FHIREd up for FAIRness

Andrey Soares, Ph.D.
Assistant Professor
School of Medicine, Internal Medicine
andrey.soares@cuanschutz.edu

Data Science to Patient Value (D2V)
UNIVERSITY OF COLORADO ANSCHUTZ MEDICAL CAMPUS

March 17, 2020
Objectives

**FHIR**
Fast Healthcare Interoperability Resources (FHIR) standard to support data exchange

**SMART on FHIR**
Substitutable Medical Applications, Reusable Technologies (SMART) standard to support authorization and connection with electronic health records

**FAIR**
Challenges and opportunities to support Findable, Accessible, Interoperable, Reusable (FAIR) data and research
ONC’s Cures Act Final Rule

Interoperability, Information Blocking, and the ONC Health IT Certification Program

The 21st Century Cures Act requires that a certified health information technology developer or entity have application programming interfaces (APIs) to allow interoperability and “provide access to all data elements of a patient’s electronic health record to the extent permissible under applicable privacy laws”.

Source: https://www.healthit.gov/curesrule/
Putting the patient first in health technology enables the health care system to deliver:

- Transparency into the cost and outcomes of their care
- Competitive options in getting medical care
- Modern smartphone apps to provide them convenient access to their records
- An app economy that provides patients, physicians, hospitals, payers, and employers with innovation and choice

Source: [https://www.healthit.gov/curesrule/](https://www.healthit.gov/curesrule/)
Key Points

- Permit health information to be accessed, exchanged, and used from APIs without special effort
- API requirements for patients securely access their health information
- Advance interoperability of API-enabled “read” services for single and multiple patients
- The API certification criterion requires the use of FHIR Release 4
- Mandatory support of the SMART on FHIR Core Capabilities
- Compliance six months after publication of the final rule
Fast Healthcare Interoperability Resources

http://www.hl7.org/fhir
FHIR History

- **2009**: HITECH ACT
  - February
- **2011**: Draft
  - August
- **2013**: DSTU 1
  - Version 0.0.82
  - October
- **2014**: DSTU 2
  - Version 1.0.2
  - October
- **2015**: STU3
  - Version 3.0.2
  - February
- **2017**: R4
  - Version 4.0.1
  - October
- **2019**: R5
  - Work In Progress
- **2020**:
Electronic Health Record (EHR)
Patient, Conditions, Encounters, Observations, Medications, etc.

From paper  To electronic

Image Source: https://en.wikipedia.org/wiki/Medical_record
Image Source: https://en.wikipedia.org/wiki/Electronic_health_record
Data Integration: People-People

Adapted from ONC FHIR at Scale Taskforce (FAST) 101
Data Integration: System-System

Adapted from ONC FHIR at Scale Taskforce (FAST) 101
Interoperability problems

<table>
<thead>
<tr>
<th>System A</th>
<th>System B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Code</strong></td>
<td><strong>Code</strong></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Code</strong></td>
</tr>
<tr>
<td>“S”</td>
</tr>
<tr>
<td>“M”</td>
</tr>
</tbody>
</table>

Adapted from ONC FHIR at Scale Taskforce (FAST) 101
Standard to exchange clinical data

FHIR Standard

FHIR

Mapping

EHR

A

DOB

B

Birthdate

C

DateOfBirth

birthDate

birthDate

03/17/2020
### HL7 Committees:
- Biomedical Research and Regulation
- Community Based Collaborative Care
- Clinical Decision Support
- Clinical Genomics
- Health Care Devices
- FHIR Infrastructure
- Financial Management
- Imaging Integration
- Infrastructure And Messaging
- Orders and Observations
- Patient Administration
- Patient Care
- Public Health and Emergency Response
- Pharmacy
- Structured Documents
- Security
- Vocabulary

---

**FHIR Resources Categorized**

![Diagram of FHIR Resources Categorized]

**Source:** [https://www.hl7.org/fhir/resourcelist.html](https://www.hl7.org/fhir/resourcelist.html)
## Condition Resource

