

FHIR as a Potential Common Logical Model for Clinical Quality Measures and Decision Support

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On the Suitability of FHIR in the Clinical Quality Measure and Decision Support Domains

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# Table of Contents

[Important Notes 3](#_Toc382574591)

[Table of Contents 4](#_Toc382574592)

[1 Introduction 5](#_Toc382574593)

[1.1 Background 5](#_Toc382574594)

[1.2 Assumptions 6](#_Toc382574595)

[1.3 Method of Analysis 6](#_Toc382574596)

[1.4 Terminology and Notational Conventions 7](#_Toc382574597)

[2 Mapping QIDAM to FHIR 7](#_Toc382574598)

[2.1 Comparison of Modeling Approaches 7](#_Toc382574599)

[2.2 Class-Level Mapping 9](#_Toc382574600)

[2.2.1 QIDAM to FHIR 9](#_Toc382574601)

[2.2.2 QDM and vMR Residuals to FHIR 11](#_Toc382574602)

[2.3 Representation of Negation 11](#_Toc382574603)

[2.4 Representation of Moods 12](#_Toc382574604)

[2.5 Representation of “Unknown” 13](#_Toc382574605)

[2.6 Attribute-Level Mapping 14](#_Toc382574606)

[2.6.1 Clinical Statement Attributes 14](#_Toc382574607)

[2.6.2 Example 1: Adverse Event 15](#_Toc382574608)

[2.6.3 Example 2: AllergyIntolerance 16](#_Toc382574609)

[2.6.4 Example 3: Communication Order 16](#_Toc382574610)

[3 Applying FHIR to CDS and CQM 18](#_Toc382574611)

[3.1 FHIR in the Execution Engine 18](#_Toc382574612)

[3.2 FHIR in Shareable Artifacts 19](#_Toc382574613)

[3.3 FHIR Throughout 19](#_Toc382574614)

[4 Data References using the FHIR Logical Model 20](#_Toc382574615)

[5 Conclusions 22](#_Toc382574616)

[6 Recommendations 23](#_Toc382574617)

[7 Glossary (Non-Normative) 24](#_Toc382574618)

[8 Bibliography 25](#_Toc382574619)

[Appendix A: Detailed Class-Level Mapping from QIDAM to FHIR 27](#_Toc382574620)

# Introduction

Separate communities have been involved with developing standards for clinical information exchange, quality measurement, and decision support. Despite the need to represent similar underlying concepts, different data models have evolved:

* The Clinical Document Architecture (CDA) and Fast Healthcare Interoperability Resources (FHIR) for clinical information exchange (CIE),
* The Virtual Medical Record (vMR) for Clinical Decision Support (CDS), and
* The Quality Data Model (QDM) for Clinical Quality Measures (CQM).

Recently, the Quality Information Domain Analysis Model (QIDAM) [1] was developed to combine the vMR and QDM. Because QIDAM is defined at the conceptual level, the Clinical Quality Information Working Group at the 2014 January HL7 meeting raised the question of whether FHIR could be used as the logical model for CDS and CQM, implementing requirements implied by QIDAM. The result could be a single logical data model for CIE, CDS, and CQM, which could reduce cost and complexity for product developers and vendors, reduce the learning curve for users, and consolidate efforts to maintain multiple standards.

In this paper, we explore whether FHIR can fulfill the data modeling requirements of CDS and CQM. To determine if FHIR can express the clinical concepts contained in QIDAM, we create a mapping between QIDAM and FHIR (Section 2). Next, we explore architectures that might leverage the FHIR standards (Section 3), and how data references might be expressed using FHIR (Section 4). We conclude with conclusions and recommendations related to data model convergence and enhancements to the FHIR model (Sections 5 and 6).

## Background

This project is part of a broader effort to align the HL7 Product Family in the area of Health Quality.

(Present origin and history of this project

A related activity, the Expression Logic Harmonization project, explores how the logical data model interoperates with the expression language.

The Health eDecisions (HeD) Knowledge Artifact (HeD-KA) is based on the Virtual Medical Record (vMR).

HQMF is based on the Quality Data Model (QDM).

The QIDAM [1] harmonizes the existing eCQM and CDS data models and combines them into a single conceptual model. The QIDAM represents the data used in CQMs and CDS, but omits elements that might be present in many EHR systems not pertinent to those domains.

