National Institutes of Health
Office of Data Science Strategy

Introduction to FHIR® for Research

National Institutes of Health (NIH),
Office of the Director (OD),
Office of Data Science Strategy (ODSS)

May 2, 2023

Webinar overview

1. Part 1: Introduction to FHIR® for Research (40 minutes)

   Learning objectives
   1. Understand FHIR®'s high level characteristics and how they are relevant for research
   2. Identify possible research applications for FHIR®
   3. Know the reasons why FHIR® has been broadly adopted in health IT, and how this impacts FHIR®'s research applications
   4. Understand how FHIR® fits into the ecosystem of other standards/data models

2. Part 2: FHIR® for Research Technical Overview (35 minutes)

   Learning objectives:
   1. Understand how FHIR® handles medical terminology to improve semantic interoperability
   2. Understand FHIR®'s approach to representing data with Resources, constraining rules, and extensions
   3. Understand FHIR®'s approach to accessing data via the FHIR® API

Part 1:
Introduction to FHIR® for Research

The HL7 FHIR Standard

FHIR® is a standard for exchanging health information electronically

Standards establish a common language and process for all health information technology (IT) systems to communicate, allowing information to be shared seamlessly and efficiently

F – **Fast** (to design & implement)

H – **Healthcare**

I – **Interoperability**

R – **Resources** (building blocks)

FHIR® is fast, efficient, and flexible

- **FREE** to use, open standard
- "Resources" → Solutions built from modular components called
- Customization is built into FHIR's design through extensions and profiling

https://hl7.org/fhir/r5/resourcelist.html

FHIR® R5 Resources (some)

Foundation

Conformance
- CapabilityStatement N
- StructureDefinition N
- ImplementationGuide 4
- SearchParameter 5
- MessageDefinition 1
- OperationDefinition N
- CompartmentDefinition 3
- StructureMap 4
- GraphDefinition 2

Terminology
- CodeSystem N
- ValueSet N
- ConceptMap 3
- NamingSystem 4
- TerminologyCapabilities 1

Security
- Provenance 4
- AuditEvent 4
- Permission 0
- Consent 2

Documents
- Composition 4
- DocumentReference 4

Other
- Basic 3
- Binary N
- Bundle N
- Linkage 0
- MessageHeader 4
- OperationOutcome N
- Parameters N
- Subscription 3
- SubscriptionStatus 2
- SubscriptionTopic 2

Base

Individuals
- Patient N
- Practitioner 5
- PractitionerRole 4
- RelatedPerson 5
- Person 4
- Group 3

Entities #1
- Organization 5
- OrganizationAffiliation 1
- HealthcareService 4
- Endpoint 2
- Location 5

Entities #2
- Substance 2
- BiologicallyDerivedProduct 2
- Device 2
- DeviceMetric 1
- NutritionProduct 1

Workflow
- Task 3
- Transport 1
- Appointment 3
- AppointmentResponse 3
- Schedule 3
- Slot 3
- VerificationResult 1

Management
- Encounter 4
- EncounterHistory 0
- EpisodeOfCare 2
- Flag 1
- List 4
- Library 4

Clinical

Summary
- AllergyIntolerance 3
- AdverseEvent 2
- Condition (Problem) 5
- Procedure 4
- FamilyMemberHistory 2
- ClinicalImpression 1
- DetectedIssue 2

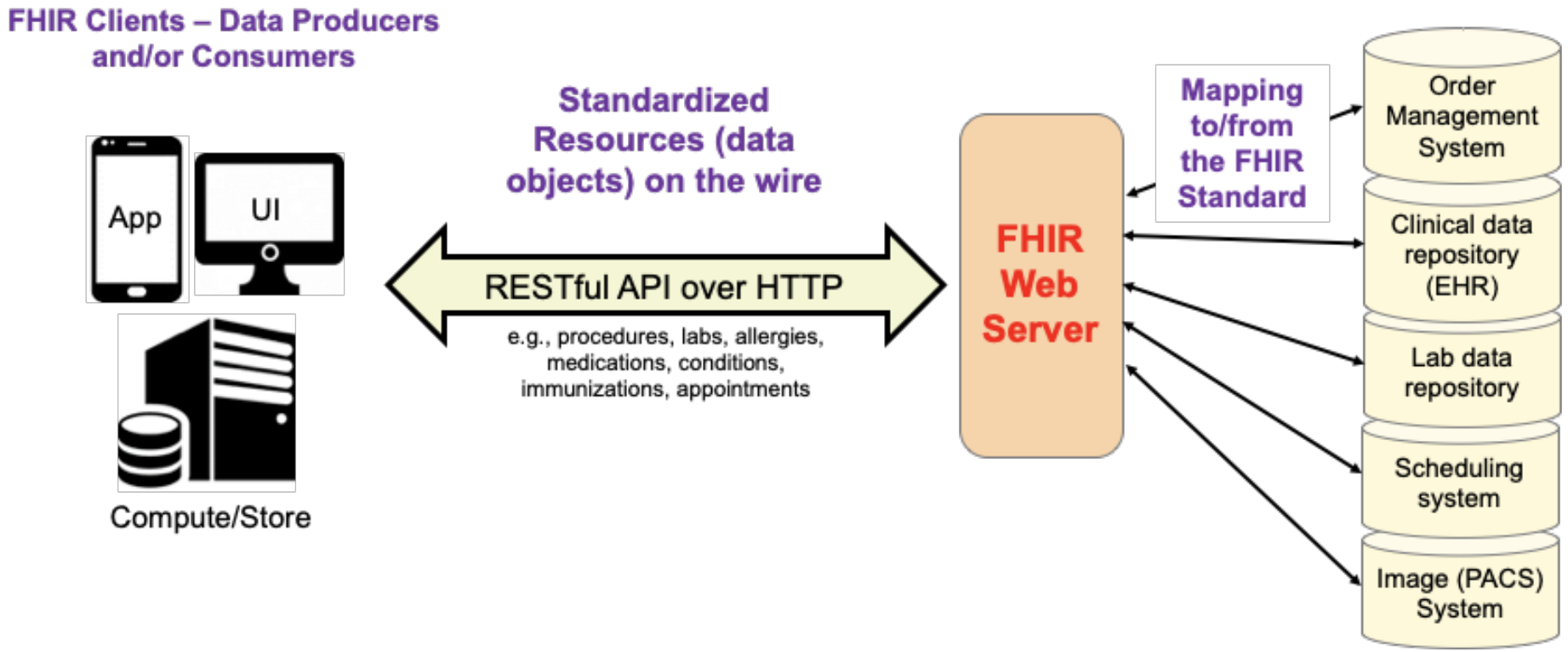
Diagnostics
- Observation N
- DocumentReference 4
- DiagnosticReport 3
- Specimen 2
- BodyStructure 1
- ImagingSelection 1
- ImagingStudy 4
- QuestionnaireResponse 5
- MolecularSequence 1
- GenomicStudy 0

Medications
- MedicationRequest 4
- MedicationAdministration 2
- MedicationDispense 2
- MedicationStatement 4
- Medication 4
- MedicationKnowledge 1
- Immunization 5
- ImmunizationEvaluation 1
- ImmunizationRecommendation 1
- FormularyItem 0

Care Provision
- CarePlan 2
- CareTeam 2
- Goal 2
- ServiceRequest 4
- NutritionOrder 2
- NutritionIntake 1
- VisionPrescription 3
- RiskAssessment 2
- RequestOrchestration 4

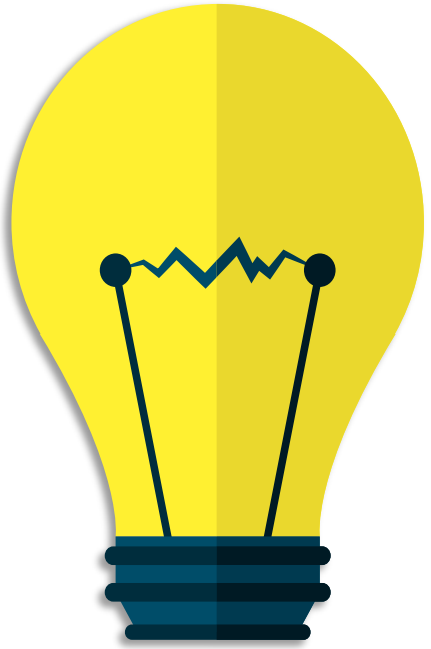
Request & Response
- Communication 2
- CommunicationRequest 2
- DeviceRequest 1
- DeviceDispense 0
- DeviceAssociation 0
- DeviceUsage 1
- BiologicallyDerivedProductDispense 0
- GuidanceResponse 2
- SupplyRequest 1
- SupplyDelivery 1
- InventoryItem 0

