Introduction and Arden Syntax

Session W16:

Clinical Decision Support Standards to Facilitate Value-Based Health Care and Quality Improvement:

Latest Developments and What You Need to Know

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Charles Drew University

Disclosure

I have no relevant relationships with commercial interests to disclose.

Discussants

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  Professor of Medicine

  Charles Drew University

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  Professor of Medicine

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  Co-Chair, HL7 Clinical Decision Support Work Group

  Co-Chair, Arden Syntax Work Group

  Discussant: Overview & Arden Syntax

Discussants

- **Bryn Rhodes**
  Alphora

  Co-Chair, HL7 Clinical Decision Support Work Group
  Discussant: CQL, FHIR, SMART on FHIR, US Core FHIR profiles, QICore FHIR profiles, FHIR Clinical Reasoning

- **Howard Strasberg, MD, MS, FACMI, FAMIA**
  Vice President, Medical Informatics, Wolters Kluwer Health

  Co-Chair, HL7 Clinical Decision Support Work Group
  Discussant: CDS Hooks

Discussants

- **Guilherme Del Fiol, MD, PhD, FACMI**
  Associate Professor & Vice Chair of Research
  Department of Biomedical Informatics
  University of Utah

Co-Chair, HL7 Clinical Decision Support Work Group

Discussant: Infobutton Standard, CDS Hooks

Discussants

- **Kensaku Kawamoto, MD, PhD, MHS, FACMI, FAMIA**
  Director, Knowledge Management and Mobilization
  Associate Professor & Vice Chair of Clinical Informatics
  Department of Biomedical Informatics
  Associate Chief Medical Information Officer
  University of Utah

Co-Chair, HL7 Clinical Decision Support Work Group

Discussant: Data models, implementation at University of Utah

Discussants

- **Peter J Haug, MD, FACMI**

  Intermountain Healthcare

  Professor of Biomedical Informatics

  University of Utah

  Co-Chair, Arden Syntax Work Group

  Discussant: Business process modeling, data interoperabilty

Overview of Workshop

- **Part 1: Overview of CDS & SDOs**

- **Part 2: Current standards and future work**
  - **Arden Syntax**
  - **CQL, FHIR, SMART on FHIR, US Core FHIR profiles, QICore FHIR profiles, FHIR Clinical Reasoning Business process modeling**
  - **CDS Hooks**
  - **Infobutton; CDS Hooks implementations**
  - **Practical uses of CDS Hooks & SMART on FHIR**
  - **BPM+, EHRs interoperability**

- **Part 3: Group exercise / interaction**

HL7 Structure: Clinical Decision Support

- **Heavily consensus-based, multilayer voting approval process (WGs & membership-wide)**
- **Clinical Decision Support Work Group (Jenders, Del Fiol, Kawamoto, Rhodes, Strasberg)**
  - **Contribute to data models, inform CDS aspects of other HL7 work, develop overall decision support system model**
- **Arden Syntax WG (Jenders, Haug)**
  - **Smaller committee focused specifically on this particular standard for knowledge sharing**
- **Clinical Quality Information WG**
  - **CDS focused on quality measurement/improvement**

hl7.org, confluence.hl7.org

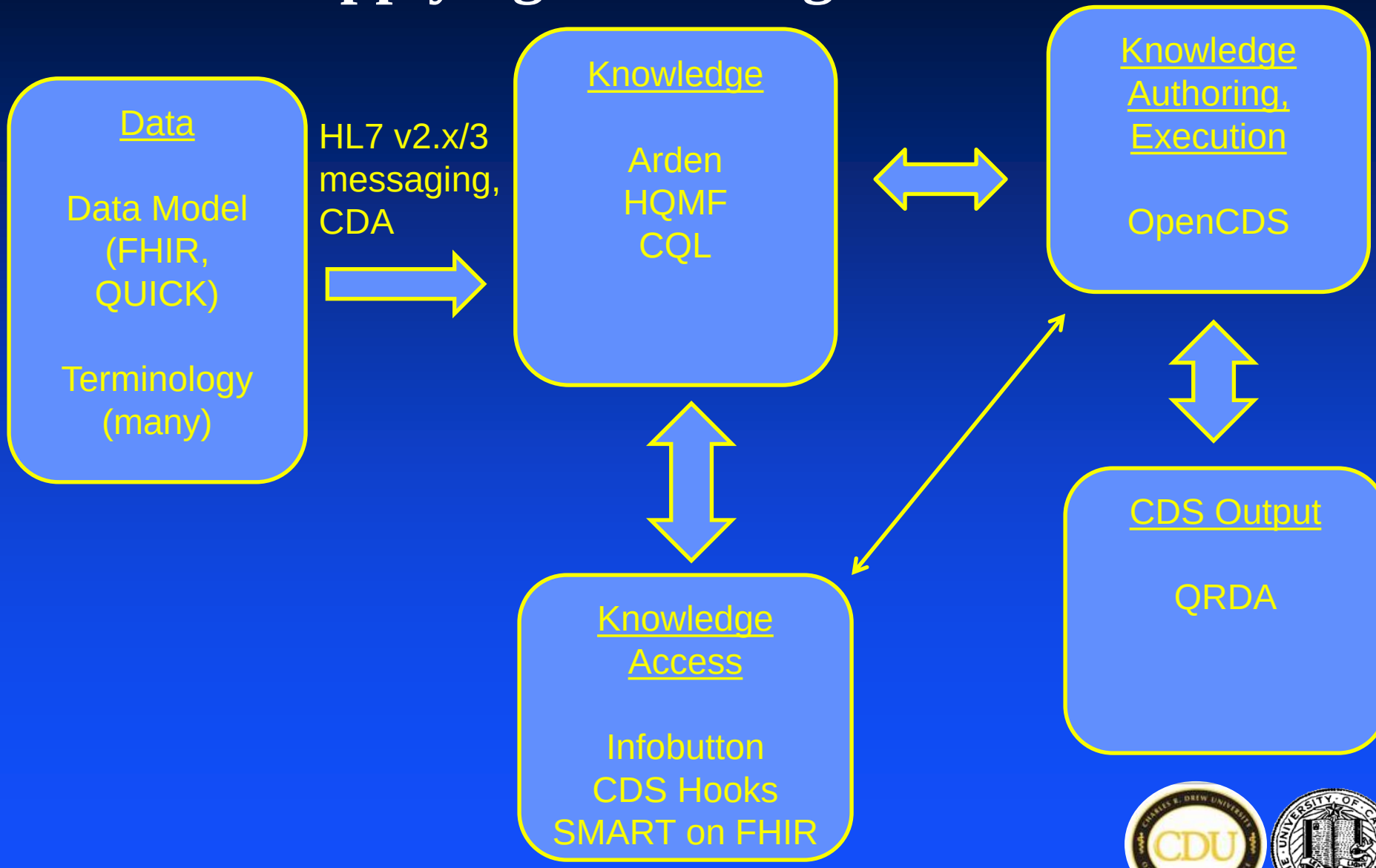
Other Organizations

- **CEN TC 251: Some CDS-specific (knowledge metadata, HIT safety risk classification), but mainly related standards (security, person identifiers, vocabulary maintenance)**

- **Joint Initiative Council for Global Health Informatics Standardization (JIC): Coordinate health informatics standards internationally**
  - **9 SDOs: CDISC, LOINC, GS1, HL7, IHTSDO, ISO TC215, CEN TC215, IHE, DICOM**
  - **Patient summary standards, genomics, drug identification**

- **Object Management Group (OMG): Work with HL7 on business process modeling**

CDS "Big Picture": Applying Knowledge to Data



Addressing the CDS Standards Challenge: HL7

- **Knowledge Transfer**
  - **Procedural/Executable: Arden Syntax, CQL**
  - **Declarative: HQMF**
- **Knowledge Access**
  - **Infobutton, CDS Hooks, SMART on FHIR**
- **Infrastructure**
  - **Data models: FHIR**

Arden Syntax for Medical Logic Modules

- Modular knowledge bases which are independent from one-another
- Share & reuse medical knowledge
- Procedural representation of medical knowledge
- Discrete units of knowledge = Medical Logic Module (MLM)
- Explicit definitions for data elements
- HL7 / ANSI / ISO Standard
- Current version: 2.10 (published 2014), v3 in progress
- Implemented by several vendors

Arden Syntax:
Evolving with User Demand

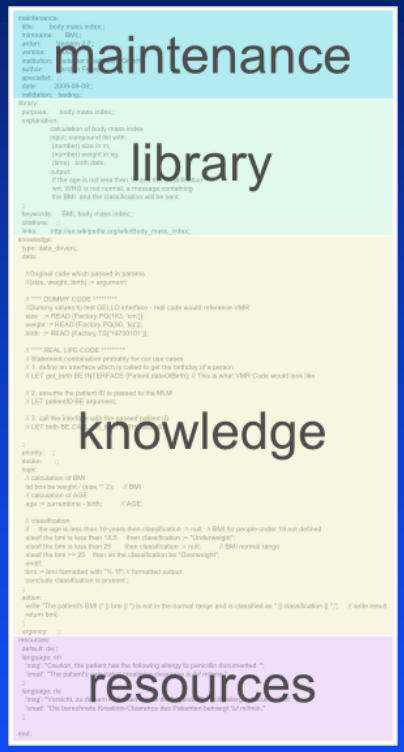
- **Moving away from relatively simple, clinician-friendly expressions to more powerful computability**
- **v2.7: Complex objects**
- **v2.8 (2011): Switch statement, complex list operators**
- **v2.9 (2012): Fuzzy logic**
- **v2.10 (2014): ArdenML = Complete XML version**
- ***v3.0* (2023): Standard data model (FHIR)**

Medical Logic Module

- **MLM = an independent unit in a health knowledge base**
- **MLM: Makes a single health decision**
  - **maintenance information**
  - **links to other sources of knowledge/data**
  - **logic**
- **MLM = a stream of text stored in an ASCII file in statements called slots**
- **Purpose: Standard format so that knowledge can be shared**

Arden Syntax: Structure

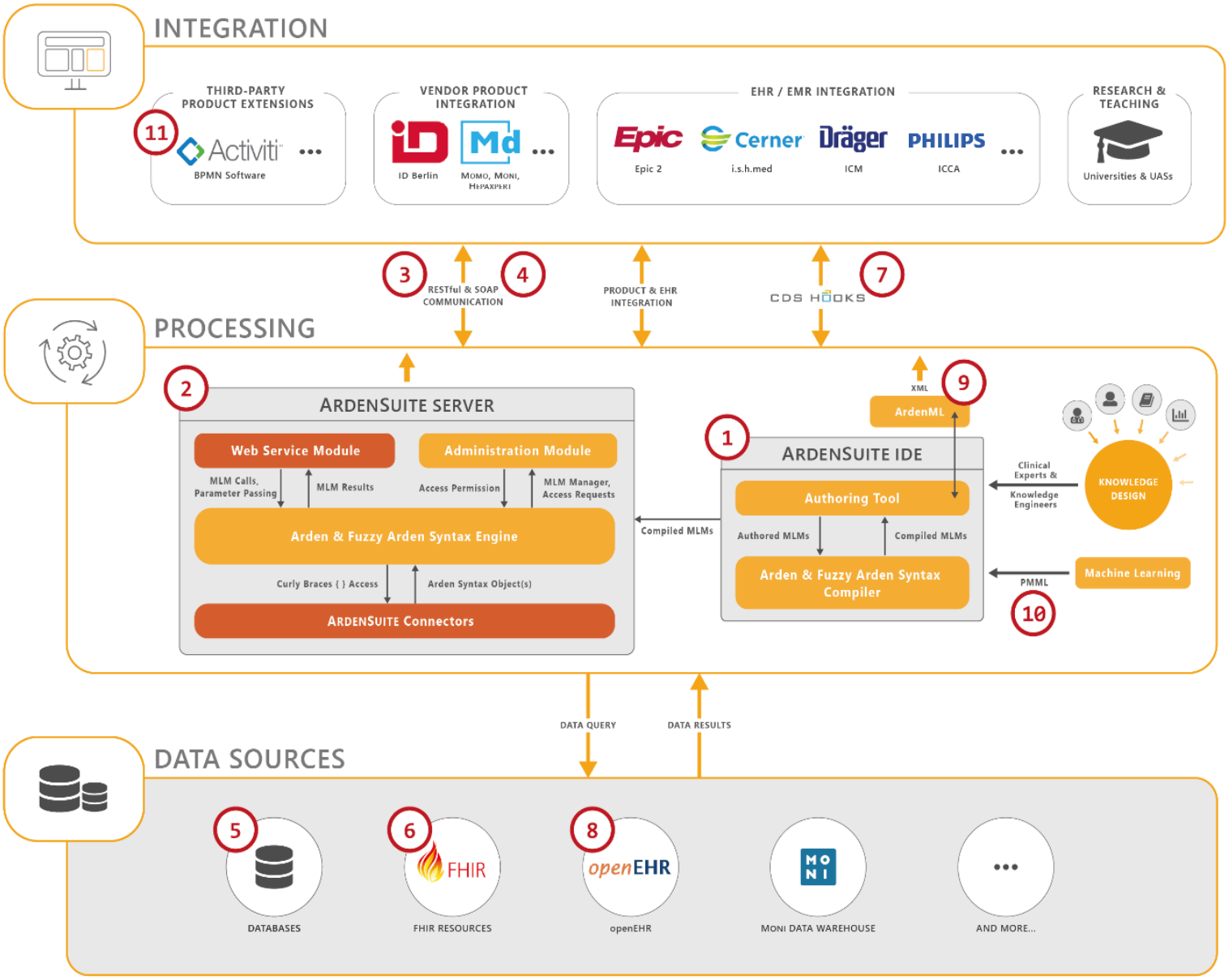
- In Arden Syntax, medical knowledge is hierarchically arranged within medical logic modules (MLMs)
- Each MLM represents sufficient knowledge to make at least one single medical decision
- An MLM is stored in a file that has the file extension ".mlm"
- Each MLM is well organized and structured into **categories** and **slots.**
- Categories must appear in a predefined order.
- Each category contains a category-specific set of **slots,** also in a predefined order.




```
maintenance:
     title:          ;;
     mlmname:        [required];;
     arden:          [required];;
     version:        [required];;
     institution:    [required];;
     author:         ;;
     specialist:     ;;
     date:           [required];;
     validation:     [required];;
library:
     purpose:        ;;
     explanation:    ;;
     keywords:       ;;
     citations:      ;;
     links:          ;;
knowledge:
     type:           data_driven;;
     data:           ;;
     priority:       ;;
     evoke:          ;;
     logic:          ;;
     action:         ;;
     urgency:        ;;
resources:           [optional]
     default:        ;;
     language:       ;;
end:
```

ARDENSUITE Architecture

MEDEXTER Healthcare



AVAILABLE FOR:

- Windows
- Linux
- Mac OS
- docker Container
- Amazon Cloud
- Microsoft Azure

Arden Syntax WG: Current Activities

- **CDS Big Picture Implementation Guide**
  - **How to integrate Arden and other standards to implement complete CDS solutions**

- **Arden Syntax IG: How to use Arden, especially recent added complex features**
  - **R3 (9/2019): Standard data models, business process modeling**
  - **R4 (planned 2023): Update for Arden Syntax v3**

- **Arden v3**
  - **"curly braces problem": FHIR = standard data model**
  - **Goal: Ballot 1/2023**

Arden Syntax: Applications

- Guideline implementation
- Interruptive alerts/reminders
- Diagnostic decision support: Many examples
  - Hepatitis test interpretation, antibiotic recommendations, immunization recommendations
- Identifying possible clinical trial subjects
- Surveillance: Cross-population
  - Hospital epidemiology

Thank you!

Questions

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Group Exercise:
CDS for Ambulatory COVID-19 Treatment

- **Goal: Model a limited CDSS for providing CDS to promote evidence-based treatment of SARS-CoV-2 infection.**
- **Process**
  - **Identify one or two CDS interventions for ambulatory care of COVID-19.**
  - **Apply Five Rights framework: Right information to the right person in the right format via the right communication channel at the right point in workflow.**
  - **Identify data sources (new vs already-captured), communication pathways, and knowledge sources for the CDS interventions, including standards for data representation, knowledge representation and knowledge delivery/integration into clinical systems (e.g., EHRs, patient-facing tools).**

Group Exercise: Clinical Background

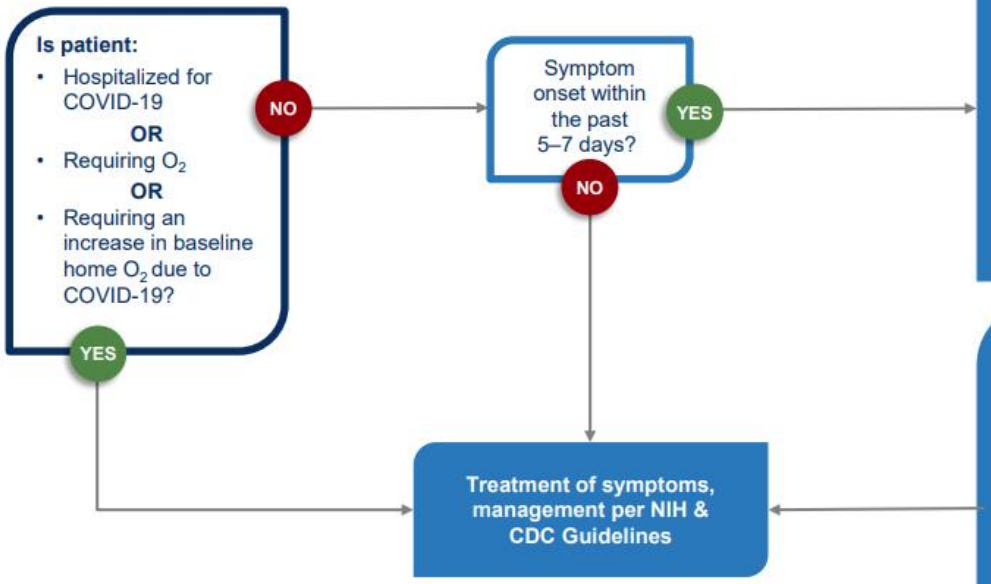
- **Possible treatments**
  - **First-line: Oral Paxlovid, IV remdesivir**
  - **Alternatives: Monoclonal ab bebtelovimab, oral molnupiravir**
- **Indications = High-risk patients**
  - **Age > 50 years**
  - **Unvaccinated or undervaccinated**
  - **High-risk condition: Obesity, immunodeficiency, tobacco use disorder, pregnancy and others**

SEP2022

COVID-19 Outpatient Therapeutics

Clinical Decision Aid for Ages 12+ years

Adult or pediatric patient (ages 12 and older weighing at least 40 kg) with mild to moderate COVID-19 and at high risk for progression to severe disease



Consider one of the following therapeutics, if available, feasible, and clinically appropriate[1]:

Paxlovid[2] within 5 days of symptom onset If patient does not have severe renal impairment (eGFR <30mL/min) OR severe hepatic impairment (Child-Pugh Class C)

- **eGFR ≥ 60mL/min:** 300 mg nirmatrelvir taken with 100 mg ritonavir twice daily for 5 days
- **eGFR ≥ 30mL/min to < 60 mL/min:** 150 mg nirmatrelvir taken together with 100 mg ritonavir twice daily for 5 days
- Evaluate concomitant use of CYP3A inducers and medications with high dependency on CYP3A for clearance as these may be contraindicated[2,3]

OR

Veklury (remdesivir)[4] 200 mg IV x 1 dose on Day 1, 100 mg IV x 1 on Days 2–3 begun **within 7 days of symptom onset if patient does not have severe renal impairment (eGFR <30mL/min)**

Prescribers must review and comply with the mandatory requirements outlined in **the Paxlovid EUA[2]** or **the Veklury Prescribing Information[4].**

If Paxlovid and Veklury (remdesivir) are not available, feasible or clinically appropriate, consider one of the following therapeutics:

bebtelovimab[5] within 7 days of symptom onset
175 mg single IV injection

OR

Lagevrio (molnupiravir)[6] if patient age 18 or older AND possibility of pregnancy, if applicable, ruled out:

800 mg by mouth every 12h for 5 days begun **within 5 days of symptom onset**

Prescribers must review and comply with the mandatory requirements outlined in **the bebtelovimab[5]** or **Lagevrio (molnupiravir) EUA[6]**

References:

[1] NIH COVID-19 Treatment Guidelines Therapeutic Management of Nonhospitalized Adults With COVID-19. https://www.covid19treatmentguidelines.nih.gov/therapies/statement-on-therapies-for-high-risk-nonhospitalized-patients/
[2] Paxlovid EUA. https://www.fda.gov/media/155050/download
[3] NIH's COVID-19 Treatment Guidelines Panel: Ritonavir-Boosted Nirmatrelvir (Paxlovid). https://www.covid19treatmentguidelines.nih.gov/therapies/antiviral-therapy/ritonavir-boosted-nirmatrelvir--paxlovid-/
[4] Veklury (remdesivir) Prescribing Information. https://www.gilead.com/-/media/files/pdfs/medicines/covid-19/veklury/veklury_pi.pdf
[5] Bebtelovimab EUA. https://www.fda.gov/media/156152/download
[6] Lagevrio EUA. https://www.fda.gov/media/155054/download

ASPR Administration for Strategic Preparedness and Response

CDU Charles R. Drew University of Medicine and Science

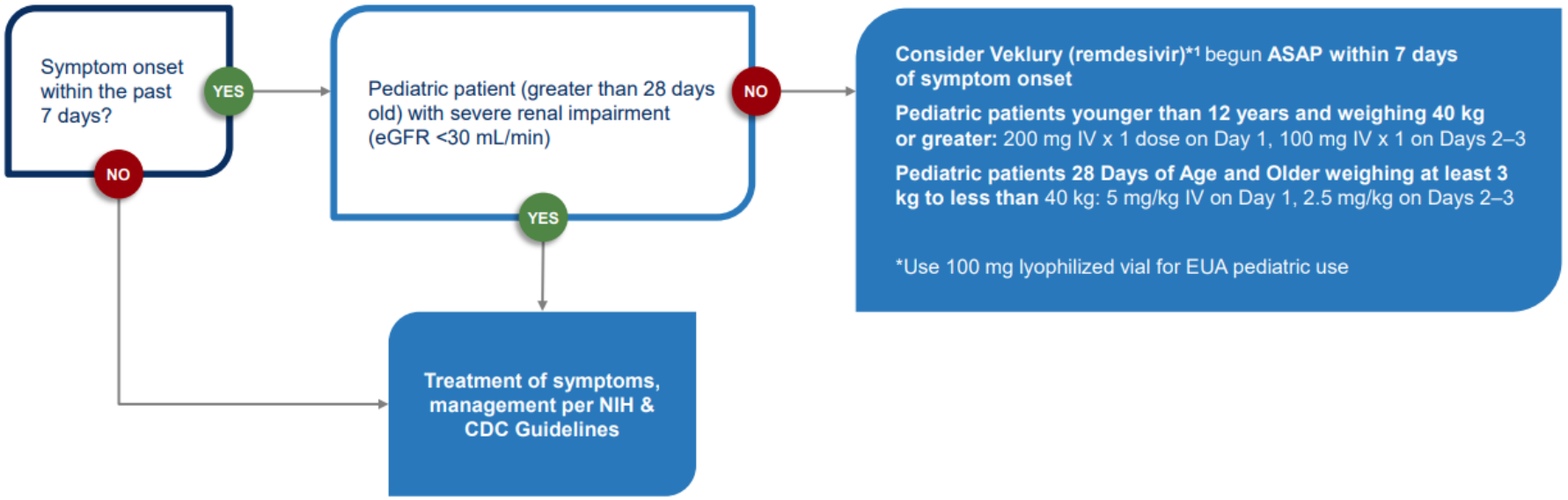
The University of California UCLA

SEP2022

COVID-19 Outpatient Therapeutics

Clinical Decision Aid for Ages 28 days to less than 12 years

Pediatric patient (28 days of age to less than 12 years, weighing at least 3 kg to less than 40 kg) with mild to moderate COVID-19 and at high risk for progression to severe disease



Reference:

[1] Veklury Prescribing Information; https://www.gilead.com/-/media/files/pdfs/medicines/covid-19/veklury/veklury_pi.pdf

ASPR
Administration for Strategic Preparedness and Response

Group Exercise: IT Considerations

- **Data sources: Hospital EHR/CPOE system, ambulatory EMR, public registry (e.g., vaccinations), HIE, laboratory information system**
- **Platform for delivering CDS: CPOE, ambulatory EMR, mobile app, secure email**
- **Interventions: Interruptive alert, order set, etc**
- **Triggers for CDS: Patient arrival at care site, telehealth visit, abnormal laboratory test**

Goal: Combine these elements to create CDS for treating COVID-19

Group Exercise: Guidelines

- **CDC treatment guideline => https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-care/outpatient-treatment-overview.html**

- **CDC provider decision aid => https://aspr.hhs.gov/COVID-19/Therapeutics/Documents/COVID-Therapeutics-Decision-Aid.pdf**

- **High-risk conditions => https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-care/underlyingconditions.html**

Workshop 16: Group Exercise
CDS for COVID-19 Treatment
AMIA Annual Symposium 2022

Objective: Design the basics of a computer-based clinical decision support system to provide CDS for treating COVID-19 principally in the ambulatory setting.

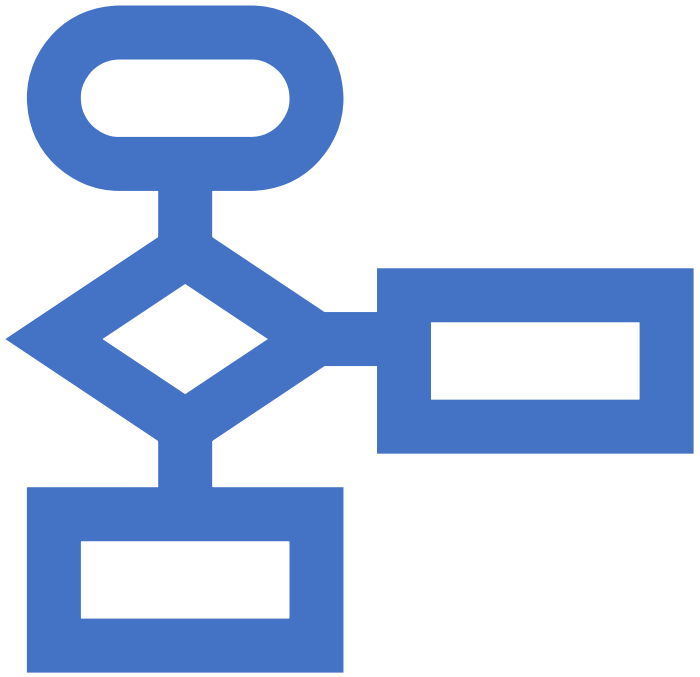
Method: Considering standards for data representation and for implementing knowledge (or access to it) should be identified; considering both health care provider-facing and patient-facing interventions; assuming an ambulatory environment; and taking into consideration how you will obtain the risk data in order to drive the CDS; do the following:

1. Identify one or two CDS interventions for ambulatory care of COVID-19.
2. Characterize the interventions in terms of clinical workflow using the CDS Five Rights framework.
3. Identify data sources (including access to already-captured data and how you will obtain new data), communication pathways, and knowledge sources for the CDS interventions, including standards for data representation, knowledge representation and knowledge delivery/integration into clinical systems (e.g., EHR, patient-facing tools).

Work Product: List of components of the CDS system: Intervention, human targets of the intervention, data sources, standards and like, aligning these with the Five Rights.

