripts
Surescripts Compliance Resource

<resource>
  <Observation id="0:2f661c-0132-481f-b783-1ba511a5f626"/>
  <meta lastUpdated="2015-04-09T00:00:02"/>
  <contained>
    <MedicationPrescription id="1"/>
    <meta lastUpdated="2015-04-09T00:00:02"/>
    <patient reference="Patient/68c8b430-9c3a-11d9-9669-0800200c9a67"/>
    <prescriber reference="Practitioner/18e6d318-f8e8-4d2c-9d9e-be73c92c2c82"/>
    <medication reference="#2"/>
  </contained>
</resource>

<code system="http://surescripts.com/fhir/Identifiers/nrd" value="63304-829-90"/>
<extension url="http://surescripts.com/fhir/StructureDefinition/medication-prescription-reference">
  <valueReference reference="#1"/>
</extension>
<code system="http://surescripts.com/fhir/mmpoc/disease-categories" value="Hypertension"/>
<valueQuantity value="80" system="https://rtmms.nist.gov" value="262688"/>
<issued value="2014-06-17T09:31:43Z" status="final" reliability="ok"/>
<subject reference="Patient/68c8b430-9c3a-11d9-9669-0800200c9a67"/>
<performer reference="Organization/46901b85-5433-447f-a50c-50c9d65e1b5"/>
</Observation>
</resource>

Courtesy Surescripts
You on FHIR (Homework)!
Search for Patient

Progress...
Adding Your Name
Added patient with the id: 152860
Checking that the required reference resources exist
adding Encounters...
Added 5 Encounters
adding Observations...
adding Appointments...
adding Medication List...
adding Allergy List...
adding Condition List...
Added Medications List
Added Allergies List
Added Conditions List
Added 2 Appointments
Added 15 Observations
Explore your Resources

End up with an Observation Resource

Note its LOINC Code

Find the LOINC browser

Find your LOINC code’s “fully specified name”
Problems FHIR Doesn’t Solve (yet)

Universal patient identifier (US, project underway)

Suboptimal health data (missing, inaccurate, noisy, etc.)

Dense data (images, intensive care, mHealth)

Support for population level analytics
Thank You!