FHIRed up for FAIRness

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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

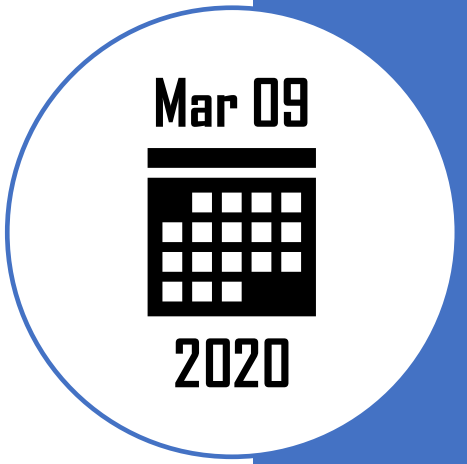
Challenges and opportunities to support **Findable, Accessible, Interoperable, Reusable (FAIR)** data and research

The Office of the National Coordinator for Health Information Technology

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".



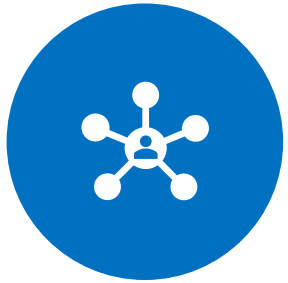
Source: https://www.healthit.gov/curesrule/

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/

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

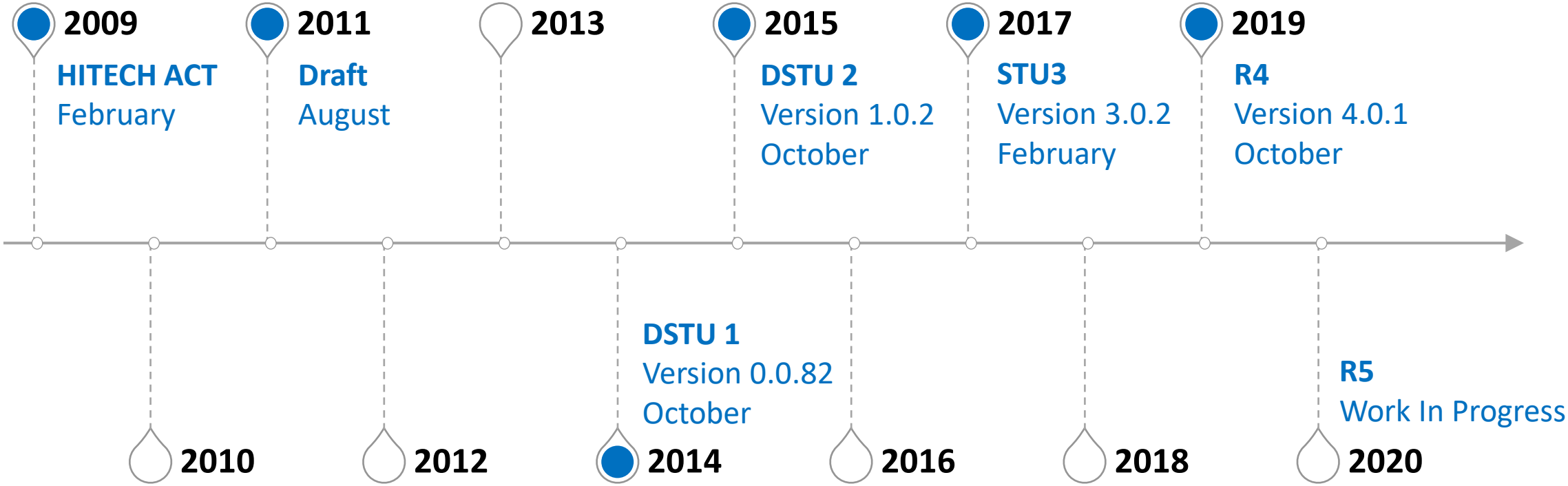
Compliance **six months** after publication of the final rule

HL7® FHIR®

Fast
Healthcare
Interoperability
Resources

http://www.hl7.org/fhir

FHIR History



Electronic Health Record (EHR)

Patient, Conditions, Encounters, Observations, Medications, etc.

From paper → To electronic

Image Source: https://en.wikipedia.org/wiki/Medical_record

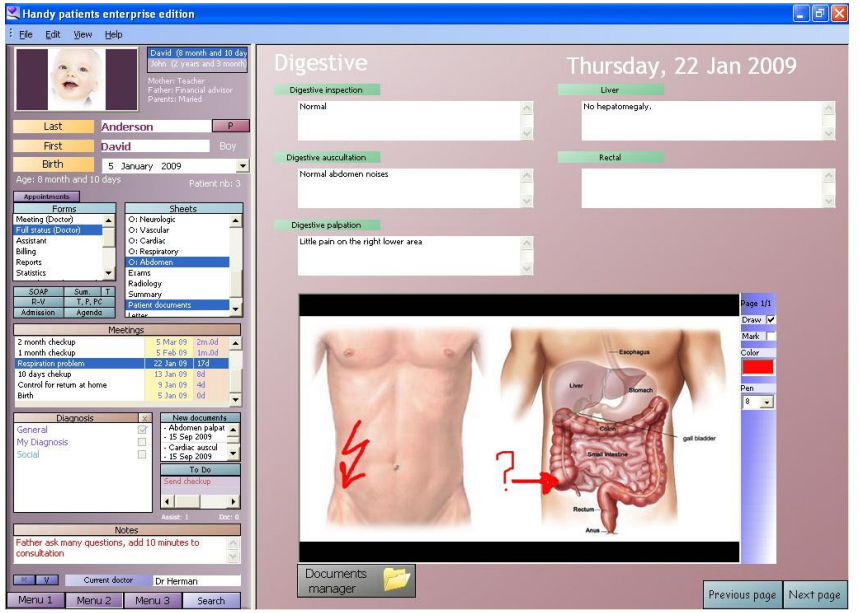
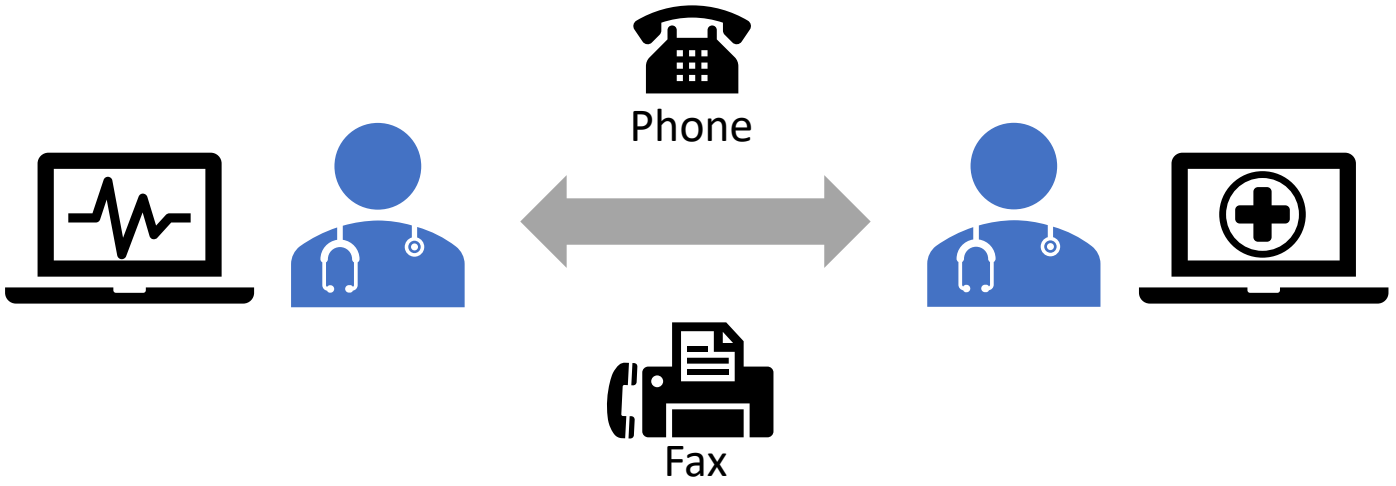