Clinical Background: Infection with SARS-CoV-2, a virus that emerged in late 2019 and erupted into a pandemic in 2020, can result in a severe, multisystem illness, COVID-19, centered on the respiratory system with significant morbidity and mortality. Two key antiviral treatments, oral Paxlovid and intravenous remdesivir, have emerged that reduce mortality in individuals at high-risk for complications, which are mainly patients who are older than 50 years, who are unvaccinated or not up-to-date on vaccinations for this disease; and who have one or more conditions that increase the risk of complications (e.g., obesity, immunodeficiency, tobacco use disorder, pregnancy and others). The US Centers for Disease Control and Prevention (CDC) has developed guidelines and a decision aid to assist practitioners in identifying patients who should receive antiviral therapy and to guide that therapy, including dosing based on renal function (eGFR = estimated glomerular filtration rate, with a lower number indicating worse kidney function) and hepatic function. CDS may help improve recognition of these patients and prescribing of the appropriate treatment.

- CDC treatment guideline => https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-care/outpatient-treatment-overview.html
- CDC provider decision aid => https://aspr.hhs.gov/COVID-19/Therapeutics/Documents/COVID-Therapeutics-Decision-Aid.pdf
- High-risk conditions => https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-care/underlyingconditions.html



Clinical Decision Support Standards

Bryn Rhodes

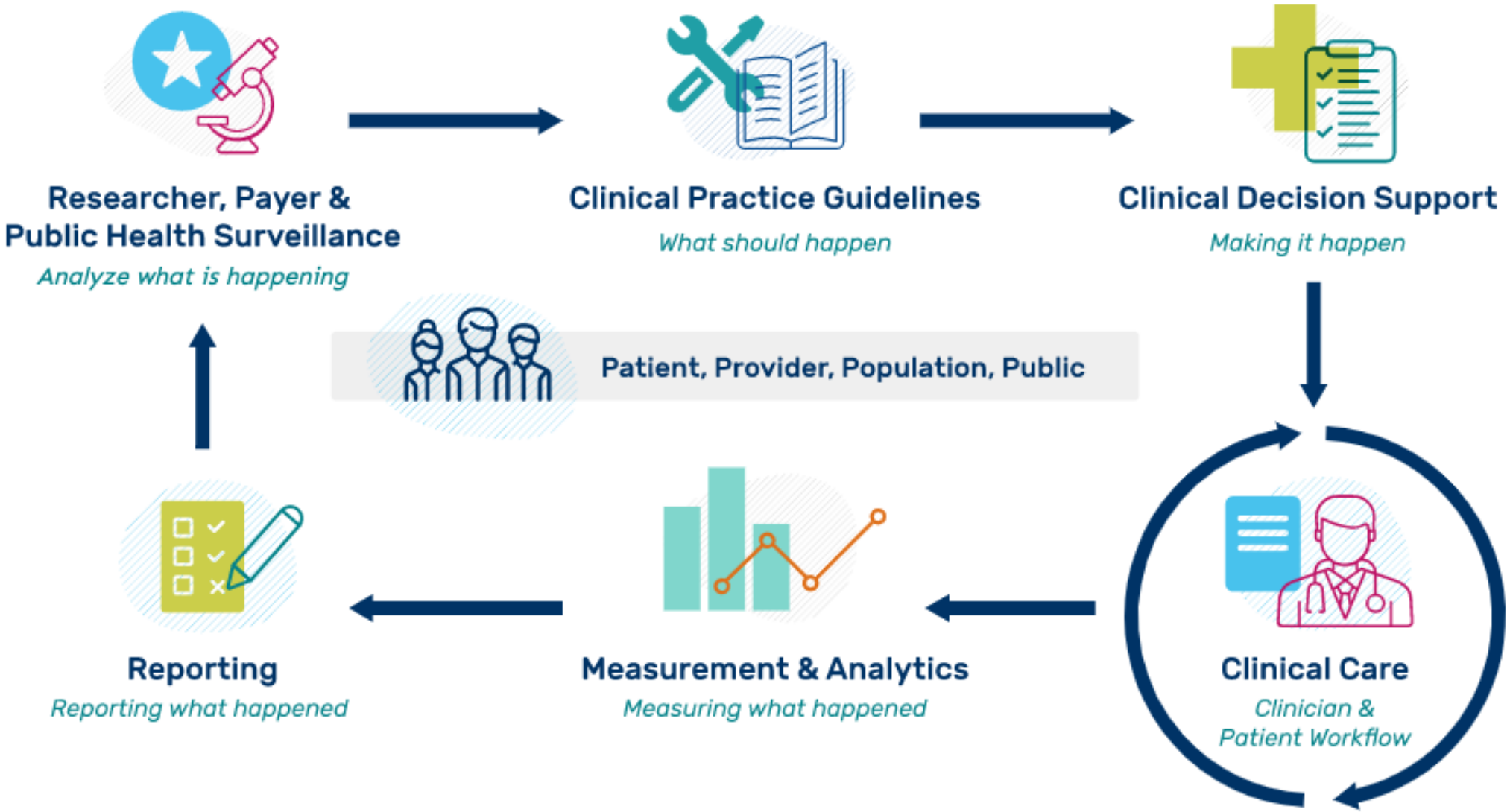
Chief Technology Officer, Alphora

Alphora

Disclosures

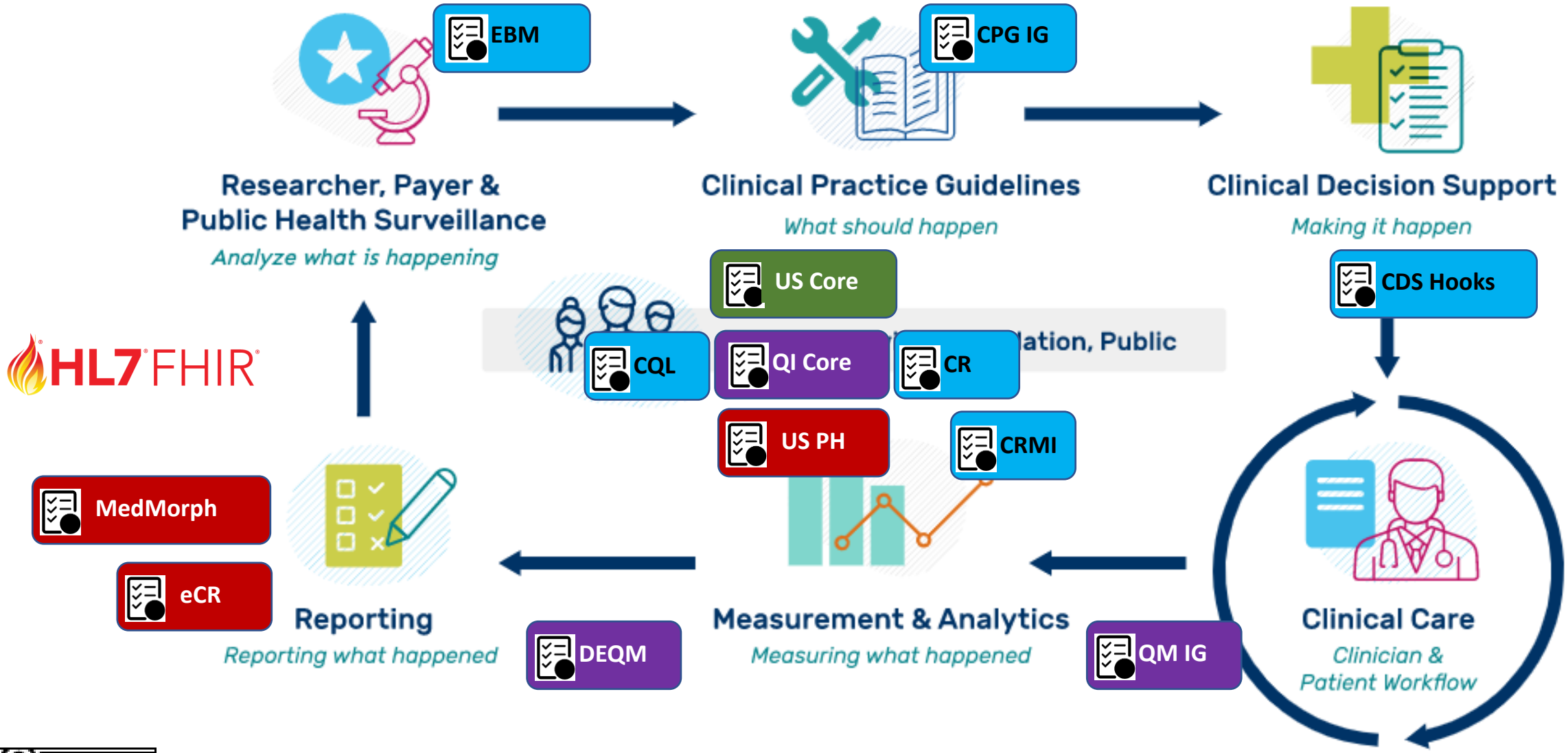
- In the past year I have served as a consultant or invited speaker with honorarium for the U.S. Office of the National Coordinator for Health IT (via Security Risk Solutions (SRS), ICF, Centers for Medicare and Medicaid (via ICF and Yale), Centers for Disease Control (via SRS), World Health Organization, Association of Public Health Laboratories, Apervita, McKesson, RTI International, Cerner, Optum, Point of Care Partners, and the National Association of Community Health Centers.
- Dynamic Content Group (dba Alphora) provides support and maintenance for clinical quality improvement evaluation and authoring using FHIR and Clinical Quality Language.

Quality Improvement Ecosystem

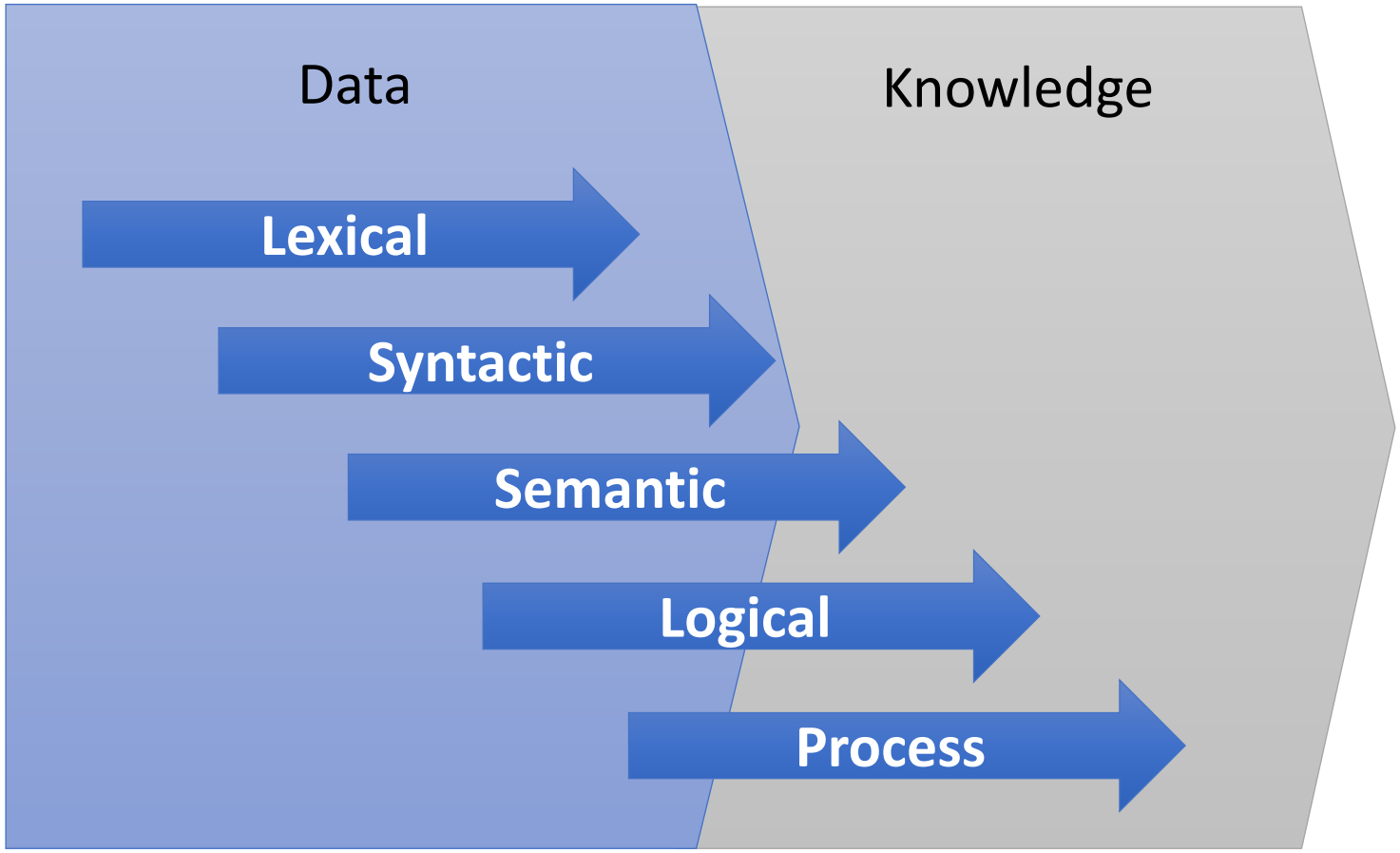


LEGEND: Sponsoring HL7 Workgroups
Clinical Decision Support (CDS)
Clinical Quality Information (CQI)
Public Health (PH)
Cross Group Projects (CGP)

Quality Improvement Ecosystem

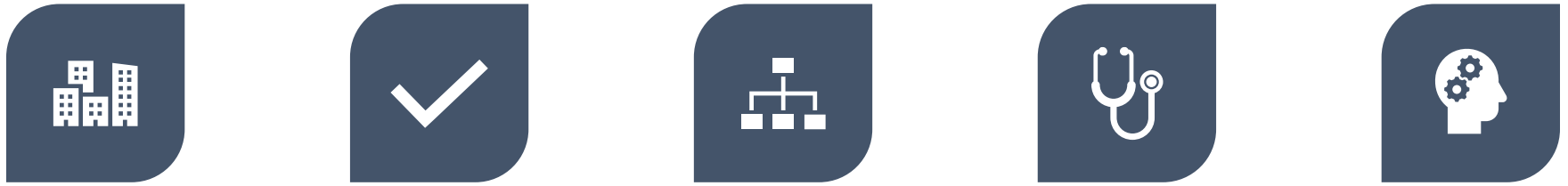


Types of Interoperability



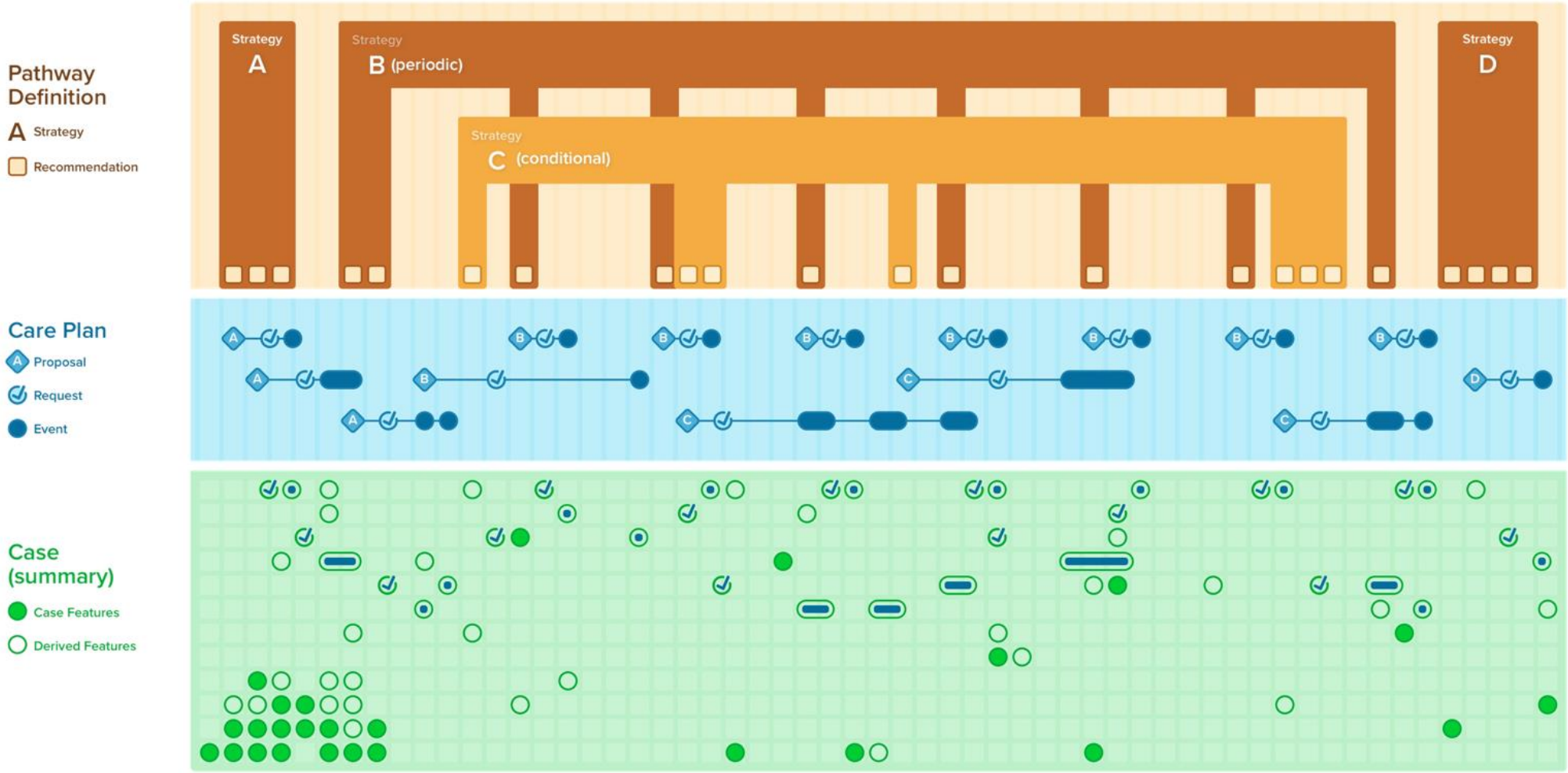
HL7 FHIR

- **F**ast **H**ealthcare **I**nteroperability **R**esources
- Resources – Building blocks (provide *syntax*)
- Profiles – Usage descriptions (provide *semantics*)
- Protocol – Defines interactions



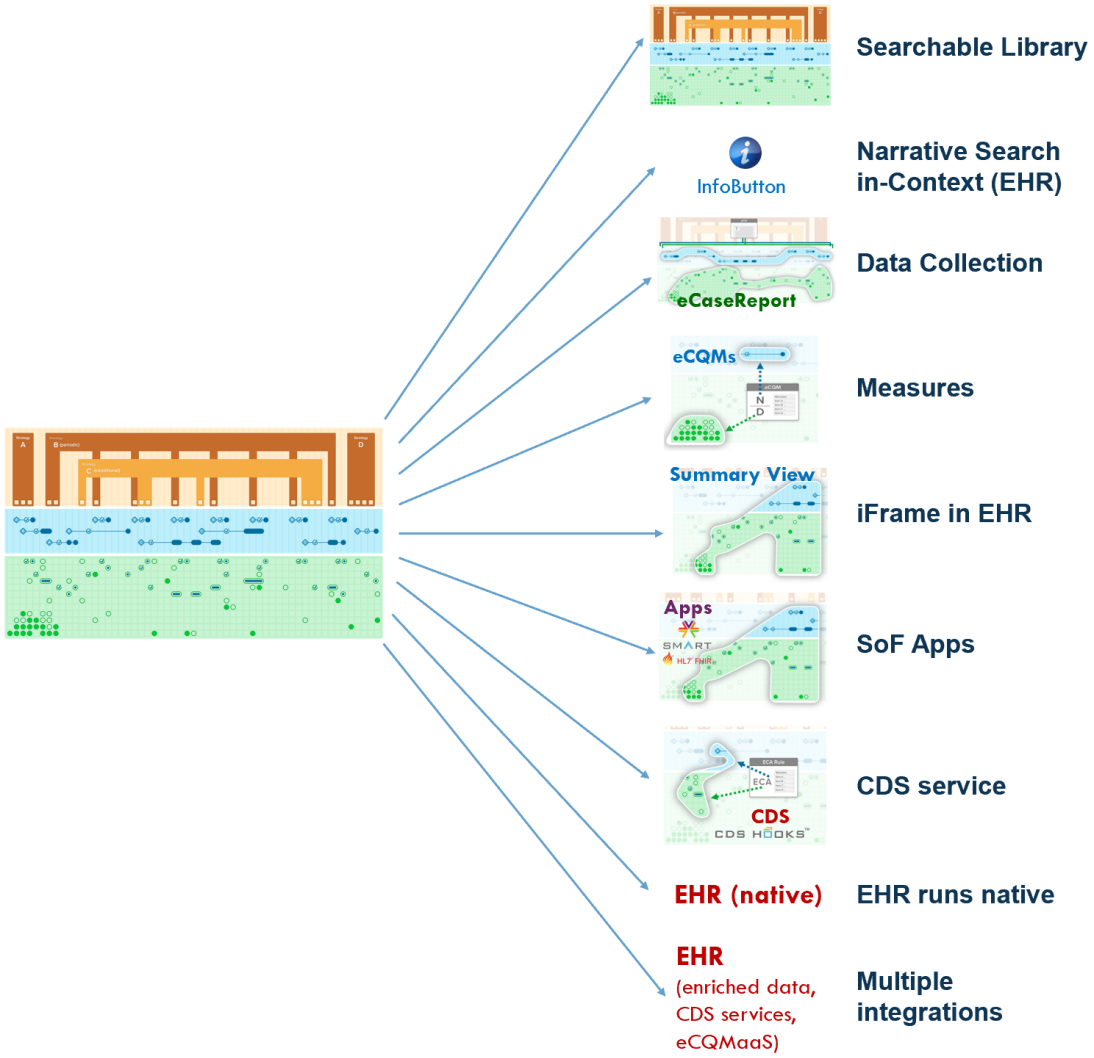
http://hl7.org/fhir

FHIR Clinical Guidelines (CPG-on-FHIR)



http://hl7.org/fhir/uv/cpg

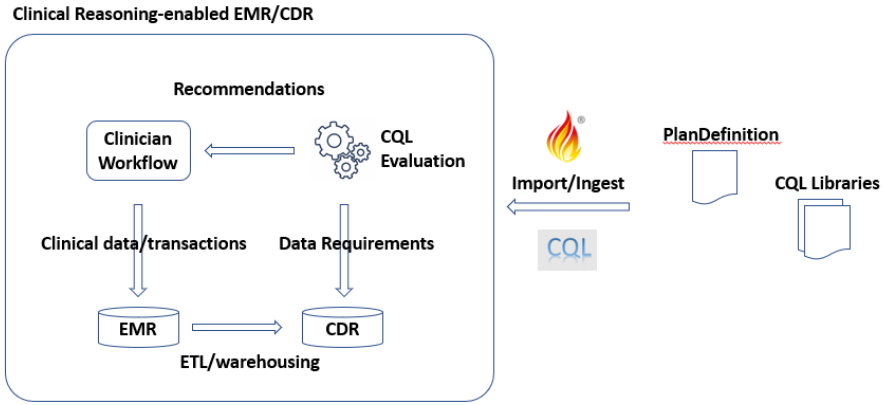
Delivery/Enablement



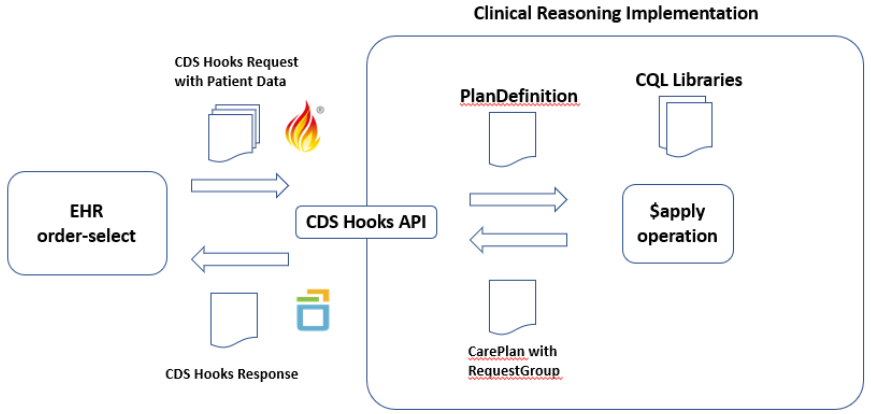
http://hl7.org/fhir/uv/cpg/documentation-approach-03-conformance-levels.html

Integration Approaches

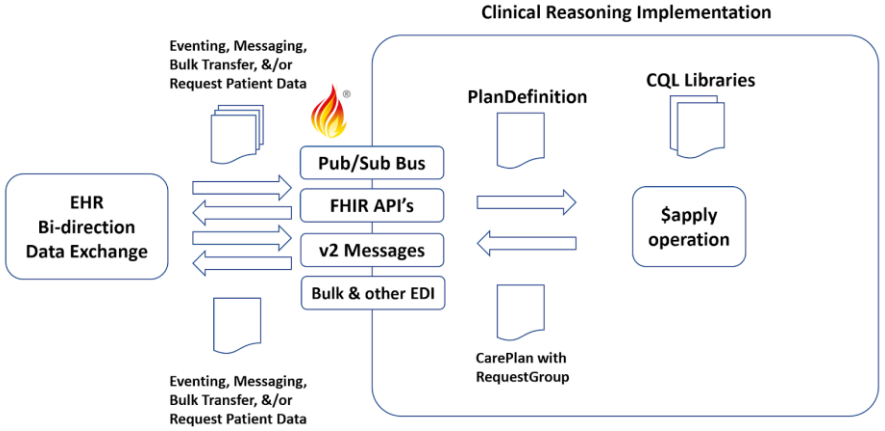
Ingestion



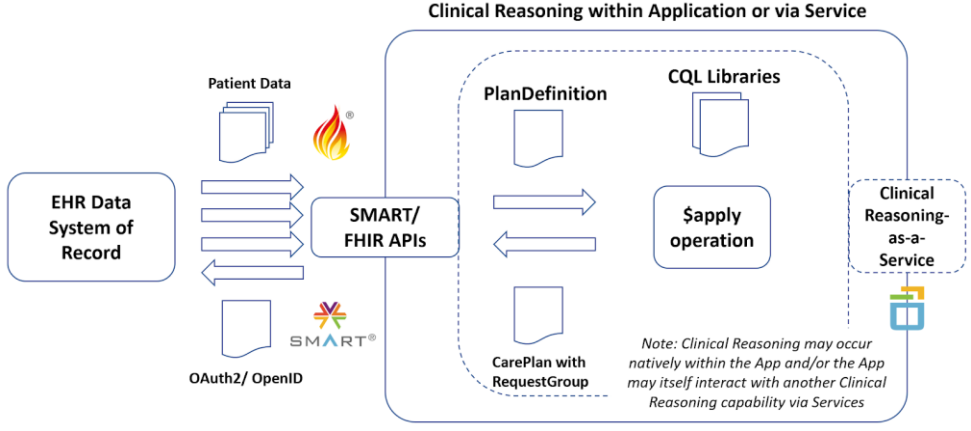
Service-based



Real-time Data Enrichment and Delivery



As an Application



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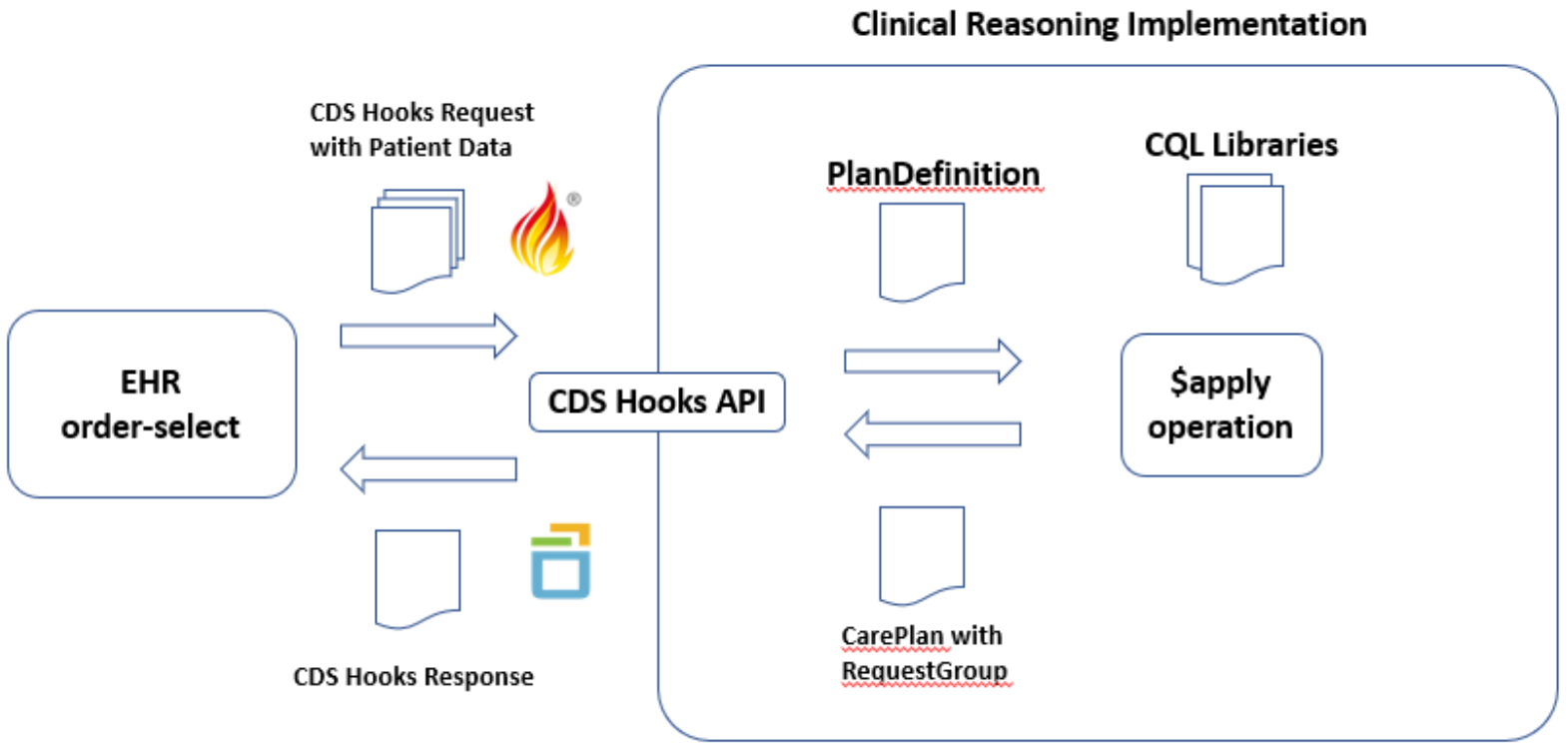
Service-based Integration via CDS Hooks



