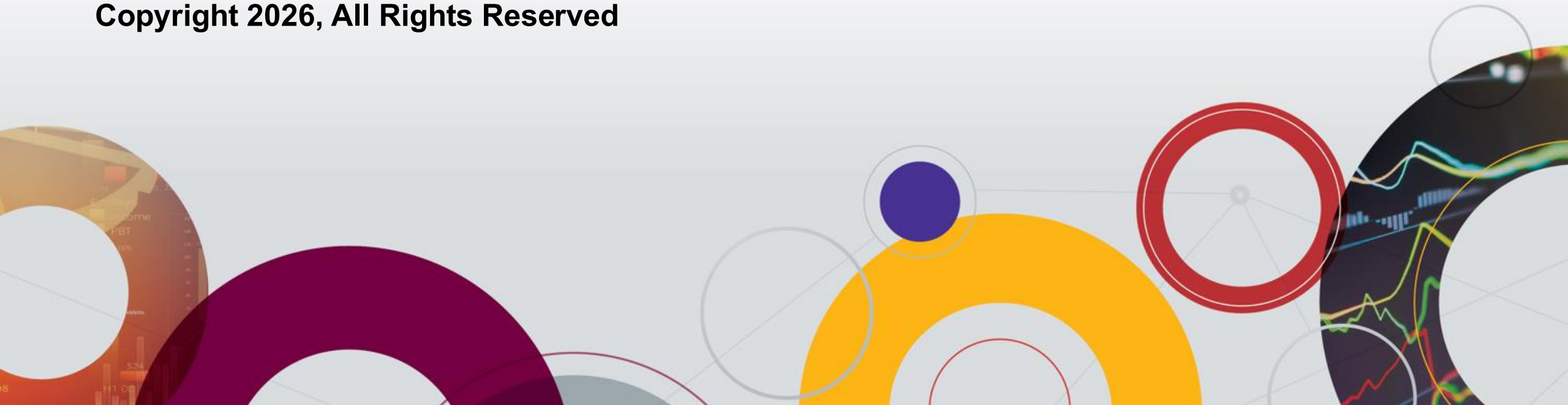


4.5a SMART on FHIR

10x10 – Introduction to Biomedical Informatics & Artificial Intelligence
William Hersh, MD, FACMI, FAMIA, FIAHSI
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SMART on FHIR

FHIR

SMART

SMART on FHIR

ONC Cures Act Final Rule

Current activities and challenges

Right standards at right time

HITECH Act led to widespread adoption of EHRs but incomplete interoperability

21st Century Cures Act further defined interoperability, enshrining SMART on FHIR into new rules and regulations

Maintains compatibility with HL7 and other standards

Fast Healthcare Interoperability Resources (FHIR)

FHIR is a messaging standard aiming to facilitate interoperability among health IT systems

- [Maintained by HL7 International](#)
- Adds more semantics than HL7 V2 but has less complexity than V3
- Release 4 in early 2019 provided first normative content

FHIR is not

- Terminology standard – though it can use standardized terminologies
- Security standard – though it can be used with modern security standards
- A user interface standard

FHIR design principles

Focus on “80-20 approach” – aiming for common functionality but extensible for more

Uses modern Internet standards

- XML, JSON
- HTTP, REST

Set of primitive data types upon which healthcare-specific ones built

Overviews for

- [Clinicians](#)
- [Developers](#)
- [Architects](#)
- [Patients](#)

Overview of FHIR (Hay, 2017; Benson, 2021; Braunstein, 2022)

Resources – common data structures, built from basic data types

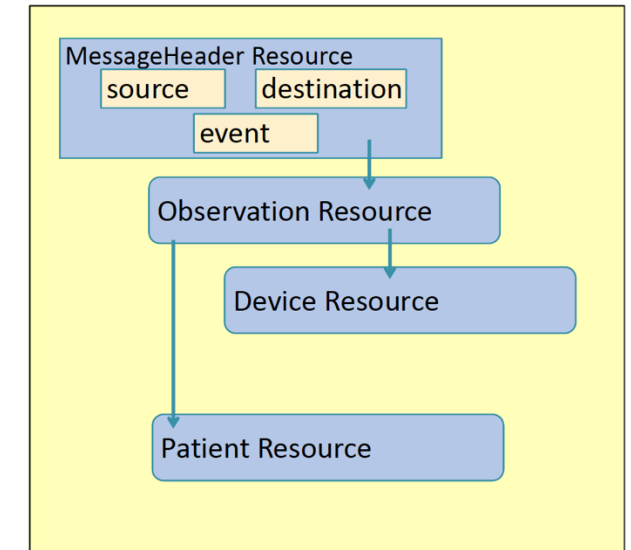
Bundles – group of interacting Resources representing a clinical situation