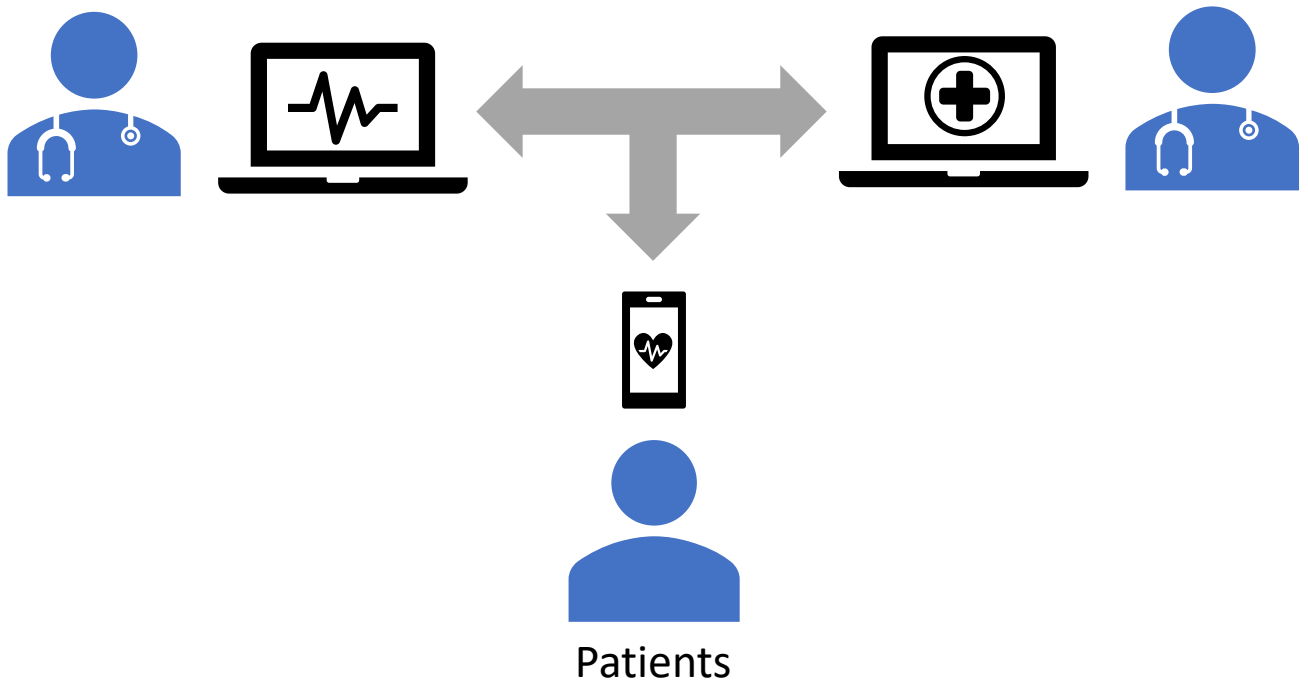
Image Source: https://en.wikipedia.org/wiki/Electronic_health_record

Data Integration: People-People



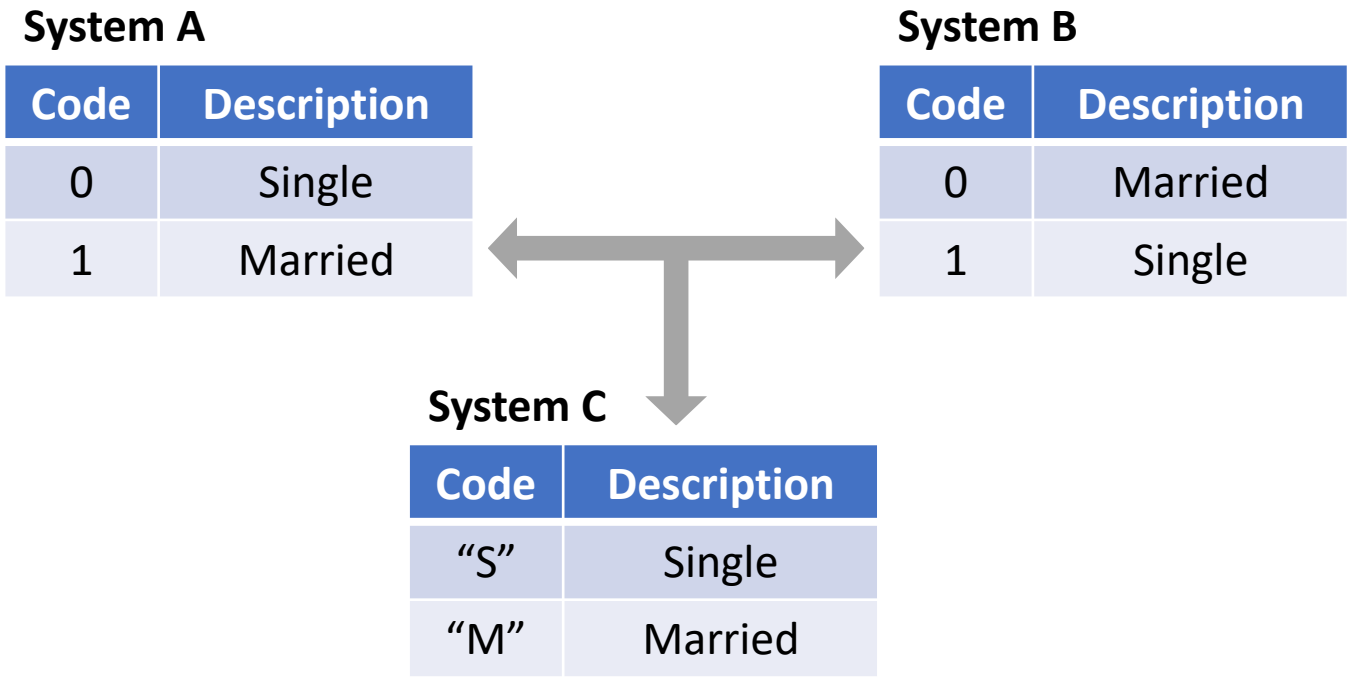
Adapted from ONC FHIR at Scale Taskforce (FAST) 101

Data Integration: System-System



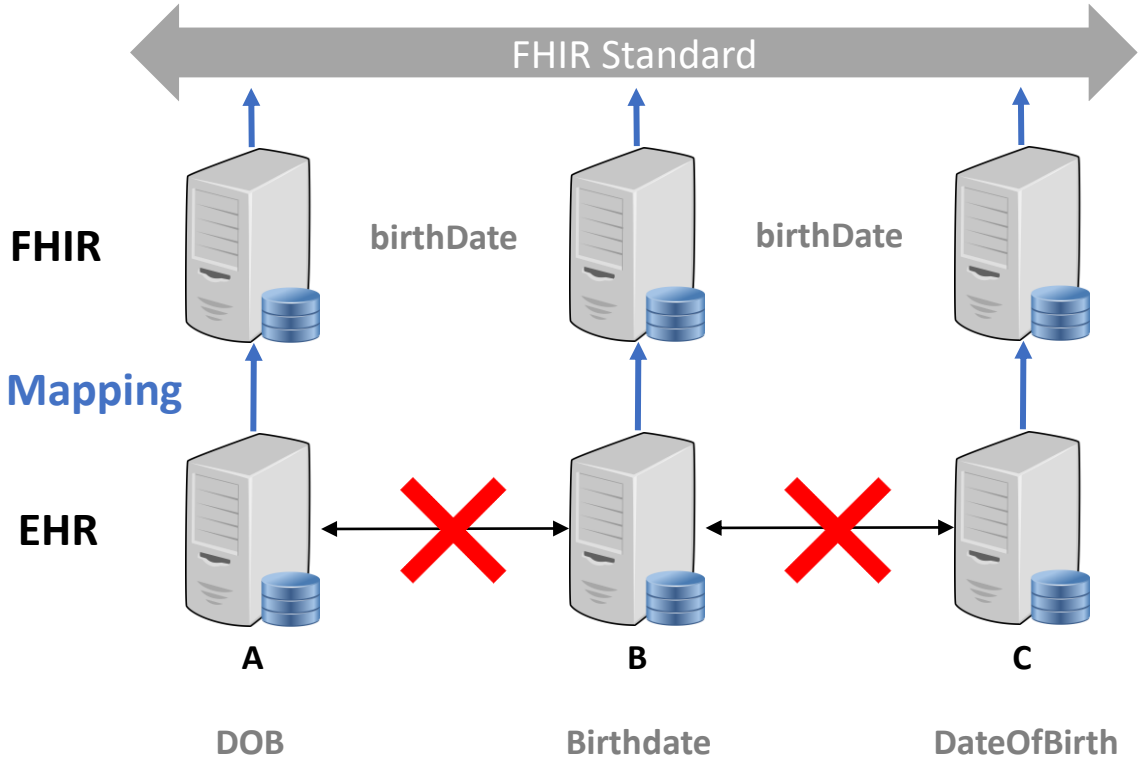
Adapted from ONC FHIR at Scale Taskforce (FAST) 101