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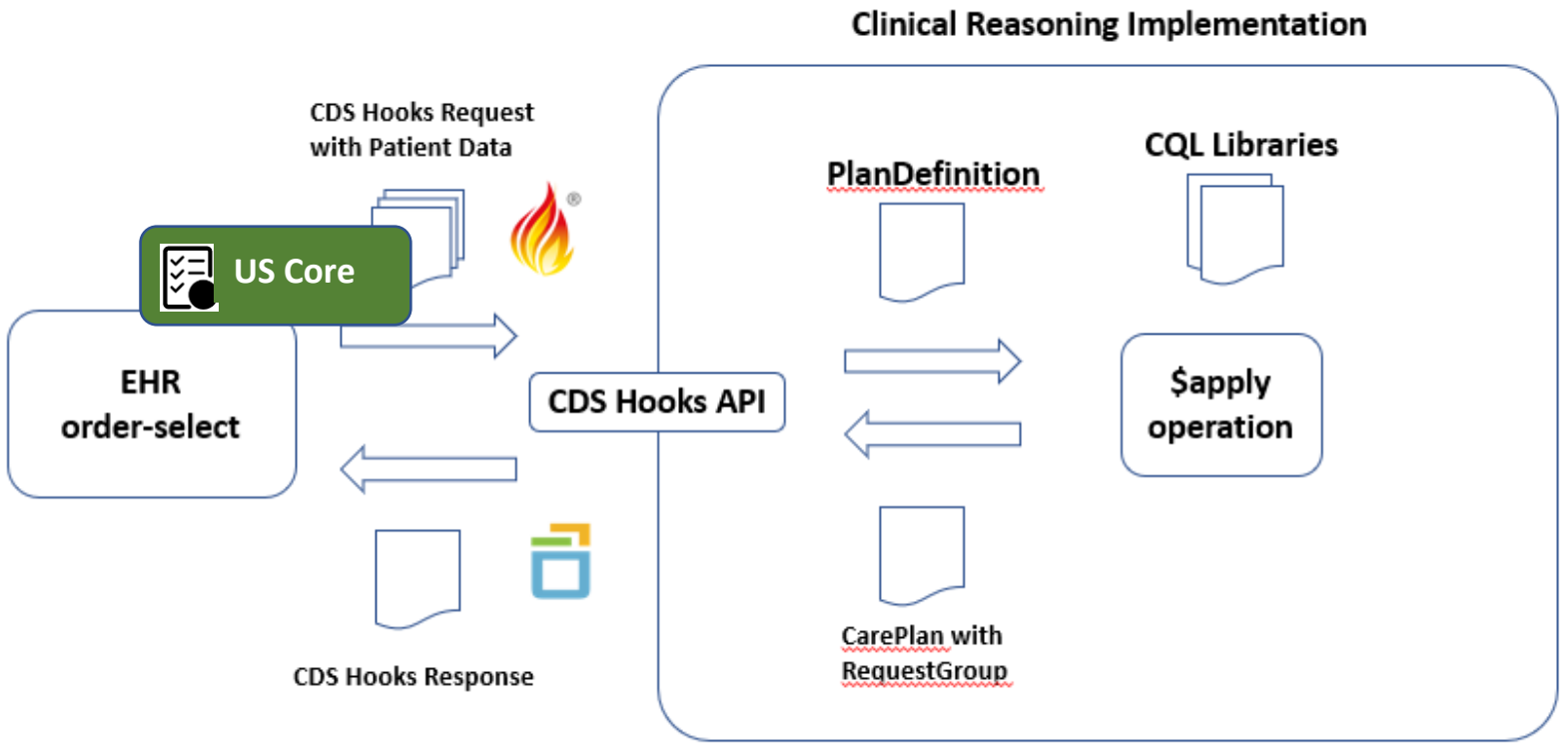
Service-based Integration via CDS Hooks



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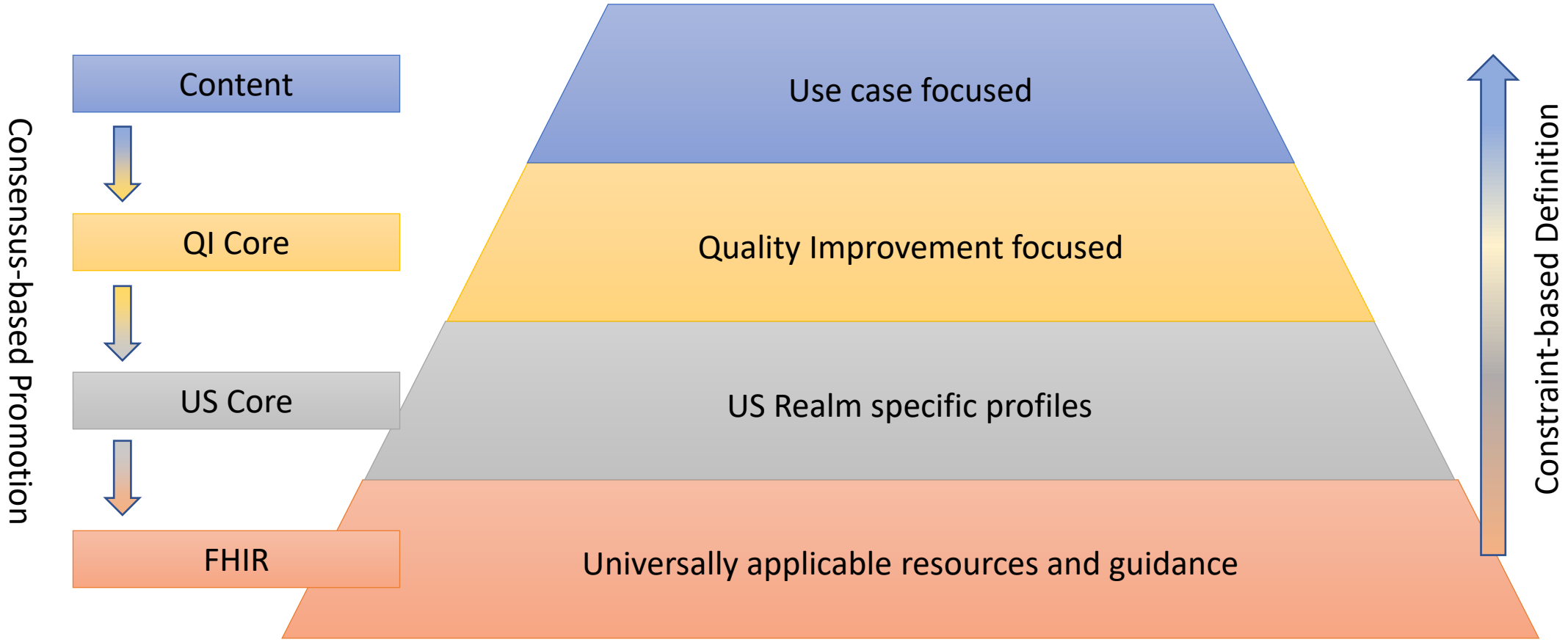
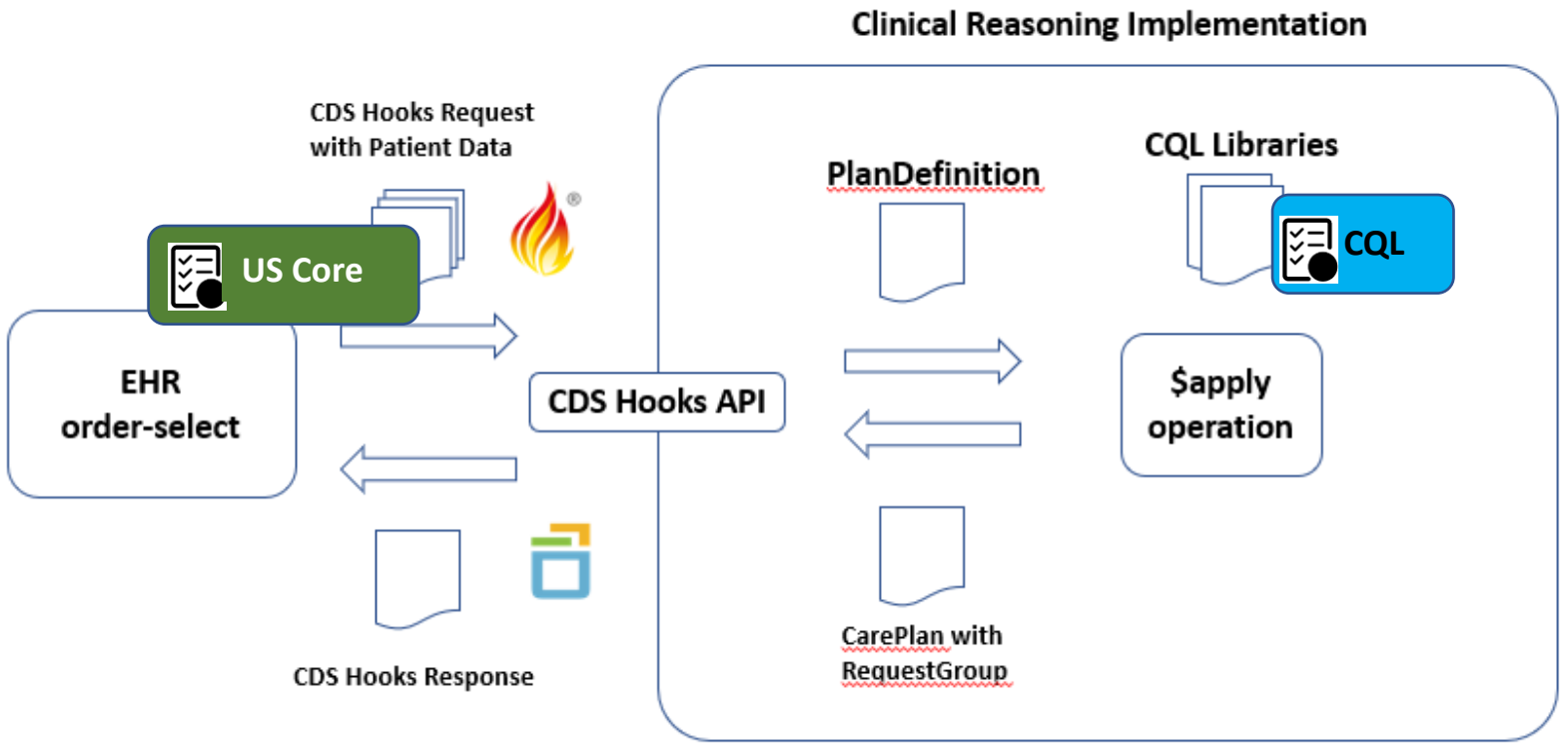
Data Model Standards



Service-based Integration via CDS Hooks

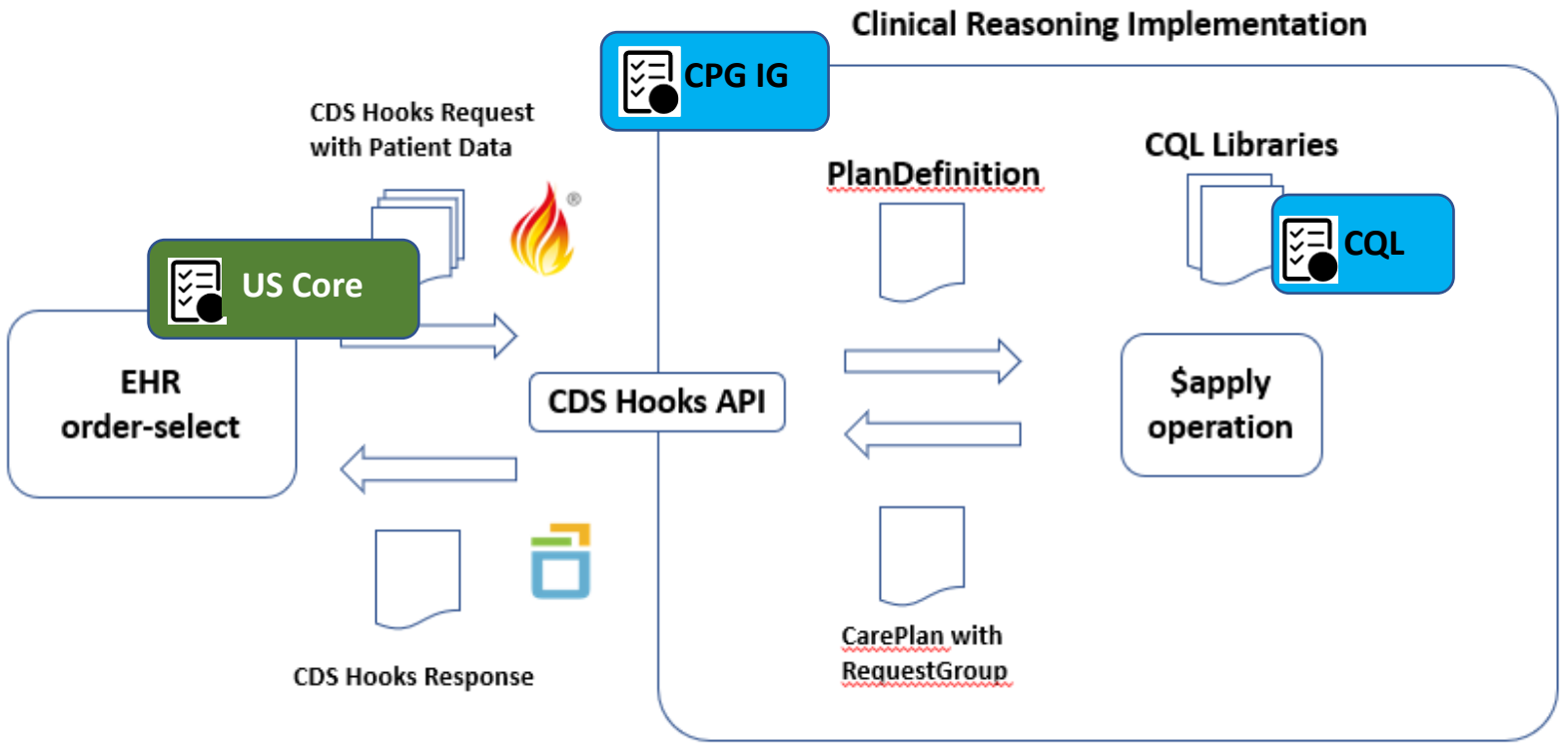


http://hl7.org/fhir/uv/cpg/documentation-approach-10-mechanisms-of-integration.html

HL7 International CQL

- **C**linical **Q**uality **L**anguage
- Health Level 7(HL7) standard designed to:
  - Enable automated point-to-point sharing of executable clinical knowledge
  - Provide a clinically focused, author-friendly, and human-readable language
- Currently an HL7 and ANSI Normative Standard
  - As with FHIR, some aspects are still Trial-Use, marked in the specification

Service-based Integration via CDS Hooks



http://hl7.org/fhir/uv/cpg/documentation-approach-10-mechanisms-of-integration.html

Key Interoperability Resources

Model
(syntax)

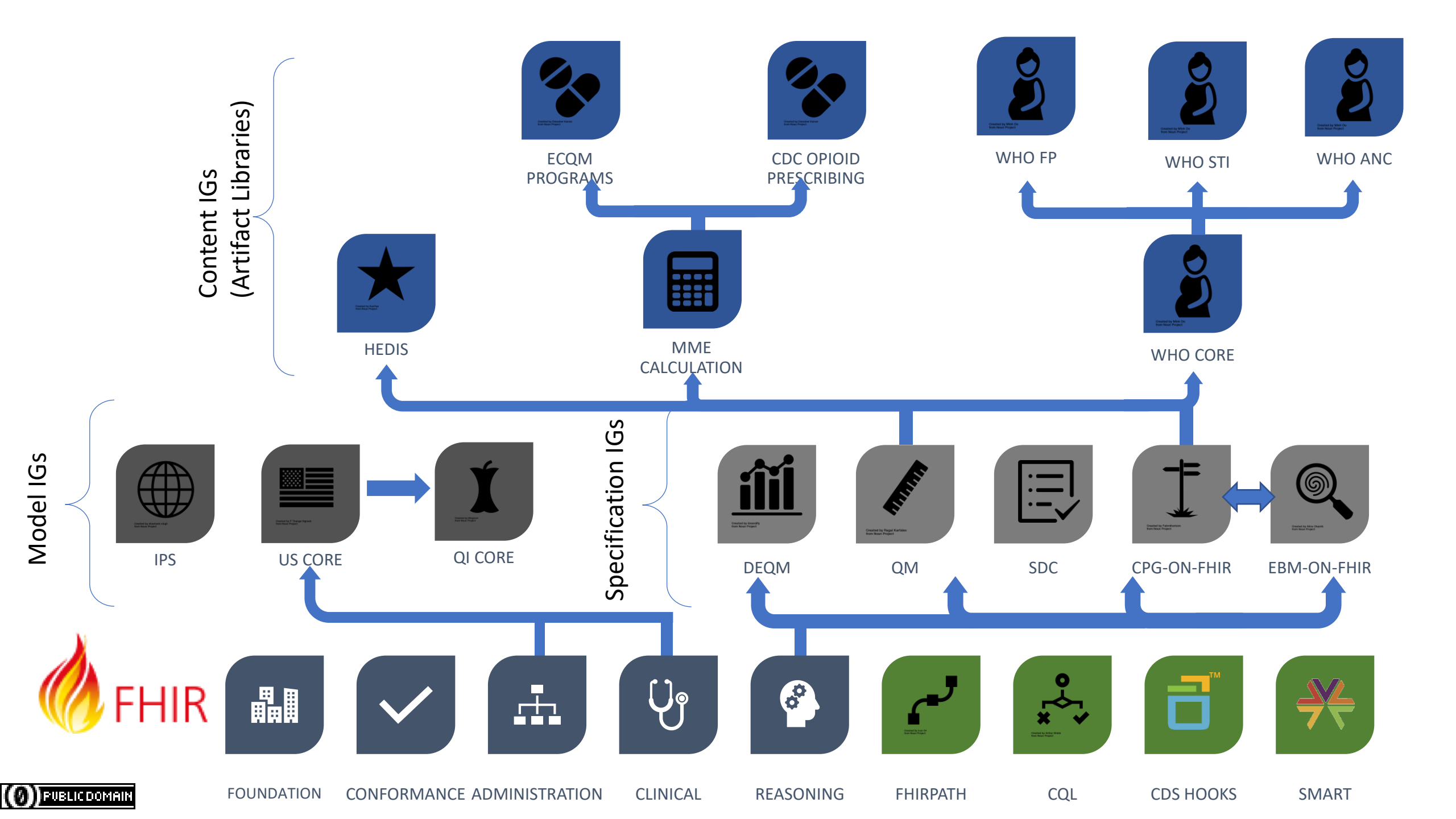
- StructureDefinition
- StructureMap

Terminology
(semantics)

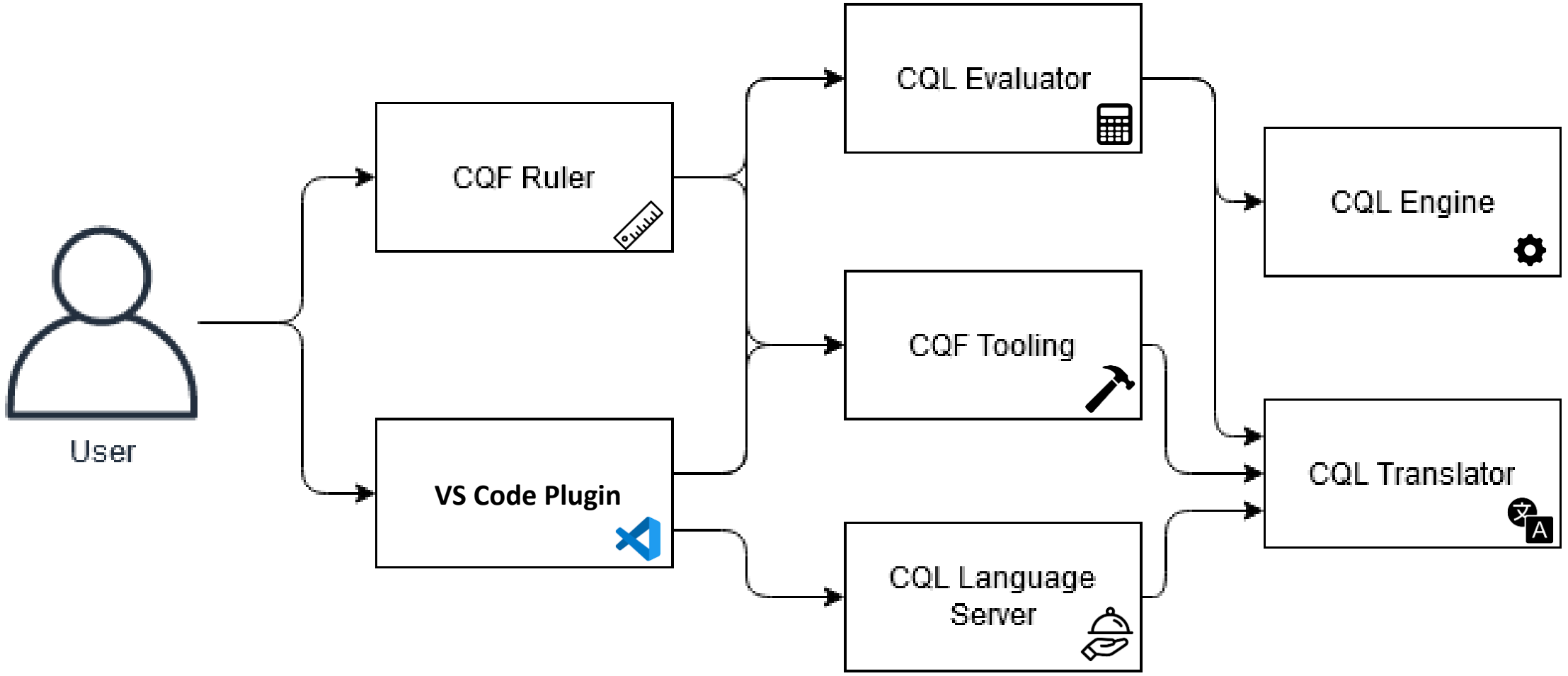
- CodeSystem
- ValueSet
- ConceptMap

Behavior
(Knowledge/process)

- *Library*
- *Questionnaire*
- *ActivityDefinition*
- *PlanDefinition*
- *Measure*



Clinical Quality Framework – Open Source Stack

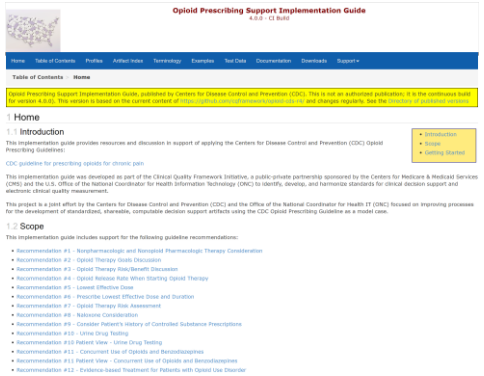


https://confluence.hl7.org/display/CQIWC/Clinical+Quality+Framework

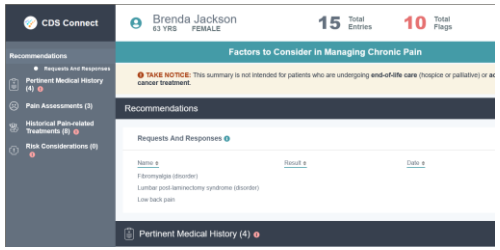
Opioid-related Projects

CDC 2016 Opioid Prescribing Guideline

CDC Opioid Prescribing IG

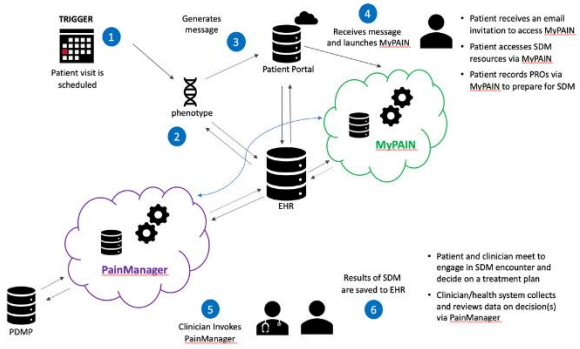


AHRQ Pain Management Summary



Opioid eCQMs

AHRQ Chronic Pain Management



https://github.com/cqframework/clinical_quality_language/wiki/Community-Projects#content

Get Involved!

- Adapting Clinical Guidelines for the Digital Age
  - CPG-on-FHIR Project
- Clinical Quality Framework Initiative
  - Clinical Decision Support and Clinical Quality Information HL7 Work Groups
- WHO SMART Guidelines Initiative
- EBM-on-FHIR (COKA) Initiative
- CQL FHIR Zulip Stream
- CQFramework Repository
- eCQI Resource Center

Questions?