FHIR (Fast Healthcare Interoperability Resources) [2] is a new HL7 standard for representing healthcare data typically found in an electronic medical records. FHIR captures the most frequently-used information items involved in clinical data exchanges. FHIR includes features drawn from HL7 Version 2 and Version 3 and CDA product lines, but does so in a simpler, cleaner way that is focused on implementation, building on common web tools and techniques such as XML, JSON, REST-style interfaces, Atom, and OAuth. FHIR provides a set of entities or “resources” that describe basic healthcare information in a form suitable for information exchange.

## Assumptions

The analysis is based on the January 2014 DSTU version of FHIR. Statements like “FHIR has X” or “FHIR does not have Y” or “FHIR cannot express Z” refer specifically to the base DSTU version of FHIR [2], **without extensions or profiling**. It is understood that FHIR is an extensible framework that permits users to add to the FHIR model and constrain the FHIR model through profiles. References to QIDAM refer to the May 2014 Release 2 version [3], unless otherwise noted.

For the purposes of this paper, we assume the current HQMF and current HeD specifications are not constraining, and if the convergence path proves attractive, that future versions of those specifications could be modified to use a common logical model.

This paper assumes the reader has a basic knowledge of moods, negation, and null flavors from HL7 v3 Reference Information Model (RIM) [4].

## Method of Analysis

QIDAM and FHIR provide different levels of modeling detail. QIDAM defines classes, attributes, and relationships, but lacks detailed definitions of data types, value sets, and does not delve into computational representations. FHIR not only has detailed definitions of classes (resources), attributes (data elements), and relationships, but also data types and specific computational representations (including XML and JSON), and definitions of RESTful web services [5] for data access.

In terms of the traditional levels of data modeling[[1]](#footnote-2), QIDAM provides a complete conceptual model and partly-defined logical model. FHIR provides a conceptual, logical, and a partial physical model[[2]](#footnote-3). As shown conceptually in Figure 1, comparison is fundamentally limited to things defined in both models. We can compare classes and attributes, but we cannot compare physical models. This is sufficient to assess FHIR’s semantic completeness (expressivity) with respect to QIDAM requirements. We will therefore focus on *what* can be modeled in FHIR, and less about *how* it is modeled.

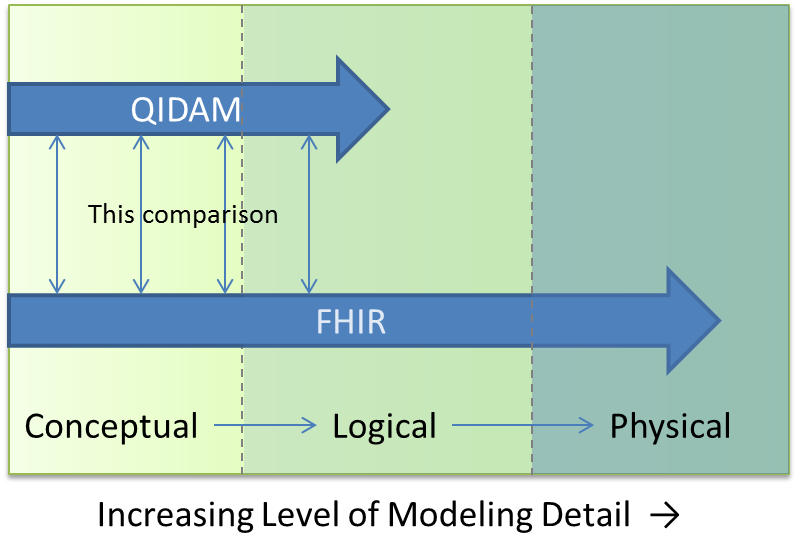


Figure 1. Relative completeness of QIDAM and FHIR models

## Terminology and Notational Conventions

For the purposes of this paper, we use the terms “classes” and “resources” interchangeably. We also use the terms “data element,” “field,” “attribute,” and “property” interchangeably.

Paths from class to property to subproperty are indicated in dot notation. For example, X.Y refers to property Y of class X, and X.Y.Z refers to subproperty Z of property Y of class X, etc.

Cardinality is indicated as 0..1 (optional element), 1..1 (required element), 1..\* (one or more), or 0..\* (zero or more).

# Mapping QIDAM to FHIR

In this section, we examine the ability of FHIR to represent the concepts in QIDAM. This is a one-directional analysis, meaning that we are not concerned with concepts in FHIR that fall outside of QIDAM.