Interoperability problems



Adapted from ONC FHIR at Scale Taskforce (FAST) 101

Standard to exchange clinical data



FHIR Resources Categorized

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

	Conformance	Terminology	Security	Documents	Other
Foundation	• CapabilityStatement N • StructureDefinition N • ImplementationGuide 1 • SearchParameter 3 • MessageDefinition 1 • OperationDefinition N • CompartmentDefinition 1 • StructureMap 2 • GraphDefinition 1 • ExampleScenario 0	• CodeSystem N • ValueSet N • ConceptMap 3 • NamingSystem 1 • TerminologyCapabilities 0	• Provenance 3 • AuditEvent 3 • Consent 2	• Composition 2 • DocumentManifest 2 • DocumentReference 3 • CatalogEntry 0	• Basic 1 • Binary N • Bundle N • Linkage 0 • MessageHeader 4 • OperationOutcome N • Parameters N • Subscription 3

	Individuals	Entities #1	Entities #2	Workflow	Management
Base	• Patient N • Practitioner 3 • PractitionerRole 2 • RelatedPerson 2 • Person 2 • Group 1	• Organization 3 • OrganizationAffiliation 0 • HealthcareService 2 • Endpoint 2 • Location 3	• Substance 2 • BiologicallyDerivedProduct 0 • Device 0 • DeviceMetric 1	• Task 2 • Appointment 3 • AppointmentResponse 3 • Schedule 3 • Slot 3 • VerificationResult 0	• Encounter 2 • EpisodeOfCare 2 • Flag 1 • List 1 • Library 2

	Summary	Diagnostics	Medications	Care Provision	Request & Response
Clinical	• AllergyIntolerance 3 • AdverseEvent 0 • Condition (Problem) 3 • Procedure 3 • FamilyMemberHistory 2 • ClinicalImpression 0 • DetectedIssue 1	• Observation N • Media 1 • DiagnosticReport 3 • Specimen 2 • BodyStructure 1 • ImagingStudy 3 • QuestionnaireResponse 3 • MolecularSequence 1	• MedicationRequest 3 • MedicationAdministration 2 • MedicationDispense 2 • MedicationStatement 3 • Medication 3 • MedicationKnowledge 0 • Immunization 3 • ImmunizationEvaluation 0 • ImmunizationRecommendation 1	• CarePlan 2 • CareTeam 2 • Goal 2 • ServiceRequest 2 • NutritionOrder 2 • VisionPrescription 2 • RiskAssessment 1 • RequestGroup 2	• Communication 2 • CommunicationRequest 2 • DeviceRequest 0 • DeviceUseStatement 0 • GuidanceResponse 2 • SupplyRequest 1 • SupplyDelivery 1

	Support	Billing	Payment	General
Financial	• Coverage 2 • CoverageEligibilityRequest 2 • CoverageEligibilityResponse 2 • EnrollmentRequest 0 • EnrollmentResponse 0	• Claim 2 • ClaimResponse 2 • Invoice 0	• PaymentNotice 2 • PaymentReconciliation 2	• Account 2 • ChargeItem 0 • ChargeItemDefinition 0 • Contract 1 • ExplanationOfBenefit 2 • InsurancePlan 0

Source: https://www.hl7.org/fhir/resourcelist.html

Condition Resource

Structure

Name	Flags	Card.	Type	Description & Constraints
Condition	I TU		DomainResource	Detailed information about conditions, problems or diagnoses *+ Guideline: Condition.clinicalStatus SHALL be present if verificationStatus is not entered-in-error and category is problem-list-item* *+ Rule: If condition is abated, then clinicalStatus must be either inactive, resolved, or remission* *+ Rule: Condition.clinicalStatus SHALL NOT be present if verification Status is entered-in-error* Elements defined in Ancestors: id, meta, implicitRules, language, text, contained, extension, modifierExtension
identifier	Σ	0..*	Identifier	External Ids for this condition
clinicalStatus	?! Σ I	0..1	CodeableConcept	active | recurrence | relapse | inactive | remission | resolved Condition Clinical Status Codes (Required)
verificationStatus	?! Σ I	0..1	CodeableConcept	unconfirmed | provisional | differential | confirmed | refuted | entered-in-error ConditionVerificationStatus (Required)
category		0..*	CodeableConcept	problem-list-item | encounter-diagnosis Condition Category Codes (Extensible)
severity		0..1	CodeableConcept	Subjective severity of condition Condition/Diagnosis Severity (Preferred)
code	Σ	0..1	CodeableConcept	Identification of the condition, problem or diagnosis Condition/Problem/Diagnosis Codes (Example)
bodySite	Σ	0..*	CodeableConcept	Anatomical location, if relevant SNOMED CT Body Structures (Example)
subject	Σ	1..1	Reference(Patient | Group)	Who has the condition?
encounter	Σ	0..1	Reference(Encounter)	Encounter created as part of
onset[x]	Σ	0..1		Estimated or actual date, date-time, or age
onsetDateTime			dateTime	
onsetAge			Age	
onsetPeriod			Period	
onsetRange			Range	
onsetString			string	
abatement[x]	I	0..1		When in resolution/remission
abatementDateTime			dateTime	
abatementAge			Age	
abatementPeriod			Period	
abatementRange			Range	
abatementString			string	
recordedDate	Σ	0..1	dateTime	Date record was first recorded
recorder	Σ	0..1	Reference(Practitioner | PractitionerRole | Patient | RelatedPerson)	Who recorded the condition
asserter	Σ	0..1	Reference(Practitioner | PractitionerRole | Patient | RelatedPerson)	Person who asserts this condition
stage	I	0..*	BackboneElement	Stage/grade, usually assessed formally *+ Rule: Stage SHALL have summary or assessment*
summary	I	0..1	CodeableConcept	Simple summary (disease specific)

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

Sample Condition Resource


```
{
  "fullUrl": "https://r4.smarthealthit.org/Condition/fb90244d-bd87-4824-acfe-3698f57b2271",
  "resource": {
    "resourceType": "Condition",
    "id": "fb90244d-bd87-4824-acfe-3698f57b2271",
    "meta": {
      "versionId": "2",
      "lastUpdated": "2019-06-05T03:00:26.619-04:00",
      "tag": [
        {
          "system": "https://smarthealthit.org/tags",
          "code": "synthea-5-2019"
        }
      ]
    },
    "clinicalStatus": {
      "coding": [
        {
          "system": "http://terminology.hl7.org/CodeSystem/condition-clinical",
          "code": "active"
        }
      ]
    },
    "verificationStatus": {
      "coding": [
        {
          "system": "http://terminology.hl7.org/CodeSystem/condition-ver-status",
          "code": "confirmed"
        }
      ]
    },
    "code": {
      "coding": [
        {
          "system": "http://snomed.info/sct",
          "code": "80394007",
          "display": "Hyperglycemia (disorder)"
        }
      ],
      "text": "Hyperglycemia (disorder)"
    },
    "subject": {
      "reference": "Patient/b2eeab29-a67d-4941-8540-6372911cfc17"
    },
    "encounter": {
      "reference": "Encounter/1dcb4af5-74bb-46a3-a92a-088197902d7a"
    },
    "onsetDateTime": "2001-02-05T16:42:54-05:00",
    "recordedDate": "2001-02-05T16:42:54-05:00"
  },
```