INFORMATICS PROFESSIONALS. LEADING THE WAY.

CDS Hooks

Clinical Decision Support Standards to Facilitate Value-Based Health Care and Quality Improvement: Latest Developments and What You Need to Know

W16

Howard R. Strasberg, MD, MS, FAMIA, FACMI

Wolters Kluwer

Twitter: @HowardStrasberg

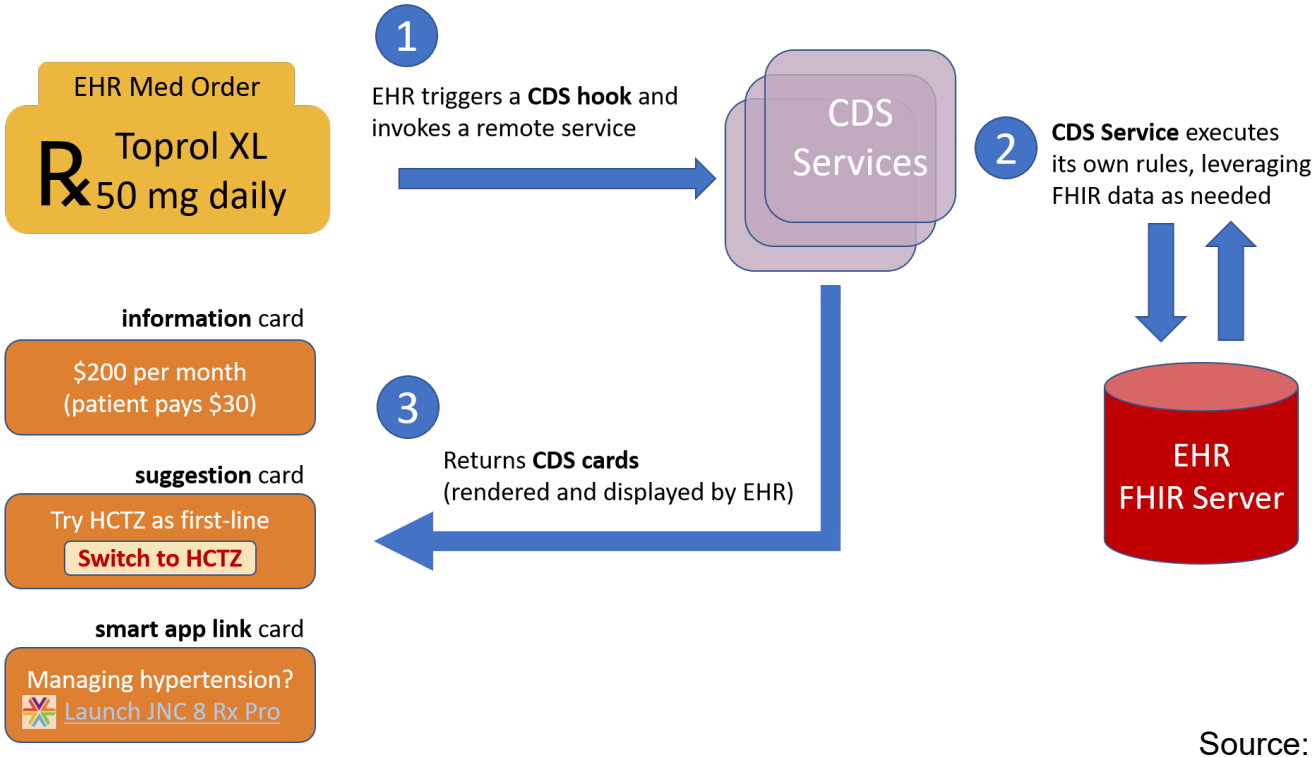
#AMIA2022

Disclosure

I disclose the following relevant relationship with commercial interests:

- Employee of Wolters Kluwer

CDS Hooks 1.0



Source: cds-hooks.org

Accessing FHIR Data – Two Options

Option 1 – Prefetch
Send the data with the request


```
"prefetch": {
   "patient": {
    "resourceType": "Patient",
    "id": “W11",
    "meta": {
      "versionId": "1",
      "lastUpdated": "2021-04-12T14:08:53.000+00:00"
    },
    "active": true,
    "name": [
      {
        "text": “W11 AMIA",
        "family": [
          “AMIA"
        ],
        "given": [
          “W11"
        ]
      }
    ],
    "gender": "male",
    "birthDate": "1944-10-24"
  }
 }
```


Option 2 – FHIR Authorization Token
Allow the service to request the data from the FHIR server


```
"fhirAuthorization": {
"access_token": "eyJqa3UiOiJodHRwc",
"token_type": "Bearer",
"expires_in": 3599,
"scope": "patient/*.* user/*.* launch openid profile
online_access",
"subject": “34287c5e…"
```

Prefetch Template

- Uses FHIR queries to tell the calling application which data to include in the request
- Prefetch token: a placeholder in a prefetch template that is replaced by a value from the hook's context to construct the FHIR URL used to request the prefetch data (e.g. patient={{context.patientId}}).

Example

```
{
  "prefetch": {
    "patient": "Patient/{{context.patientId}}",
    "hemoglobin-a1c": "Observation?patient={{context.patientId}}&code=4548-4&_count=1&sort:desc=date",
    "user": "{{context.userId}}"
  }
}
```

Hook: patient-view

Field	Optionality	Use as prefetch token	Type	Description
userId	REQUIRED	Yes	*string*	The id of the current user. For example, if the user represents a FHIR resource on the given FHIR server, the resource type would be one of Practitioner, PractitionerRole, Patient, or RelatedPerson. Patient or RelatedPerson are appropriate when a patient or their proxy are viewing the record.
patientId	REQUIRED	Yes	*string*	The FHIR Patient.id of the current patient in context
encounterId	OPTIONAL	Yes	*string*	The FHIR Encounter.id of the current encounter in context

Hook: order-sign

Field	Optionality	Use as prefetch token	Type	Description
userId	REQUIRED	Yes	*string*	The id of the current user. For this hook, the user is expected to be of type Practitioner or PractitionerRole.
patientId	REQUIRED	Yes	*string*	The FHIR Patient.id of the current patient in context
encounterId	OPTIONAL	Yes	*string*	The FHIR Encounter.id of the current encounter in context
draftOrders	REQUIRED	No	*object*	R4 - FHIR Bundle of DeviceRequest, MedicationRequest, NutritionOrder, ServiceRequest, VisionPrescription with *draft* status

Hook: order-select

Field	Optionality	Use as prefetch token	Type	Description
userId	REQUIRED	Yes	*string*	The id of the current user. For this hook, the user is expected to be of type Practitioner or PractitionerRole.
patientId	REQUIRED	Yes	*string*	The FHIR Patient.id of the current patient in context
encounterId	OPTIONAL	Yes	*string*	The FHIR Encounter.id of the current encounter in context
selections	REQUIRED	No	*array*	The FHIR id of the newly selected order(s). The selections field references FHIR resources in the draftOrders Bundle. For example, MedicationRequest/103.
draftOrders	REQUIRED	No	*object*	R4 - FHIR Bundle of DeviceRequest, MedicationRequest, NutritionOrder, ServiceRequest, VisionPrescription with *draft* status

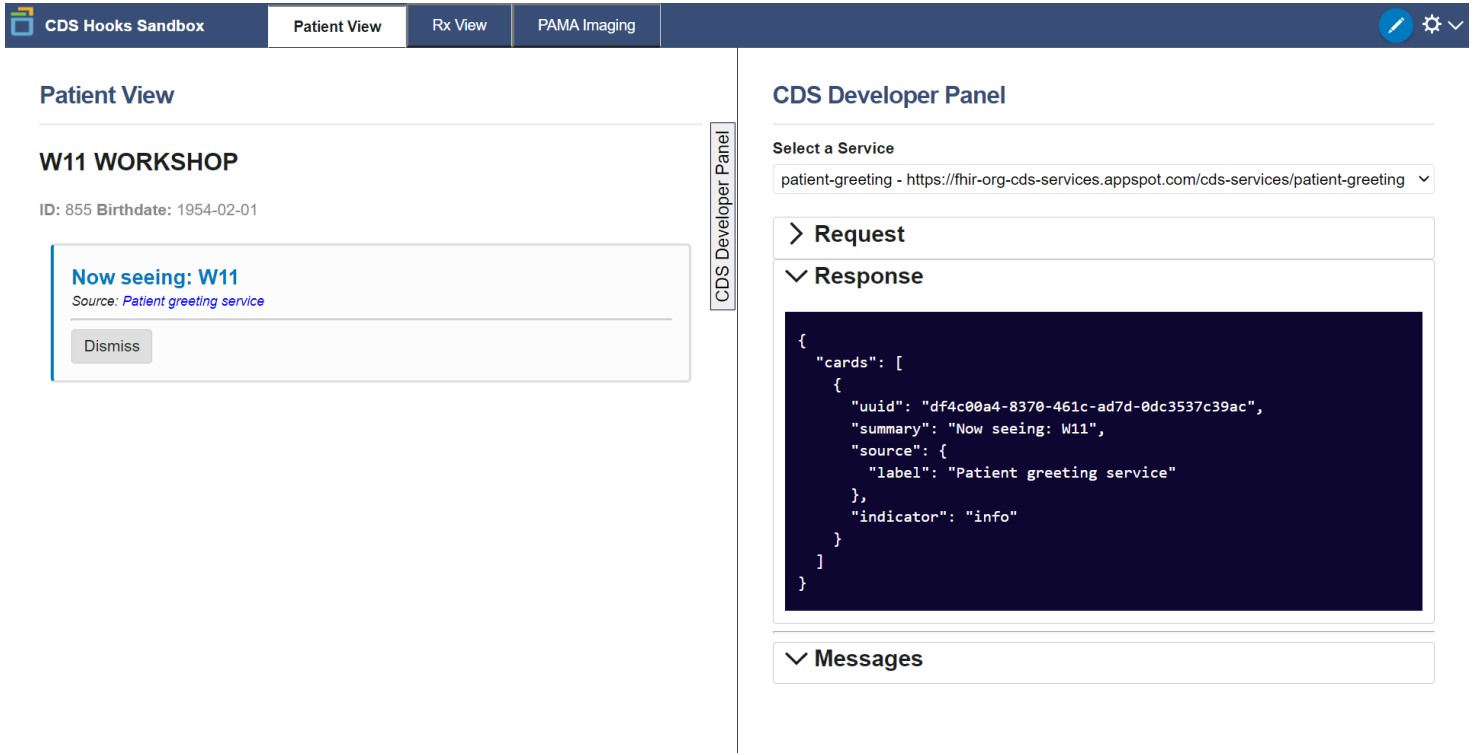
CDS Hooks – Response Card Attributes

Field	Optionality	Type	Description
uuid	OPTIONAL	*string*	Unique identifier of the card. MAY be used for auditing and logging cards and SHALL be included in any subsequent calls to the CDS service's feedback endpoint.
summary	REQUIRED	*string*	One-sentence, <140-character summary message for display to the user inside of this card.
detail	OPTIONAL	*string*	Optional detailed information to display; if provided MUST be represented in (GitHub Flavored) Markdown. (For non-urgent cards, the CDS Client MAY hide these details until the user clicks a link like "view more details...").
indicator	REQUIRED	*string*	Urgency/importance of what this card conveys. Allowed values, in order of increasing urgency, are: **info, warning, critical**. The CDS Client MAY use this field to help make UI display decisions such as sort order or coloring.
source	REQUIRED	*object*	Grouping structure for the **Source** of the information displayed on this card. The source should be the primary source of guidance for the decision support the card represents.

CDS Hooks – Response Card Attributes

Field	Optionality	Type	Description
suggestions	OPTIONAL	*array* of **Suggestions**	Allows a service to suggest a set of changes in the context of the current activity (e.g. changing the dose of a medication currently being prescribed, for the order-sign activity). If suggestions are present, selectionBehavior MUST also be provided.
selectionBehavior	OPTIONAL	*string*	Describes the intended selection behavior of the suggestions in the card. Allowed values are: **at-most-one**, indicating that the user may choose none or at most one of the suggestions; **any**, indicating that the end user may choose any number of suggestions including none of them and all of them. CDS Clients that do not understand the value MUST treat the card as an error.
links	OPTIONAL	*array* of **Links**	Allows a service to suggest a link to an app that the user might want to run for additional information or to help guide a decision.

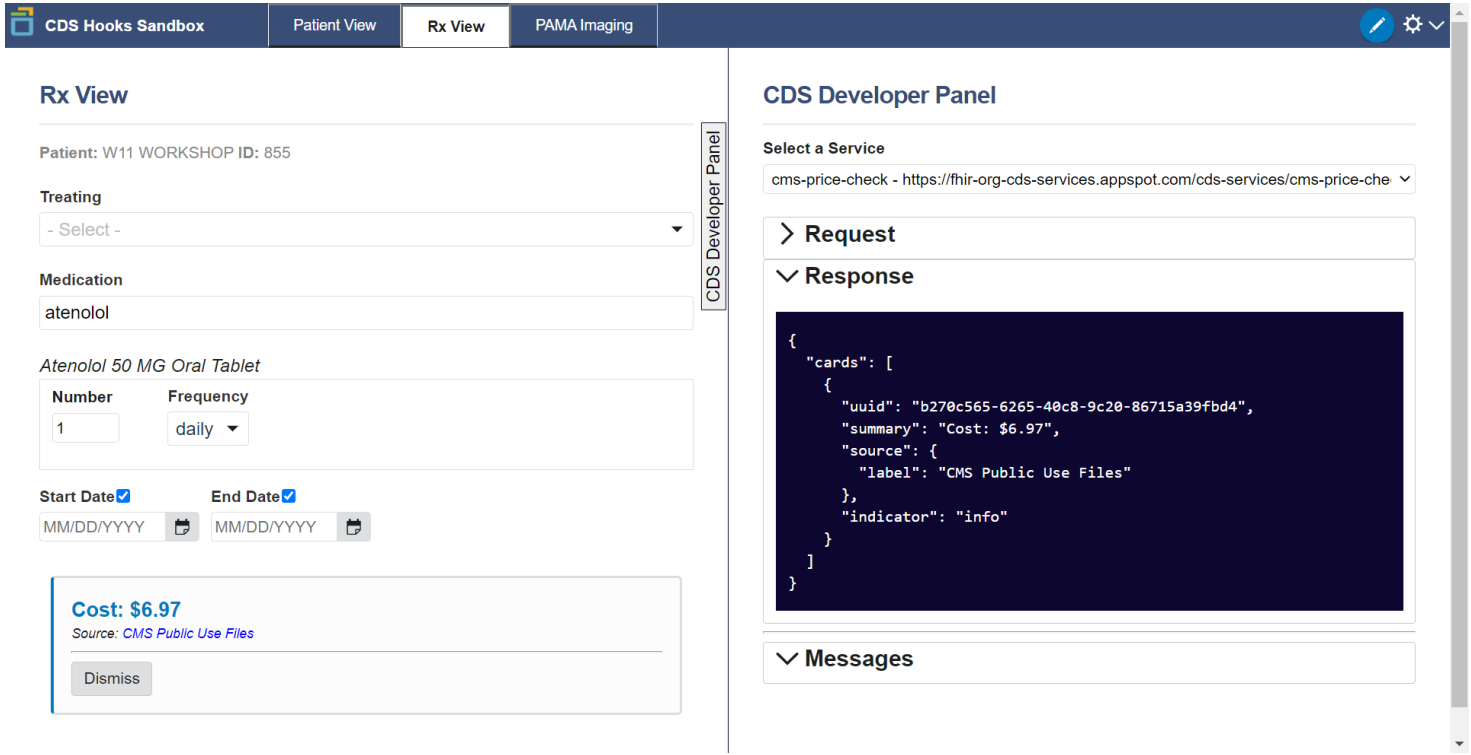
Example 1 – patient-view hook



Example 1 - Request


```
{
    "hookInstance": "d3cbe9db-295b-4ace-9a48-0d2312993503",
    "hook": "patient-view",
    "fhirServer": "https://api.logicahealth.org/ExampleServer/data",
    "context": {
        "patientId": "855",
        "userId": "Practitioner/2"
    },
    "fhirAuthorization": {
        "access_token": "eyJqa3UiOiJ...",
        "token_type": "Bearer",
        "expires_in": 3599,
        "scope": "patient/*.* user/*.* launch openid profile online_access",
        "subject": "48163c5e..."
    },
    "prefetch": {
        "patient": {
            "resourceType": "Patient",
            "id": "855",
            "meta": {
                "versionId": "1",
                "lastUpdated": "2021-05-05T23:17:23.000+00:00"
            },
            "active": true,
            "name": [
                {
                    "text": "W11 WORKSHOP",
                    "family": [
                        "WORKSHOP"
                    ],
                    "given": [
                        "W11"
                    ]
                }
            ],
            "gender": "male",
            "birthDate": "1954-02-01"
        }
    }
}
```

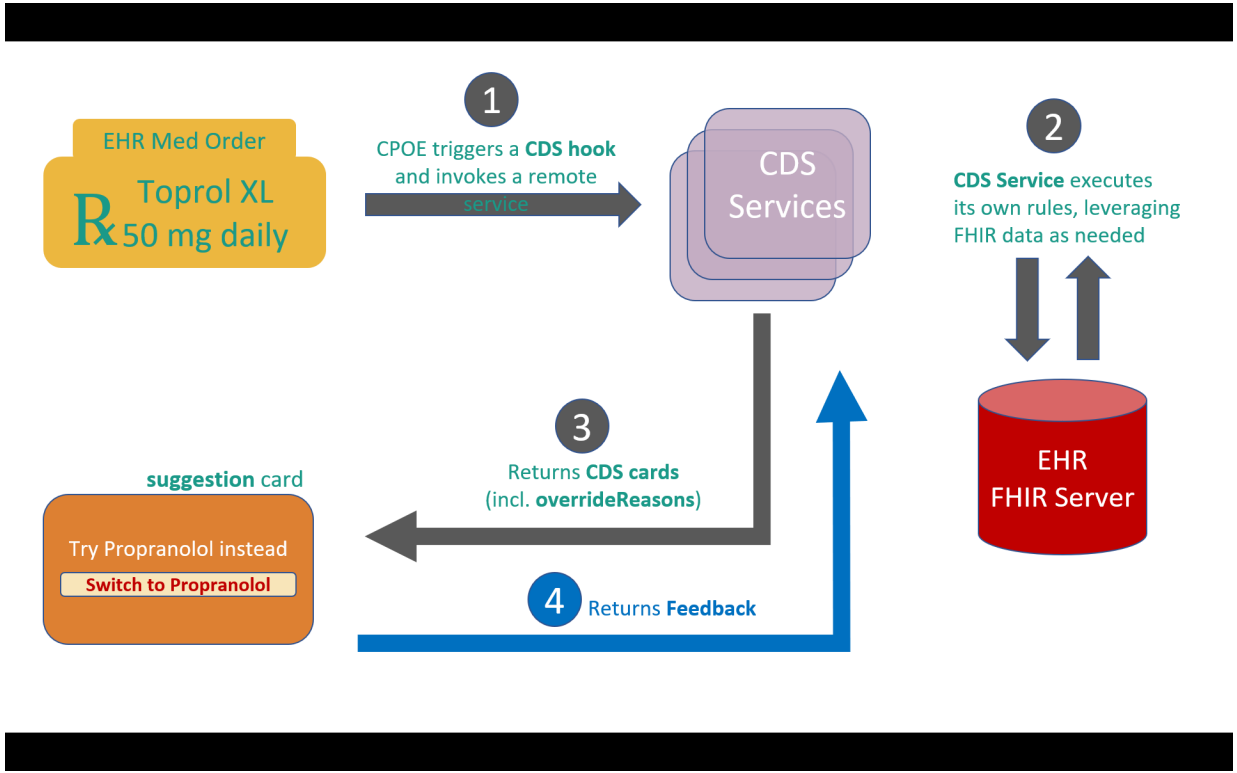
Example 2 – order-select hook



Example 2 - Request


```
{
    "hookInstance": "6aa186d1-8353-4eb4-8c12-d54a4c5ff717",
    "hook": "order-select",
    "fhirServer": "https://api.logicahealth.org/ExampleServer/data",
    "context": {
        "patientId": "855",
        "userId": "Practitioner/2",
        "selections": [
            "MedicationOrder/order-123"
        ],
        "draftOrders": {
            "resourceType": "Bundle",
            "entry": [
                {
                    "resource": {
                        "resourceType": "MedicationOrder",
                        "id": "order-123",
                        "status": "draft",
                        "patient": {
                            "reference": "Patient/855"
                        },
                        "dateWritten": "2021-05-05",
                        "medicationCodeableConcept": {
                            "text": "Atenolol 50 MG Oral Tablet",
                            "coding": [
                                {
                                    "display": "Atenolol 50 MG Oral Tablet",
                                    "system": "http://www.nlm.nih.gov/research/umls/rxnorm",
                                    "code": "197381"
                                }
                            ]
                        }
                    }
                }
            ]
        }
    },
    "fhirAuthorization": {
        "access_token": "eyJqa3UiOiJ...",
        "token_type": "Bearer",
        "expires_in": 3599,
```

CDS Hooks 2.0 – Adds Feedback



CDS Hooks – Response Card Attributes

Field	Optionality	Type	Description
overrideReasons	OPTIONAL	*array* of **Coding**	Override reasons can be selected by the end user when overriding a card without taking the suggested recommendations. The CDS service MAY return a list of override reasons to the CDS client. The CDS client SHOULD present these reasons to the clinician when they dismiss a card. A CDS client MAY augment the override reasons presented to the user with its own reasons.

Feedback (Optional)

Field	Optionality	Type	Description
card	REQUIRED	*string*	The card.uuid from the CDS Hooks response. Uniquely identifies the card.
outcome	REQUIRED	*string*	A value of accepted or overridden.
acceptedSuggestions	CONDITIONAL	*array*	An array of json objects identifying one or more of the user's **AcceptedSuggestion**s. Required for accepted outcomes.
overrideReason	OPTIONAL	**Override Reason**	A json object capturing the override reason as a **Coding** as well as any comments entered by the user.
outcomeTimestamp	REQUIRED	*string*	ISO timestamp in UTC when action was taken on card.

Feedback Example

Response card override reasons

```
{
        "uuid": "123456",
        "overrideReasons": [
                {
                        "display": "Screening not wanted",
                        "code": 171103002,
                        "system": "http://snomed.info/sct"
                },
                {
                        "display": "Care plan reviewed",
                        "code": 335031000000106,
                        "system": "http://snomed.info/sct"
                },
                {
                        "display": "Personal health plan not appropriate",
                        "code": 755201000000108,
                        "system": "http://snomed.info/sct"
                }
        ]
}
```

Request payload back to CDS Hooks service feedback endpoint

```
POST {baseUrl}/cds-services/{serviceId}/feedback

{
        "feedback": [
                {
                "card": "123456",
                "outcome": "overridden",
                "outcomeTimestamp": "2021-05-06",
                "overrideReason": {
                        "reason": {
                                "code": 171103002,
                                "system": "http://snomed.info/sct"
                                }
                        }
                }
        ]
}
```

Next steps

- Suppose the draftOrders context contains a MedicationRequest with a reference to a Medication resource
- Suppose you really need the details of that Medication resource because, for example, it contains the RXNORM code for the drug being ordered
- How do you get those details?
- Answer: advanced prefetch templates, such as:

{{context.draftOrders.ofType(MedicationRequest).medicationReference.reference}}

More Information

- https://cds-hooks.org/ (continuous build)
- https://cds-hooks.hl7.org/ (published versions)
- https://github.com/cds-hooks/docs (repository, issues)

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Thank you!

@HowardStrasberg

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Infobutton Standard

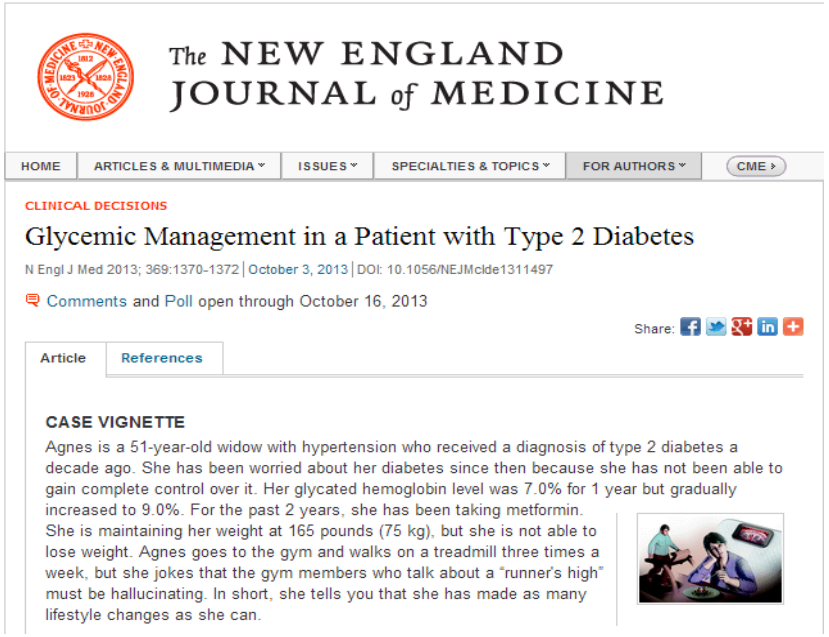
W16 Workshop - Clinical Decision Support Standards to Facilitate Value-Based Health Care and Quality Improvement: Latest Developments and What You Need to Know

Guilherme Del Fiol, MD, PhD
Professor and Vice-Chair for Research
Department of Biomedical Informatics
University of Utah

Disclosure

I and my spouse/partner have no relevant relationships with commercial interests to disclose.

Case Vignette



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CLINICAL DECISIONS

Glycemic Management in a Patient with Type 2 Diabetes

N Engl J Med 2013; 369:1370-1372 | October 3, 2013 | DOI: 10.1056/NEJMcIde1311497

Comments and Poll open through October 16, 2013

Share:

Article | References

CASE VIGNETTE

Agnes is a 51-year-old widow with hypertension who received a diagnosis of type 2 diabetes a decade ago. She has been worried about her diabetes since then because she has not been able to gain complete control over it. Her glycated hemoglobin level was 7.0% for 1 year but gradually increased to 9.0%. For the past 2 years, she has been taking metformin. She is maintaining her weight at 165 pounds (75 kg), but she is not able to lose weight. Agnes goes to the gym and walks on a treadmill three times a week, but she jokes that the gym members who talk about a "runner's high" must be hallucinating. In short, she tells you that she has made as many lifestyle changes as she can.

51-year-old female with diabetes type 2, unable to control it in last year (HbA1c = 9%). Taking metformin for past 2 years. Needs additional drug, but won't take insulin. Concern about weight gain.

Alternatives: DPP-4 inhibitors vs. SGLT2 inhibitors

- Both are effective
- Studies of the cardiovascular safety of the drugs are under way
- Distinct side effect profiles and mechanism of action

Which is the best approach for this patient?