Semantics can be standardized via common terminologies

- Explicit mechanism for using standard code systems
- Value sets for specific uses of codes in a given clinical context, with value defined (and constrained)

Profiles – specification for Resources in specific contexts

Conformance – set of rules to test conformance to FHIR standards



- CodeableConcept: {
 "coding": [{
 "system": "http://snomed.info/sct",
 "code": "39579001",
 "display": "Anaphylactic reaction"
 }],
 "text": "Anaphylaxis"
}

Growing number of Resources

Level 1 Basic framework on which the specification is built

 Foundation	Base Documentation, XML, JSON, Data Types, Extensions
---	---

Level 2 Supporting implementation and binding to external specifications

 Implementer Support	 Security & Privacy	 Conformance	 Terminology	 Exchange
Downloads, Version Mgmt, Use Cases, Testing	Security, Consent, Provenance, AuditEvent	StructureDefinition, CapabilityStatement, ImplementationGuide, Profiling	CodeSystem, ValueSet, ConceptMap, Terminology Svc	REST API + Search Documents Messaging Services Databases

Level 3 Linking to real world concepts in the healthcare system

 Administration	Patient, Practitioner, CareTeam, Device, Organization, Location, Healthcare Service
---	---

Level 4 Record-keeping and Data Exchange for the healthcare process

 Clinical	 Diagnostics	 Medications	 Workflow	 Financial
Allergy, Problem, Procedure, CarePlan/Goal, ServiceRequest, Family History, RiskAssessment, etc.	Observation, Report, Specimen, ImagingStudy, Genomics, Specimen, ImagingStudy, etc.	Medication, Request, Dispense, Administration, Statement, Immunization, etc.	Introduction + Task, Appointment, Schedule, Referral, PlanDefinition, etc	Claim, Account, Invoice, ChargeItem, Coverage + Eligibility Request & Response, ExplanationOfBenefit, etc.

Level 5 Providing the ability to reason about the healthcare process

 Clinical Reasoning	 Medication Definition
Library, PlanDefinition & GuidanceResponse, Measure/MeasureReport, etc.	Medicinal, Packaged & Administrable product definitions, Regulated Authorization, etc.

FHIR Clinical Resources (Braunstein, 2022)



General

AllergyIntolerance
Condition (Problem)
Procedure
ClinicalImpression
FamilyMemberHistory
RiskAssessment
DetectedIssue