FHIR® Information Flow



PACS – Picture Archive and Communication System

Genesis of FHIR®



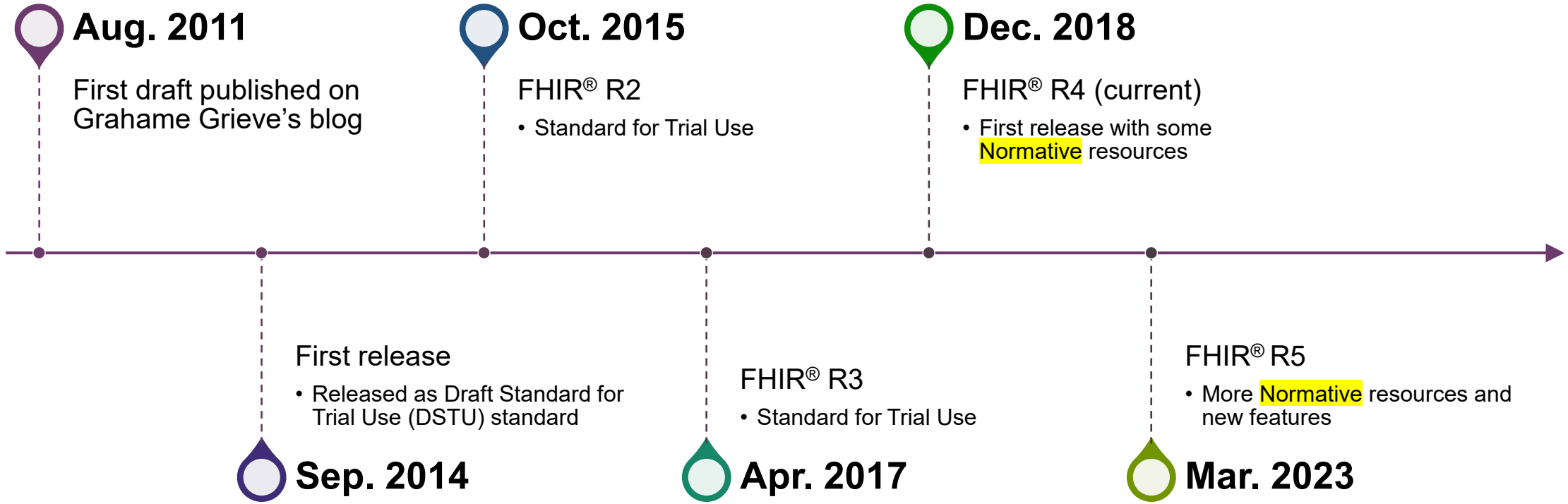
The Catalyst

- HL7 V2 is a point-to-point messaging standard that is over 30 years old
- HL7 V3 is very complex, not widely implemented
- Pressure to broaden scope of data sharing
    - More flexible sharing across institutions, borders, domains
    - Mobile & cloud-based applications

The Benefits of HL7 FHIR®

- Promotes cross-industry standards
- Uses the same technologies already used across the tech industry
    - JSON and XML
    - HTTPS and RESTful interfaces
    - OAuth2 and OpenID Connect
- Supported by existing software tools
- Easier to understand by technical end-users

Timeline of FHIR® releases



Note: R2, R3, R4, and R5 are updated versions of the FHIR® standard

FHIR® for Research Examples

Published Research Using FHIR® Examples

1. Clinical trial case report forms
   - Cheng, A.C. *et al.* (2023) 'Evaluating automated electronic case report form data entry from electronic health records', *Journal of Clinical and Translational Science*, 7(1), p. e29. Available at: https://doi.org/10.1017/cts.2022.514.
2. Portable phenotyping for cohort definition
   - Brandt, P.S. *et al.* (2022) 'Design and validation of a FHIR-based EHR-driven phenotyping toolbox', *Journal of the American Medical Informatics Association: JAMIA*, 29(9), pp. 1449–1460. Available at: https://doi.org/10.1093/jamia/ocac063.
3. Integrate patient-reported data into an EHR
   - Lobach, D.F. *et al.* (2022) 'Integrating a Patient Engagement App into an Electronic Health Record-Enabled Workflow Using Interoperability Standards', *Applied Clinical Informatics*, 13(5), pp. 1163–1171. Available at: https://doi.org/10.1055/s-0042-1758736.
4. Clinical decision support integration into EHRs
   - Tarumi, S. *et al.* (2021) 'Leveraging Artificial Intelligence to Improve Chronic Disease Care: Methods and Application to Pharmacotherapy Decision Support for Type-2 Diabetes Mellitus', *Methods of Information in Medicine*, 60(S 01), pp. e32–e43. Available at: https://doi.org/10.1055/s-0041-1728757.

Links to references: https://purl.org/fhir-for-research/2023-05-refs

Clinical Trial Case Report Forms

Cheng 2023:

- EHR to CRF using FHIR
  for 40 patients in COVID
  trial at Vanderbilt
- FHIR® populated
  10,081/11,952 (84%) of
  values with 89%
  concordance with humar
  entry (often due to data
  entry error)

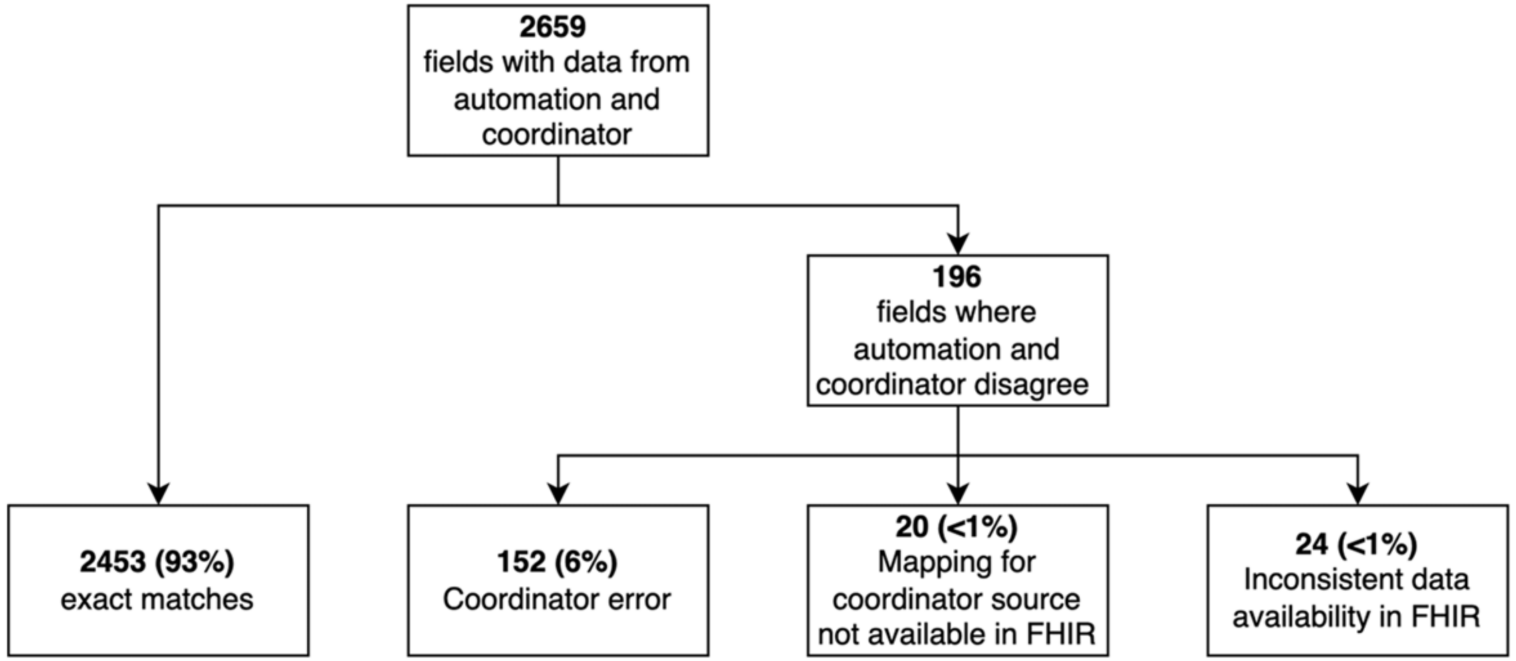


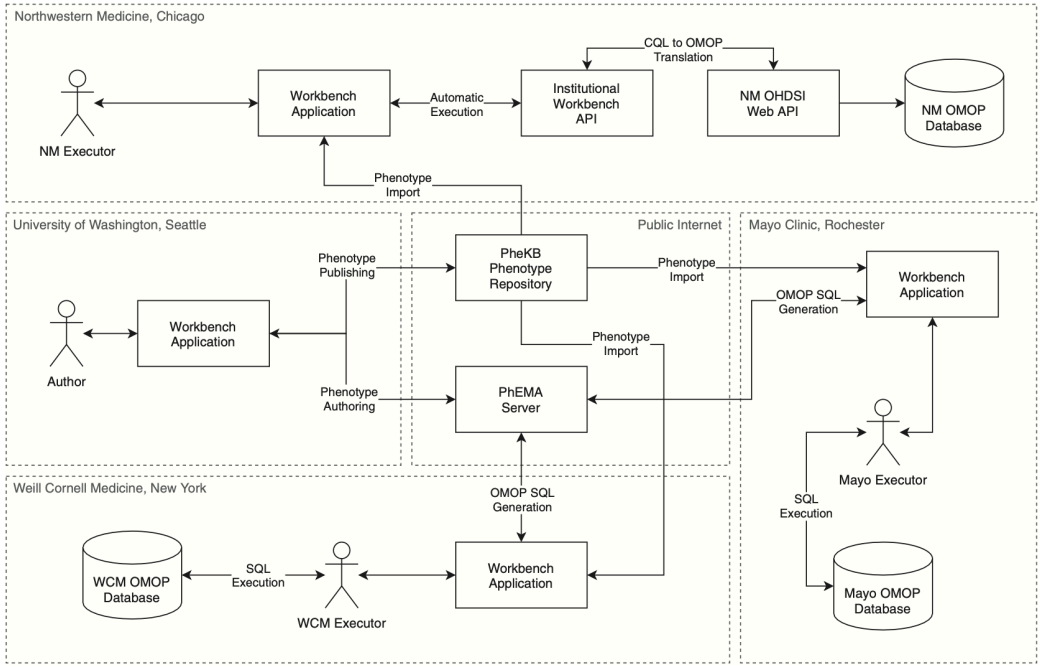
Fig. 1. Summary of data concordance for the first 10 participants in the trial at Vanderbilt University Medical Center. FHIR, Fast Healthcare Interoperability Resources.