N Engl J Med 2013; 369:1370-1372. 2013

Clinicians' Information Needs

20 patients

12 Clinical questions raised

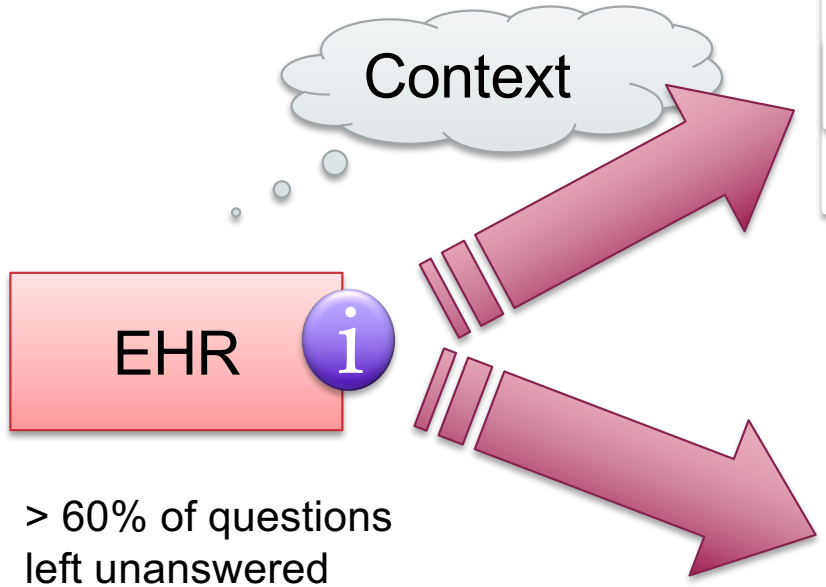
6 pursued

4 answered

Del Fiol G, Workman TE, Gorman PN. Questions raised by clinicians at the point of care. JAMA Int Med. 2014.

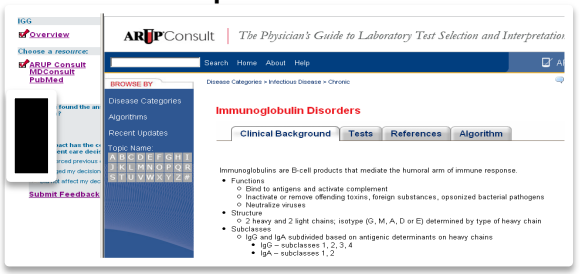
Clinicians' information needs

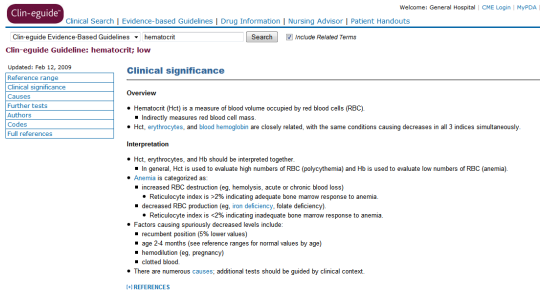
1 question out of every
2 patients seen

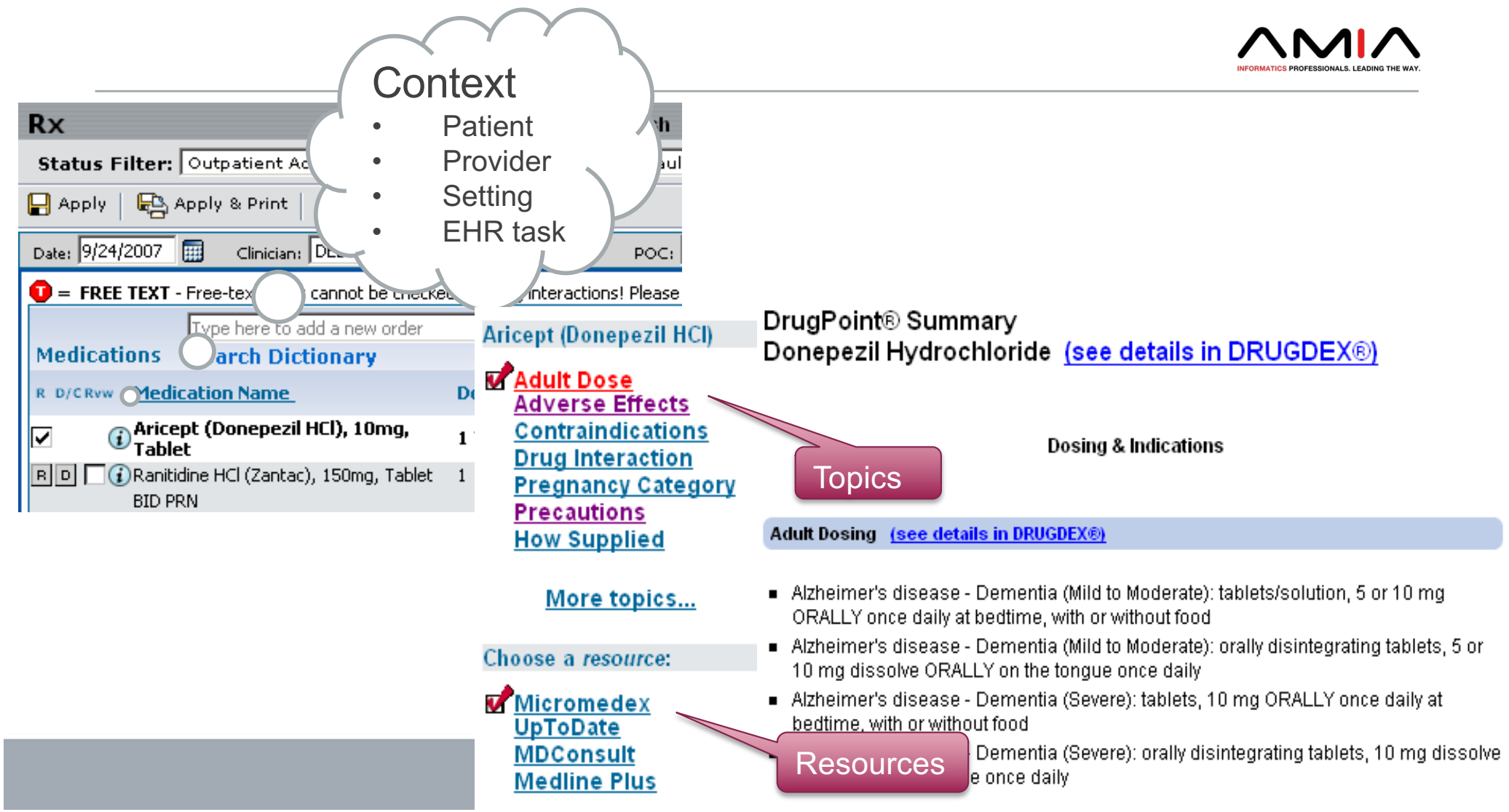


> 60% of questions
left unanswered

Resources: answer
>90% of questions






Context
• Patient
• Provider
• Setting
• EHR task
Rx
Status Filter:
Apply
Apply & Print
Date: 9/24/2007
Clinician:
POC:
= FREE TEXT - Free-tex
cannot be checked
interactions! Please
Type here to add a new order
Medications
arch Dictionary
R D/C Rvw
Medication Name
Aricept (Donepezil HCl), 10mg, Tablet
Ranitidine HCl (Zantac), 150mg, Tablet
BID PRN
Aricept (Donepezil HCl)
Adult Dose
Adverse Effects
Contraindications
Drug Interaction
Pregnancy Category
Precautions
How Supplied
More topics...
Choose a resource:
Micromedex
UpToDate
MDConsult
Medline Plus
DrugPoint® Summary
Donepezil Hydrochloride (see details in DRUGDEX®)
Dosing & Indications
Adult Dosing (see details in DRUGDEX®)
Alzheimer's disease - Dementia (Mild to Moderate): tablets/solution, 5 or 10 mg ORALLY once daily at bedtime, with or without food
Alzheimer's disease - Dementia (Mild to Moderate): orally disintegrating tablets, 5 or 10 mg dissolve ORALLY on the tongue once daily
Alzheimer's disease - Dementia (Severe): tablets, 10 mg ORALLY once daily at bedtime, with or without food
Dementia (Severe): orally disintegrating tablets, 10 mg dissolve
e once daily
Topics
Resources

Context-sensitive decision support (infobuttons) in electronic health records: a systematic review

RECEIVED 23 March 2016
REVISED 5 May 2016
ACCEPTED 27 May 2016

David A Cook,[1,2,3] Miguel T Teixeira,[3] Bret SE Heale,[4] James J Cimino,[5] and Guilherme Del Fiol,[4]

ABSTRACT

Objective Infobuttons appear as small icons adjacent to electronic health record (EHR) data (e.g., medications, diagnoses, or test results) that, when clicked, access online knowledge resources tailored to the patient, care setting, or task. Infobuttons are required for "Meaningful Use" certification of US EHRs. We sought to evaluate infobuttons' impact on clinical practice and identify features associated with improved outcomes.

Methods We conducted a systematic review, searching MEDLINE, EMBASE, and other databases from inception to July 6, 2015. We included and cataloged all original research in any language describing implementation of infobuttons or other context-sensitive links. Studies evaluating clinical implementations with outcomes of usage or impact were reviewed in greater detail. Reviewers worked in duplicate to select articles, evaluate quality, and abstract information.

Results Of 599 potential articles, 77 described infobutton implementation. The 17 studies meriting detailed review, including 3 randomized trials, yielded the following findings. Infobutton usage frequency ranged from 0.3 to 7.4 uses per month per potential user. Usage appeared to be influenced by EHR task. Five studies found that infobuttons are used less often than non–context-sensitive links (proportionate usage 0.20–0.34). In 3 studies, users answered their clinical question in $>69\%$ of infobutton sessions. Seven studies evaluated alternative approaches to infobutton design and implementation. No studies isolated the impact of infobuttons on objectively measured patient outcomes.

Conclusions Weak evidence suggests that infobuttons can help providers answer clinical questions. Research on optimal infobutton design and implementation, and on the impact on patient outcomes and provider behaviors, is needed.

Impact of Infobuttons

	Infobuttons	Unaided Search
Median Session Time	35 sec	2 to 8 min
Questions Answered	85%	78%

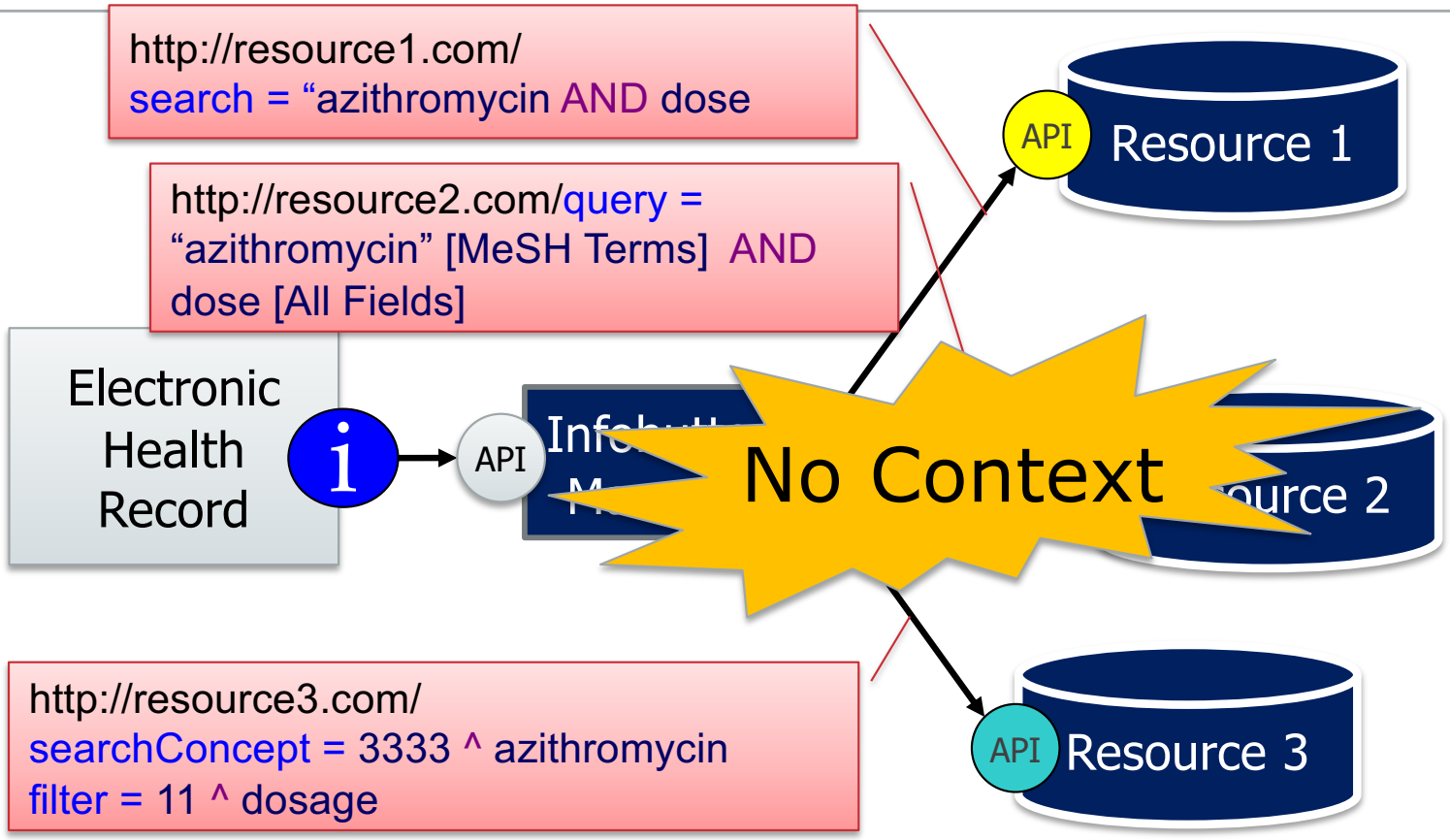
Decision enhancement or learning

- Over 62% of sessions

Slow usage uptake

- Partners Healthcare: ~100,000 sessions / month
- Intermountain: ~20,000 sessions / month

Why did we need a standard?



Context Dimensions

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Patient

- Gender
- Age group
- Concept of interest

User

- Patient vs. provider
- Discipline / specialty

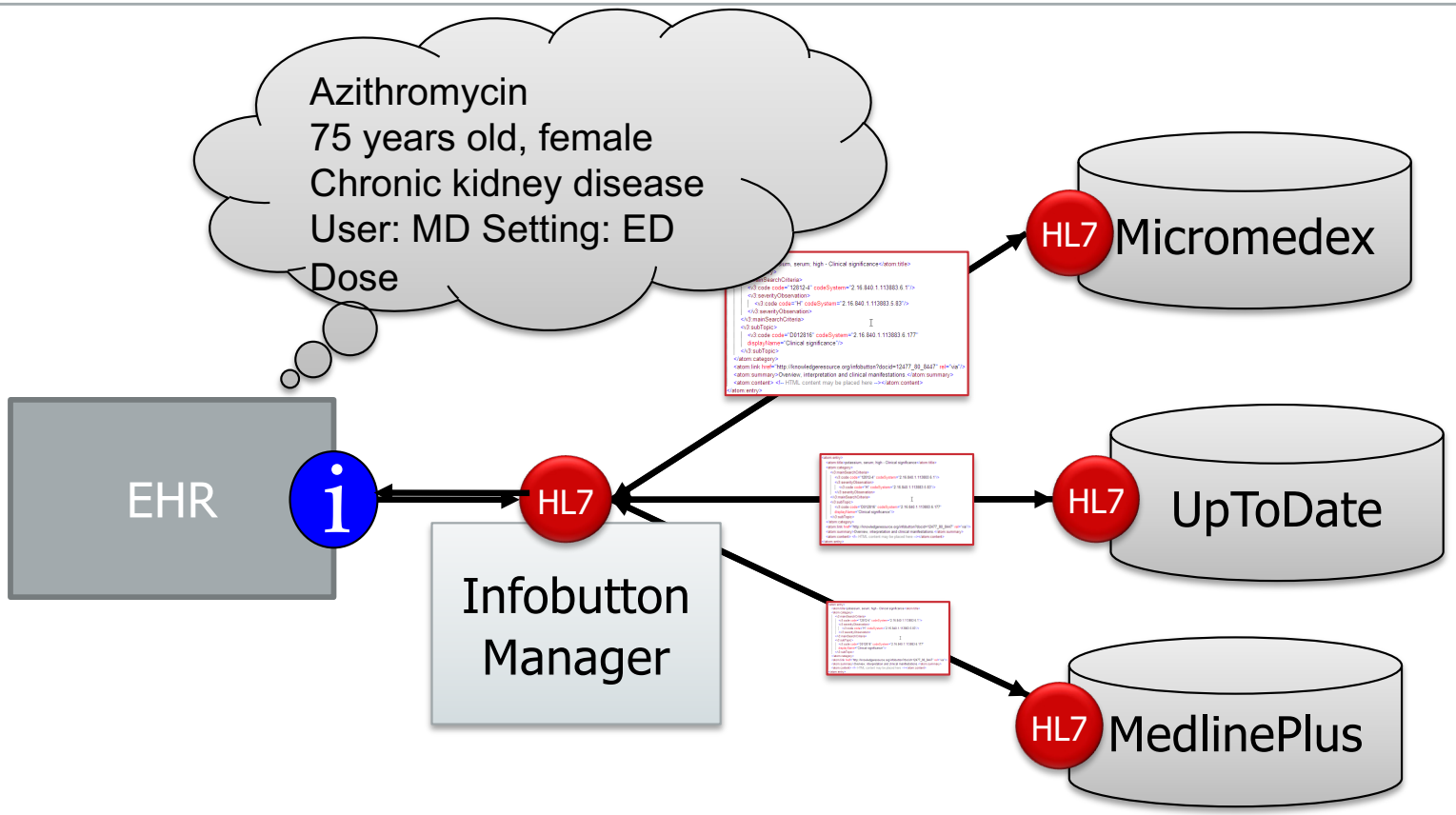
EHR

- Task (e.g., order entry, problem list entry, lab results review)

Organization

- Care setting
- Service delivery location
- Location of interest

HL7 Infobutton Standard



US EHR Certification (Meaningful Use)

Infobuttons: Required CDS capability compliant with Infobutton Standard

- Provider reference information
- Patient education

Widely adopted by content providers and EHR products

- Over 1,000 certified EHR products by 500+ vendors

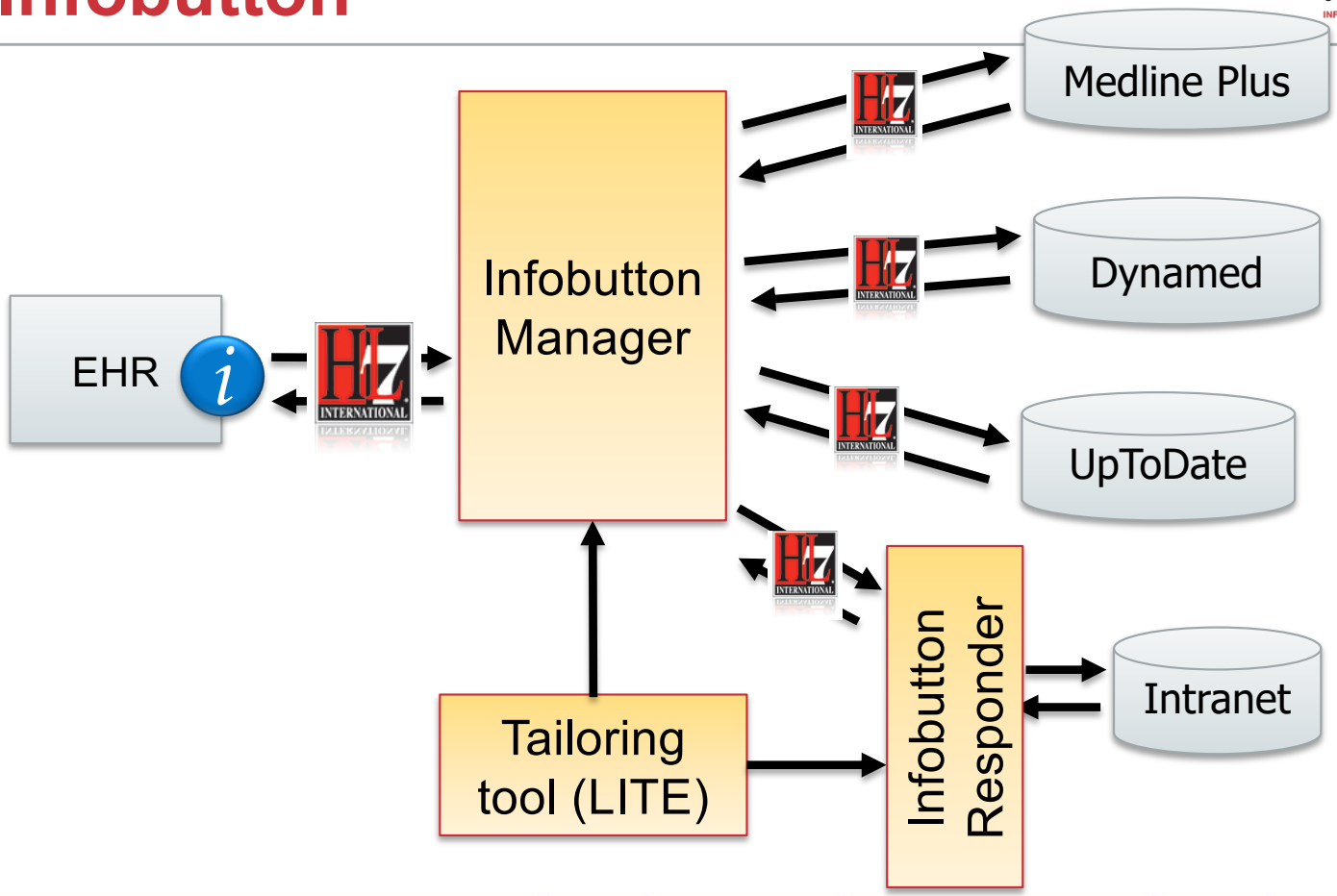
Example: MedlinePlus Connect

MedlinePlus Connect: 10 Years of Linking Electronic Health Records to Consumer Health Information

https://nlmdirector.nlm.nih.gov/2021/01/13/medlineplus-connect-10-years-of-linking-electronic-health-records-to-consumer-health-information/

- Launched in 2010
- Broad support for standard terminologies
  - Content coverage for 171,000 concepts
  - SNOMED-CT, ICD, CPT, RxNorm, NDC
- Both URL and Web services specs
- Integrated with ~70 EHRs/PHRs
- 252 million infobutton requests in 2020

OpenInfobutton

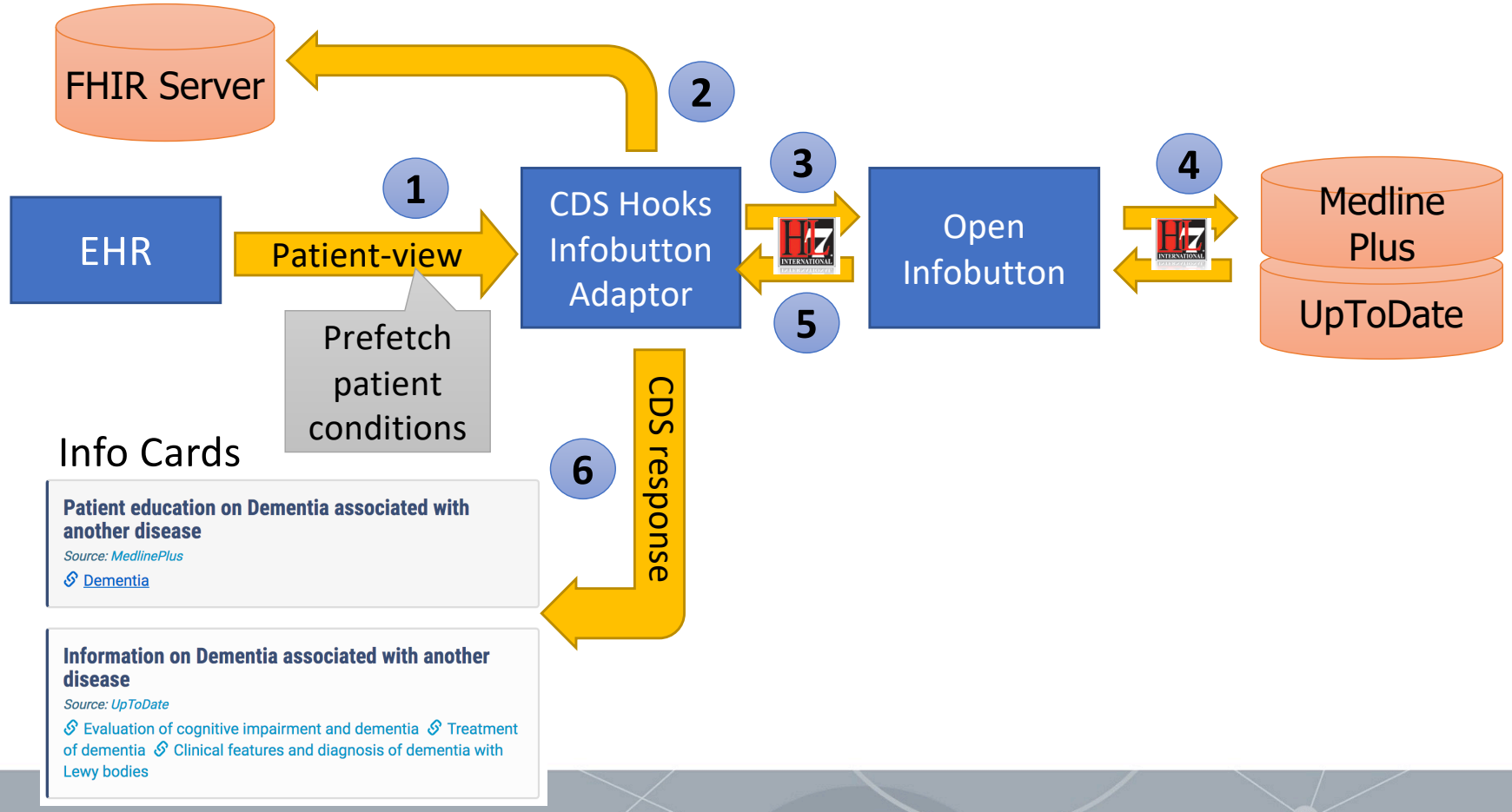


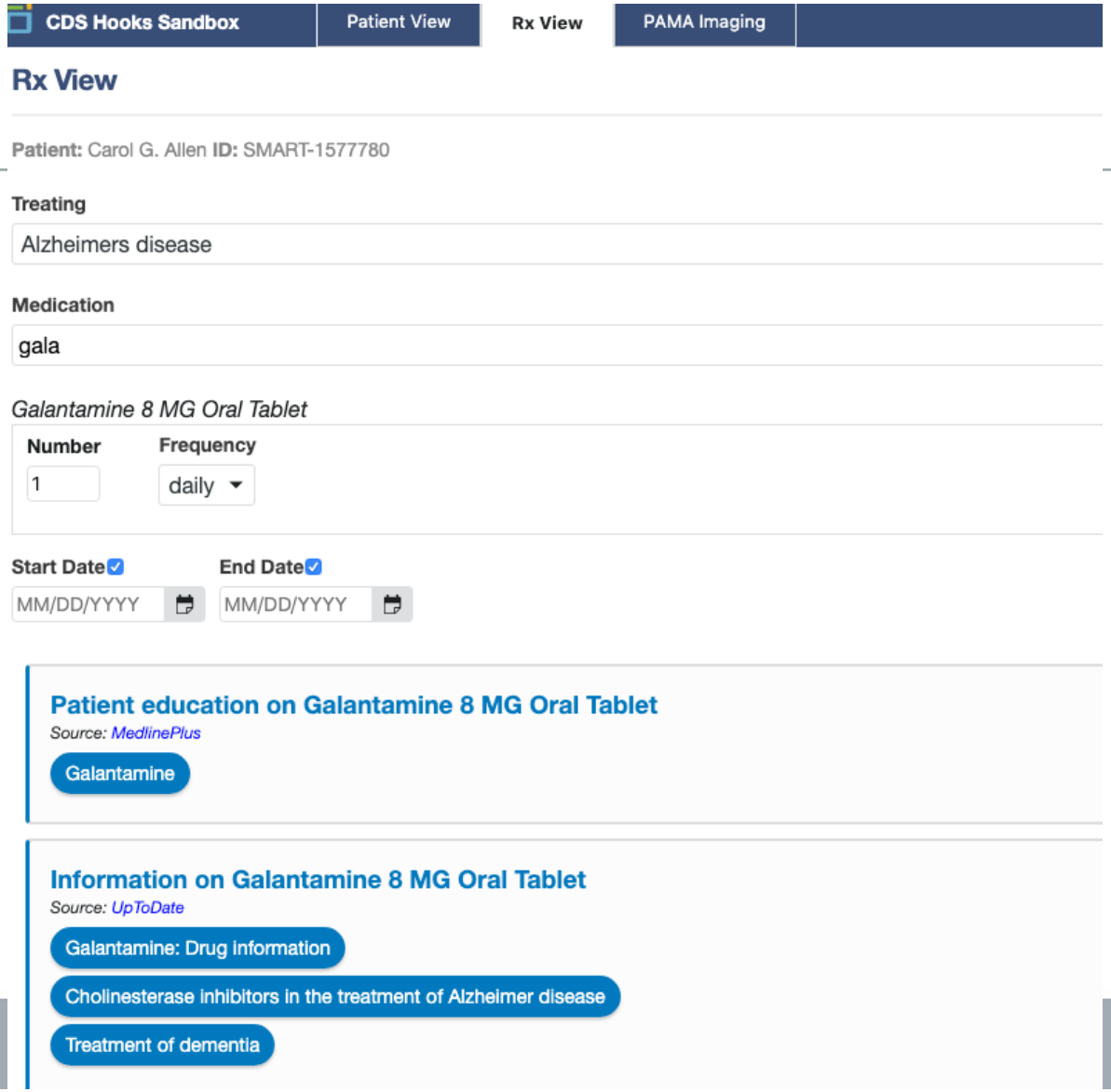
Del Fiol et al. Disseminating Context-Specific Access to Online Knowledge Resources within Electronic Health Record Systems. Stud Health Technol Inform. 2013; 192: 672–676.