Care Provision

CarePlan
Goal
ReferralRequest
ProcedureRequest
NutritionOrder
VisionPrescription



Medication & Immunization

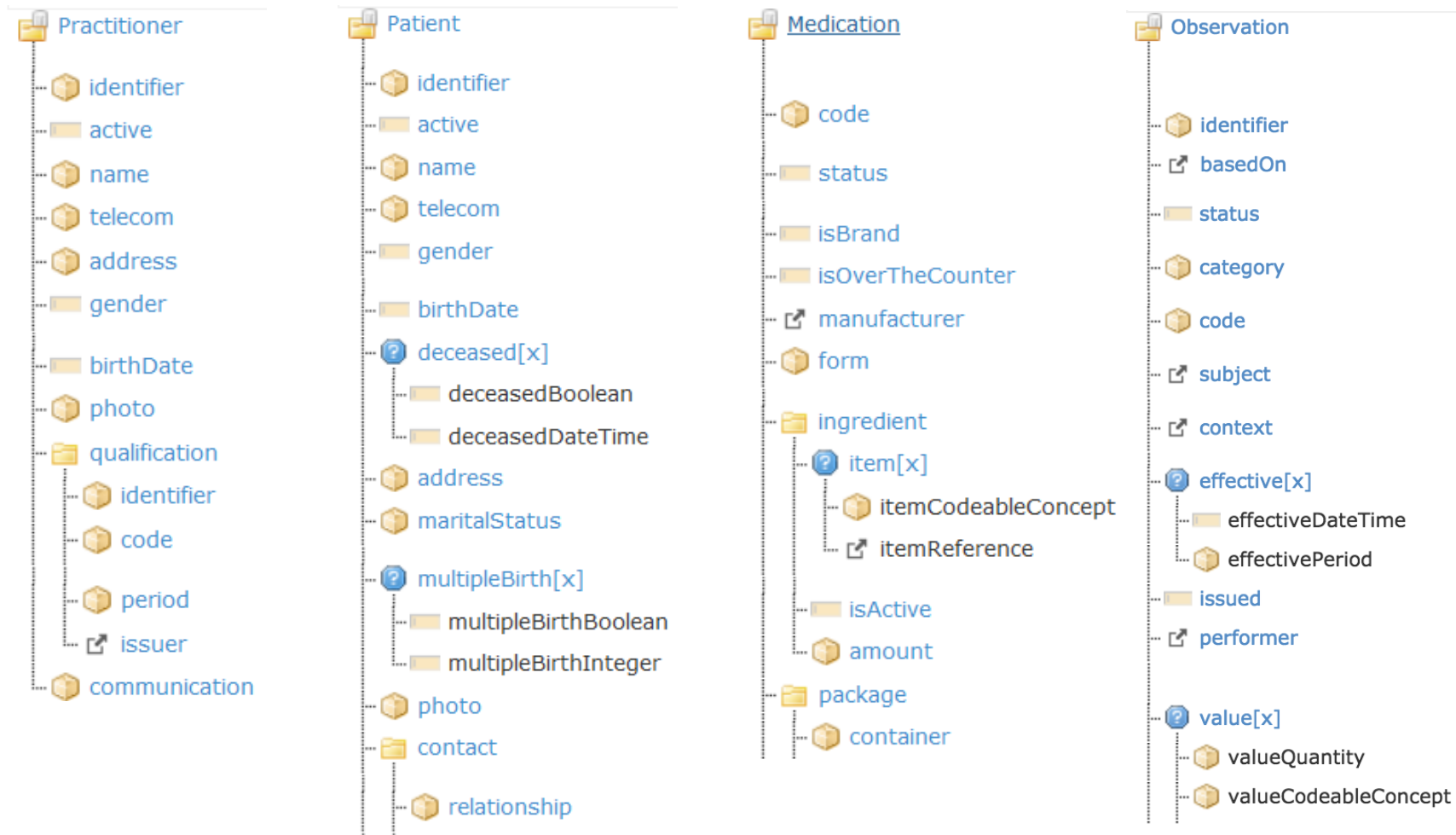
Medication
MedicationOrder
MedicationAdministration
MedicationDispense
MedicationStatement
Immunization
ImmunizationRecommendation



Diagnostics

Observation
DiagnosticReport
DiagnosticOrder
Specimen
BodySite
ImagingStudy

More details on some FHIR Resources



From patient story to FHIR Resources (Hay, 2017)