Cheng, A.C. *et al.* (2023) 'Evaluating automated electronic case report form data entry from electronic health records', *Journal of Clinical and Translational Science*, 7(1), p. e29. Available at: https://doi.org/10.1017/cts.2022.514.

Portable Phenotyping for Cohort Definitions

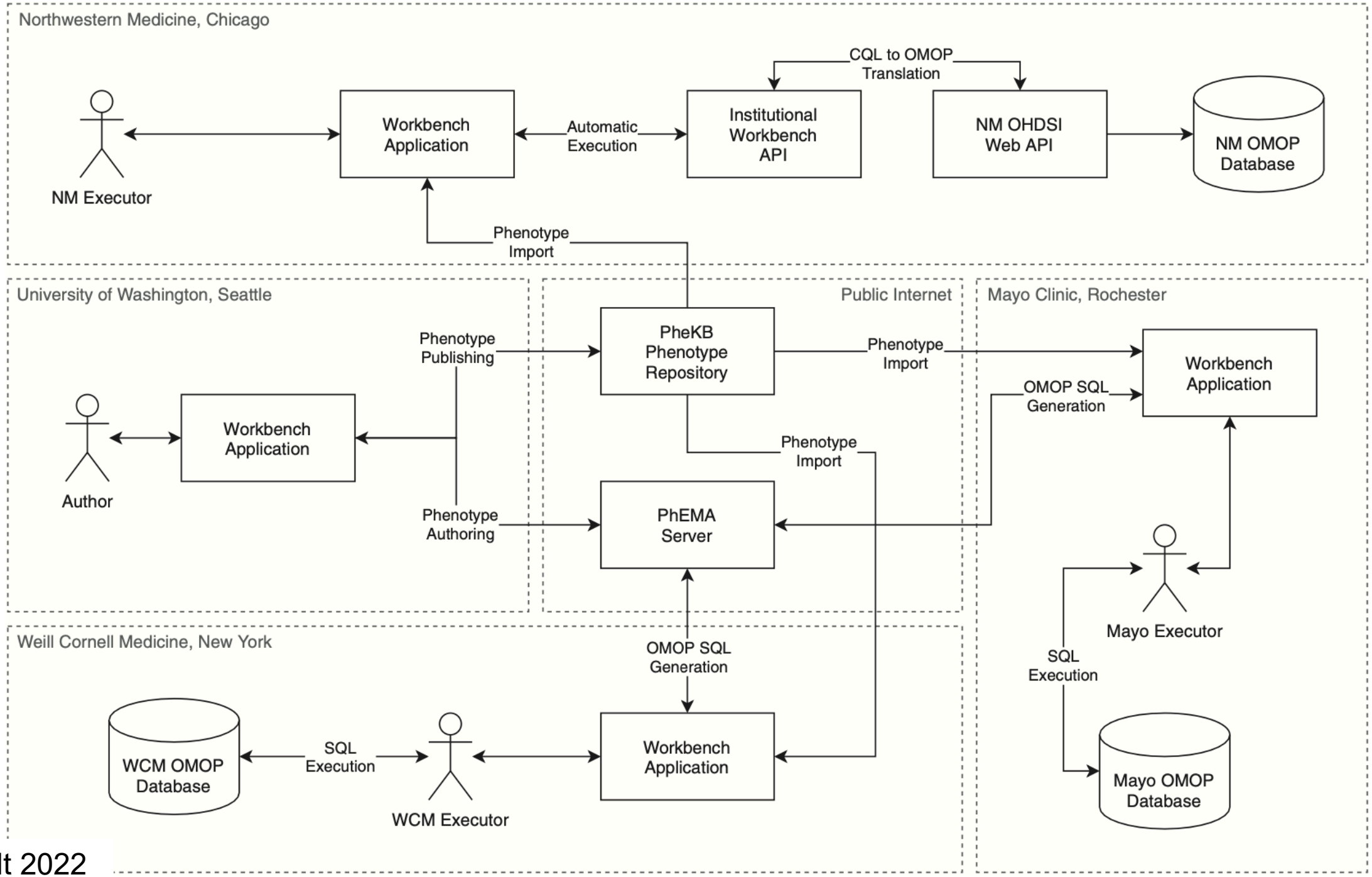
Brandt 2022:

- FHIR®/CQL phenotype definitions
- Validated at 3 institutions (Mayo, Northwestern, Weill Cornell)
  - Used OMOP with FHIR® /CQL → OMOP query translation tool
  - Leverages existing FHIR® /CQL → [other] mappings



(enlarged on next slide)

Brandt, P.S. *et al.* (2022) 'Design and validation of a FHIR-based EHR-driven phenotyping toolbox', *Journal of the American Medical Informatics Association: JAMIA*, 29(9), pp. 1449–1460. Available at: https://doi.org/10.1093/jamia/ocac063.

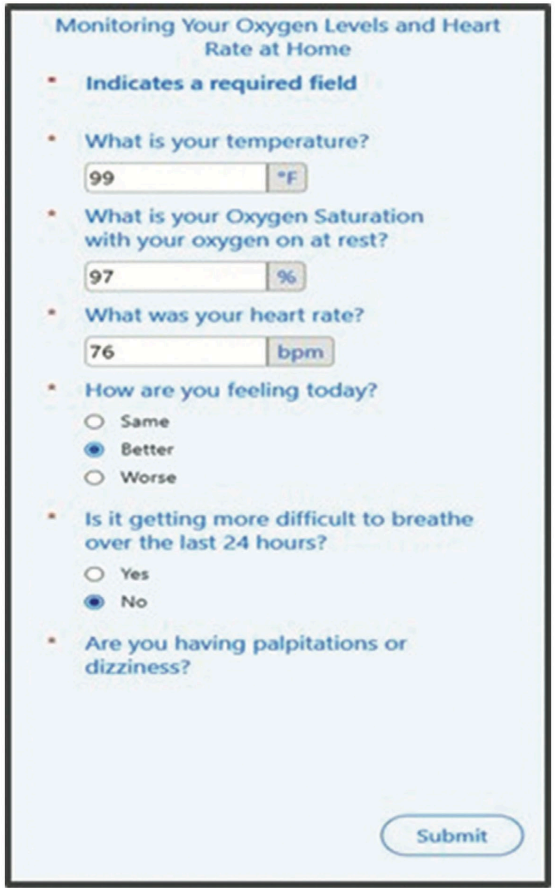

Northwestern Medicine, Chicago
CQL to OMOP Translation
Workbench Application
Automatic Execution
Institutional Workbench API
NM OHDSI Web API
NM OMOP Database
NM Executor
Phenotype Import
University of Washington, Seattle
Public Internet
Mayo Clinic, Rochester
Phenotype Publishing
PheKB Phenotype Repository
Phenotype Import
Workbench Application
OMOP SQL Generation
Workbench Application
Author
Phenotype Import
Phenotype Authoring
PhEMA Server
Mayo Executor
SQL Execution
Mayo OMOP Database
Weill Cornell Medicine, New York
OMOP SQL Generation
WCM OMOP Database
SQL Execution
Workbench Application
WCM Executor

Brandt 2022

Integrate Patient-Reported Data

Lobach 2022:

- Integrated patient mobile application for COVD-19 symptom tracking with Yale EHR
- Successfully recorded patient-reported data (e.g. oxygen saturation) into EHR
- Paper discusses IT challenges and their solutions



Lobach, D.F. *et al.* (2022) 'Integrating a Patient Engagement App into an Electronic Health Record-Enabled Workflow Using Interoperability Standards', *Applied Clinical Informatics*, 13(5), pp. 1163–1171. Available at: https://doi.org/10.1055/s-0042-1758736.

Clinical Decision Support (CDS)

Tarumi 2021:

- AI predicted likelihood of alternate treatment strategy success for T2DM
- CDS recommendations provided via SMART on FHIR® integration with EHR (Univ. of Utah)

T2DM = type-2 diabetes mellitus

Tarumi, S. *et al.* (2021) 'Leveraging Artificial Intelligence to Improve Chronic Disease Care: Methods and Application to Pharmacotherapy Decision Support for Type-2 Diabetes Mellitus', *Methods of Information in Medicine*, 60(S 01), pp. e32–e43. Available at: https://doi.org/10.1055/s-0041-1728757.