<table>
<thead>
<tr>
<th>Name</th>
<th>Flags</th>
<th>Card.</th>
<th>Type</th>
<th>Description &amp; Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>I</td>
<td>U</td>
<td>DomainResource</td>
<td>Detailed information about conditions, problems or diagnoses. + Rule: Condition.clinicalStatus SHALL be present if verificationStatus is not entered-in-error and category is problem-list-item</td>
</tr>
<tr>
<td>identifier</td>
<td>Z</td>
<td>0.7</td>
<td>Identifier</td>
<td>External Ids for this condition</td>
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<tr>
<td>clinicalStatus</td>
<td>?i</td>
<td>0.1</td>
<td>CodeableConcept</td>
<td>active</td>
</tr>
<tr>
<td>verifcationStatus</td>
<td>?i</td>
<td>0.1</td>
<td>CodeableConcept</td>
<td>unconfirmed</td>
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<tr>
<td>category</td>
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<td>0.7</td>
<td>CodeableConcept</td>
<td><strong>Condition/Clinical Status Codes (Required)</strong></td>
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<tr>
<td>severity</td>
<td>Z</td>
<td>0.1</td>
<td>CodeableConcept</td>
<td>Subjective severity of condition</td>
</tr>
<tr>
<td>code</td>
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<td>CodeableConcept</td>
<td><strong>Condition/Prognosis Codes (Preferred)</strong></td>
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<td>bodySite</td>
<td>Z</td>
<td>0.7</td>
<td>CodeableConcept</td>
<td>Anatomical location, if relevant</td>
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<tr>
<td>subject</td>
<td>Z</td>
<td>1.1</td>
<td>Reference(Patient</td>
<td>Group)</td>
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<tr>
<td>encounter</td>
<td>Z</td>
<td>0.1</td>
<td>Reference(Encounter)</td>
<td>Encounter created as part of</td>
</tr>
<tr>
<td>onset[x]</td>
<td>Z</td>
<td>0.1</td>
<td></td>
<td>Estimated or actual date, date-time, or age</td>
</tr>
<tr>
<td>onsetDateTime</td>
<td></td>
<td></td>
<td>dateTime</td>
<td></td>
</tr>
<tr>
<td>onsetStage</td>
<td></td>
<td></td>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>onsetPeriod</td>
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<td>Period</td>
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<td>onsetRange</td>
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<td>Range</td>
<td></td>
</tr>
<tr>
<td>onsetString</td>
<td></td>
<td></td>
<td>string</td>
<td></td>
</tr>
<tr>
<td>abatement[x]</td>
<td>I</td>
<td>0.1</td>
<td></td>
<td>When in resolution/remission</td>
</tr>
<tr>
<td>abatementDateTime</td>
<td></td>
<td></td>
<td>dateTime</td>
<td></td>
</tr>
<tr>
<td>abatementAge</td>
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<td></td>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>abatementPeriod</td>
<td></td>
<td></td>
<td>Period</td>
<td></td>
</tr>
<tr>
<td>abatementRange</td>
<td></td>
<td></td>
<td>Range</td>
<td></td>
</tr>
<tr>
<td>abatementString</td>
<td></td>
<td></td>
<td>string</td>
<td></td>
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<tr>
<td>recordedDate</td>
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<td>dateTime</td>
<td>Who recorded the condition</td>
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<tr>
<td>recorder</td>
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<td>Reference(Practitioner</td>
<td>PractitionerRole</td>
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<tr>
<td>assertor</td>
<td>Z</td>
<td>0.1</td>
<td>Reference(Practitioner</td>
<td>PractitionerRole</td>
</tr>
<tr>
<td>stage</td>
<td>I</td>
<td>0.1</td>
<td>BackboneElement</td>
<td>Stage/grade, usually assessed formally</td>
</tr>
<tr>
<td>summary</td>
<td>I</td>
<td>0.1</td>
<td>CodeableConcept</td>
<td>Simple summary (disease specific)</td>
</tr>
</tbody>
</table>