## Comparison of Modeling Approaches

QIDAM is built around the notion of “clinical statements” derived from the HL7 Version 3 Clinical Statements model. Clinical Statements are divided into statements about inferences, observations, and actions (including proposals for actions). The types of clinical statements are further divided into positive and negative statements (for example, ActionNonPerformance and ActionPerformance). Clinical Statements involve fundamental entities such as BodySite, Device, Location, Medication, Organization, Person, Substance, and Schedule.

FHIR defines a set of “resources” meant to represent healthcare information in a form suitable for information exchange. FHIR makes no explicit distinction between clinical statements and fundamental entities, and does not provide separate resources for positive and negative statements.

QIDAM is structured as a class hierarchy. Since multiple classes share subsets of properties but not strictly along hierarchical lines, QIDAM uses Java-like “interfaces” to assign properties to classes[[3]](#footnote-4). For example, the Performance interface, implemented by every class that represents the actual performance of a healthcare-related action, gives each implementing class the attributes performedAtTime, task, and status.

The FHIR model has no class hierarchy, and defines each resource separately in terms of its data elements. Because resources are defined independently there is no guarantee of consistent naming of similar data elements across resources. Unlike the simple attribute structure of QIDAM, FHIR data elements can be nested, as in AdverseReaction.symptom.severity (where severity is a subelement of symptom) or CarePlan.Activity.Simple.performer.

Value types are not completely specified in QIDAM, but include Code, IntervalOfQuantity, Quantity, Text, TimePoint, TimePeriod, and Value (any of the value types). Data types in FHIR are more varied and sophisticated than in QIDAM, reflecting the fact that FHIR is a more complete model. Without going into detail, FHIR has all the basic data types (Boolean, integer, string, etc.), quantities with units, types related to time (instant, dateTime, time period, etc.), as well as more complex types (address, sampled data, money, etc.).

Both models use relationships to create associations between entities and actions, for example, to relate participants to an encounter. Relationships are also used in both models to express causal, logical, and sequentially-related activities. In QIDAM, the mechanism is general: any clinical statement can be related to predecessor clinical statements and successor clinical statements. In FHIR, these relationships are defined on a class-by-class basis, as shown in Table 1. FHIR defines the semantics of relationships using an auxiliary data element that indicates how the relationship is to be interpreted, and also specifically defines the allowable types for the related items.

Table 1. Examples of relationships defined in FHIR

|  |  |  |  |
| --- | --- | --- | --- |
| FHIR Resource | Element Name | Relationship types | Related Resource Type |
| Condition | relatedItem | due-to, following | Condition, Procedure, MedicationAdministration, Immunization, MedicationStatement |
| Observation | related | has-component, has-member, derived-from, sequel-to, replaces, qualified-by, interfered-by | Observation |
| Procedure | relatedItem | caused-by, because-of | AdverseReaction, AllergyIntolerance, CarePlan, Condition, DeviceObservationReport, DiagnosticReport, FamilyHistory, ImagingStudy, Immunization, ImmunizationRecommendation, MedicationAdministration, MedicationDispense, MedicationPrescription, MedicationStatement, Observation, Procedure |

## Class-Level Mapping

### QIDAM to FHIR

In mapping classes from QIDAM to FHIR, the most obvious problem is that there are far more QIDAM classes (~70) than FHIR resources (~30). This means there are going to be either unmapped classes or many-to-one mappings, or both. As we considered the closest FHIR resource for each QIDAM class, the following mapping types were identified:

1. **One-to-one mapping**. The QIDAM class maps directly to a FHIR class, value set, or complex data type.
2. **Many-to-one mapping**. More than one QIDAM class maps to the same FHIR class. In this case, filtering on an attribute value is required to produce the QIDAM concept.
3. **One-to-zero mapping.** A QIDAM concept is represented by the absence of a FHIR resource, i.e., the absence of indication is taken as an indication of absence.
4. **One-to-many mapping**. A single QIDAM concept that can be represented in more than one way in FHIR.
5. **No mapping.** The concept represented in QIDAM has no corresponding resource in FHIR.

Table 2 summarizes each of the non-abstract (instantiable) classes in QIDAM in terms of these categories. In addition to the mapping type, we also make note of any significant semantic differences between the QIDAM class and the closest concept in FHIR, adding a minus (-) to indicate semantic mismatches[[4]](#footnote-5). Details are given in Appendix A. It is important to emphasize that

**Table** 2 **does not account for the quality of the mapping at the level of attributes.** Even classes with one-to-one correspondence have significantly different attributes (see Section 2.6).