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

FHIR API Endpoints

https://open.epic.com

Organization Name	Production FHIR Base URL
Access Community Health Network	https://eprescribing.accesscommunityhealth.net/FHIR/api/FHIR/DSTU2/
AdvantageCare Physicians	https://epwebapps.acpny.com/FHIRproxy/api/FHIR/DSTU2/
Adventist Health West	https://epicescribe1.ah.org/ARR-FHIR-PRD/api/FHIR/DSTU2/
Akron Children's Hospital	https://haiku-canto-prod.chmca.org/ARR-FHIR-PRD/api/FHIR/DSTU2/
Alameda Health System	https://epicproxy.et1075.epichosted.com/FHIRProxy/api/FHIR/DSTU2/
Allegheny Health Network	https://epicprisfd01.wpahs.org/PRD-FHIR/api/FHIR/DSTU2/
Allina Health System	https://webproxy.allina.com/FHIR/api/FHIR/DSTU2/
AltaMed	https://epicproxy.et1123.epichosted.com/FHIRProxy/api/FHIR/DSTU2/
Altru Health System	https://epicsoap.altru.org/fhir/api/FHIR/DSTU2/
AnMed Health	https://epicproxy.et0971.epichosted.com/FHIRProxy/api/FHIR/DSTU2/
Anne Arundel Medical Center	https://epicarr.aahs.org/fhir/api/FHIR/DSTU2/
Ardent	https://epicproxy.ardenthealth.com/fhir/api/FHIR/DSTU2/
Arkansas Children's	https://fhir.archildrens.org/fhir/api/FHIR/DSTU2/
Asante Health Systems	https://epicmobile.asante.org/FHIR-PRD/api/FHIR/DSTU2/
Ascension - Providence Healthcare Network	https://stofo.providence-waco.org/FHIRProxy/api/FHIR/DSTU2/
Ascension WI	https://eprescribe.wfhc.org/FHIRproxy/api/FHIR/DSTU2/
Aspirus	https://erx.aspirus.org/FHIR/api/FHIR/DSTU2/
Atlantic Health	https://soapproxy.atlantichealth.org/FHIRPrd/api/FHIR/DSTU2/
Atrius Health	https://iatrius.atriushealth.org/FHIR/api/FHIR/DSTU2/
Aurora Health Care - myAurora	https://EpicFHIR.aurora.org/FHIR/MYAURORA/api/FHIR/DSTU2/
Austin Regional Clinic	https://mobileprod.arcmd.com/FHIR/api/FHIR/DSTU2/
Ballad Health	https://soap.wellmont.org/FHIRPRD/api/FHIR/DSTU2/
Baptist Health – KY & IN	https://epicproxy.bhsi.com/PRD-FHIR/api/FHIR/DSTU2/
Children's Hospital Colorado	https://fhir.childrenscolorado.org/fhirprd/api/FHIR/DSTU2/
University of Colorado Health	https://ss.uch.edu/FHIRProxy/api/FHIR/DSTU2/
Kaiser Permanente - Colorado	https://fhir.kp.org/service/ptnt_care/EpicEdiFhirRoutingSvc/v2014/esb-envlbl/14

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/

Substitutable Medical Applications, Reusable Technologies (SMART)

Mandel JC, *et al.* J Am Med Inform Assoc 2016;23:899–908. doi:10.1093/jamia/ocv189, Research and Applications

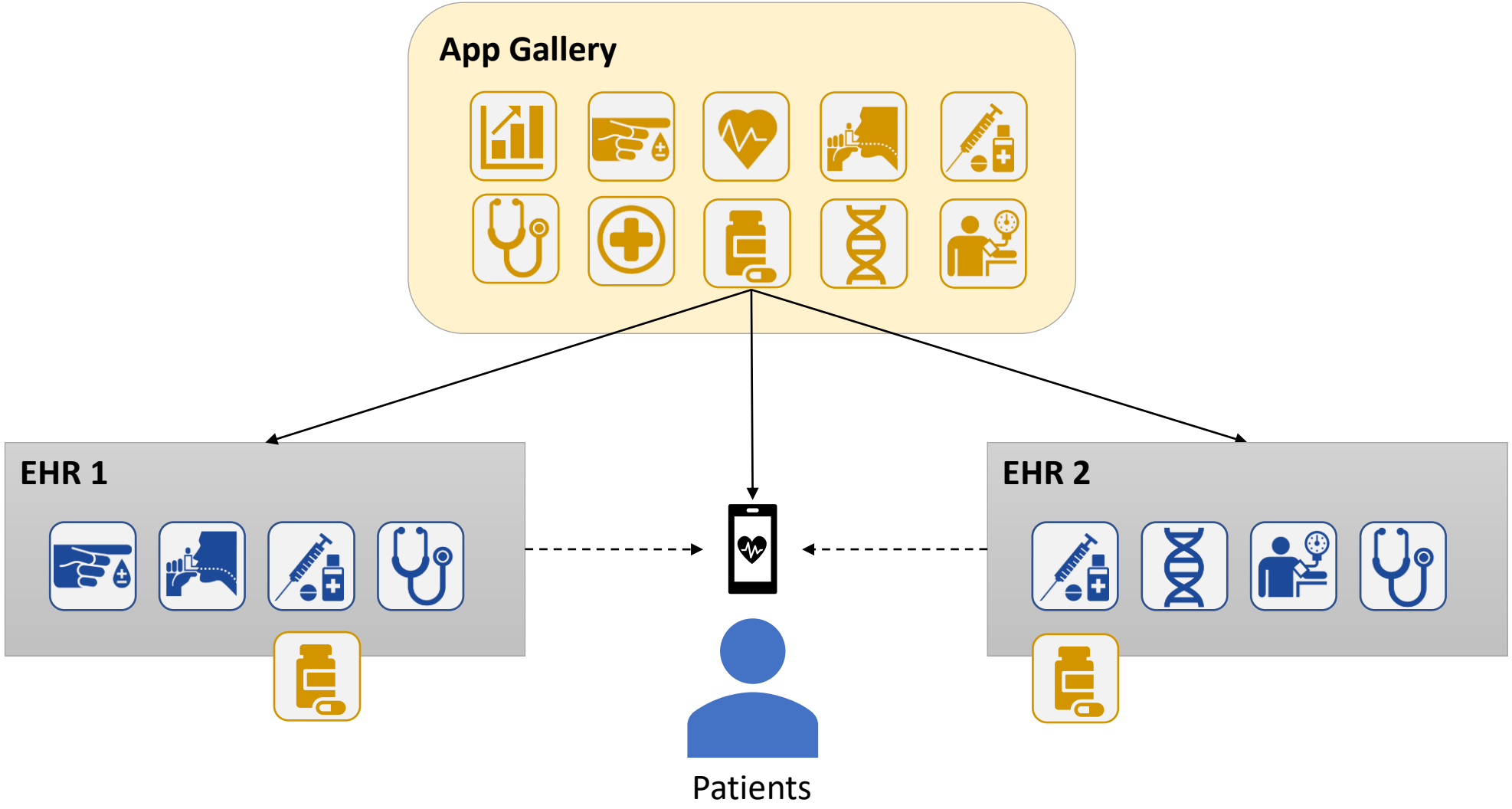
SMART on FHIR: a standards-based, interoperable apps platform for electronic health records

RECEIVED 27 December 2014
REVISED 7 September 2015
ACCEPTED 7 November 2015
PUBLISHED ONLINE FIRST 17 February 2016

Joshua C Mandel,[1,2,4] David A Kreda,[3] Kenneth D Mandl,[1,2] Isaac S Kohane,[1,4] Rachel B Ramoni[3,5]