OpenInfobutton

http://www.OpenInfobutton.org
Demo at: http://lite.bmi.utah.edu/OpenInfobuttonDemo.html

Infobutton and CDS Hooks




CDS Hooks Sandbox
Patient View
Rx View
PAMA Imaging
Rx View
Patient: Carol G. Allen ID: SMART-1577780
Treating
Alzheimers disease
Medication
gala
Galantamine 8 MG Oral Tablet
Number
1
Frequency
daily
Start Date
MM/DD/YYYY
End Date
MM/DD/YYYY
Patient education on Galantamine 8 MG Oral Tablet
Source: MedlinePlus
Galantamine
Information on Galantamine 8 MG Oral Tablet
Source: UpToDate
Galantamine: Drug information
Cholinesterase inhibitors in the treatment of Alzheimer disease
Treatment of dementia

Galantamine

pronounced as (ga lan' ta meen)

Why is this medication prescribed?

Galantamine is used to treat the symptoms of Alzheimer's disease (AD; a brain disease that slowly destroys the memory and the ability to think, learn, communicate and handle daily activities). Galantamine is in a class of medications called acetylcholinesterase inhibitors. It works by increasing the amount of a certain natural substance in the brain that is needed for memory and thought. Galantamine may improve the ability to think and remember or slow the loss of these abilities in people who have AD. However, galantamine will not cure AD or prevent the loss of mental abilities at some time in the future.

Thank you!

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CLINICAL USE OF CDS STANDARDS AND APPROACHES TO DEALING WITH VENDOR DIFFERENCES IN FHIR IMPLEMENTATIONS

AMIA ANNUAL MEETING, WASHINGTON, DC, NOVEMBER 5, 2022

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UNIVERSITY OF UTAH

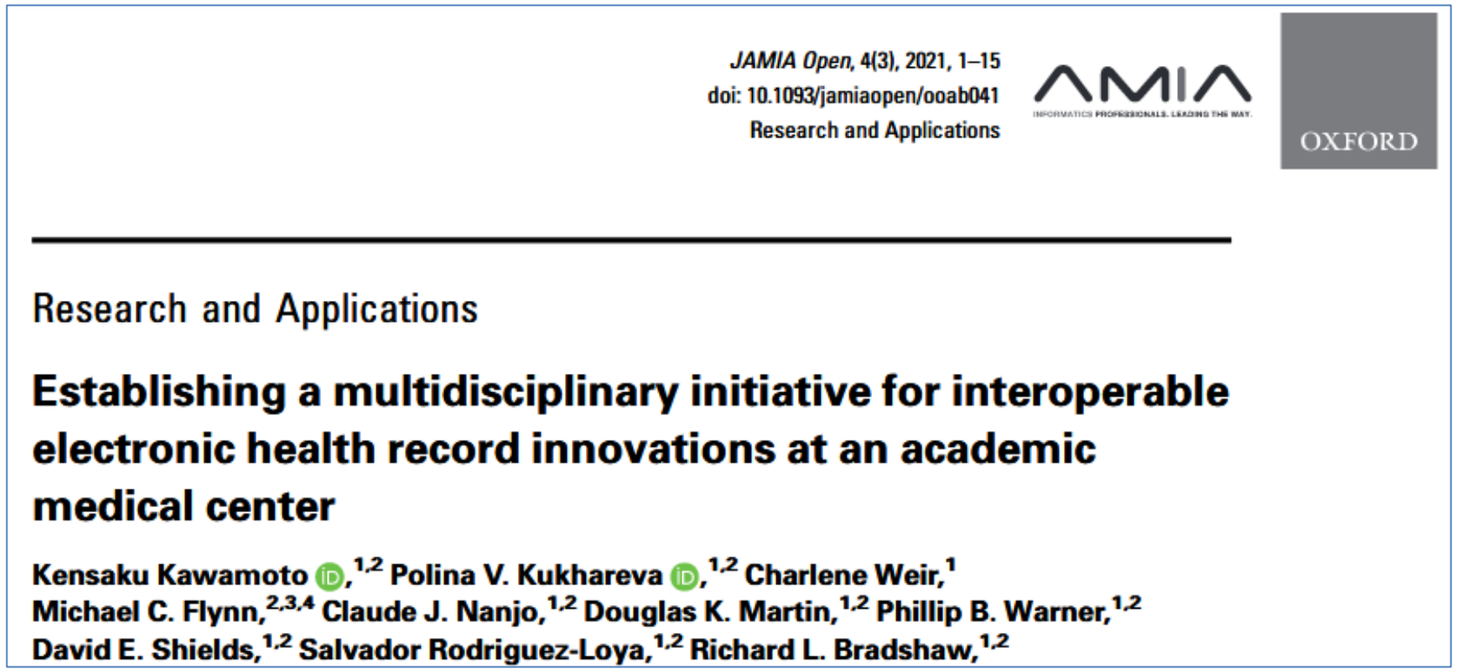
REIMAGINEEHR

DISCLOSURES

- I report honoraria, consulting, sponsored research, writing assistance, licensing, or co-development in the past 24 months with Hitachi, Pfizer, NORC, RTI International, UC San Francisco, Indiana University, the Regenstrief Foundation, University of Nebraska, KOSMI, MD Aware, and the U.S. Office of the National Coordinator for Health IT (via Security Risk Solutions)
- Some of the EHR apps described are or may be commercialized to enable wider impact

UNIVERSITY OF UTAH REIMAGINE EHR INITIATIVE

- Multi-stakeholder initiative started in 2016
- Goal is to improve patient care and the provider experience through interoperable EHR apps that convert data to actionable insight
- >15 solutions
- >$40M in grants
- Multiple awards
- Pillar of Digital Health Initiative



JAMIA Open, 4(3), 2021, 1–15
doi: 10.1093/jamiaopen/ooab041
Research and Applications

Research and Applications

Establishing a multidisciplinary initiative for interoperable electronic health record innovations at an academic medical center

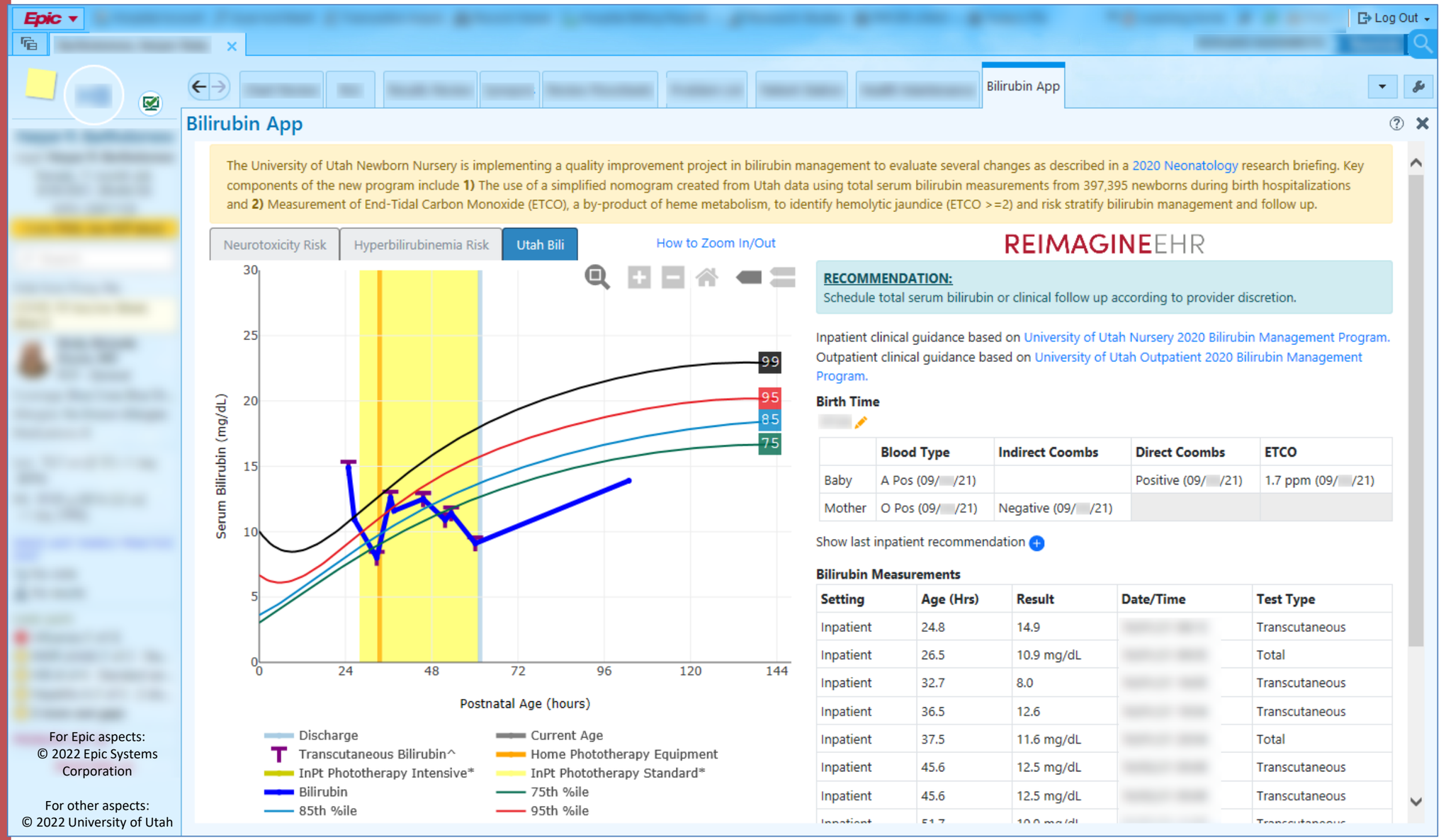
Kensaku Kawamoto,[1,2] Polina V. Kukhareva,[1,2] Charlene Weir,[1] Michael C. Flynn,[2,3,4] Claude J. Nanjo,[1,2] Douglas K. Martin,[1,2] Phillip B. Warner,[1,2] David E. Shields,[1,2] Salvador Rodriguez-Loya,[1,2] Richard L. Bradshaw,[1,2]

THE VISION

- Imagine as a doctor…
  - It is a joy to use the EHR
  - The EHR is constantly saving you time
  - It is easy to do the right thing, every time
  - When you imagine how the EHR *should* work, it soon becomes how it *does* work

REIMAGINEEHR

BILIRUBIN APP

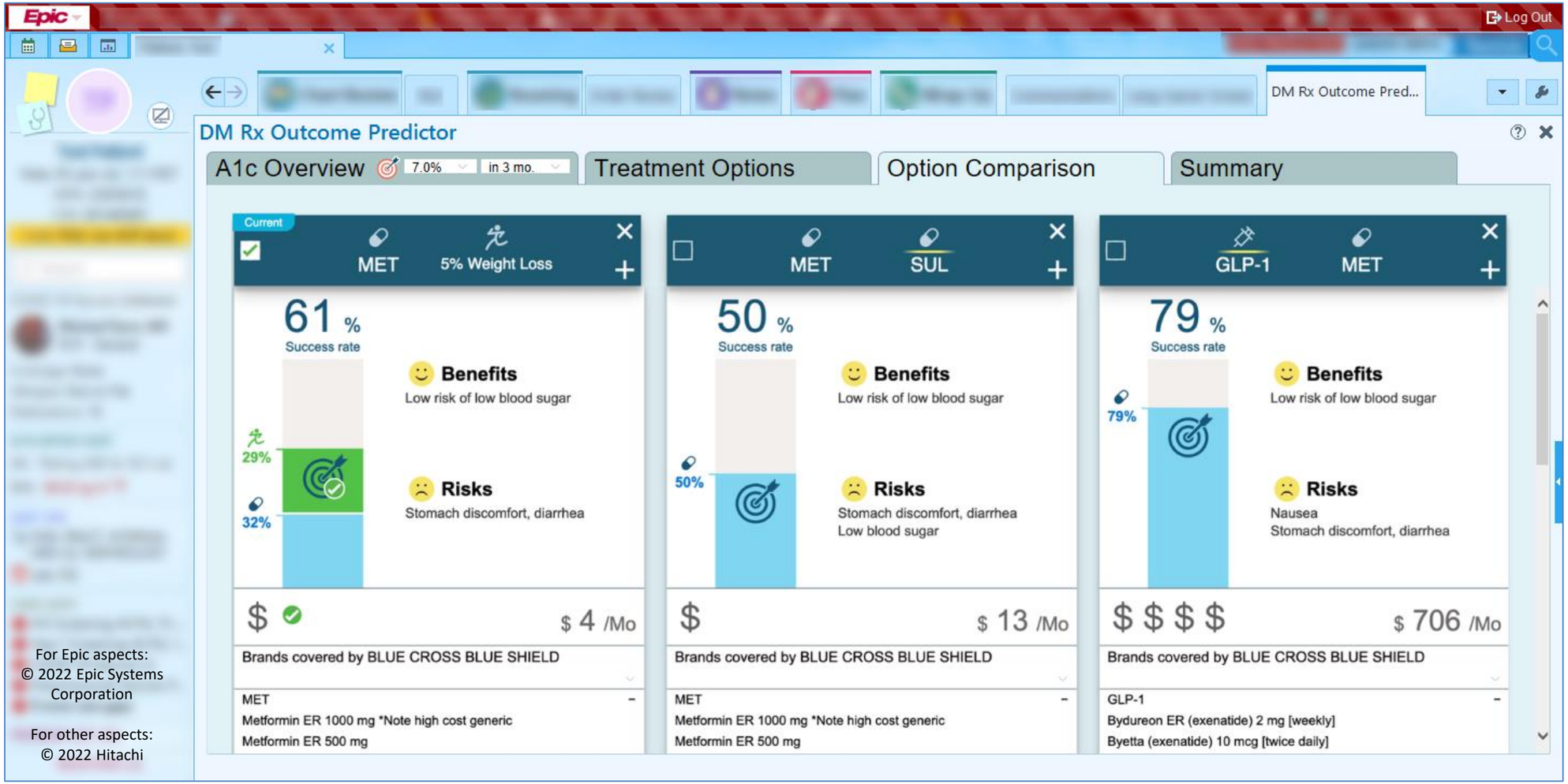


	Blood Type	Indirect Coombs	Direct Coombs	ETCO
Baby	A Pos (09/ /21)		Positive (09/ /21)	1.7 ppm (09/ /21)
Mother	O Pos (09/ /21)	Negative (09/ /21)		

Setting	Age (Hrs)	Result	Date/Time	Test Type
Inpatient	24.8	14.9		Transcutaneous
Inpatient	26.5	10.9 mg/dL		Total
Inpatient	32.7	8.0		Transcutaneous
Inpatient	36.5	12.6		Transcutaneous
Inpatient	37.5	11.6 mg/dL		Total
Inpatient	45.6	12.5 mg/dL		Transcutaneous
Inpatient	45.6	12.5 mg/dL		Transcutaneous

- Goal: prevent brain damage in newborns
- Impact: (*JAMA Open*. 2019;e1915343)
  - Odds of clinically appropriate phototherapy ↑ 84%
  - Clinician time required ↓ 3 fold
  - Attending provider usability rating: "best imaginable"
- Iterative enhancements
- Winner, 2019 HL7/AMIA FHIR App Showcase

DIABETES RX SHARED DECISION MAKING APP

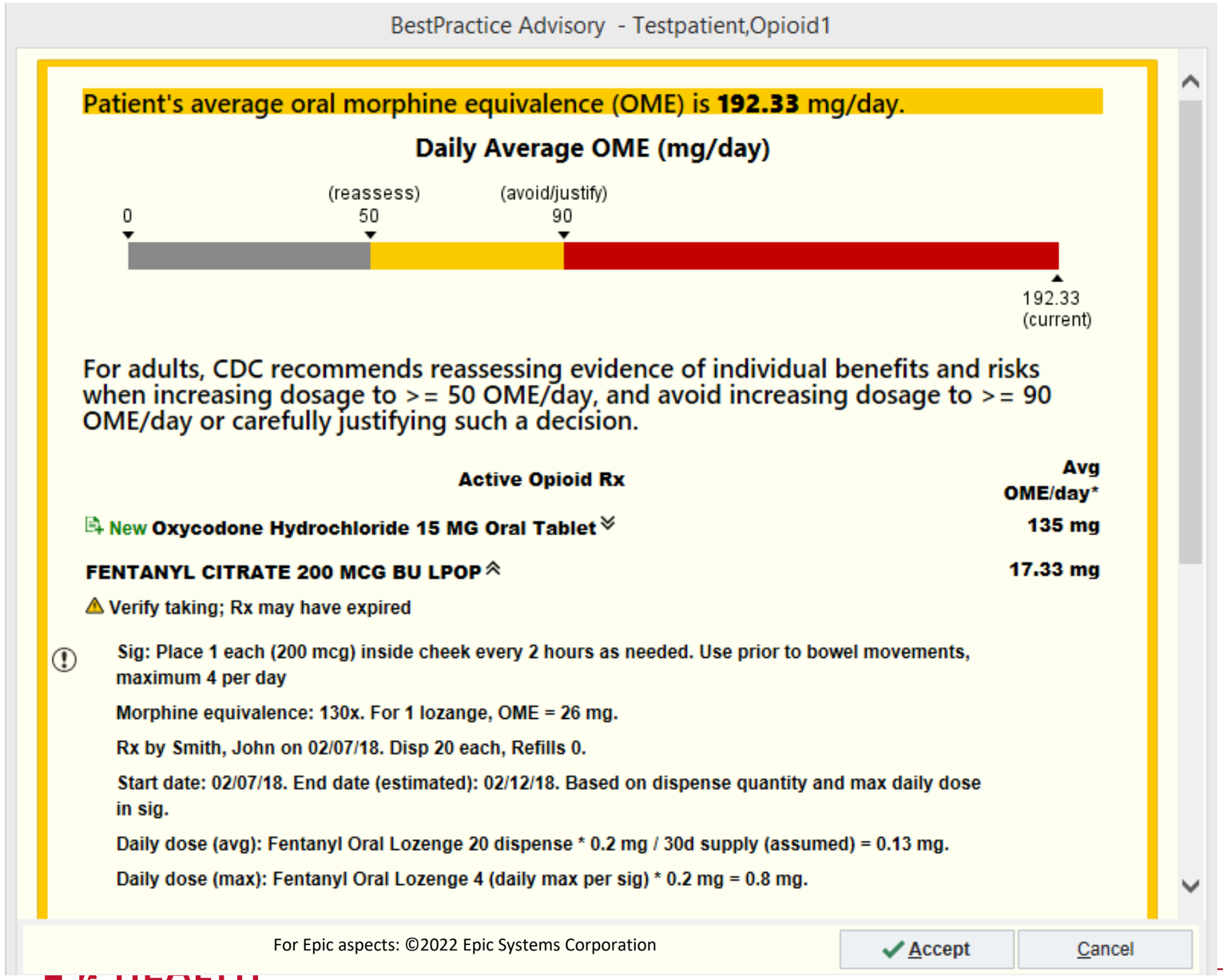


- Collaboration with Hitachi
- AI-driven Rx guidance (predictive model, AUC 0.84)
- Accounts for insurance for cost info
- Multiple adaptations

Leveraging Artificial Intelligence to Improve Chronic Disease Care: Methods and Application to Pharmacotherapy Decision Support for Type-2 Diabetes Mellitus
Methods Inf Med 2021; 60(S 01): e32-e43

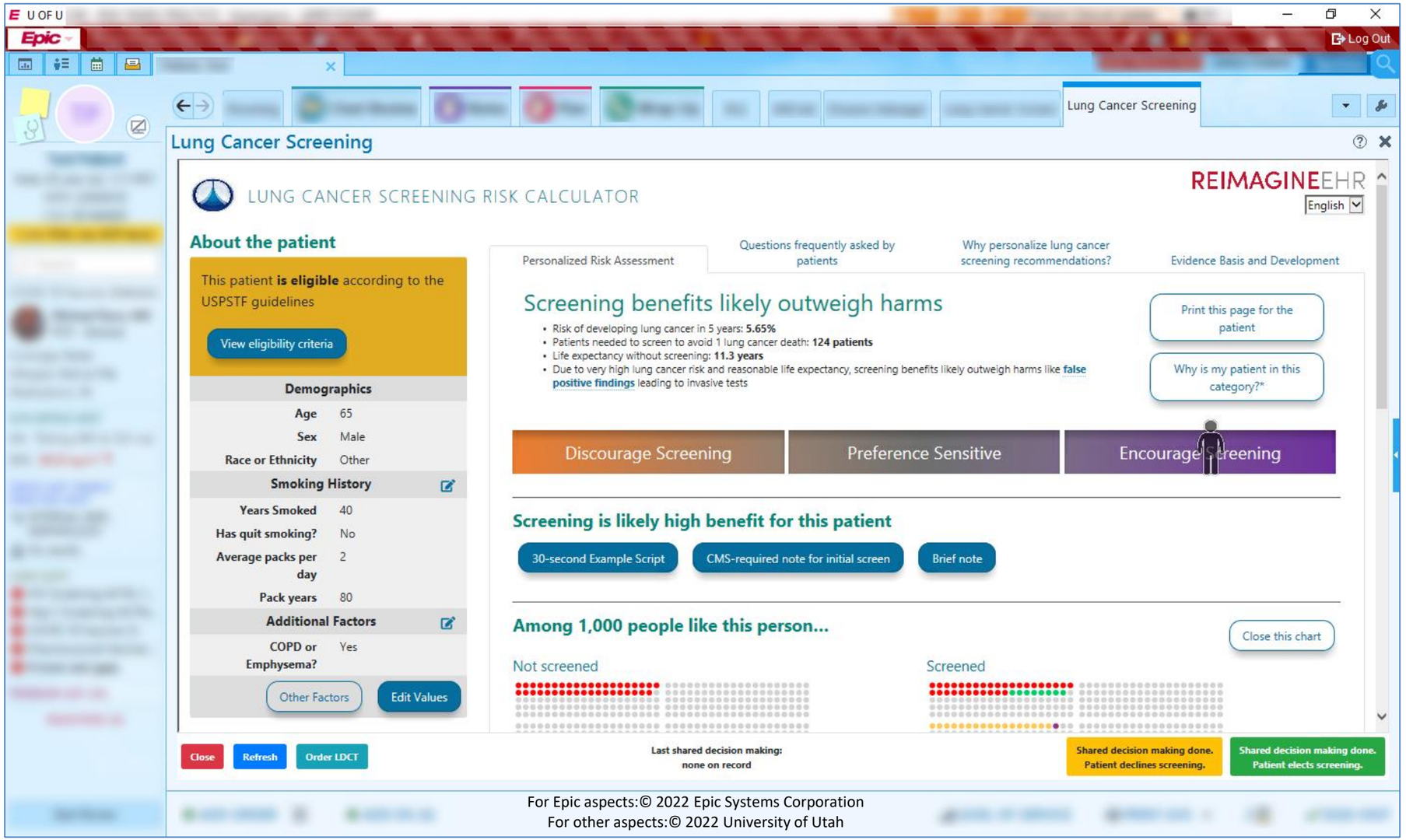
Predicting pharmacotherapeutic outcomes for type 2 diabetes: An evaluation of three approaches to leveraging electronic health record data from multiple sources
Journal of Biomedical Informatics 129 (2022) 104001

OPIOID DECISION SUPPORT



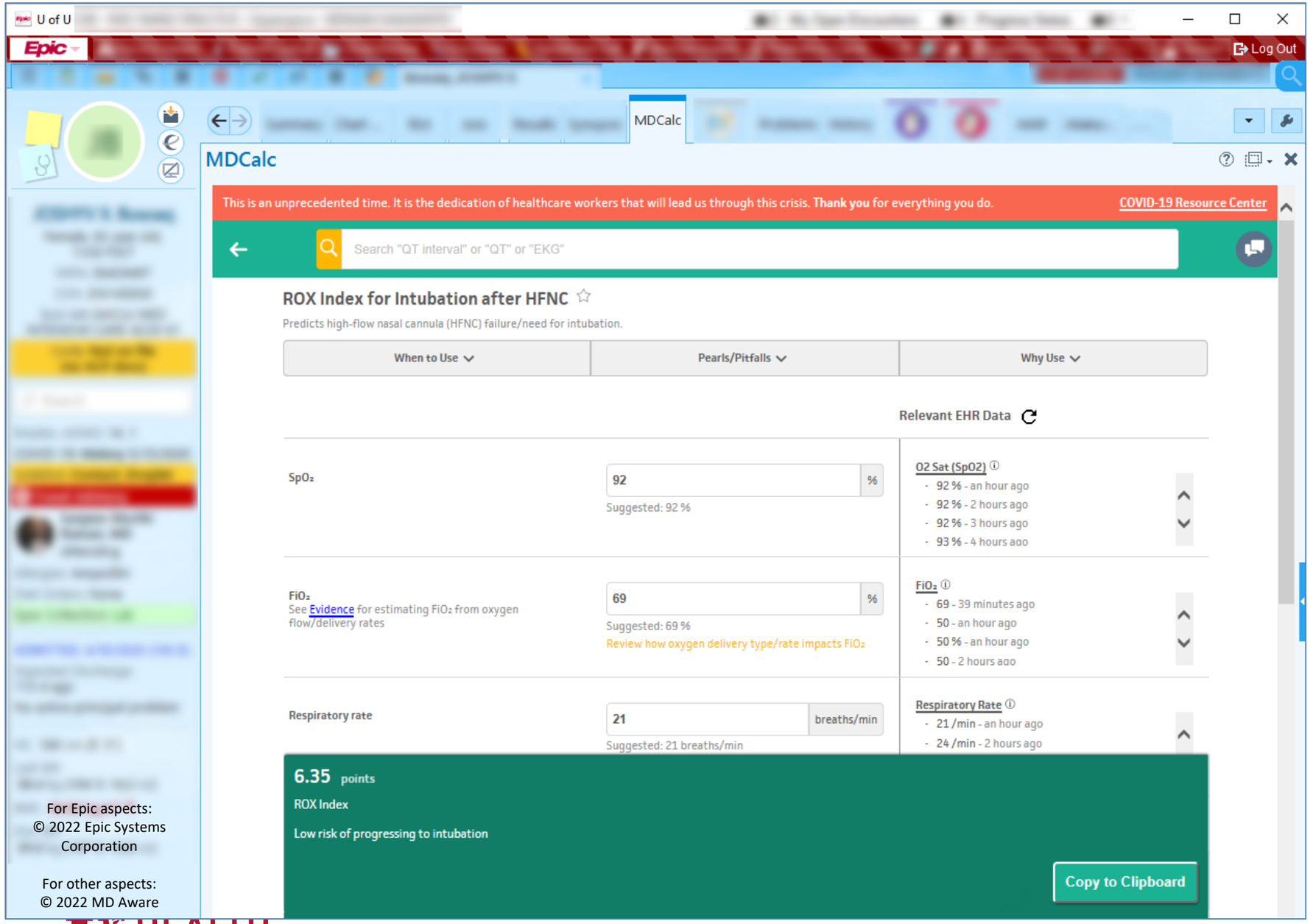
- Goal: provide point-of-care support for [2016 CDC Prescribing Guideline]
- CDC-sponsored and ONC-CDC led effort. Collaborators: AHRQ, Yale, Indiana Univ., Duke, MUSC, Univ. of Colorado, Security Risk Solutions, Epic, Cerner, and others.
- Use of regex for sig parsing; potential use of NLP
- http://build.fhir.org/ig/cqframework/opioid-cds-r4/