Table 2. Summary of class-level mapping from QIDAM to FHIR.

|  |  |
| --- | --- |
| Type | QIDAM Classes |
| A | BodySite, Cycle, Device, EncounterEvent, FamilyHistoryConditionPresent, ImmunizationDoseAdministration, Location, Medication, MedicationDispense, MedicationDoseAdministration, MedicationPrescription, MedicationStatement, ObservationResult, Organization, Patient, Practitioner, ProcedureEvent, RelatedPerson, Schedule, Specimen |
| A- | AdverseEvent, AllergyIntolerance, ImmunizationProposal |
| B | CommunicationEvent, CommunicationOrder, DeviceApplicationOrder, EncounterRequest, GoalPerformance, GoalProposal, ImmunizationOrder, ParticipationInProgram, ProcedureOrder, ProgramParticipationOrder, ScheduledEncounter |
| B- | ConditionAbsent, ConditionPresent, DeviceApplicationNotPerformed, DeviceApplicationPerformed, EncounterCondition, NoAdverseEvent, NoAllergyIntolerance, Vaccine |
| C | AllergyIntoleranceUnknown, ConditionPresenceUnknown, FamilyHistoryConditionUnknown, NoKnownAllergy |
| D | Participant |
| E | CareExperience, CommunicationProposal, ContraindicationToMedication, ContraindicationToProcedure, DeviceApplicationProposal, DietAdministration, DietOrder, DietProposal, EncounterProposal, FamilyHistoryConditionAbsent, MedicationAdministrationProposal, NutritionProduct, PhenomenonPresenceUnknown, ProcedureNotPerformed, ProcedureProposal, Prognosis, ProgramParticipationProposal, ProposalToNotPerformProcedure, ScheduledProcedure |

### QDM and vMR Residuals to FHIR

There are several QDM concepts missing from the current version of QIDAM. For FHIR to represent the complete semantics of QDM and vMR, the following additional concepts are needed:

* QDM includes Device Recommendation and Substance Recommendation, but QIDAM does not include recommendations for devices and substances. QIDAM includes the semantically similar DeviceApplicationProposal and MedicationAdministrationProposal classes. FHIR can represent a Device Order or a Substance Order, but not a device or substance recommendation or proposal.
* QDM represents the patient characteristics of Race, Ethnicity, Payer, and Clinical Trial Participation, but these are not directly represented in QIDAM. FHIR also does not have built-in support for these patient characteristics, although they can be expressed using extensions.
* QDM represents Transfer To and Transfer From as classes, but these are not represented in QIDAM. FHIR can represent a transfer using the ????????
* The vMR concept of a facility is not represented in QIDAM, although both QIDAM and FHIR can represent organizations and locations.

## Representation of Negation

QIDAM models some negated concepts as distinct classes, for example, ConditionPresent and ConditionAbsent, an approach shared with vMR. vMR explains its use of explicit negation classes in terms of safety and clarity [6]:

“If the vMR were to include a negation indicator, and a CDS knowledge engineer was not familiar with the term, he or she may write the rule “Give Medication X if Problem Y exists,” which may result in medication X being recommended when Problem Y does not exist, because Problem Y has a negation indicator of true, and the CDS knowledge engineer did not know to write the rule as “Give Medication X if Problem Y exists and Problem Y has a negation indicator of false.”

In Release 2, QIDAM includes certain attributes that imply negation. For example, the ActionStatus interface, implemented by many classes, includes a statusCode with values “like Complete, Rejected, or Pending,” accompanied by a reason code that is “used typically when the status indicates the action was canceled, rejected, or not performed. E.g., patient declined” [3]. Consequently, certain classes in QIDAM, such as MedicationDispense, must be checked for negation[[5]](#footnote-6). Likewise, StatementAboutAction (a high-level class inherited by many subclasses) includes a reason field explained as follows: “The thought process or justification for proposing performance of an action or for not proposing the performance of an action... Reasons may also be specified for not performing an action.”

FHIR does not have explicit negation classes, and addresses negation on a class-by-class basis. For example, there is no explicit class for absent conditions, but Condition.status can be “refuted,” meaning the condition has been ruled out. Other FHIR classes express negation differently, for example, in AdverseReaction, the negation element is named “didNotOccurFlag,” and in Immunization it is called the “refusedIndicator.” Other FHIR resources, such as Procedure, do not include negation indicators, meaning FHIR cannot[[6]](#footnote-7) express the concept of a procedure that did not (or maybe should not) occur.