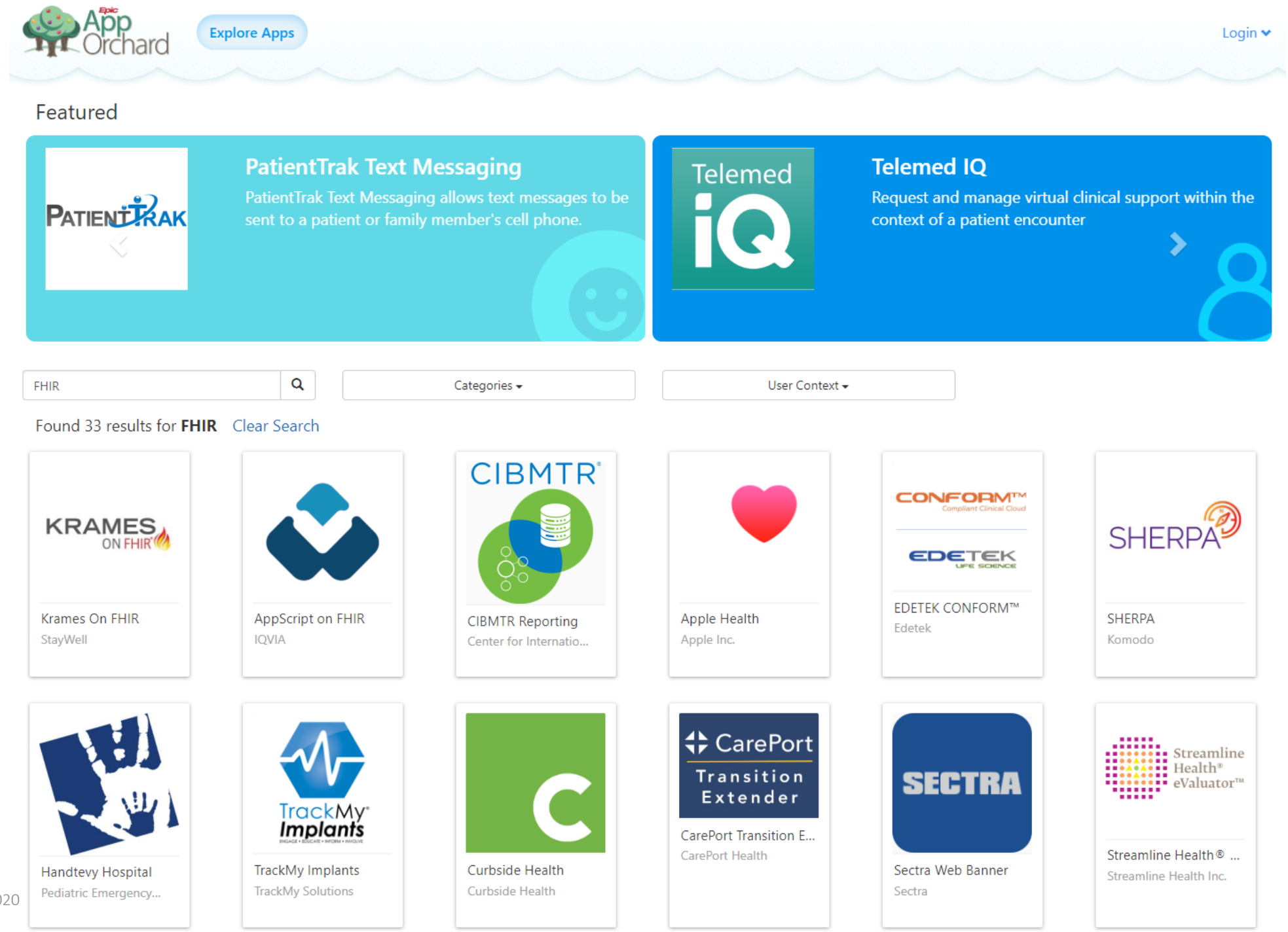
SMART Health IT is an open, standards based technology platform that enables innovators **to create apps that seamlessly and securely run across the healthcare system**.

Apps-based information economy

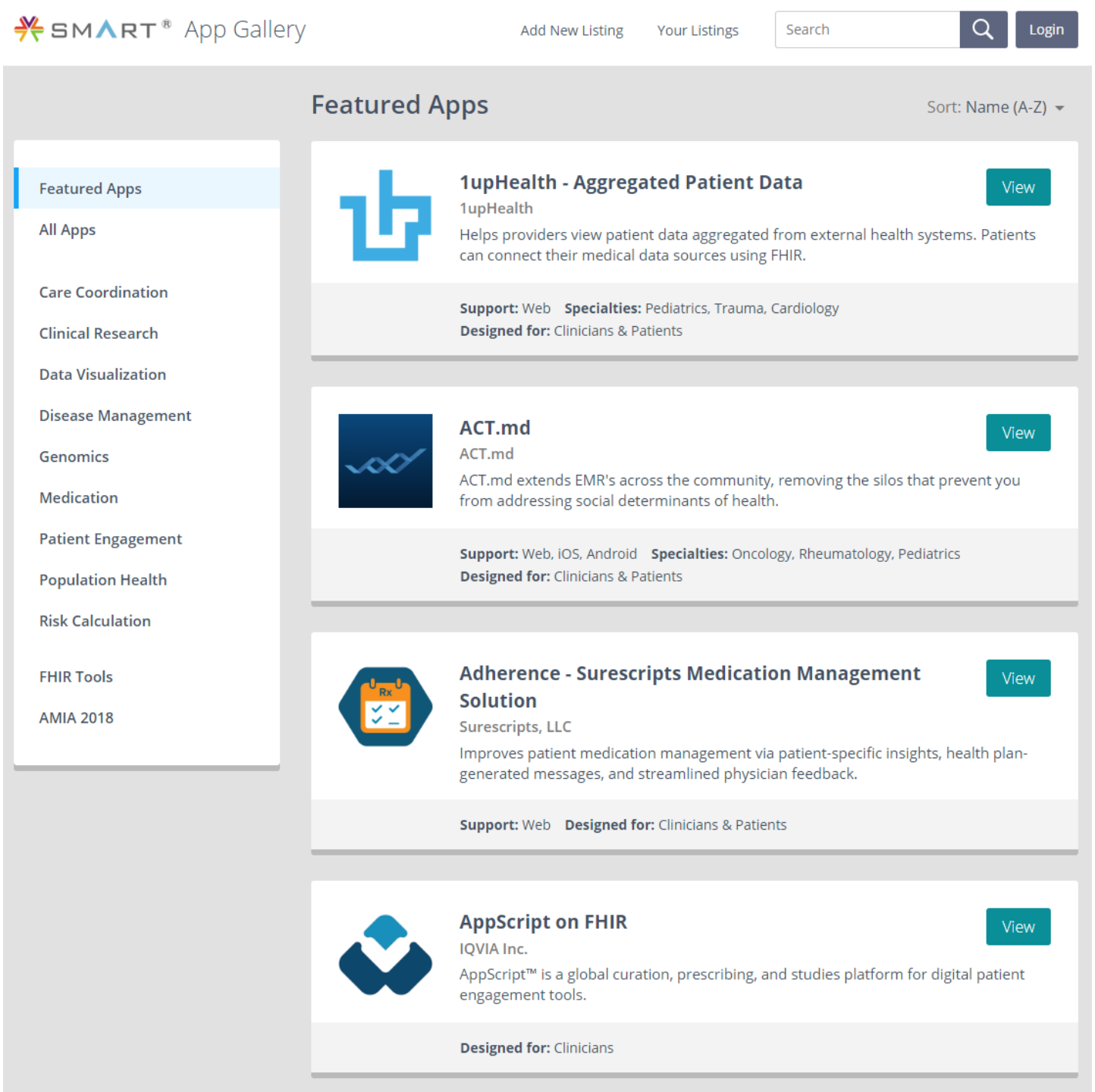


Adapted from *Cell Systems* 2015 1, 8-13, DOI: (10.1016/j.cels.2015.05.001)