12-year-old boy

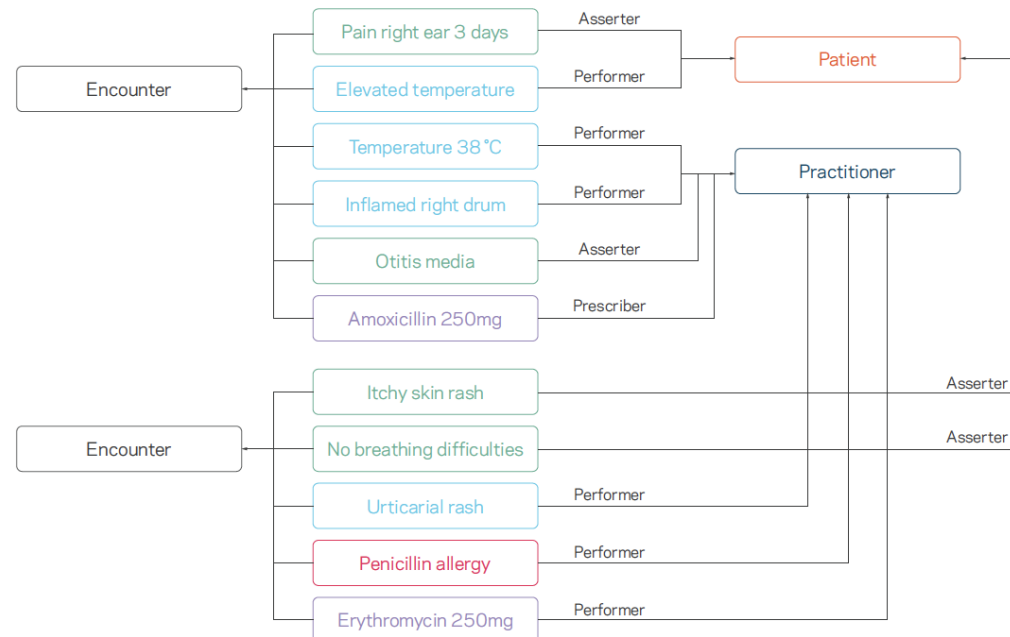
First consultation

Complaining of **pain in the right ear for 3 days** with an **elevated temperature**. On examination, temperature **38°C** and an **inflamed right eardrum** with no perforation. Diagnosis **Otitis media**, and prescribed **Amoxicillin 250mg 3 times per day for 7 days**.

Follow up consultation

2 days later returned with an **itchy skin rash**. No **breathing difficulties**. On examination, **urticarial rash** on both arms. No evidence meningitis. Diagnosis of penicillin **allergy**. Antibiotics changes to **Erythromycin 250mg 4 times per day for 10 days**.

- Patient
- Encounter
- Condition
- Observation
- Medication
- Allergy Intolerance



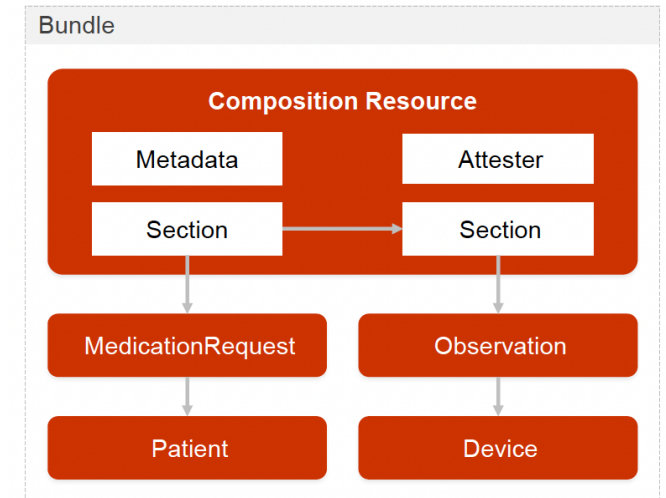
What about documents in FHIR?

Composition Resource

[CCDA on FHIR](#) (Geimer, 2018)

Contains

- Patient
- Author
- Custodian
- Type of document (e.g., discharge summary)
- Narrative of document



Name	Flags	Card.	Type	Description & Constraints
Composition	TU		DomainResource	A set of resources composed into a single coherent clinical statement with clinical attestation Elements defined in Ancestors: id , meta , implicitRules , language , text , contained , extension , modifierExtension
identifier		Σ 0..1	Identifier	Logical identifier of composition (version-independent)
status	?! Σ	1..1	code	preliminary final amended entered-in-error CompositionStatus (Required)
type		Σ 1..1	CodeableConcept	Kind of composition (LOINC if possible) FHIR Document Type Codes (Preferred)
class		Σ 0..1	CodeableConcept	Categorization of Composition FHIR Document Class Codes (Example)
subject		Σ 0..1	Reference(Any)	Who and/or what the composition is about
encounter		Σ 0..1	Reference(Encounter)	Context of the Composition
date		Σ 1..1	dateTime	Composition editing time
author		Σ 1..*	Reference(Practitioner PractitionerRole Device Patient RelatedPerson Organization)	Who and/or what authored the composition

Profiles

Profiles adapt FHIR for specific contexts

- Constrain a Resource – remove element or specify variation of values
 - e.g., different country conventions for gender
- Change coded element designation
- Add new element (extension)

Implementation guides specify profiles

- e.g., [US Core Implementation Guide](#)