Source: [https://www.hl7.org/fhir/patient.html](https://www.hl7.org/fhir/patient.html)
Sample Condition Resource

API request: https://r4.smarthealthit.org/Condition?patient=b2eeab29-a67d-4941-8540-6372911cfc17

03/17/2020
FHIR API Endpoints

https://open.epic.com

<table>
<thead>
<tr>
<th>Organization Name</th>
<th>Production FHIR Base URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access Community Health Network</td>
<td><a href="https://eprescribing.accesscommunityhealth.net/FHIR/api/FHIR/DSTU2/">https://eprescribing.accesscommunityhealth.net/FHIR/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>AdvantageCare Physicians</td>
<td><a href="https://epwebapps.acpny.com/FHIRproxy/api/FHIR/DSTU2/">https://epwebapps.acpny.com/FHIRproxy/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Adventist Health West</td>
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<tr>
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<td><a href="https://haiku-canto-produ.chmc.org/ARR-FHIR-PRD/api/FHIR/DSTU2/">https://haiku-canto-produ.chmc.org/ARR-FHIR-PRD/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Alameda Health System</td>
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<tr>
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<tr>
<td>Allina Health System</td>
<td><a href="https://webproxy.allina.com/FHIR/api/FHIR/DSTU2/">https://webproxy.allina.com/FHIR/api/FHIR/DSTU2/</a></td>
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<tr>
<td>AltaMed</td>
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<tr>
<td>Altru Health System</td>
<td><a href="https://epicsoap.altru.org/fhir/api/FHIR/DSTU2/">https://epicsoap.altru.org/fhir/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Anne Arundel Medical Center</td>
<td><a href="https://epicarr.sahs.org/fhir/api/FHIR/DSTU2/">https://epicarr.sahs.org/fhir/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Ardent</td>
<td><a href="https://epicproxy.ardenhealth.com/fhir/api/FHIR/DSTU2/">https://epicproxy.ardenhealth.com/fhir/api/FHIR/DSTU2/</a></td>
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<tr>
<td>Arkansas Children’s</td>
<td><a href="https://fhir.archildrens.org/fhir/api/FHIR/DSTU2/">https://fhir.archildrens.org/fhir/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Asante Health Systems</td>
<td><a href="https://epicmobile.asante.org/FHIR-PROD/api/FHIR/DSTU2/">https://epicmobile.asante.org/FHIR-PROD/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Ascension - Providence Healthcare Network</td>
<td><a href="https://stofo.providence-waco.org/FHIRProxy/api/FHIR/DSTU2/">https://stofo.providence-waco.org/FHIRProxy/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Ascension WI</td>
<td><a href="https://eprescribe.wfhc.org/FHIRProxy/api/FHIR/DSTU2/">https://eprescribe.wfhc.org/FHIRProxy/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Aspirus</td>
<td><a href="https://en.aspirus.org/FHIR/api/FHIR/DSTU2/">https://en.aspirus.org/FHIR/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Atlantic Health</td>
<td><a href="https://soapproxy.atlantichealth.org/FHIRPrd/api/FHIR/DSTU2/">https://soapproxy.atlantichealth.org/FHIRPrd/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Atrius Health</td>
<td><a href="https://atriusatriushealth.com/fhir/api/FHIR/DSTU2/">https://atriusatriushealth.com/fhir/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Aurora Health Care - myAurora</td>
<td><a href="https://EpicFHIR.aurora.org/FHIR/MYAURORA/api/FHIR/DSTU2/">https://EpicFHIR.aurora.org/FHIR/MYAURORA/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Austin Regional Clinic</td>
<td><a href="https://mobileprod.arcmd.com/FHIR/api/FHIR/DSTU2/">https://mobileprod.arcmd.com/FHIR/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Ballad Health</td>
<td><a href="https://soap.wellmont.org/FHIRPRD/api/FHIR/DSTU2/">https://soap.wellmont.org/FHIRPRD/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Baptist Health – KY &amp; IN</td>
<td><a href="https://epicproxy.bhsi.com/PRD-FHIR/api/FHIR/DSTU2/">https://epicproxy.bhsi.com/PRD-FHIR/api/FHIR/DSTU2/</a></td>
</tr>
<tr>
<td>Children’s Hospital Colorado</td>
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<tr>
<td>University of Colorado Health</td>
<td><a href="https://ssuch.edu/FHIRProxy/api/FHIR/DSTU2/">https://ssuch.edu/FHIRProxy/api/FHIR/DSTU2/</a></td>
</tr>
</tbody>
</table>