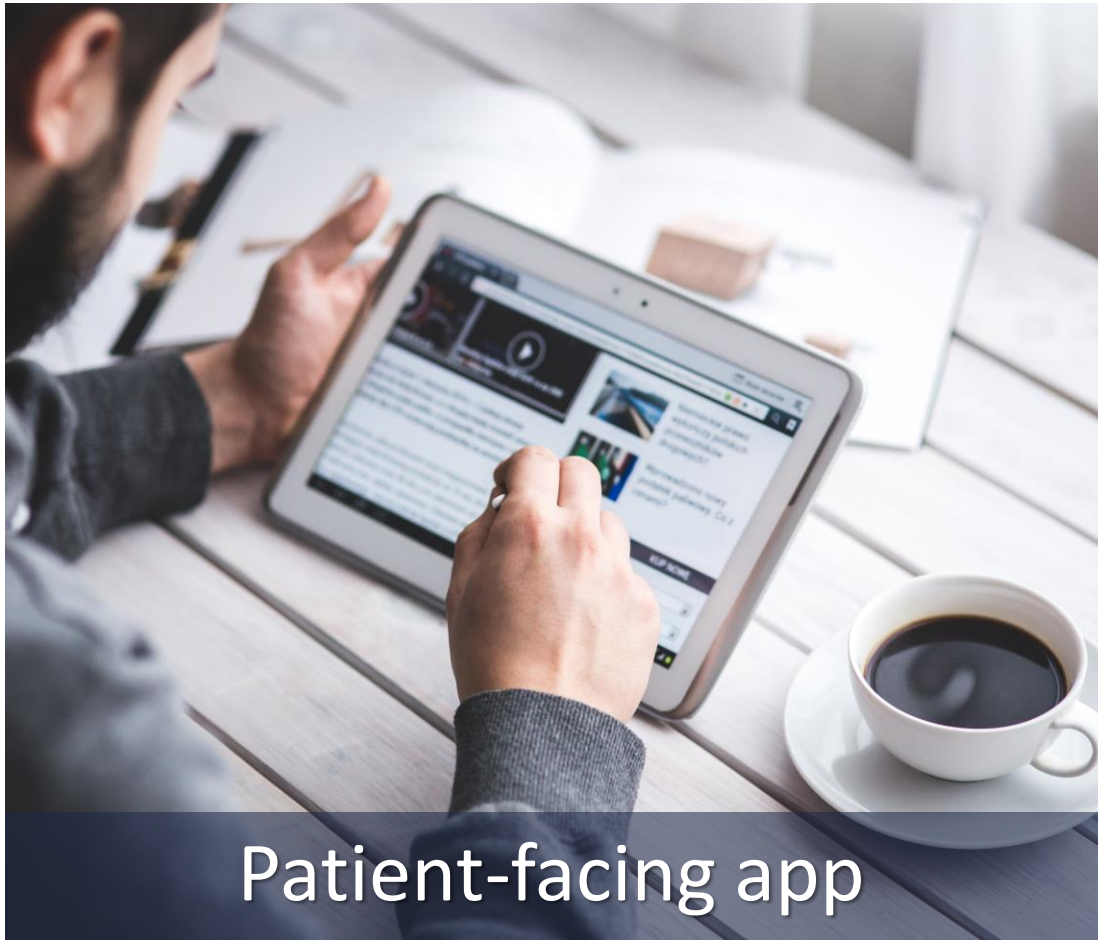
Sample App Gallery

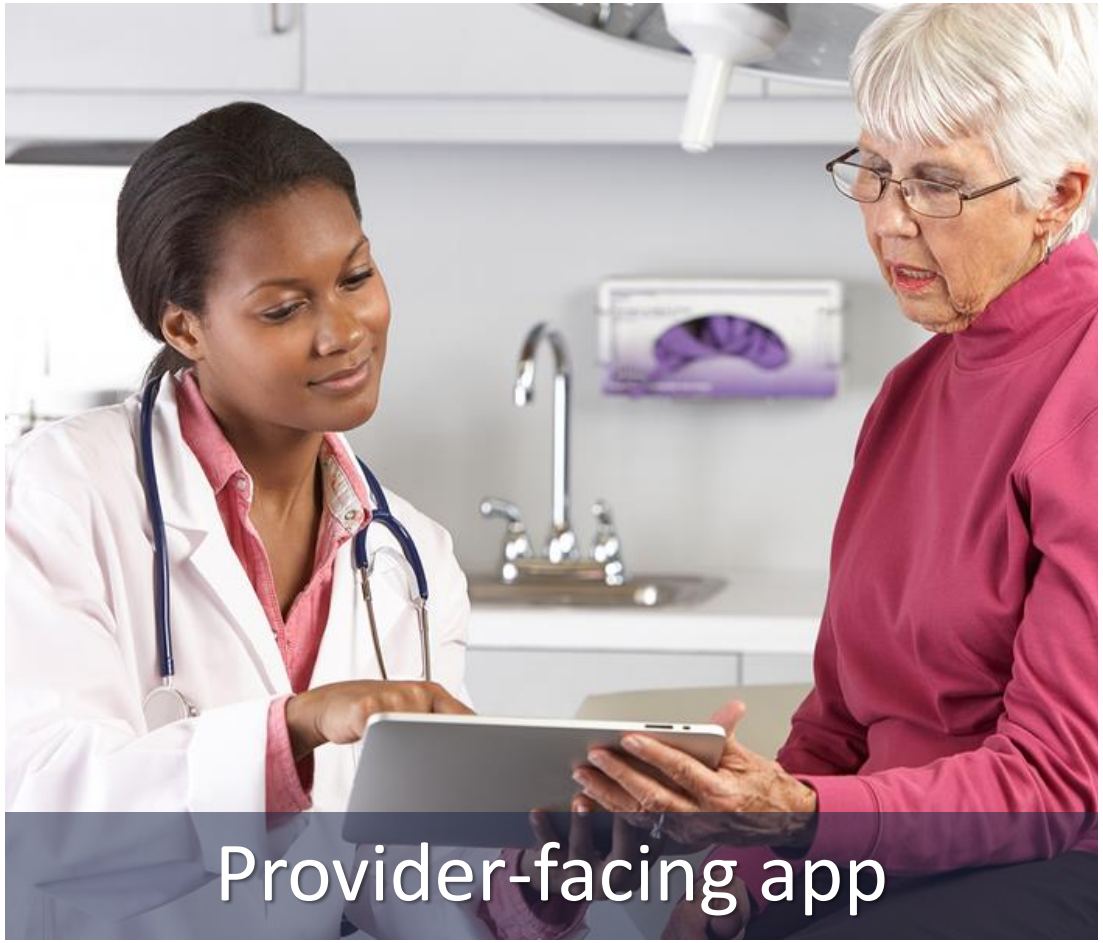


Sample App Gallery



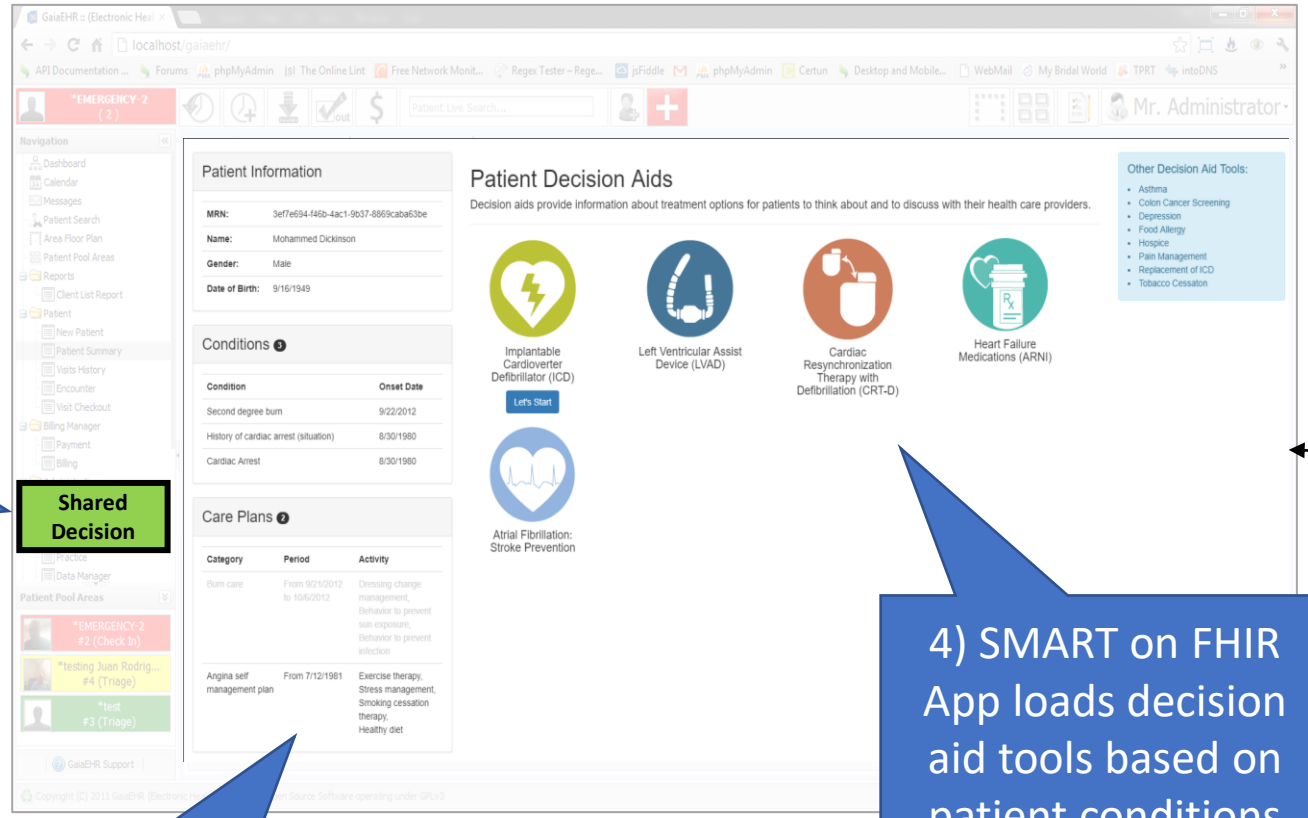
App integration





Embedded Integration

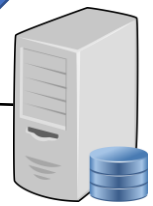
EHR System



1) A way to trigger the app

2) EHR embeds SMART on FHIR App for seamless integration

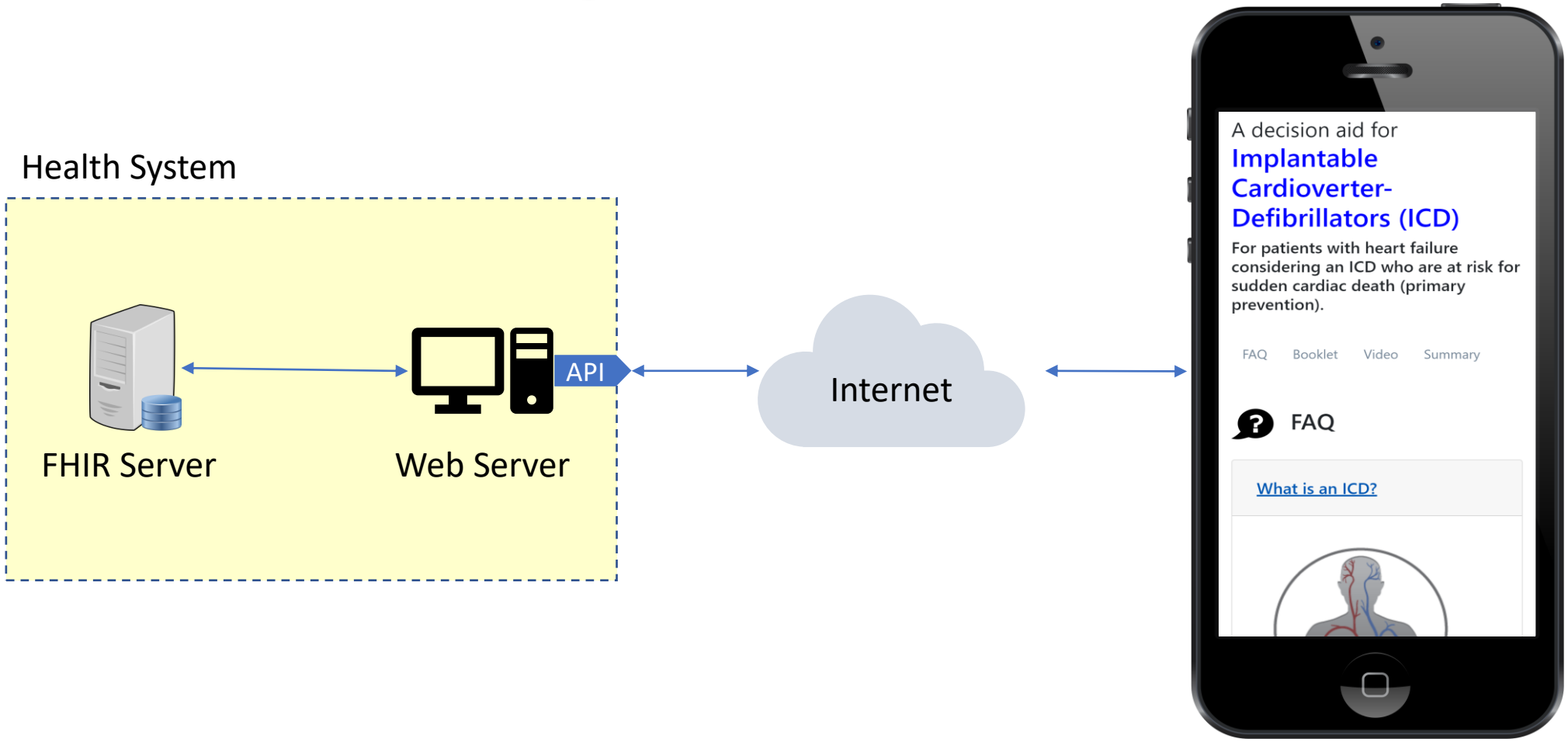
3) SMART on FHIR App retrieves patient information from FHIR Server



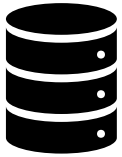
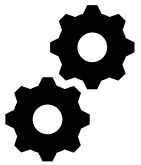
FHIR Server

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

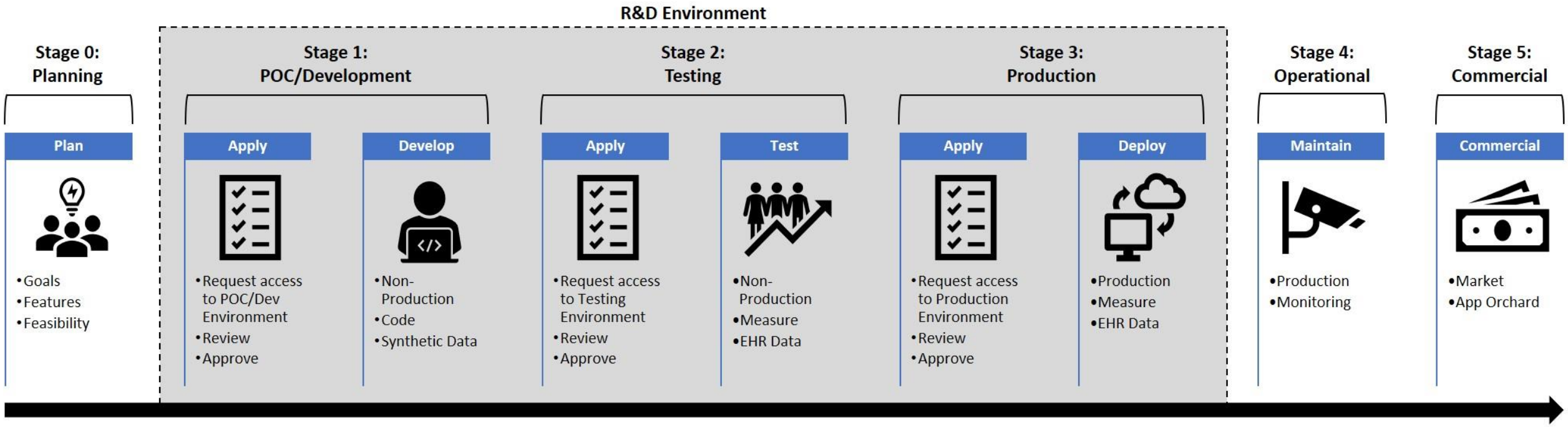
Standalone Integration



CDS Sandbox with FHIR

1	2	3	4	5	6
HAPI-FHIR Server	clinFHIR Synthea	CDS Authoring Tool	CQL Engines	CDS Hooks	SMART on FHIR Apps
					
Patient Data in FHIR	Create Patient Profiles	Create Rules Artifacts	Process Rules and Data	Trigger CDS	External Apps

CU-UCH R&D Environment



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

Clinical Research Informatics and Innovation Unit (CRIIU)

Lisa Schilling, MD, MSPH
Professor Dept of Medicine
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Data Science to Patient Value (D2V)

UNIVERSITY OF COLORADO **ANSCHUTZ MEDICAL CAMPUS**

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

FAIR for research

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 DANIEL NIVEN | JAN 17 2017

Annals of Internal Medicine®

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ARTICLES | 21 AUGUST 2007

How Quickly Do Systematic Reviews Go Out of Date? A Survival Analysis

FREE

Kaveh G. Shojania, MD; Margaret Sampson, MLIS; Mohammed T. Ansari, MBBS, MMedSc, MPhil; Jun Ji, MD, MHA; Steve Doucette, MSc; David Moher, PhD