- [US Core AllergyIntolerance Profile](#)
- [US Core CarePlan Profile](#)
- [US Core CareTeam Profile](#)
- [US Core Condition \(a.k.a Problem\) Profile](#)
- [US Core Device Profile](#)
- [US Core DiagnosticReport Profile](#)
- [US Core DocumentReference Profile](#)
- [US Core Encounter Profile](#)
- [US Core Goal Profile](#)
- [US Core Immunization Profile](#)
- [US Core Location Profile](#)
- [US Core Medication Profile](#)
- [US Core MedicationRequest Profile](#)
- [US Core MedicationStatement Profile](#)
- [US Core Organization Profile](#)
- [US Core Patient Profile](#)
- [US Core Practitioner Profile](#)
- [US Core PractitionerRole Profile](#)
- [US Core Procedure Profile](#)
- [US Core Results Profile](#)
- [US Core Smoking Status Profile](#)

Conformance

Conformance testing determines if implementation conforms to base specification or to any published implementation guide with profiles to

- Validate resources exchanged
- Test servers
- Test clients

Several server conformance tools available (Walonoski, 2018), including Inferno

FHIR uses “modern” APIs

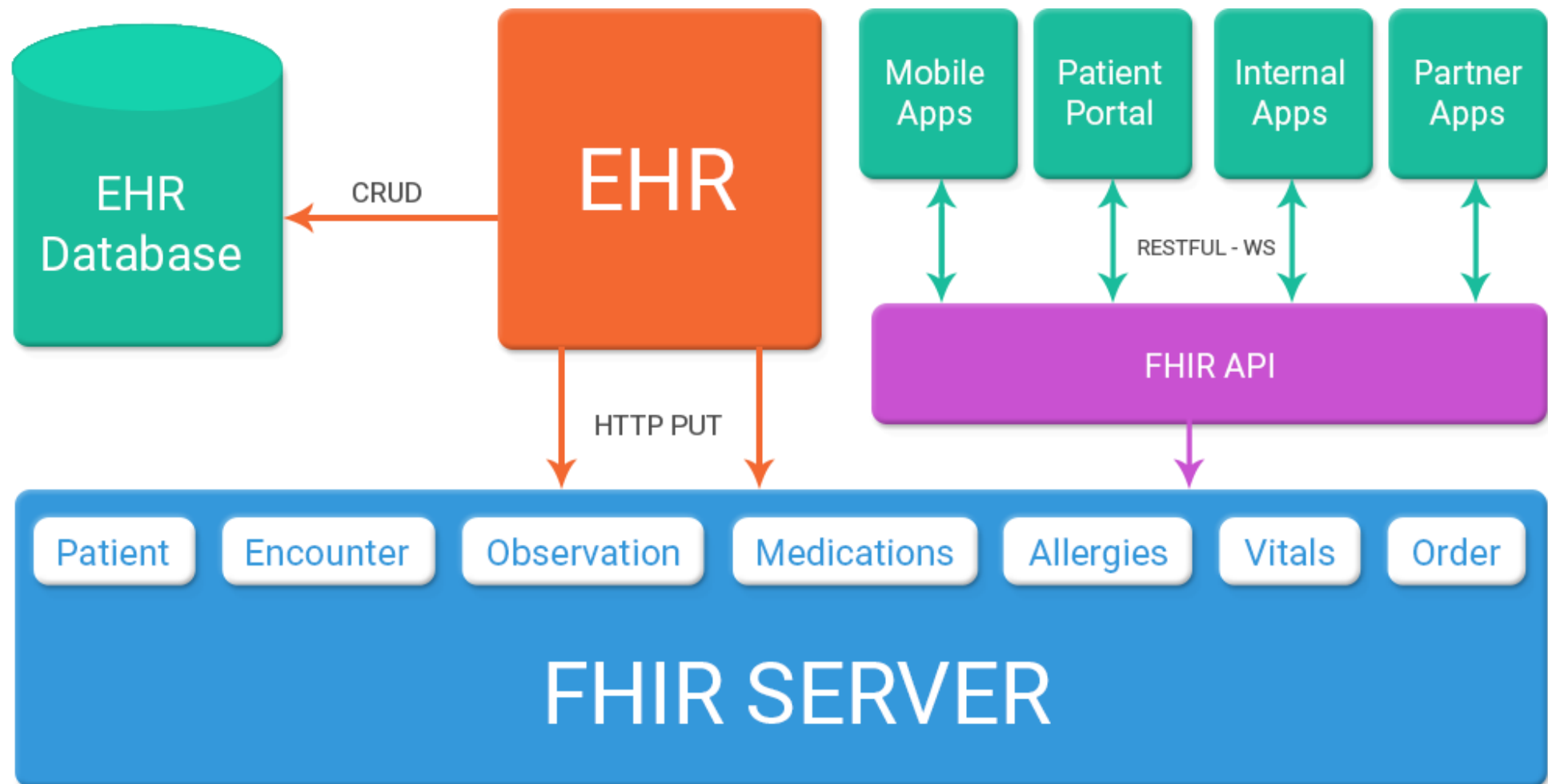
Interaction via RESTful API

Uses HTTP requests to perform standard database CRUD operations

- Create – POST
- Read – GET
- Update – PUT
- Delete – DELETE