03/17/2020
FHIR Resources (R4)

- Patient
- Encounter
- Condition
- Observation
- Medication
- Procedure
- etc.

A set of building blocks to represent patient data
HL7® FHIR® Accelerator Program

FHIR-based API and Core Data Services

Consumer-directed exchange across the U.S.

Value-based care data exchange across communities

High-quality, computable data for cancer care and research

National standards for representing SDH data in EHRs

Source: https://www.hl7.org/about/fhir-accelerator/
SMART Health IT is an open, standards-based technology platform that enables innovators to create apps that seamlessly and securely run across the healthcare system.
Apps-based information economy

Adapted from *Cell Systems* 2015 1, 8-13, DOI: (10.1016/j.cels.2015.05.001)
Sample App Gallery

Featured

PatientTrak Text Messaging
PatientTrak Text Messaging allows text messages to be sent to a patient or family member's cell phone.

Telemed IQ
Request and manage virtual clinical support within the context of a patient encounter.

Found 33 results for FHIR

Krames On FHIR
Krames On FHIR StayWell

AppScript on FHIR
IQVIA

CIBMTR Reporting
CIBMTR Reporting Center for Internation...

Apple Health
Apple Inc.

EDTEK CONFORM™
Edtekt

SHERPA
SHERPA Komodo

Handley Hospital
Pediatric Emergency...

TrackMy Implants
TrackMy Solutions

Curbside Health
Curbside Health

CarePort Transition E...
CarePort Health

Sectra Web Banner
Sectra

Streamline Health® eValuator™
Streamline Health Inc.
App integration
1) A way to trigger the app

2) EHR embeds SMART on FHIR App for seamless integration

3) SMART on FHIR App retrieves patient information from FHIR Server

4) SMART on FHIR App loads decision aid tools based on patient conditions
Standalone Integration

Health System

FHIR Server  Web Server  API  Internet

A decision aid for **Implantable Cardioverter-Defibrillators (ICD)**
For patients with heart failure considering an ICD who are at risk for sudden cardiac death (primary prevention).

FAQ  Booklet  Video  Summary

What is an ICD?
CDS Sandbox with FHIR

1. HAPI-FHIR Server
2. clinFHIR Synthea
3. CDS Authoring Tool
4. CQL Engines
5. CDS Hooks
6. SMART on FHIR Apps

- Patient Data in FHIR
- Create Patient Profiles
- Create Rules Artifacts
- Process Rules and Data
- Trigger CDS
- External Apps

03/17/2020
CU-UCH R&D Environment

Stage 0: Planning
- Plan
  - Goals
  - Features
  - Feasibility

Stage 1: POC/Development
- Apply
  - Request access to POC/Dev Environment
  - Review
  - Approve
- Develop
  - Non-Production
  - Code
  - Synthetic Data

Stage 2: Testing
- Apply
  - Request access to Testing Environment
  - Review
  - Approve
- Test
  - Non-Production
  - Measure
  - EHR Data

Stage 3: Production
- Apply
  - Request access to Production Environment
  - Review
  - Approve
- Deploy
  - Production
  - Measure
  - EHR Data

Stage 4: Operational
- Maintain
  - Production
  - Monitoring

Stage 5: Commercial
- Commercial
  - Market
  - App Orchard
Clinical Research Informatics and Innovation Unit (CRIIU)