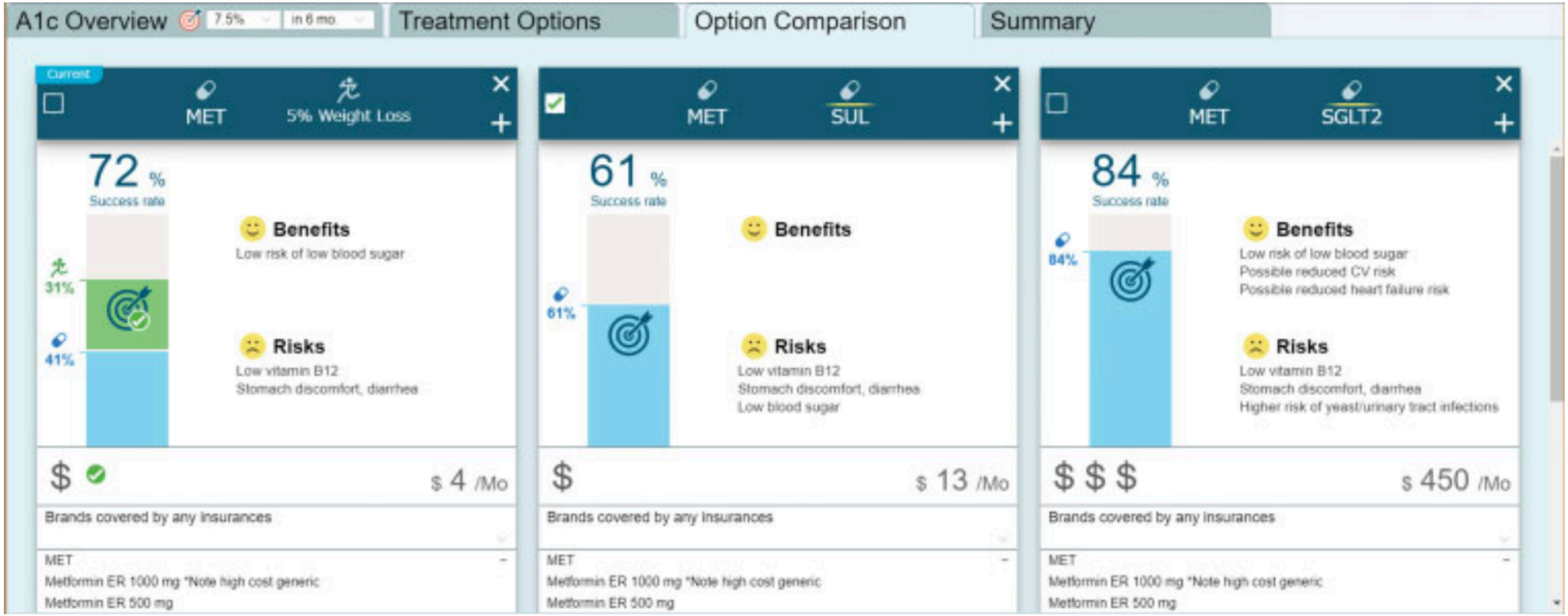


Fig. 8 Options comparison tab in the dashboard: The clinician and patient can review potential treatment options in detail using this view. Comparative data are provided for three treatment options. The “success rate” shows the predicted probability of treatment success for each potential treatment regimen. The effect of 5% body weight loss is also shown for the current medication regimen. The predictions are specific to the current patient and are based on the various data points that have been pulled in from the EHR. Clinicians and patients can also review the benefits and risks of each medication option. In addition, cost information is provided, including the National Average Drug Acquisition Cost. The patient’s insurance information is pulled in from the EHR, and coverage information specific to the patient’s insurance is provided (All synthetic data). EHR, electronic health record.

Additional References of Interest

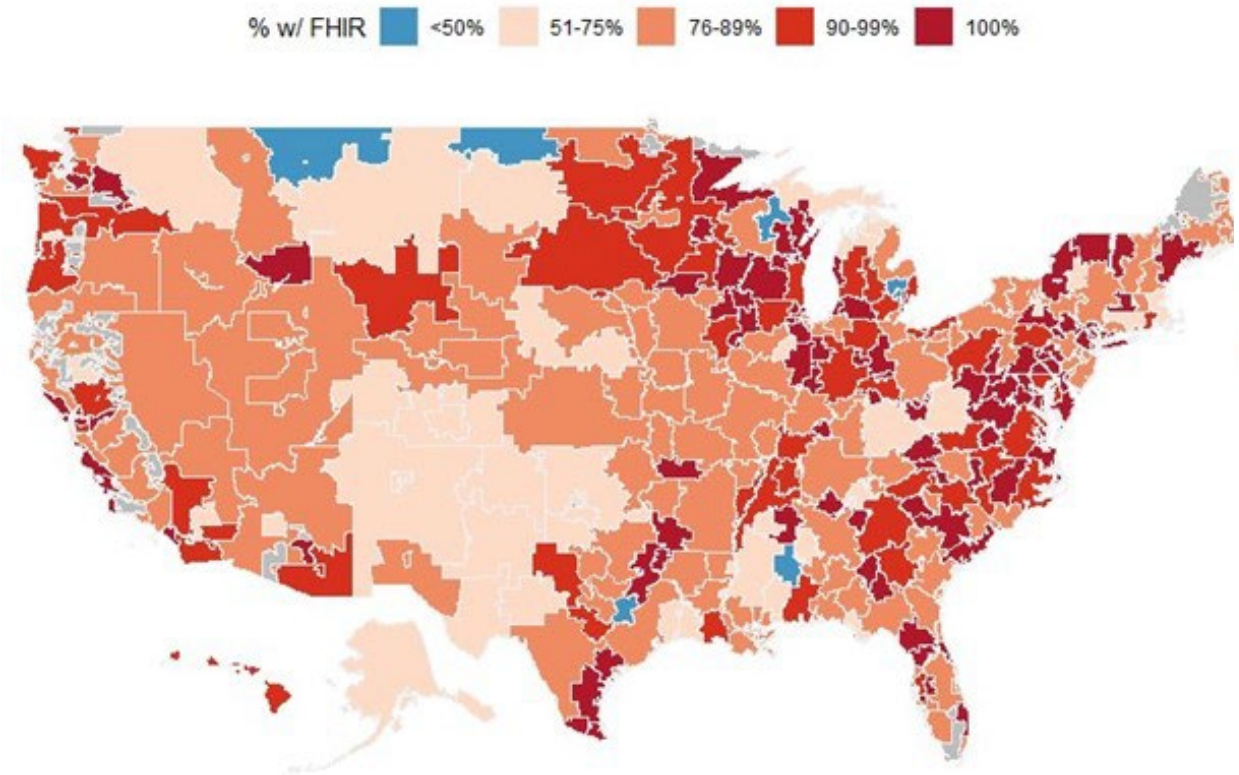
- **Clinical trial case report forms:** Zong, N. *et al.* (2021) 'Modeling cancer clinical trials using HL7 FHIR to support downstream applications: A case study with colorectal cancer data', *International Journal of Medical Informatics*, 145, p. 104308. Available at: https://doi.org/10.1016/j.ijmedinf.2020.104308.
- **Patient data:** Wesley, D.B. *et al.* (2021) 'A novel application of SMART on FHIR architecture for interoperable and scalable integration of patient-reported outcome data with electronic health records', *Journal of the American Medical Informatics Association : JAMIA*, 28(10), pp. 2220–2225. Available at: https://doi.org/10.1093/jamia/ocab110.
- **CDS using FHIR® (review):** Strasberg, H.R. *et al.* (2021) 'Contemporary clinical decision support standards using Health Level Seven International Fast Healthcare Interoperability Resources', *Journal of the American Medical Informatics Association : JAMIA*, 28(8), pp. 1796–1806. Available at: https://doi.org/10.1093/jamia/ocab070.

All References:

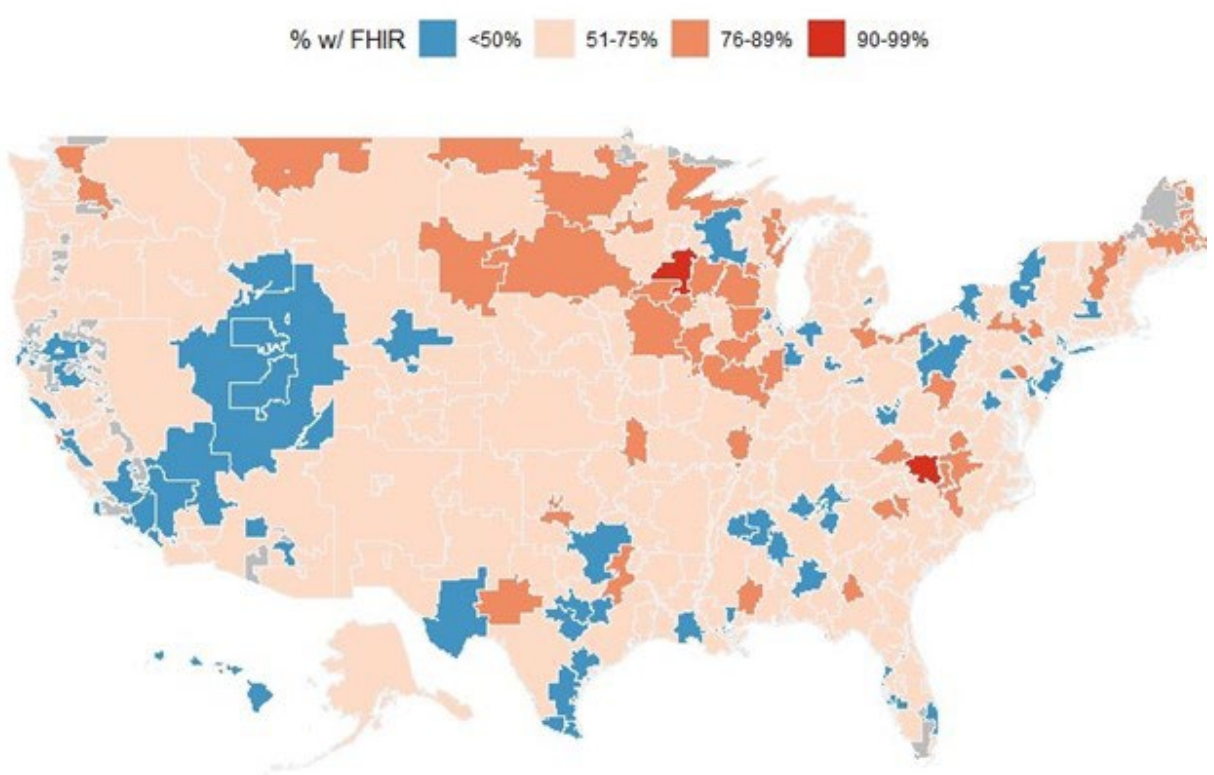
https://purl.org/fhir-for-research/2023-05-refs

Current State of FHIR® Adoption

As a Researcher, this is where your FHIR® data might come from [2019 data]...



Hospitals



Clinicians

87% OF HOSPITALS AND 69% OF MIPS ELIGIBLE CLINICIANS USE EHRS CERTIFIED TO HL7 FHIR®

SOURCE: https://www.healthit.gov/buzz-blog/interoperability/heat-wave-the-u-s-is-poised-to-catch-fhir-in-2019

Driving FHIR® Adoption

- ONC 21st Century Cures Act (“Cures Act”)
  - ONC = The Office of the National Coordinator for Health Information Technology, https://healthit.gov
- The Cures Act supports seamless and secure access to health information
  - As part of this, ONC added interoperability criteria to the existing 2015 Health IT Certification Program
- Health IT Certification Program is voluntary, but CMS provides a financial incentive (https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/Certification)

2016: 21st Century Cures Act

- Sec. 4002. Transparent Reporting on Usability, Security, and Functionality
  - Certification requires publishing an API
- Sec. 4003. Interoperability
  - Has ONC assist public-private partnerships to create a “trusted exchange framework, including a common agreement among health information networks nationally”
- Sec. 4004. Information Blocking
  - Defines “information blocking” as a practice that (accept as required by law) “is likely to interfere with, prevent, or materially discourage access, exchange, or use of health information”
- Sec. 4005. Leveraging Electronic Health Records to Improve Patient Care
- Sec. 4006. Empowering Patients and Improving Patient Access to their Electronic Health Information

http://www.himss.org/library/summary-key-health-it-provisions-21st-century-act-passed-house-11302016

A Patient-Centric Approach to Interoperability

From HealthIT.gov:

The Patient at the Center

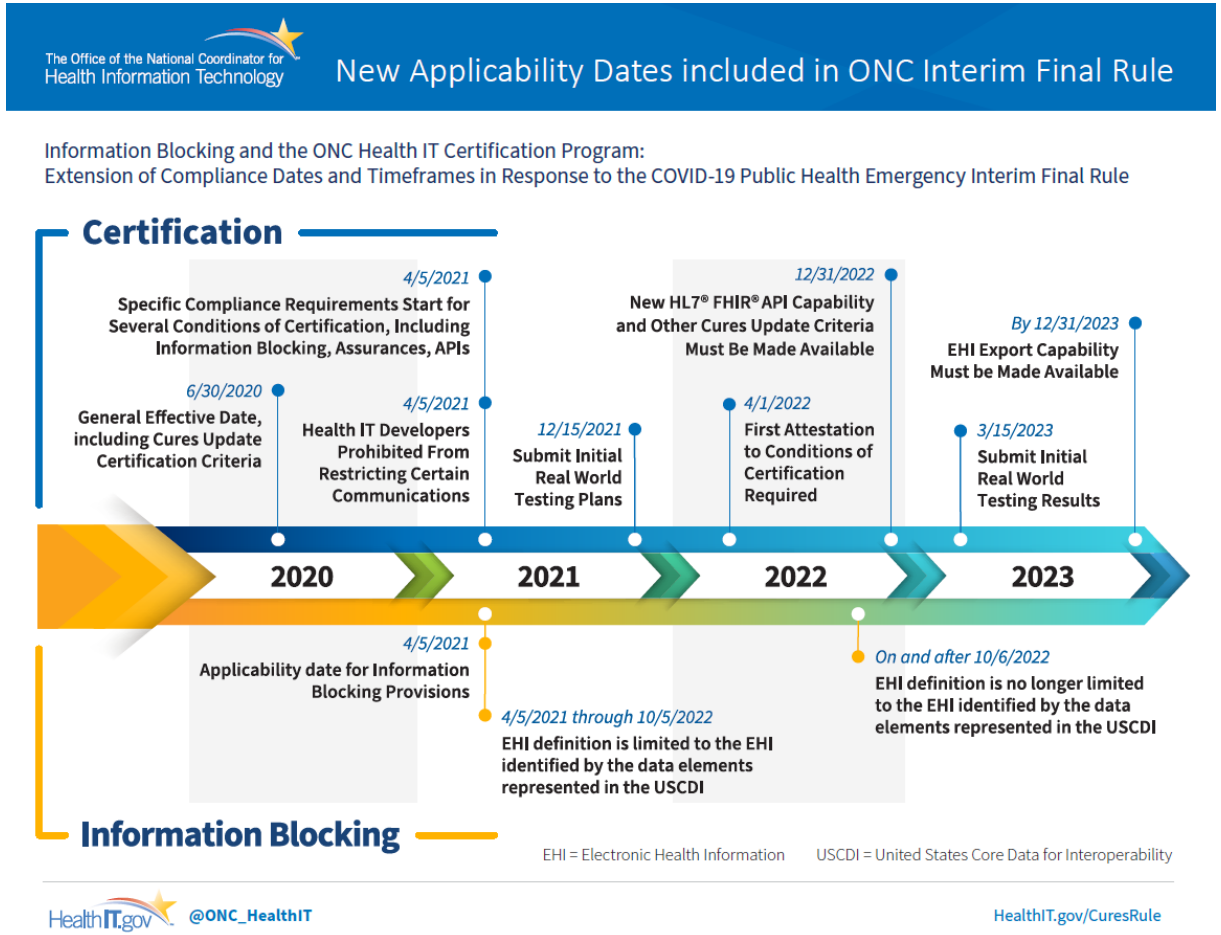
When this Cures Act Final Rule is fully implemented, putting the patient first means that health information technology should:

- Enable patients to make choices that work for them by increasing transparency into the cost and outcomes of care
- Allow patients to shop for and understand their options in getting medical care
- Provide patients with convenient, easy access and visualizations of health information through smartphone apps
- Support an “app economy” that provides innovation and choice to patients, physicians, hospitals, payers, and employers

https://www.healthit.gov/curesrule/

Timeline for Implementation of Interoperability Standards

- **USCDI – 4/2021**
- **FHIR® API – 12/2022**
- **FHIR® Bulk Export – 12/2023**



US FHIR® Core Profile

- Profiles 23 FHIR® resources specifically for the US healthcare market
- US Core is driven by and interacts with United States Core Data for Interoperability (USCDI)
- **USCDI** is a standardized set of health data for nationwide, interoperable health information exchange
- ONC Cures Act requires as a condition of certification that EHRs adopt the USCDI standard, a "standardized API for patient and population services," which includes an initial set of 16 data classes comprised of 52 data elements
    - **USCDI Data Element**: most granular level at which a piece of data is represented for exchange
    - **USCDI Data Class**: data elements grouped by common theme or use case
- Initial US Core ballot occurred in 2021 and subsequent ballots to update US Core occurs every January beginning in 2022
- US-based FHIR® Implementation Guides should use US Core Profiles as building blocks when possible