HTTP call returns data in XML or JSON

FHIR interfaces with (but not limited to) EHRs (Sangem, 2016)



Beyond single-patient data

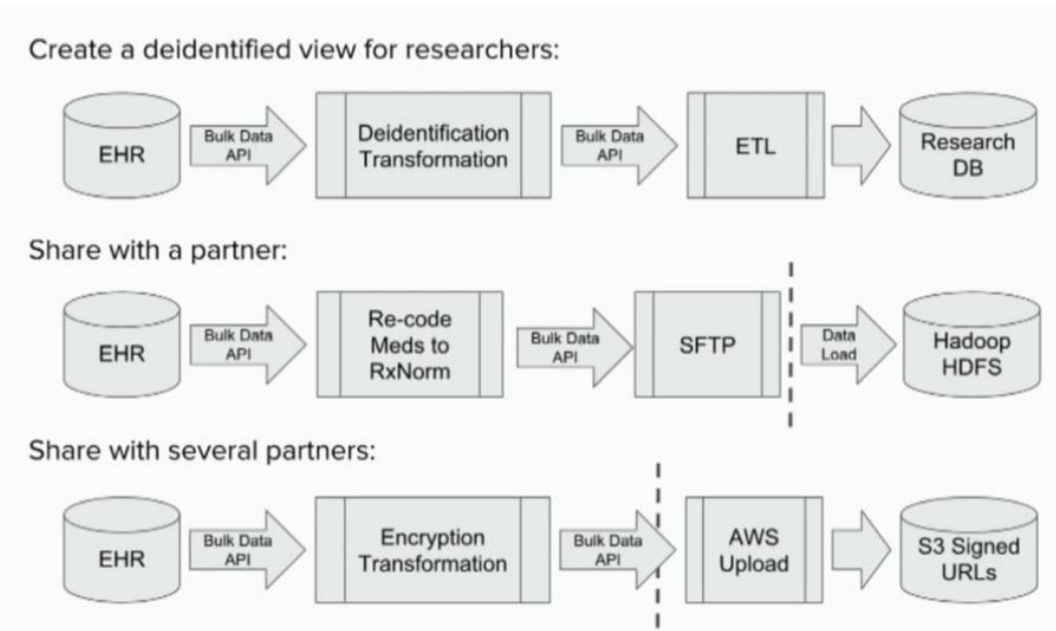
Initial FHIR efforts focused on single-patient exchange of data

Many uses/exchanges of EHR data involve more than one patient, e.g.,

- Population health management
- Quality measurement
- Clinical research
- Public health

FHIR API extended to allow exchange of [bulk data](#) (Mandl, 2020; Jones, 2023)

Aided by tools such as application of Structured Query Language (SQL) (Grimes, 2025)



Beyond patient data

Also developing Resources for medical knowledge and their integration with patient data for clinical decision support (CDS)

[Health Evidence Knowledge Accelerator \(HEvKA\)](#) – developing framework for implementing evidence-based medicine within FHIR (Alper, 2021; Alper, 2023)

[Clinical Reasoning module](#) – developing CDS rules, order sets, clinical protocols, and quality measures

[FHIR Clinical Guidelines](#)

Tools for FHIR

Test servers with sample patients and data (aka, “sandboxes”)

- [HAPI](#)
- [Logica](#) (formerly HSPC)

Tools to build and view Resources

- [ClinFHIR](#) – build Resources and scenarios on test servers
- [FORGE](#) – build and edit profiles

FHIR for jurisdictions