Lisa Schilling, MD, MSPH
Professor Dept of Medicine
Division of General Internal Medicine
lisa.schilling@cuanschutz.edu

Brainstorm
Consult
Builds/prototypes
Technical designs/methods for proposals
Help navigate the UCH Epic governance infrastructure
Scope of works
Budget drafts/budget justifications
LOS, Facilities and Resources
Policies and Technical Guidelines for App evaluation and approval

- Substitutable Medical Applications, Reusable Technologies (SMART)
- International Organization for Standardization (ISO)
- Open Web Application Security Project (OWASP)
- Epic System
- Android Developers
- Apple Developers
- University of Colorado Health System
Categories of Concern:

- Compatibility
- Data integrity
- Design and development
- Launch
- Legal responsibility
- Performance
- Privacy
- Reliability
- Safety
- Scalability
- Security
- Stability
- System integrity
- Updates
- Workflow
FAIR Data Principles

Wilkinson et al., 2016

• Findable:
  • F1. (meta)data are assigned a globally unique and persistent identifier
  • F2. data are described with rich metadata (defined by R1 below)
  • F3. metadata clearly and explicitly include the identifier of the data it describes
  • F4. (meta)data are registered or indexed in a searchable resource

• Accessible:
  • A1. (meta)data are retrievable by their identifier using a standardized communications protocol
    • A1.1 the protocol is open, free, and universally implementable
    • A1.2 the protocol allows for an authentication and authorization procedure, where necessary
  • A2. metadata are accessible, even when the data are no longer available

• Interoperable:
  • I1. (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.
  • I2. (meta)data use vocabularies that follow FAIR principles
  • I3. (meta)data include qualified references to other (meta)data

• Reusable:
  • R1. meta(data) are richly described with a plurality of accurate and relevant attributes
    • R1.1. (meta)data are released with a clear and accessible data usage license
    • R1.2. (meta)data are associated with detailed provenance
    • R1.3. (meta)data meet domain-relevant community standards
Closing the 17-year gap between scientific evidence and patient care

Newer tests and treatments are not always better and too much care can be bad for your health.

By Carole Divito | Jan 17 2017
This is How We Do it Now - Evidence Pathway

Evidence Source

Evidence Extraction

Evidence Use

RCT

Biomedical Knowledge Base

Clinical Practice Guidelines

Clinical Decision Support

Systematic Reviews

03/17/2020
Meeting FAIR Principles for Study Results?

...standard for machine-interpretable expression
...interoperability (every group communicating it needs to do it the same way, not their own way)
...universal agreement about the right way to do it
...functional demonstration of how it can be done
What If We Did it Like This? Evidence Pathway

Evidence Source

Evidence Extraction/Formatting

Interoperable Format

Computable Evidence

RCT Results

EBMonFHIR

Biomedical Knowledge Base

Clinical Practice Guidelines

Clinical Decision Support

Systematic Reviews

03/17/2020
EBMonFHIR Resources

<table>
<thead>
<tr>
<th>Name</th>
<th>Flags</th>
<th>Card</th>
<th>Type</th>
<th>Description &amp; Constraints</th>
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</thead>
<tbody>
<tr>
<td>Evidence</td>
<td></td>
<td></td>
<td>MetadataResource</td>
<td>Single evidence bit</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+ Warning: Name should be usable as an identifier for the module by machine processing applications such as code generation</td>
</tr>
<tr>
<td>url</td>
<td>I</td>
<td>0..1</td>
<td>uri</td>
<td>Canonical identifier for this evidence, represented as a globally unique URI</td>
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<td>Identifier</td>
<td>Additional identifier for the summary</td>
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<tr>
<td>version</td>
<td>I</td>
<td>0..1</td>
<td>string</td>
<td>Business version of this summary</td>
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<tr>
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<td>0..1</td>
<td>string</td>
<td>Name for this summary (human friendly)</td>
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<tr>
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<td>1..1</td>
<td>code</td>
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Source: https://confluence.hl7.org/display/CDS/EBMonFHIR
EBMonFHIR Resources