FHIR’s Fit With Other Standards

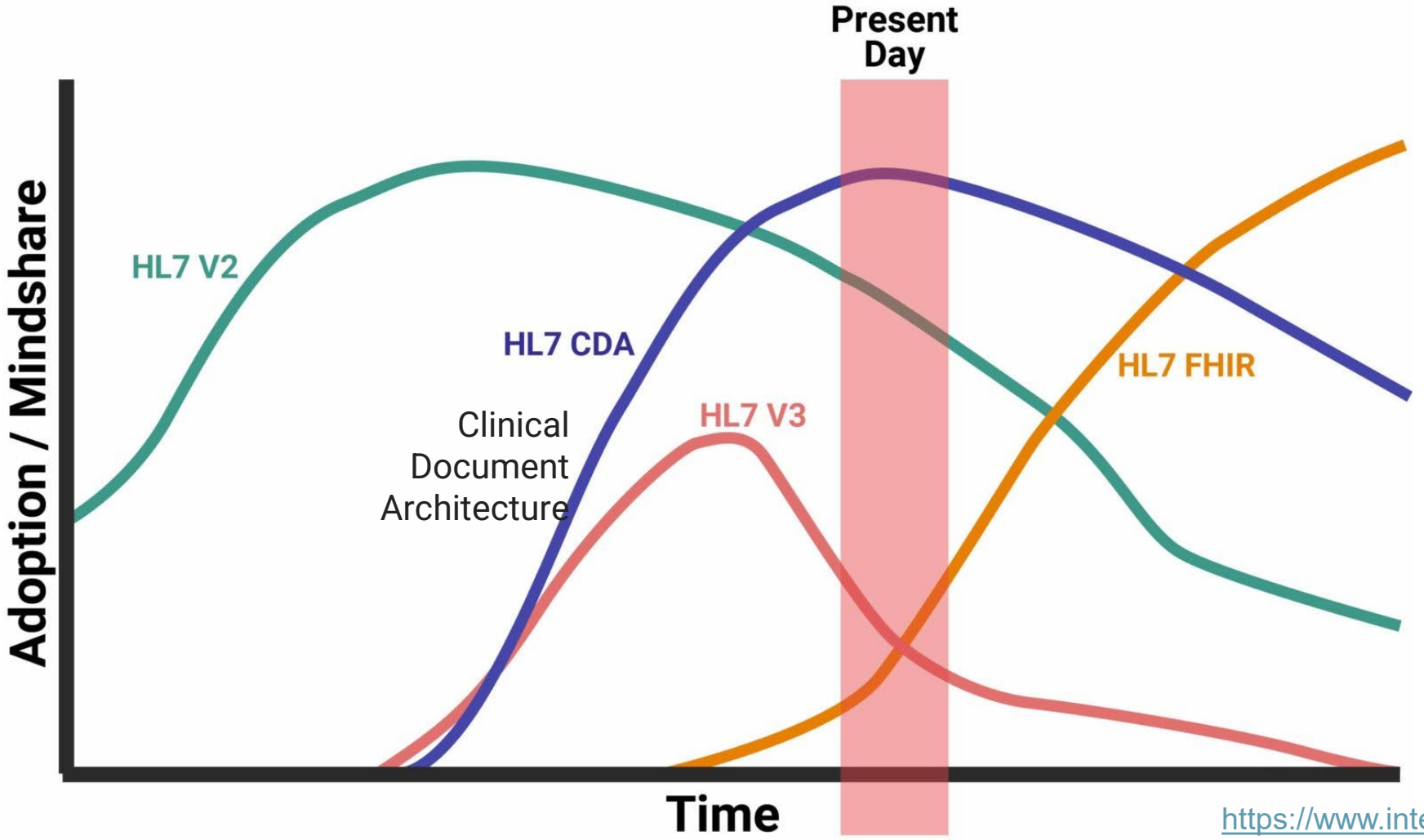
Evolution of Healthcare Standards

- **HL7 V2**
  - Allows for simple transfer of information
  - Point-to-point messaging
  - More complex interactions are not supported

- **HL7 V3 / Clinical Document Architecture (CDA)**
  - Intended to enable next level of complexity
  - Interface specification based on Simple Object Access Protocol (SOAP) and XML
    - Specifies the ***content of the data*** exchanged between healthcare applications, and ***how the exchange is implemented*** and managed
  - Very complex - difficult to implement and requires tremendous technical expertise

- **HL7 FHIR®**
  - Most commonly used standard in healthcare today
  - Specification based on current mobile web technologies
  - Developers can read documentation and get up to speed quickly
  - Messaging, Documents, and Query
  - Easily create rich and complex applications, particularly mobile applications

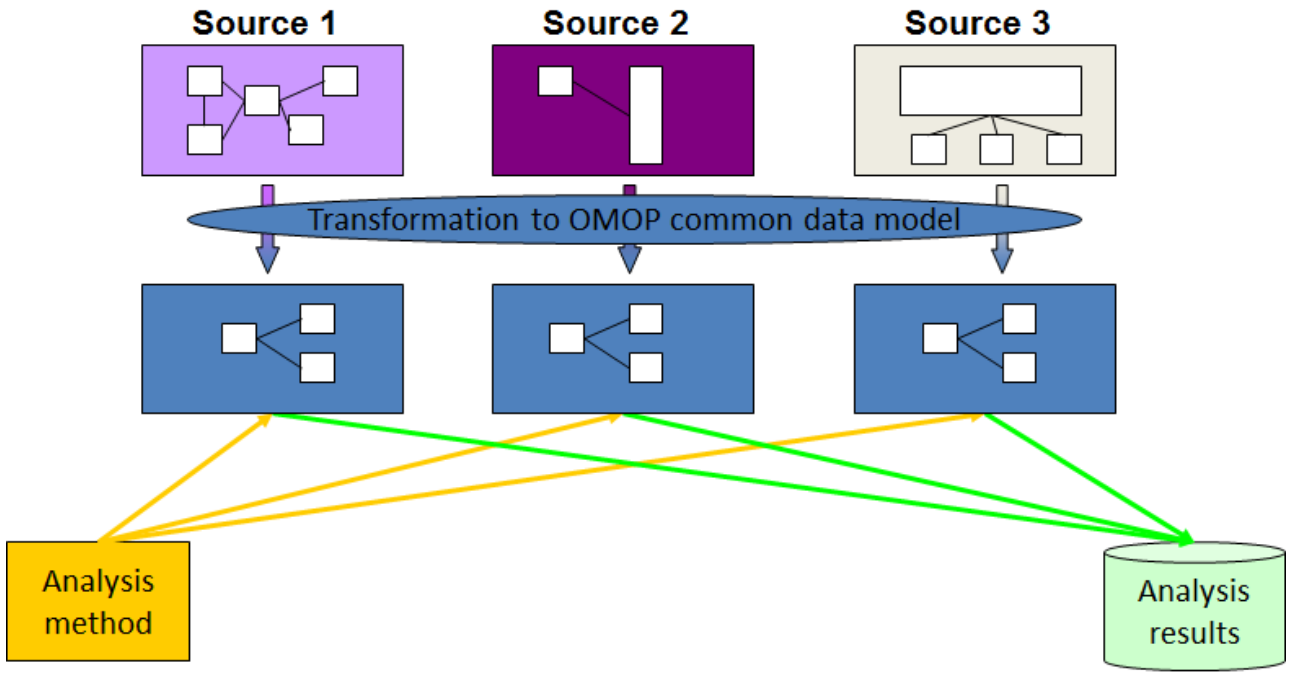
FHIR® vs. Other Standards



https://www.intersystems.com/fhir/

OMOP

- Observational Health Data Sciences and Informatics (OHDSI)
- Observation Medical Outcomes Partnership (OMOP)
- OMOP Common Data Model (CDM)



https://www.ohdsi.org/data-standardization/the-common-data-model/

National COVID Cohort Collaborative

https://covid.cd2h.org/n3c

Example: OMOPonFHIR

- Georgia Tech's FHIR® and OMOP CDM mapping platform
- Supports mapping between versions of FHIR® and OMOP CDM
- Bidirectional read and write capabilities for FHIR® versions DSTU2, STU3, R4 and OMOP CDM v.5.3.1 and v6.0
- **OMOP to FHIR®**
  - Retrieval of relational data stored in OMOP CDM as FHIR® Resources
  - Standard FHIR® queries are translated into SQL queries to be performed on the OMOP CDM database
  - The data is mapped and converted into FHIR® Resources
- **FHIR® to OMOP**
  - Allows users to post FHIR® Resources to the server
  - Resources are mapped and written to the OMOP CDM relational database
  - https://omoponfhir.org

Summary

- FHIR® is an open standard for exchanging health data that is widely adopted and has untapped potential to enable/accelerate research.
- FHIR® *may* be useful for research touching EHR data
  - Integration with clinical workflows (CDS, patient-reported data)
  - Extracting data (e.g., clinical trial case report forms)
  - Phenotyping (e.g., multi-site cohort building)
- FHIR® is overtaking older standard (V2, V3) in adoption
- FHIR® peacefully coexists with research CDMs like OMOP
- More information: https://purl.org/fhir-for-research/web

Part 2:
FHIR® for Research Technical Overview

Outline

1. Terminology and FHIR® [10 min]
2. FHIR® resources and profiles [15 min]
3. Using FHIR® with other systems [10 min]

Terminology and FHIR®

Importance of Terminology

- Using standard terminologies allows researchers to access, exchange, organize, and utilize health data in a consistent and reliable way.
  - e.g., standardized terminology to identify conditions in a problem list → automated cohort building based on presence/absence of conditions
- Common code systems: LOINC, SNOMED CT, ICD, RxNorm
- FHIR® supports:
  - Defining code systems
  - Mapping between them
  - “Binding” a FHIR® data element to a specific subset of concepts from selected code systems