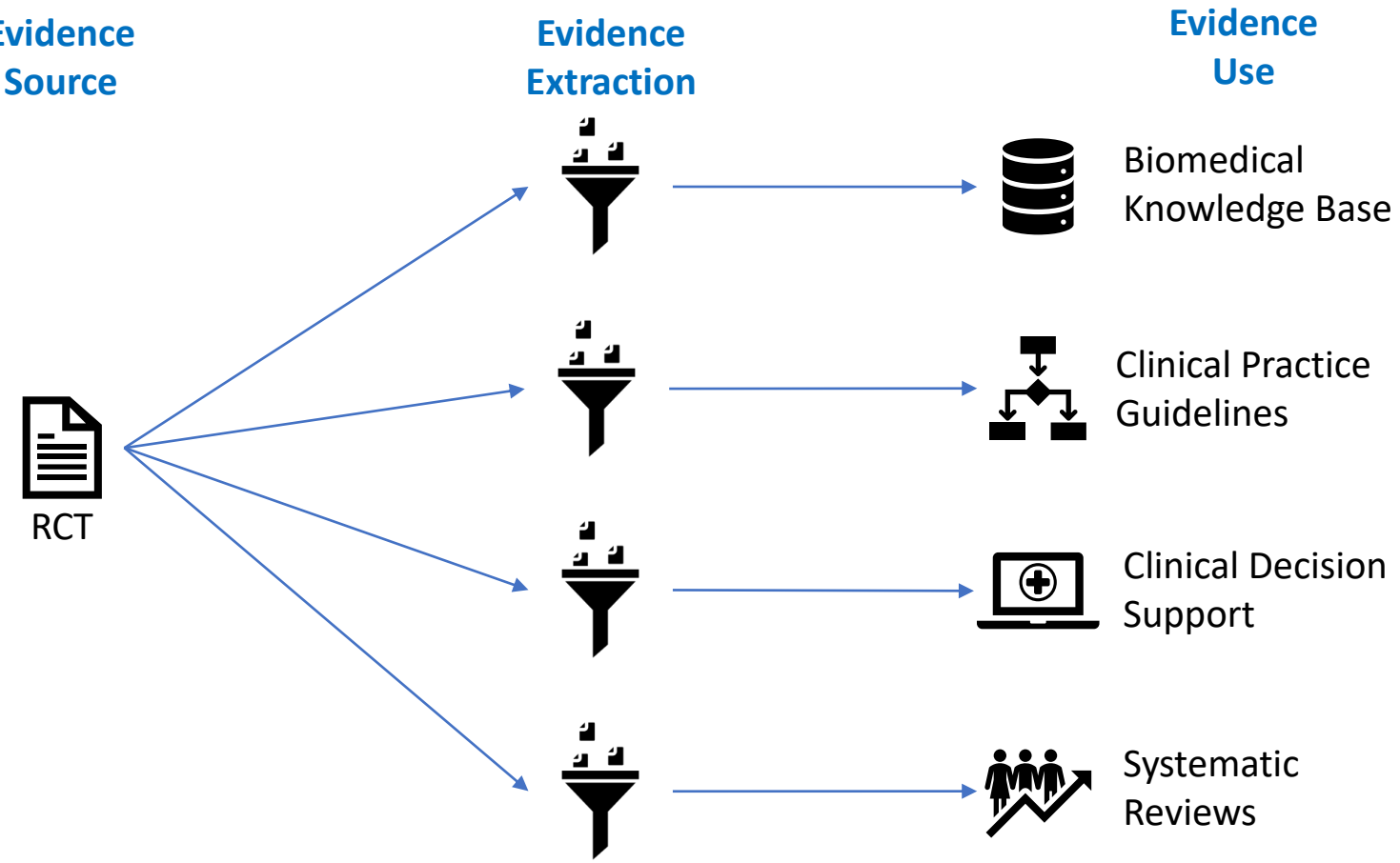
Policy Forum

Seventy-Five Trials and Eleven Systematic Reviews a Day: How Will We Ever Keep Up?

Hilda Bastian[1]*, Paul Glasziou[2], Iain Chalmers[3]

1 German Institute for Quality and Efficiency in Health Care (IQWiG), Cologne, Germany, **2** Centre for Research in Evidence-Based Practice, Faculty of Health Sciences, Bond University, Gold Coast, Australia, **3** James Lind Library, James Lind Initiative, Oxford, United Kingdom

This is How We Do it Now - Evidence Pathway



Meeting FAIR Principles for Study Results?

NEED

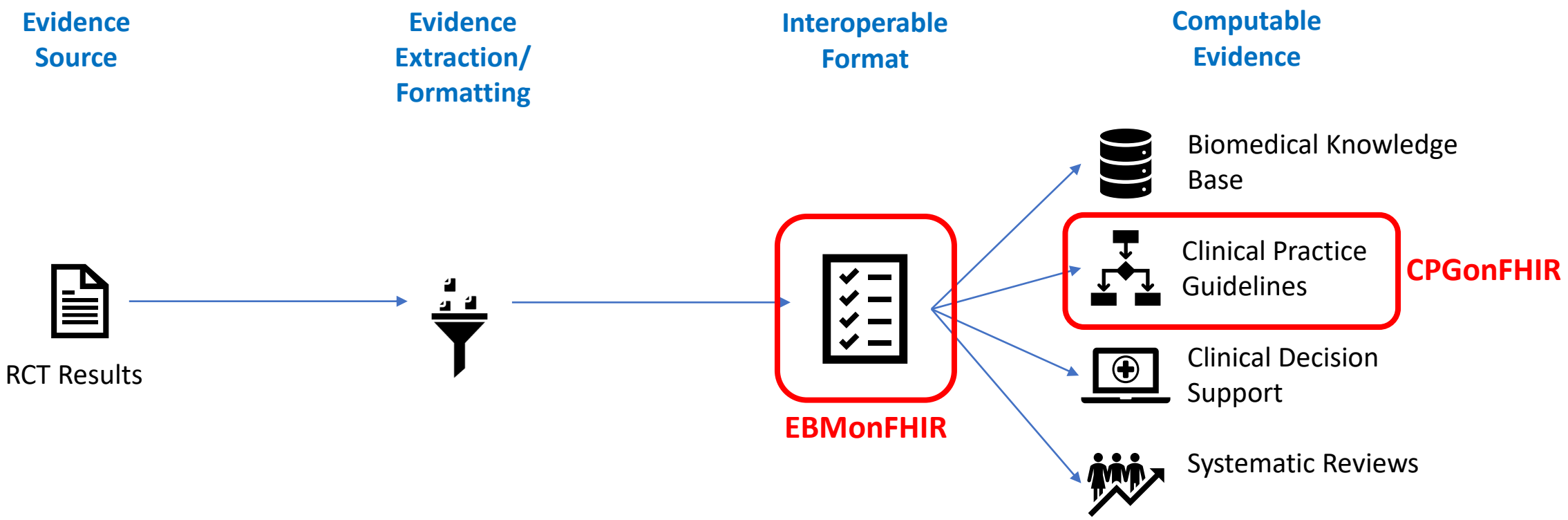
…standard for machine-interpretable expression

…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



EBMonFHIR Resources

Name	Flags	Card.	Type	Description & Constraints
Evidence	TU		MetadataResource	Single evidence bit *+ Warning: Name should be usable as an identifier for the module by machine processing applications such as code generation* Elements defined in Ancestors: id, meta, implicitRules, language, text, contained, extension, modifierExtension, url, identifier, version, name, title, status, experimental, date, publisher, contact, description, useContext, jurisdiction, purpose, copyright, approvalDate, lastReviewDate, effectivePeriod
url	Σ	0..1	uri	Canonical identifier for this evidence, represented as a globally unique URI
identifier	Σ	0..*	Identifier	Additional identifier for the summary
version	Σ	0..1	string	Business version of this summary
title	Σ	0..1	string	Name for this summary (human friendly)
status	?! Σ	1..1	code	draft | active | retired | unknown PublicationStatus (Required)
date	Σ	0..1	dateTime	Date last changed
useContext	Σ	0..*	UsageContext	Use context
approvalDate		0..1	date	When the summary was approved by publisher
lastReviewDate		0..1	date	When the summary was last reviewed
contributor		0..*	Contributor	Contact detail and role for contributor to summary
relatedArtifact		0..*	RelatedArtifact	Link or citation to artifact associated with the summary
description		0..1	markdown	Description of the particular summary
assertion		0..1	markdown	Declarative description of the Evidence
note		0..*	Annotation	Footnotes and/or explanatory notes
referentGroup	Σ	1..1	BackboneElement	Group being referenced
description		0..1	markdown	Textual description of referent group
note		0..*	Annotation	Footnotes and/or explanatory notes
evidenceSource		0..1	Reference(Group)	Group from which the evidence is derived
intendedGroup		0..1	Reference(Group)	Group for which the evidence applies
directnessMatch		0..1	CodeableConcept	low | moderate | high | exact EvidenceDirectness (Extensible)
variableDefinition		0..*	BackboneElement	Evidence variable
description		0..1	markdown	Description of the variable
note		0..*	Annotation	Footnotes and/or explanatory notes
variableRole		0..1	CodeableConcept	exposure | referenceExposure | measuredVariable | confounder EvidenceVariableRole (Extensible)
actualDefinition	Σ	0..1	Reference(EvidenceVariable)	Definition of the actual variable related to the statistic(s)
intendedDefinition		0..1	Reference(EvidenceVariable)	Definition of the intended variable related to the Evidence
directnessMatch		0..1	CodeableConcept	low | moderate | high | exact

Source: https://confluence.hl7.org/display/CDS/EBMonFHIR

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