PREDICTION MODEL-DRIVEN LUNG CANCER SCREENING SHARED DECISION MAKING APP



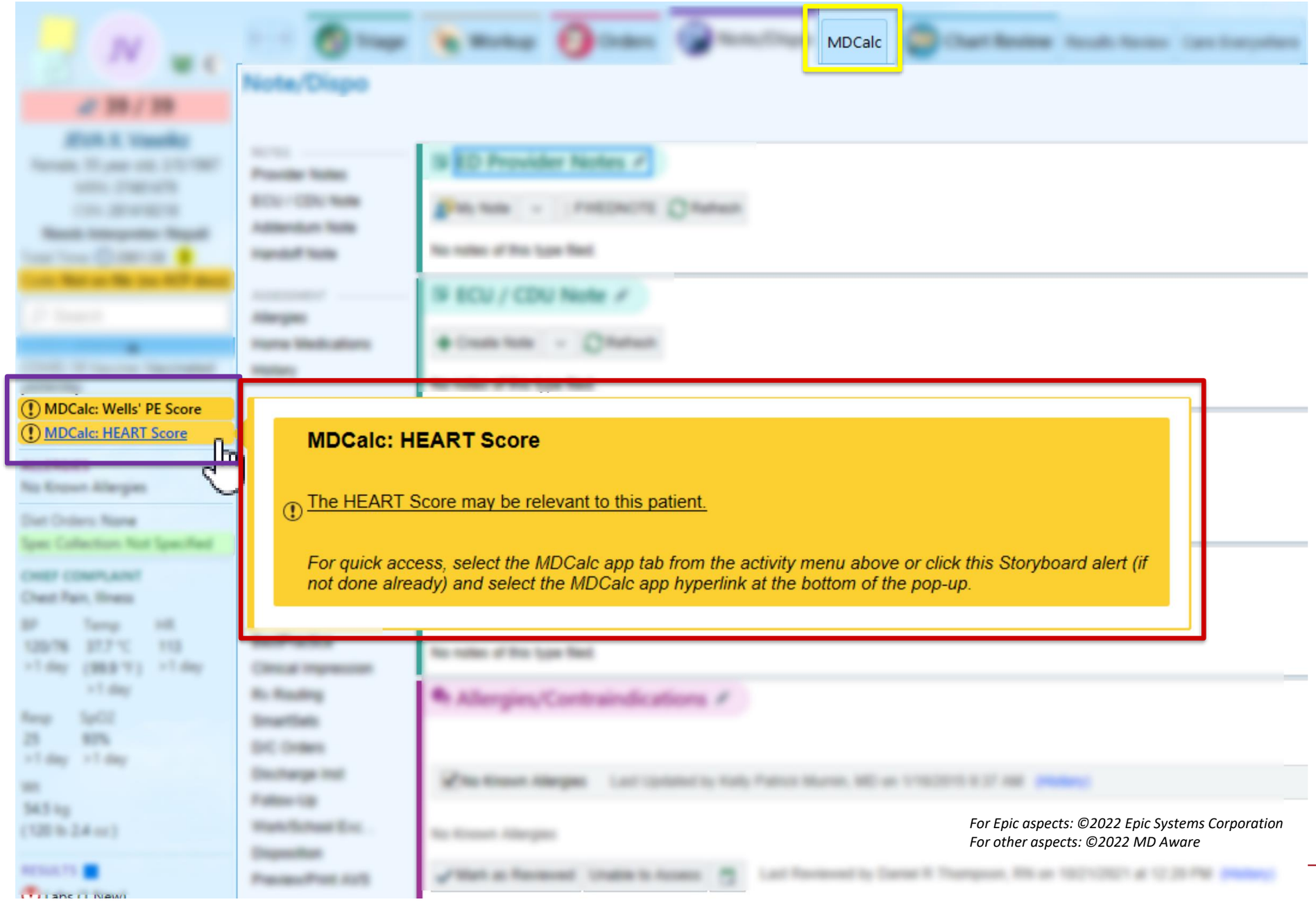
- AHRQ R18
- Low-dose CT screening could save more lives than breast cancer screening (10,000/yr)
- Driven by 23-variable NCI predictive model of individual outcomes
- Odds of screening referral ↑ 5x in primary care clinics
- Being disseminated with Epic as a free app (https://appmarket.epic.com/Gallery?id=9278)
- Patient-facing app in development

MDCALC FOR EHR



- MDCalc: leading calculation tool
  - Millions of monthly users; 65% of US MDs
- Many prediction rules, including those leveraging ML
- Auto-fills inputs and integrates with documentation
- Improves accuracy
  (Abedin et al. *Circ Cardiovasc Qual Outcomes*. 2020.13(2):e006286)
- Can be enhanced with CDS Hooks
  (Morgan et al. *J Am Med Inform Assoc*. 2022. 29(9):1461-70)

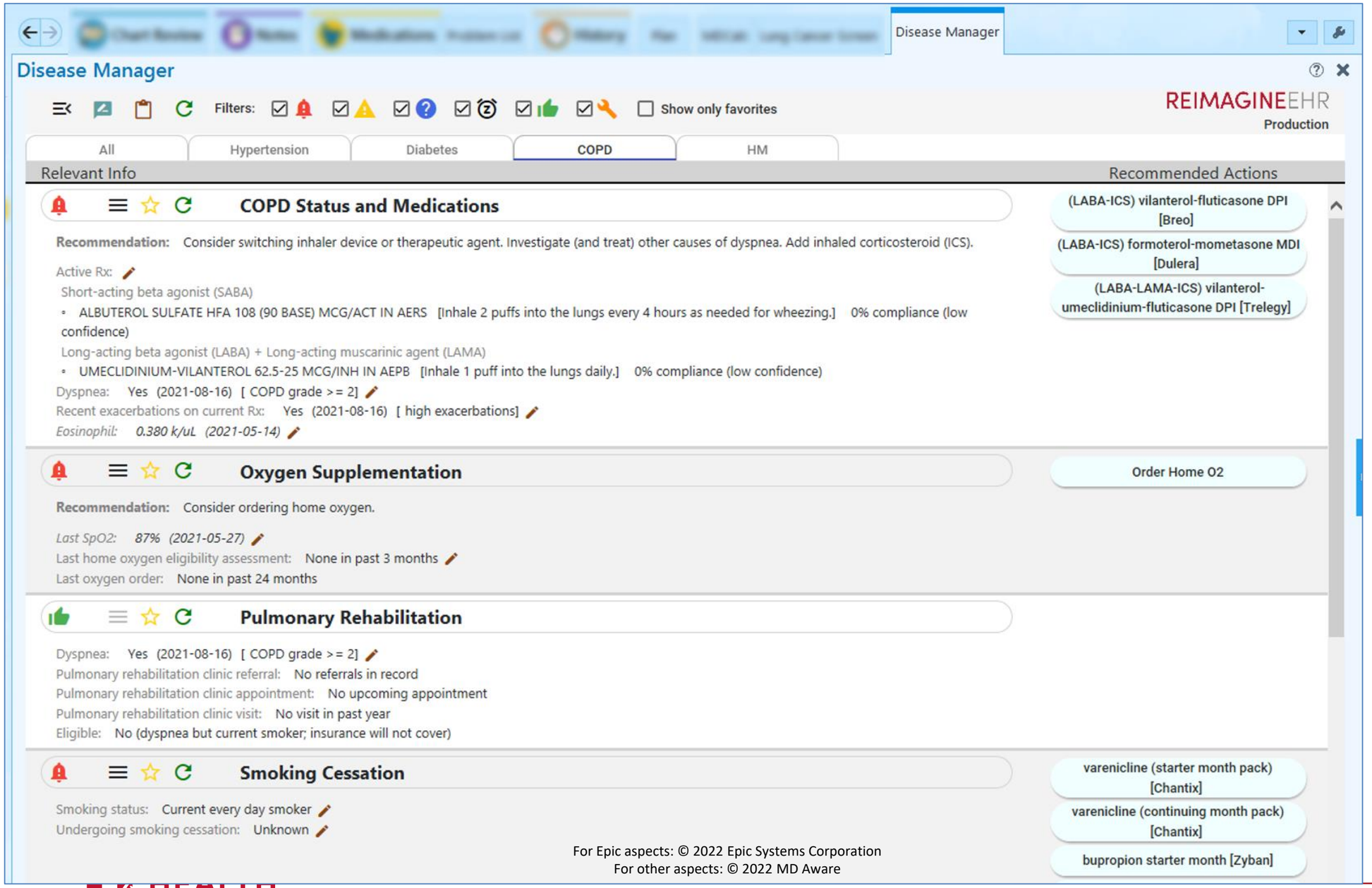
CDS HOOKS PROMPTING FOR SMART ON FHIR APP



- A primary motivation for CDS Hooks

- First reported RCT to formally evaluate: (Morgan et al. *J Am Med Inform Assoc*. 2022. 29(9):1461-70)
  - 130% increase in use of context- relevant MDCalc calculator in ED (odds ratio 2.45, p = 0.02)

DISEASE MANAGER



- Target: chronic diseases (70% of deaths, 90% of $)
- Ever-growing disease modules
- Synthesizes data from across EHR
- Multiple time-saving features
- Completion of recommended care 81% vs. 48% *(JAMIA. 2020. 27:1225-34)*
- Winner, 2021 HL7/AMIA FHIR App Showcase

CRITICAL CHALLENGE: VENDOR DIFFERENCES IN FHIR IMPLEMENTATIONS

- **What** is supported
  - What data can be **read** (e.g., years smoked, packs per day, referral orders)
  - Whether relevant data can be **written** (e.g., patient-reported outcomes, goals of care)
- **How** it is supported
  - E.g., standards used (or not), query parameters, speed
- Can change over time even within same EHR product

POTENTIAL SOLUTIONS

- Only use FHIR capabilities required by regulation (US Core)
  - Required capabilities still may not be met (e.g., use of standard codes for encounter types)
  - Recommended capabilities may not be supported (e.g., ability to restrict MedicationRequest queries with a date)
- Support multiple FHIR implementation flavors in apps
  - E.g., if data X not available via FHIR, prompt user for X
- Handle differences in a transformation layer (e.g., FHIR Wrapper, COOL logical data model)
- Extend EHR FHIR APIs
  - EHR vendors may not allow, or allow only for intra-institutional use

KEY RESOURCES

JAMIA Open, 4(3), 2021, 1–15
doi: 10.1093/jamiaopen/ooab041
Research and Applications

Research and Applications

Establishing a multidisciplinary initiative for interoperable electronic health record innovations at an academic medical center

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Journal of the American Medical Informatics Association, 28(8), 2021, 1796–1806
doi: 10.1093/jamia/ocab070
Advance Access Publication Date: 8 June 2021
Review

Review

Contemporary clinical decision support standards using Health Level Seven International Fast Healthcare Interoperability Resources

Howard R. Strasberg,[1] Bryn Rhodes,[2] Guilherme Del Fiol,[3] Robert A. Jenders,[4,5] Peter J. Haug,[6] and Kensaku Kawamoto[3]

Monday 1:45-3:15pm panel (S35):
Establishing a Multidisciplinary Initiative for Interoperable EHR Innovations at an Academic Medical Center: the University of Utah ReImagine EHR Experience

Tuesday 8:30-10am oral presentation (S60):
Dr. Polina Kukhareva: Lung Cancer Screening Implementation in Primary Care Using an Electronic Health Record-integrated Shared Decision Making Tool and Clinician-facing Prompts

Wed 8:30-10am oral presentation (S101):
Dr. Keaton Morgan: Using CDS Hooks to Increase SMART on FHIR App Utilization: A Cluster-Randomized Trial

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- Michael Flynn, MD
- Mike Strong, MD
- Nitu Kashyap, MD
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- Phillip Warner, MS
- Polina Kukhareva, PhD, MPH
- Rachel Hess, MD, MS
- Rebecca Curran, MD, PhD
- Richard Bradshaw, PhD
- Rebecca Curran, MD, PhD
- Richard Bradshaw, PhD
- Robert McClure, MD
- Robert Richens
- Ryan Cornia
- Salvador Rodriguez, PhD
- Samir Abdelrahman, MS, PhD
- Scott Junkins, MD
- Scott Narus, PhD
- Shinji Tarumi
- Siru Liu, PhD
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- Wataru Takeuchi
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- Yves Lussier, MD

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DISCLAIMER

The content of this document does not necessarily reflect the views or policies of the US Department of Health and Human Services, the Centers for Disease Control and Prevention, the Office of the National Coordinator for Health IT, or the other organizations involved, nor does the mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government.

THANK YOU!

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Associate Chief Medical Information Officer

Director, ReImagine EHR Initiative

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INFORMATICS PROFESSIONALS. LEADING THE WAY.

Clinical Decision Support Standards to Facilitate Value-Based Health Care and Quality Improvement: Latest Developments and What You Need to Know

Session: W16

Speaker: Peter Haug, MD

Intermountain Healthcare

Disclosure

I and my spouse/partner have no relevant relationships with commercial interests to disclose.

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Business Process Management Standards: Tools for Delivering Clinical Decision *Processes*

Goal: Support Portable Clinical *Workflows*

Intermountain® Healthcare

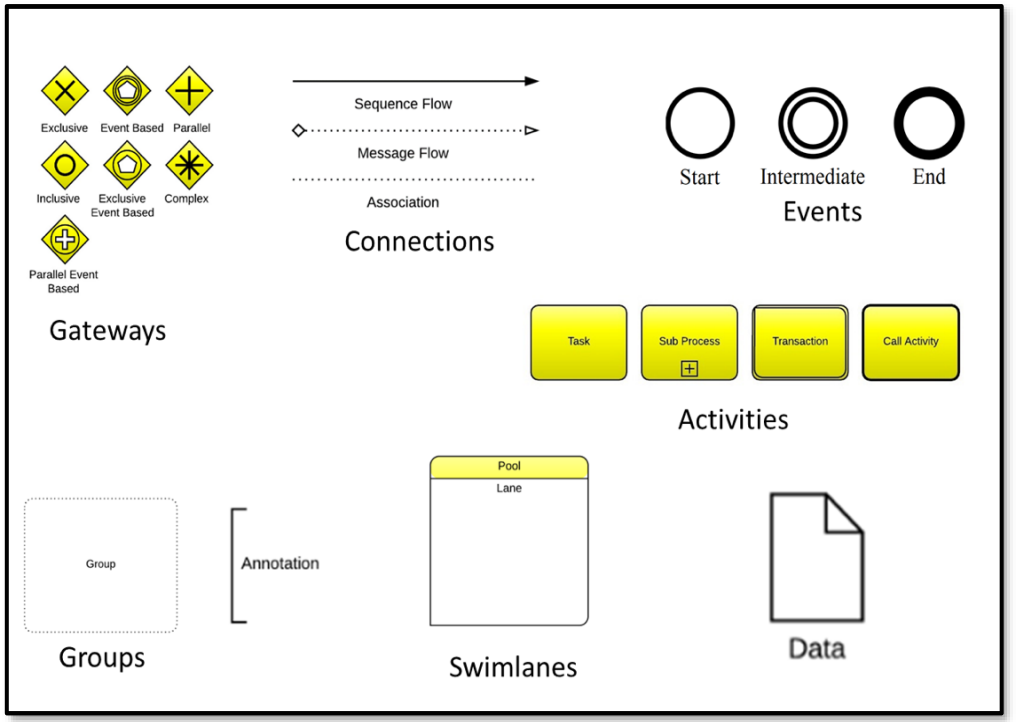
BPM+ Health: Business Process Management for Healthcare

An Initiative of the ***Object Management Group (OMG)***

- International, open membership, not-for-profit, technology-standards consortium, founded in 1989.
- OMG Task Forces develop enterprise automation standards for a wide range of industries.
- **BPM+ Health** is an OMG-sponsored Community of Practice dedicated to identifying the best practices around the use of *business process management standards* in Healthcare.
    - At: https://www.bpm-plus.org/

OMG's Business Process Management Standards

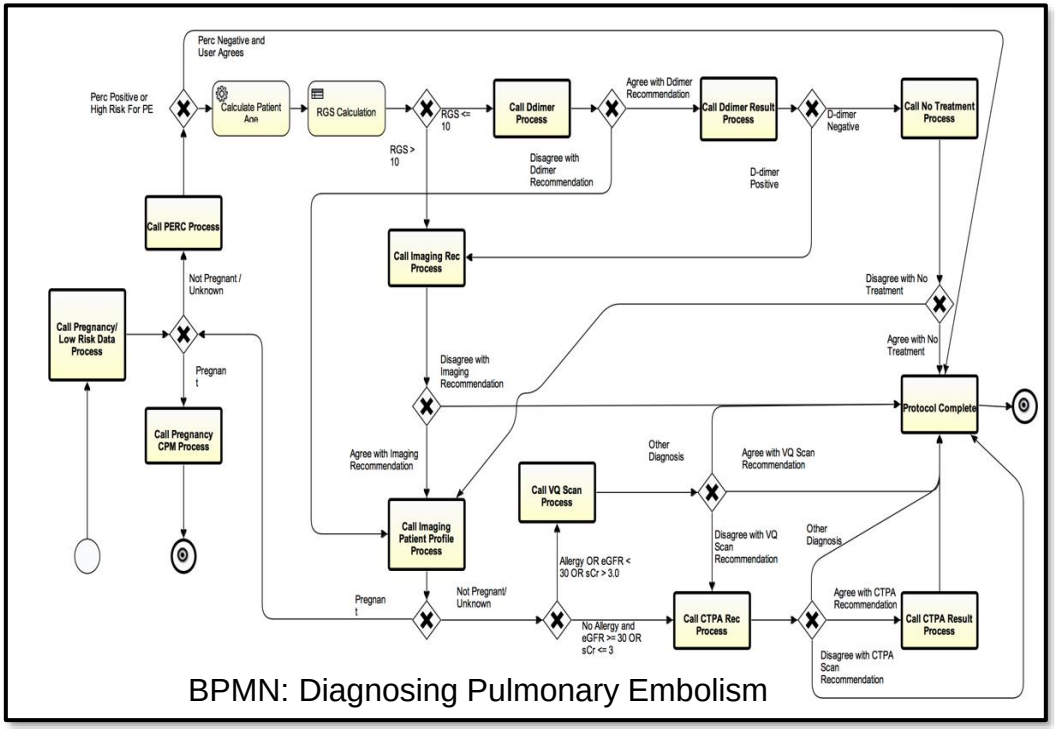
- Describe **Processes.**
  - Captures the **Workflow** needed (Stateful).
  - **Decisions** that direct the **Workflow** (Stateless).
- Are general-purpose tools for use across Industries.
- OMG has a sharp focus on **Graphical Authoring Tools.**
- These tools support the discipline of **Process Modeling**.



*The Models produce **Executable Code!***

BPM+ is Based on 3 Process Management Tools

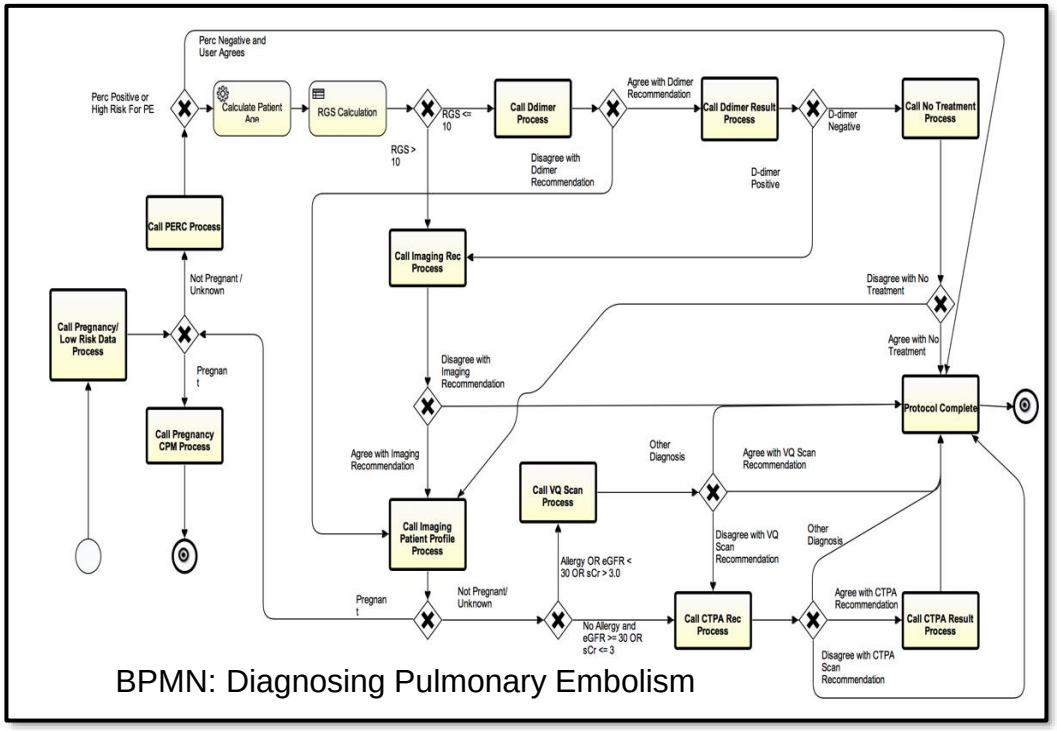
- Business Process Model and Notation (BPMN).
  - Tools for modeling multistep (stateful) workflows.
- Decision Model and Notation (DMN).
  - Authoring and executing decision logic to guide processes.
- Case Management Model and Notation (CMMN).
  - Flexible support for processes managed by Experts.



BPMN: Diagnosing Pulmonary Embolism

Business Process Model and Notation (BPMN)

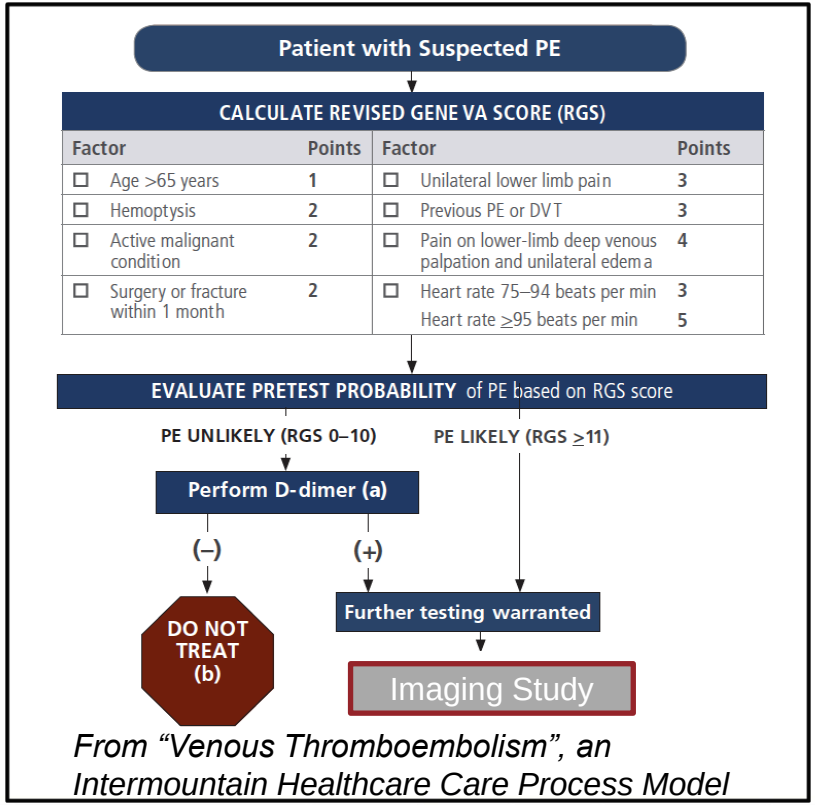
- Implement Healthcare Workflows.
  - Part of the work is done by computers.
  - Part of work done by people.
- Can Automate Complex Healthcare Processes.
  - Orchestrate calls to supporting services
- Authoring Environment Can Produce **Executable Output.**
  - Workflow execution engines run the process specification.



BPMN: Diagnosing Pulmonary Embolism

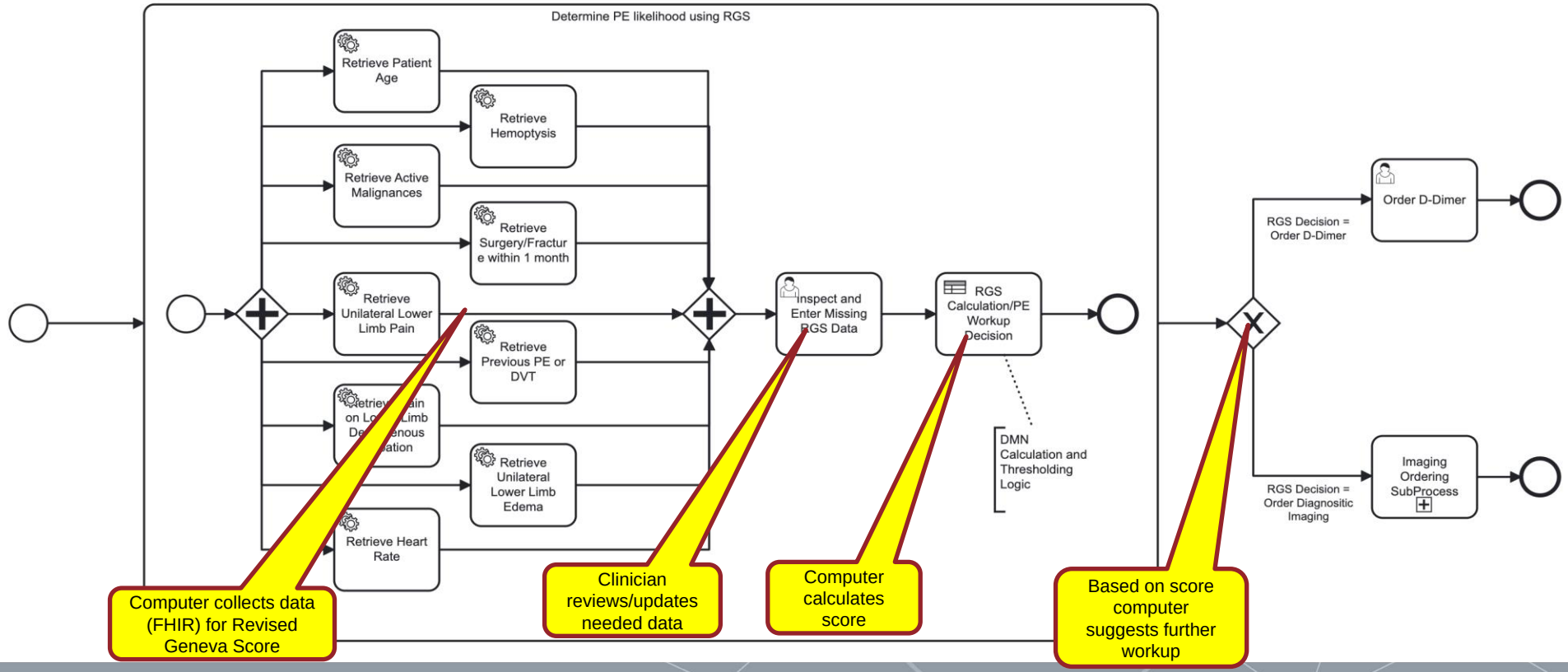
Example: Testing for Pulmonary Embolism

- Decision logic requires 8 data elements.
- Each is weighted according to diagnostic importance.
- Testing decisions are based on the total of these weights.
- Graphic contains both logic and workflow.
- Data can be retrieved from an EHR or entered by clinicians.