Example: Patients in FHIR®

Name	Flags	Card.	Type	Description & Constraints
Patient	N		DomainResource	Information about an individual or animal receiving health care services Elements defined in Ancestors: id, meta, implicitRules, language, text, contained, extension, modifierExtension
identifier	Σ	0..*	Identifier	An identifier for this patient
active	?! Σ	0..1	boolean	Whether this patient's record is in active use
name	Σ	0..*	HumanName	A name associated with the patient
telecom	Σ	0..*	ContactPoint	A contact detail for the individual
gender	Σ	0..1	code	male | female | other | unknown Binding: AdministrativeGender (Required)
birthDate	Σ	0..1	date	The date of birth for the individual
deceased[x]	?! Σ	0..1		Indicates if the individual is deceased or not
deceasedBoolean			boolean	
deceasedDateTime			dateTime	
address	Σ	0..*	Address	An address for the individual
maritalStatus		0..1	CodeableConcept	Marital (civil) status of a patient Binding: Marital Status Codes (Extensible)

https://www.hl7.org/fhir/R5/patient.html

Patient.maritalStatus binding

https://www.hl7.org/fhir/R5/valueset-marital-status.html:

Code	Display	Definition	System
A	Annulled	Marriage contract has been declared null and to not have existed	http://terminology.hl7.org/CodeSystem/v3-MaritalStatus
D	Divorced	Marriage contract has been declared dissolved and inactive	http://terminology.hl7.org/CodeSystem/v3-MaritalStatus
I	Interlocutory	Subject to an Interlocutory Decree.	http://terminology.hl7.org/CodeSystem/v3-MaritalStatus
L	Legally Separated		http://terminology.hl7.org/CodeSystem/v3-MaritalStatus
M	Married	A current marriage contract is active	http://terminology.hl7.org/CodeSystem/v3-MaritalStatus
…	…	…	…

Patient.maritalStatus, continued

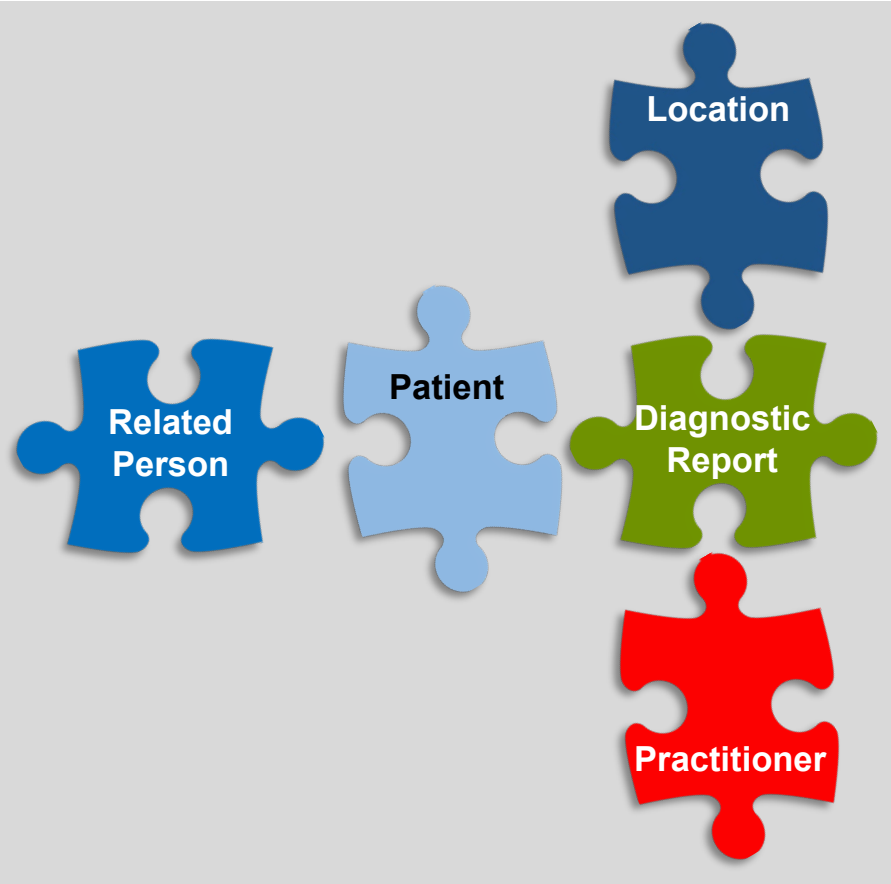
- FHIR® identifies
  1. "Value set" list of possible codes: https://www.hl7.org/fhir/valueset-marital-status.html
  2. "Code system(s)" that these codes come from: http://terminology.hl7.org/CodeSystem/v3-MaritalStatus or http://terminology.hl7.org/CodeSystem/v3-NullFlavor for ("UNK" = unknown)
  3. Binding strength: "extensible"
     - If a code in the specified value set represents the concept, then that code **must** be used. Otherwise, a different code can be used.
     - Other binding strengths: required, preferred, example
     - Definitions: https://www.hl7.org/fhir/terminologies.html#strength
- "Engaged" not represented in value set, so ok to use other code
  - e.g., SNOMED CT concept 54986009 "Engaged to be married (finding)"

Implications for Research

- FHIR® describes where “marital status” is stored (Patient.maritalStatus) and how it is encoded (using terminology, with a preference for a specific set of codes)
- Need to limit this further? You can with a FHIR profile.
- Need to identify a custom selection of codes? You can with a FHIR® ValueSet.
- Need to translate between different code systems? You can with a FHIR® ConceptMap.

FHIR® resources and profiles

Resources are the Building Blocks of FHIR®



Source: Introduction to FHIR® – Grahame Grieve

- Resources act as customizable templates within a general framework
  - Designed to be very flexible to provide structure to address many common use cases
  - Almost everything is optional, even critical information like name, gender, birth date, address
  - Resources, by themselves, are often not useful; Profiles and Extensions supplement existing resources
- Researchers can "Bundle" together any combination of the 157 FHIR® resources (e.g., Patient, Diagnostic Report, Practitioner, Location) with Profiles and/or Extensions to transmit only select information from a large amount of data (e.g., an electronic health record [EHR])

What's a Resource?

FHIR® R5 has 157 resources

Examples

Administrative

Patient, Practitioner, Organization, Location, Coverage, Claim

Clinical Concepts

Allergy Intolerance, Condition, Family Member History, Care Plan

Infrastructure

Document, Composition, Message, Profile, Capability Statement

Non-examples

Patient Name

Too small

Electronic Health Record

Too big

Blood Pressure

Too specific

Intervention

Too broad

Example: Patients in FHIR

Name	Flags	Card.	Type	Description & Constraints
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telecom	Σ	0..*	ContactPoint	A contact detail for the individual
gender	Σ	0..1	code	male | female | other | unknown Binding: AdministrativeGender (Required)
birthDate	Σ	0..1	date	The date of birth for the individual
deceased[x]	?! Σ	0..1		Indicates if the individual is deceased or not
deceasedBoolean			boolean	
deceasedDateTime			dateTime	
address	Σ	0..*	Address	An address for the individual
maritalStatus		0..1	CodeableConcept	Marital (civil) status of a patient Binding: Marital Status Codes (Extensible)

https://www.hl7.org/fhir/R5/patient.html

FHIR® Profiles

- Resources are the basic building block of the FHIR® Specification
  - Defines how data is to be structured and exchanged
  - Intended to be generic to fit a wide range of use cases
- Profiles adjust Resources for a specific use case
  - Can both restrict and extend APIs, Resources, Terminology
  - Required elements (cardinality) and ‘Must Support’
  - Specify a value set
- Profiles are typically published in an Implementation Guide

Example US Core Patient Profile

Name	Flags	Card.	Type	Description & Constraints
Patient		0..*	Patient	Information about an individual or animal receiving health care services
us-core-race		0..1	(Complex)	US Core Race Extension **URL:** http://hl7.org/fhir/us/core/StructureDefinition/us-core-race
us-core-ethnicity		0..1	(Complex)	US Core ethnicity Extension **URL:** http://hl7.org/fhir/us/core/StructureDefinition/us-core-ethnicity
us-core-birthsex		0..1	code	Extension **URL:** http://hl7.org/fhir/us/core/StructureDefinition/us-core-birthsex **Binding:** Birth Sex (required): Code for sex assigned at birth
identifier	S	1..*	Identifier	An identifier for this patient
system	S	1..1	uri	The namespace for the identifier value
value	S	1..1	string	The value that is unique within the system.
name	S I	1..*	HumanName	A name associated with the patient **us-core-8:** Either Patient.name.given and/or Patient.name.family SHALL be present.
family	S I	0..1	string	Family name (often called 'Surname')
given	S I	0..*	string	Given names (not always 'first'). Includes middle names
suffix		0..*	string	Parts that come after the name
period		0..1	Period	Time period when name was/is in use

Example US Core Patient Profile... continued

Name	Flags	Card.	Type	Description & Constraints
Patient		0..*	Patient	Information about an individual or animal receiving health care services
us-core-race		0..1	(Complex)	US Core Race Extension **URL:** http://hl7.org/fhir/us/core/StructureDefinition/us-core-race
us-core-ethnicity		0..1	(Complex)	US Core ethnicity Extension **URL:** http://hl7.org/fhir/us/core/StructureDefinition/us-core-ethnicity
us-core-birthsex		0..1	code	Extension **URL:** http://hl7.org/fhir/us/core/StructureDefinition/us-core-birthsex **Binding:** Birth Sex (required): Code for sex assigned at birth
identifier	S	1..*	Identifier	An identifier for this patient
system	S	1..1	uri	The namespace for the identifier value
value	S	1..1	string	The value that is unique within the system.
name	S I	1..*	HumanName	A name associated with the patient **us-core-8:** Either Patient.name.given and/or Patient.name.family SHALL be present.
family	S I	0..1	string	Family name (often called 'Surname')
given	S I	0..*	string	Given names (not always 'first'). Includes middle names
suffix		0..*	string	Parts that come after the name
period		0..1	Period	Time period when name was/is in use

Example US Core Patient Profile... continued part 2

Name	Flags	Card.	Type	Description & Constraints
Patient		0..*	Patient	Information about an individual or animal receiving health care services
us-core-race		0..1	(Complex)	US Core Race Extension **URL:** http://hl7.org/fhir/us/core/StructureDefinition/us-core-race
us-core-ethnicity		0..1	(Complex)	US Core ethnicity Extension **URL:** http://hl7.org/fhir/us/core/StructureDefinition/us-core-ethnicity
us-core-birthsex		0..1	code	Extension **URL:** http://hl7.org/fhir/us/core/StructureDefinition/us-core-birthsex **Binding:** Birth Sex (required): Code for sex assigned at birth
identifier	S	1..*	Identifier	An identifier for this patient
system	S	1..1	uri	The namespace for the identifier value
value	S	1..1	string	The value that is unique within the system.
name	S I	1..*	HumanName	A name associated with the patient **us-core-8:** Either Patient.name.given and/or Patient.name.family SHALL be present.
family	S I	0..1	string	Family name (often called 'Surname')
given	S I	0..*	string	Given names (not always 'first'). Includes middle names
suffix		0..*	string	Parts that come after the name
period		0..1	Period	Time period when name was/is in use

FHIR® Implementation Guides

- FHIR® Implementation Guides support specific use cases
- Implementation Guides both restrict and extend APIs, resources, and terminologies
- The Product of FHIR® Accelerators
- There are currently 205 FHIR® Implementation Guides registered with HL7

US Core Implementation Guide
4.0.0 - STU4 Release

US Core focuses on patient and provider access to ONC's U.S. Core Data for Interoperability (USCDI).

VULCAN HL7 FHIR

Vulcan focuses on connecting clinical research and healthcare, including the collection of EHR data for prospective clinical research.

mCODE™

mCode focuses on collecting oncology data in the EHR for treatment, care coordination, and research.

Using FHIR® With Other Systems

Example FHIR® Resource - JSON

```
{
  "resourceType": "Patient"
  "id": "patient1",
  "meta": {
    "versionId": "v2"
  },
  "text": {
    "status": "generated",
    "div": "<p>Henry Levin the 7th</p>"
  },

  "extension": [
    {
      "url": "http://hl7.org/fhir/StructureDefinition/patient-birthTime",
      "valueDateTime": "1932-09-24T14:35:45-05:00"
    }
  ],

  "identifier": [{
      "use": "usual",
      "system": "http://acme.org/identifiers/mrn",
      "value": "12345"
    }],
  "active": true,
  "name": [{
      "family": [ "Levin‟ ],
      "given": [ "Henry" ]
    }],
  "gender": "male",
  "birthDate": "1932-09-24",
  "managingOrganization": {
    "reference": "Organization/123xyz",
    "display": "Good Health Clinic"
  }
}
```

- Metadata
- Human Readable Summary
- Extension with reference to its definition
- Standard Data Content:
  - MRN
  - Name
  - Gender
  - Date of Birth
  - Provider

Example FHIR® Resource - XML

```
<Patient xmlns="http://hl7.org/fhir">
  <id value="patient1"/>
  <meta>
    <versionId value="v2"/>
  </meta>
  <text>
    <status value="generated"/>
    <div xmlns="http://www.w3.org/1999/xhtml">
      <p>Henry Levin the 7th</p>
    </div>
  </text>
  <extension url="http://hl7.org/fhir/StructureDefinition/patient-birthTime">
    <valueDateTime value="1932-09-24T14:35:45-05:00"/>
  </extension>
  <identifier>
    <use value="usual"/>
    <system value="http://acme.org/identifiers/mrn"/>
    <value value="12345"/>
  </identifier>
  <name>
    <family value="Levin"/>
    <given value="Henry"/>
  </name>
  <gender value="male"/>
  <birthDate value="1932-09-24"/>
  <managingOrganization>
    <reference value="Organization/123xyz"/>
    <display value="Good Health Clinic"/>
  </managingOrganization>
  <active value="true"/>
</Patient>
```

Metadata

Human Readable Summary

Extension with reference to its definition

Standard Data Content:

- MRN
- Name
- Gender
- Date of Birth
- Provider

FHIR® uses REpresentational State Transfer (REST)

- Uses the same technology as web browsers and servers: Hyper Text Transfer Protocol (HTTP)
- URL: The address you are sending the request: e.g., `https://someserver/fhir/Patient`
- Method: Four basic operations (CRUD)

POST:	**C**reate – Used to add data
GET:	**R**ead – Used to access data (including searches)
PUT:	**U**pdate – Used to update existing data
DELETE:	**D**elete – Used to delete data

- HTTP Headers: A listing that indicates what type of data (e.g., JSON, XML) is being requested (Example: Accept: application/fhir+json)
- Body: The payload of data being sent

Get a Patient…

REQUEST

```
GET http://hapi.fhir.org/baseR4/
    Patient/
    2679766
```

RESPONSE

```
Status 200 OK
Content-Type: application/fhir+json
{
  "id": "2679766",
   "resourceType": "Patient",
   "meta": {
    "versionId": "1",
    "lastUpdated": "2021-11-10T21:30:22.085+00:00”
  },
  "name": [ {
    "use": "official",
    "family": "Matos876",
    "given": [ "Arturo47" ],
    "prefix": [ "Mr." ]
  } ],
  "gender": "male",
  "birthDate": "1956-02-21"
}
```

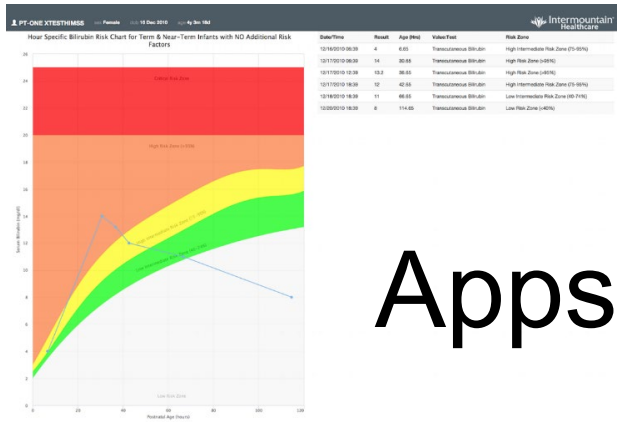
SMART

- Project run out of Boston Children's Hospital Computational Health Informatics Program
  - SMART on FHIR® (OAuth/OpenID Connect)
  - CDS Hooks
  - Bulk Data (including backend services auth)
  - SMART Health Cards (verifiable clinical information)

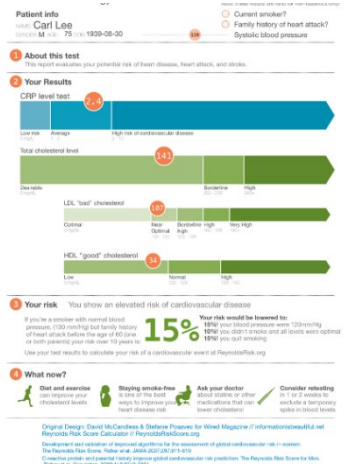
SMART: Substitutable Medical Applications, Reusable Technologies

- SMART on FHIR® provides a way for applications (apps) developed by third parties to connect to and access information from Electronic Health Records (EHR) with the assurance of adequate security to protect personal data
- Based on OAuth 2.0 and Open ID Connect, both established internet security standards
- Decouples EHR data from app builders, allowing greater innovation through substitutable apps
- Led by team out of Boston Children's Hospital and funded by ONC
- Multiple Launch Types
  - Standalone
    - Enables patient access by opening up data to apps
  - EHR Launch
    - Open within EHR
    - Instead of buying new features or waiting for monolithic EHR system to upgrade, you can integrate and display multiple apps within the EHR

EHR as a Platform



Apps



API defined by SMART on FHIR®

User Management, Patient management, Documentation, Billing, Workflow, Orders, Legal, Regulatory, Data persistence

EHR

Cerner, EPIC, Allscripts, Meditech, McKesson, athenahealth, CPSI, Medhost, etc

Summary… part 2

- FHIR's basic building blocks are "Resources"
  - Examples: Patient, Observation, Condition
- Resources define data elements names and types
  - Basic types like "integer" or "free text"
  - Terminology bindings
- Implementation Guides define how FHIR is used for a specific use case
  - Adds constraints (e.g., required elements, specific terminology allowed)
  - Adds extensions to support data elements not covered by base FHIR
  - You can make your own IG!
- FHIR® uses standard web technology for:
  - Data encoding: JSON and XML
  - Communication: REST
  - Integration with other systems via SMART technology
- More information: https://purl.org/fhir-for-research/web