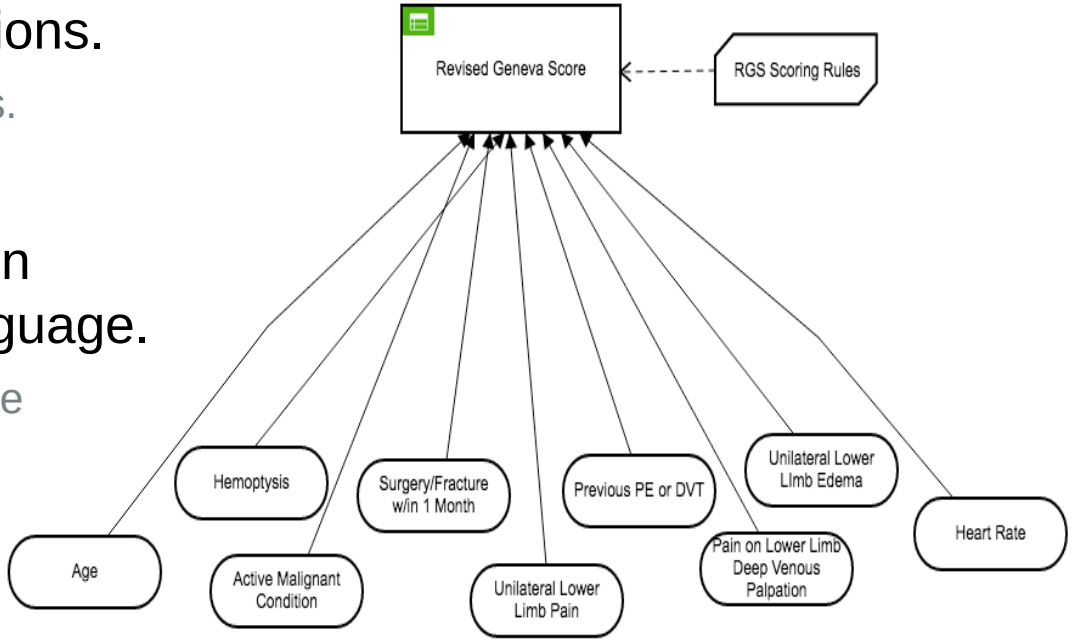
From "Venous Thromboembolism", an Intermountain Healthcare Care Process Model

Example: Testing for Pulmonary Embolism



Decision Model and Notation (DMN)

- Documents The Logic Of Decisions.
  - Enumerates necessary data elements.
  - Captures compositional logic.
- Authoring System Uses Decision Tables And An Expression Language.
  - Friendly Enough Expression Language (FEEL).
- *Produces **Executable** Output.*



Decision Requirement Diagram (DRG)

Decision Model and Notation: Decision Tables

- Specific logic can be described in decision tables.
  - Simplifies designing, critiquing, and maintaining logic.
- Can be supplemented (or replaced) by expressions.
  - Friendly Enough Expression Language (FEEL) is defined in the standard.
  - Several other expression languages can be invoked.
  - Machine-Learning-based models are available using Predictive Model Markup Language (PMML).

RGS.dmn | Test 1.bpmn | diagram_1.dmn | +

Revised Geneva Score

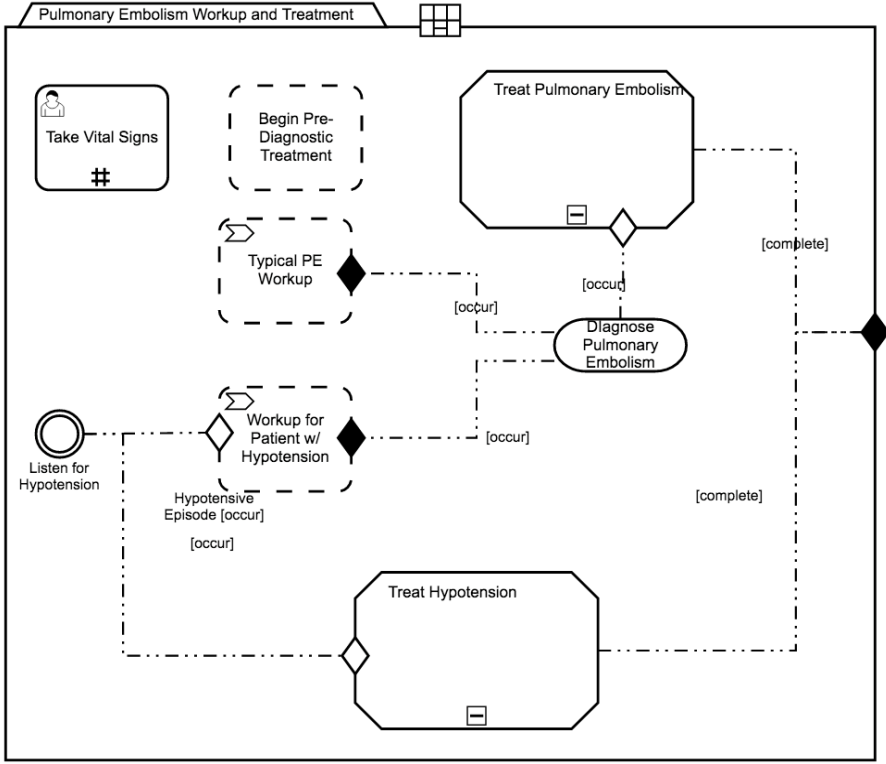
Enter Advanced Mode | Show DRD

C+	Input +									Output +	
	Age	Hemoptysis	Active Malignant Condition	Surgery/Fracture w/in 1 Month	Unilateral Lower Limb Pain	Previous PE or DVT	Unilateral Lower Limb Edema	Pain on Lower-Limb Deep Venous Palpation	Heart Rate	Points	Annotation
	double	string	string	string	string	string	string	string	integer	integer	
1	>65	-	-	-	-	-	-	-	-	1	Age > 65 worth 1 point
2	-	"Present"	-	-	-	-	-	-	-	2	Hemoptysis Present
3	-	-	"Present"	-	-	-	-	-	-	2	Malignant Condition Present
4	-	-	-	"Present"	-	-	-	-	-	2	Surgery or Fracture Present within the Last Month
5	-	-	-	-	"Present"	-	-	-	-	3	Lower Limb Pain Present
6	-	-	-	-	-	"Present"	-	-	-	3	History of PE or DVT Present
7	-	-	-	-	-	-	"Present"	"Present"	-	4	Lower Limb Tenderness and Edema Present
8	-	-	-	-	-	-	-	-	[75..94]	3	Moderately Elevated Heart Rate
9	-	-	-	-	-	-	-	-	>=95	5	Significantly Elevated Heart Rate
+	-	-	-	-	-	-	-	-	-	-	-

Decision Table

Case Management Model and Notation (CMMN)

- Designed to support Experts as they choose among relevant approaches
  - Activated for a specific context (*symptoms suggest pulmonary embolism*)
- Allows flexibility
  - When patient state is ambiguous
  - When choice of approach requires Expert judgement
- The newest of the standards-relatively untested



An Example: Pulmonary Embolism Diagnosis

Modeling Pulmonary Embolism in the Emergency Department

- Clinical Workflow for Evidence-Based Diagnosis and Treatment
- Implemented and Tested Using **OMG's Business Process Model and Notation (BPMN)** Standard for Workflows
- Initially developed with proprietary data access services against legacy systems
- Converted to Use **FHIR/SMART** Standards
- Development using the **Logica* Sandbox** as an EHR
- Provides a testbed for **FHIR/SMART/BPMN** support of complex clinical processes

**LogicaHealth.org*

From Intermountain's Venous Thromboembolism Care Process Model

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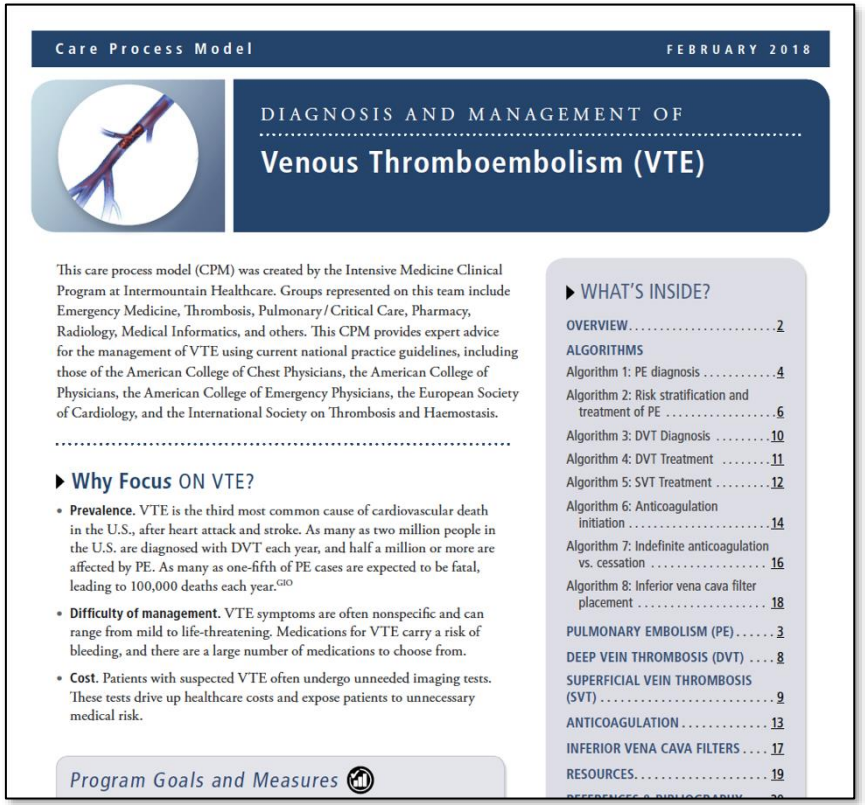


Care Process Model FEBRUARY 2018

DIAGNOSIS AND MANAGEMENT OF

Venous Thromboembolism (VTE)

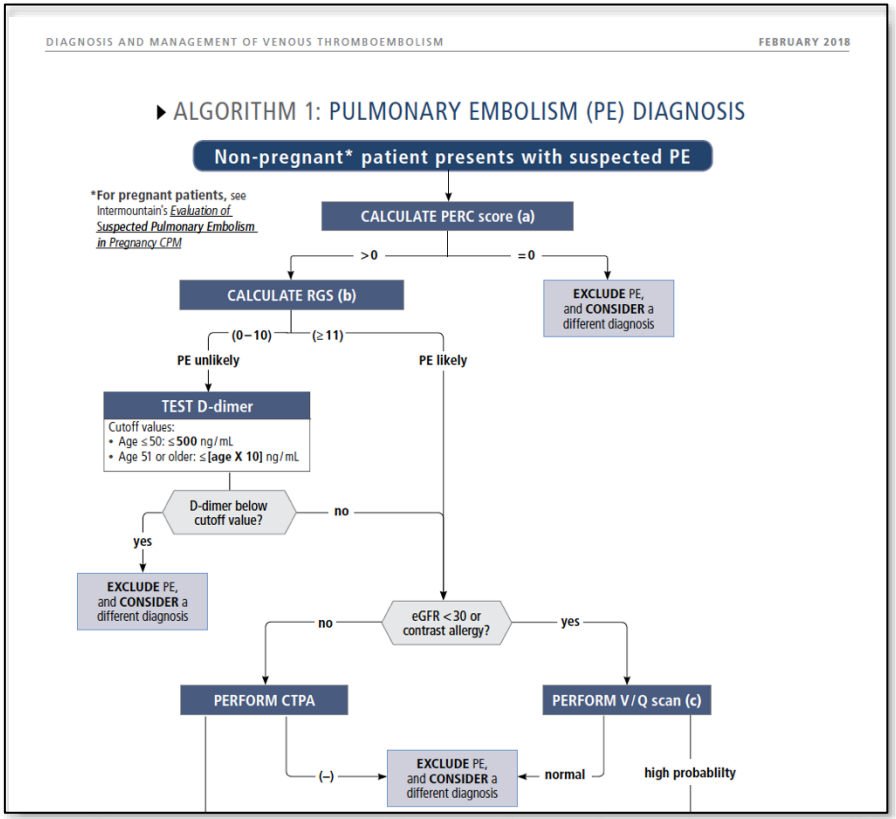
This care process model (CPM) was created by the Intensive Medicine Clinical Program at Intermountain Healthcare. Groups represented on this team include Emergency Medicine, Thrombosis, Pulmonary/Critical Care, Pharmacy, Radiology, Medical Informatics, and others. This CPM provides expert advice for the management of VTE using current national practice guidelines, including those of the American College of Chest Physicians, the American College of Physicians, the American College of Emergency Physicians, the European Society of Cardiology, and the International Society on Thrombosis and Haemostasis.

Why Focus ON VTE?

- **Prevalence.** VTE is the third most common cause of cardiovascular death in the U.S., after heart attack and stroke. As many as two million people in the U.S. are diagnosed with DVT each year, and half a million or more are affected by PE. As many as one-fifth of PE cases are expected to be fatal, leading to 100,000 deaths each year.[GIO]
- **Difficulty of management.** VTE symptoms are often nonspecific and can range from mild to life-threatening. Medications for VTE carry a risk of bleeding, and there are a large number of medications to choose from.
- **Cost.** Patients with suspected VTE often undergo unneeded imaging tests. These tests drive up healthcare costs and expose patients to unnecessary medical risk.

Program Goals and Measures

WHAT'S INSIDE?



DIAGNOSIS AND MANAGEMENT OF VENOUS THROMBOEMBOLISM FEBRUARY 2018

ALGORITHM 1: PULMONARY EMBOLISM (PE) DIAGNOSIS

Non-pregnant* patient presents with suspected PE

*For pregnant patients, see Intermountain's *Evaluation of Suspected Pulmonary Embolism in Pregnancy CPM*

CALCULATE PERC score (a)

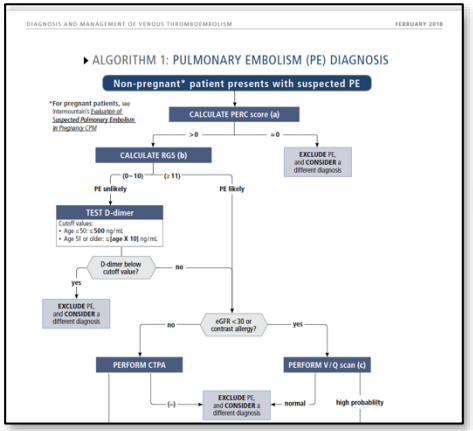
- >0 → **CALCULATE RGS (b)**
  - (0–10) → **PE unlikely** → **TEST D-dimer**
    Cutoff values:
    - Age ≤ 50: ≤ **500** ng/mL
    - Age 51 or older: ≤ **[age X 10]** ng/mL

    D-dimer below cutoff value?
    - yes → **EXCLUDE** PE, and **CONSIDER** a different diagnosis
    - no → **eGFR <30 or contrast allergy?**
  - (≥11) → **PE likely** → **eGFR <30 or contrast allergy?**
- =0 → **EXCLUDE** PE, and **CONSIDER** a different diagnosis

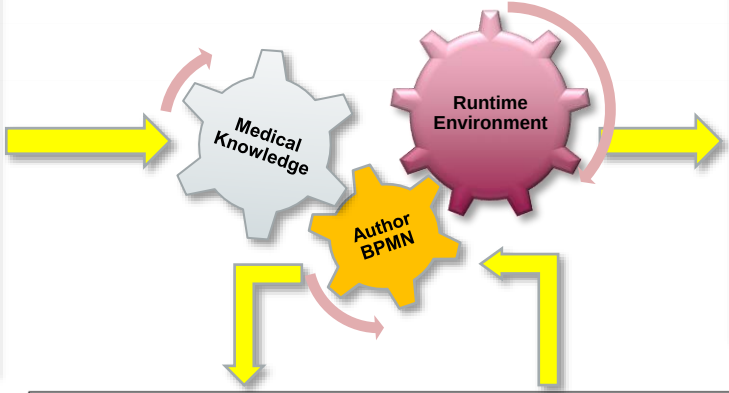
eGFR <30 or contrast allergy?
- no → **PERFORM CTPA**
  - (–) → **EXCLUDE** PE, and **CONSIDER** a different diagnosis
- yes → **PERFORM V/Q scan (c)**
  - normal → **EXCLUDE** PE, and **CONSIDER** a different diagnosis
  - high probablilty

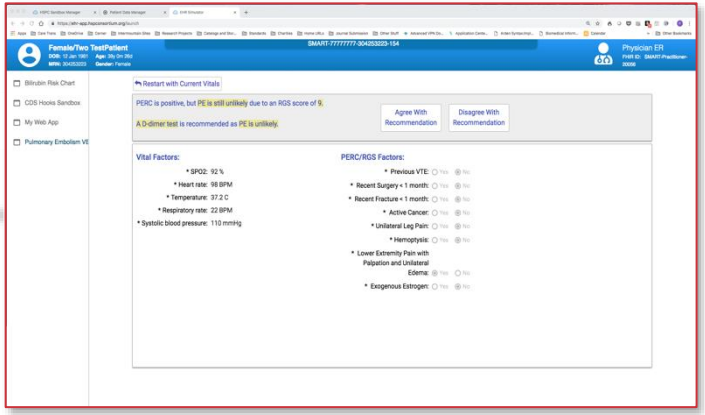
Intermountain® Healthcare

Building and Maintaining Clinical Applications with BPMN-based Graphical Authoring Tools

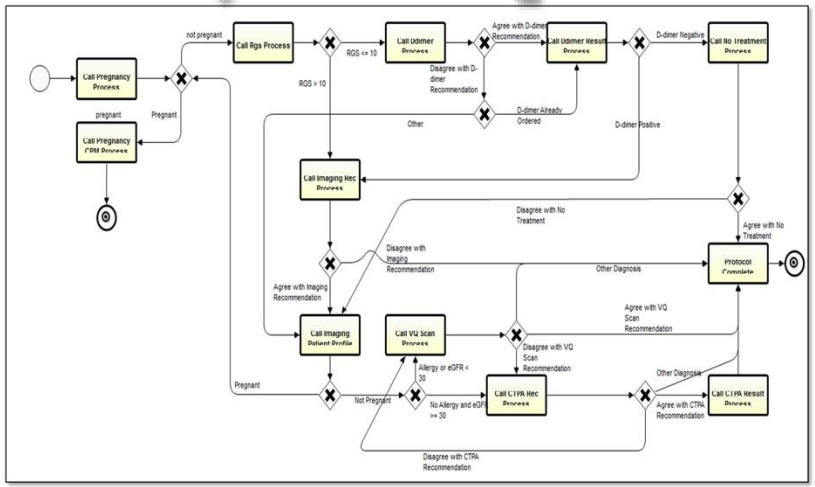


Algorithm for Pulmonary Embolism Workup



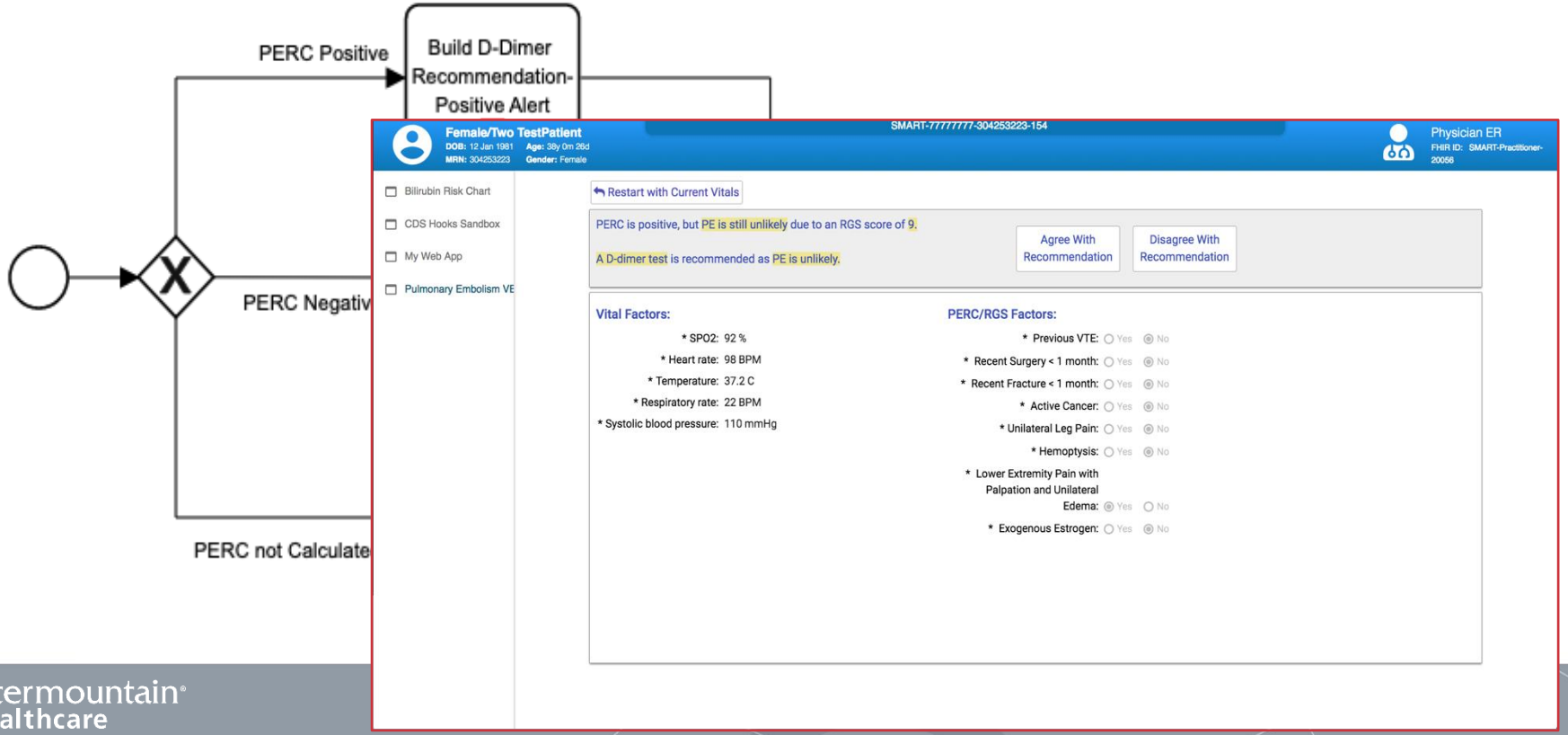


Workflow execution using a BPMN engine.

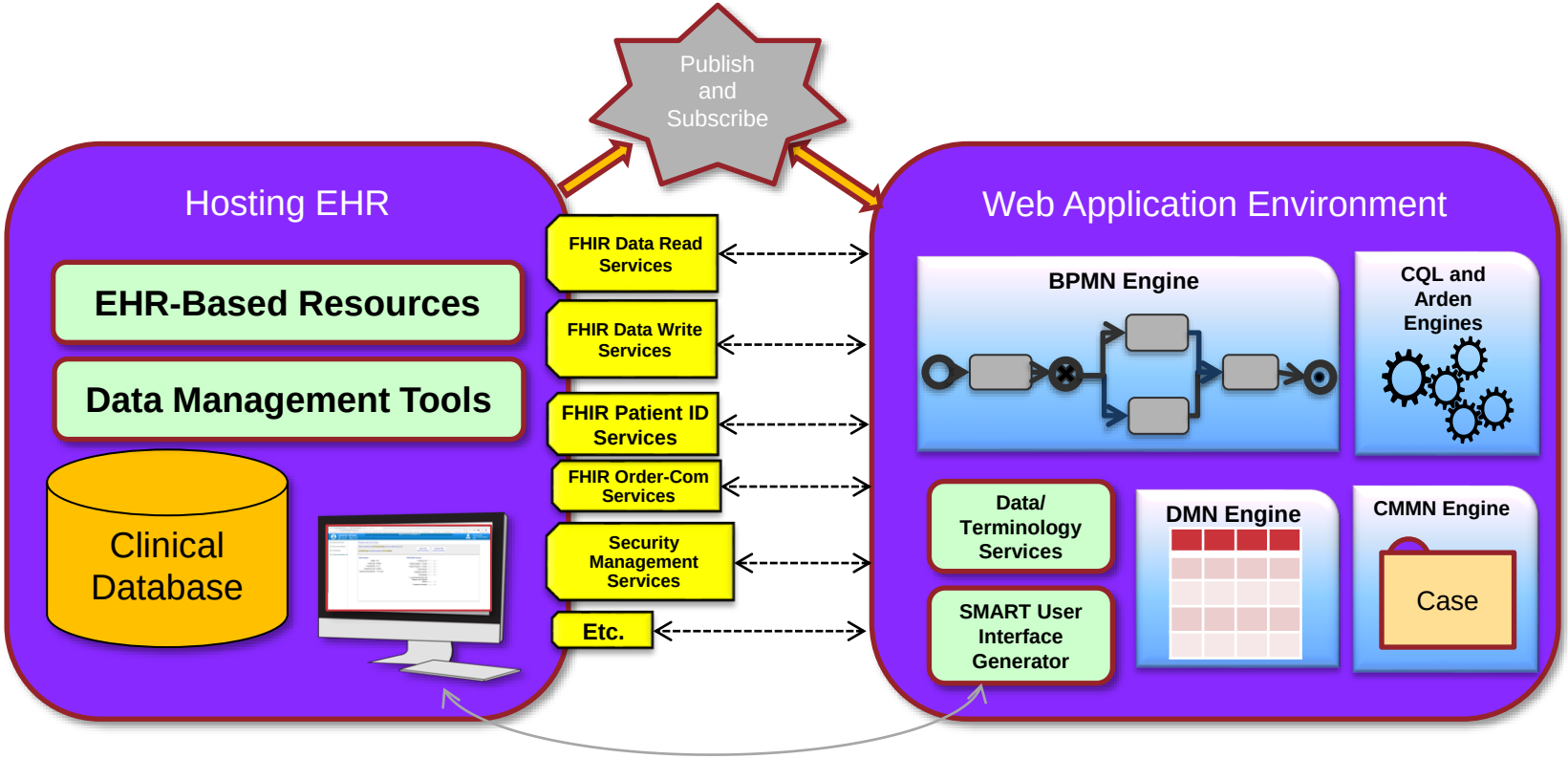


Pulmonary embolism workflow designed in a BPMN authoring tool.

Building BPMN: From the General to the Specific



An Environment for Deploying Interoperable Applications



Thank you!

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