## Representation of Moods

In QIDAM, moods are explicitly represented by classes. For example, QIDAM has classes named EncounterEvent, EncounterProposal, and EncounterRequest. Similarly, FHIR developers have communicated their intention to “use distinct resources for distinct moods” [7]. However, FHIR’s support is limited to event and order moods, with the exception of ImmunizationRecommendation. There is no support for the proposal mood.

QIDAM also has gaps with respect to mood. It does not provide the recommendation mood, and does not have an order mood for MedicationDoseAdministration. Table 3 summarizes the available actions and moods available in QIDAM and FHIR. Excluded from this table are medication-related actions (Medication Prescription, Medication Statement, and Medication Dispense) that typically exist as events only.

Table 3. Classes/Resources Implementing Actions and Moods in QIDAM and FHIR

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Action | Model | Event Mood | Request/ Order Mood | Proposal Mood | Recommendation Mood |
| Have an Encounter | **QIDAM** | EncounterEvent | EncounterRequest | EncounterProposal | none |
| **FHIR** | Encounter | Order+Encounter | none | none |
| Have or do a Procedure | **QIDAM** | ProcedureEvent | ProcedureOrder | ProcedureProposal | none |
| **FHIR** | Procedure | Order+Procedure | none | none |
| Administer Medication | **QIDAM** | MedicationDose Administration | none | Medication Administration Proposal | none |
| **FHIR** | Medication Administration | Order+Medication Administration | none | none |
| Have or do an Immunization | **QIDAM** | ImmunizationDose Administration | ImmunizationOrder | Immunization Proposal | none |
| **FHIR** | Immunization | Order+Immunization | none | Immunization Recommendation |
| Follow a Diet | **QIDAM** | DietAdministration | DietOrder | DietProposal | none |
| **FHIR** | none | none | none | none |
| Pursue a Goal[[7]](#footnote-8) | **QIDAM** | GoalPerformance | none | GoalProposal | none |
| **FHIR** | CarePlan.Goal | Order+CarePlan | none | none |
| Participate in a Care Plan | **QIDAM** | ParticipationInProgram | ProgramParticipationOrder | ProgramParticipation Proposal | none |
| **FHIR** | CarePlan.Activity | Order+CarePlan | none | none |
| Use a Device | **QIDAM** | DeviceApplication Performed | DeviceApplicationOrder | DeviceApplication Proposal | none |
| **FHIR** | OrderReponse[[8]](#footnote-9) | Order+Device | none | none |

## Representation of “Unknown”

QIDAM includes several classes modeling unknowns: ConditionPresenceUnknown, AllergyToleranceUnknown, and FamilyHistoryConditionUnknown. The definition of these classes simply states “the presence or absence of phenomenon is unknown” [3].

“Unknown” has two interpretations: uncertain or absent. The first implies that there is not enough knowledge to establish something as true or present (“The number of insect species on Earth is unknown”). This aligns with the HL7 definition of uncertainty, which “specifies that the originator of the Act statement does not have full confidence in the applicability (i.e., in event mood: factual truth) of the statement” [8]. The second interpretation implies information is missing or undisclosed (“patient’s current address: unknown”). From published documentation, it is not clear which of these two meanings is intended by QIDAM (and therefore which meaning is omitted), or if QIDAM has conflated these meanings.

If unknown means uncertain, then the classes ConditionPresent, ConditionUnknown, and ConditionAbsent represent different degrees of certainty about a condition. The difficulty here is mapping degrees of certainty into three discrete classes. On the other hand, if the intended meaning is to represent the absence of information, then QIDAM has no way to express uncertainty: a condition is simply present or absent, with no shades of gray.

The other frequently discussed aspect of “missing information” deals with null flavors. Null flavors express the reasons for missing information, for example, the patient was not asked, the patient was asked but refused to answer, or the information is known but cannot be released. vMR explicitly rejects the use of null flavors on the basis they are hard to understand and unnecessary in CDS [6], and indeed, the “unknown” classes in QIDAM do not have null flavor indicators.

To some extent, FHIR supports both meanings of unknown. FHIR typically indicates the lack of information by the absence of a resource [9]. For example, a query for a patient’s allergy intolerances could return an empty list, indicating the patient has no known allergies or intolerances. This list can specify an “emptyReason” code, essentially a null flavor. In addition, some FHIR resources have data elements representing degree of confidence, including:

* Condition.certainty to indicate degree of confidence that the condition exists, with values known present, probably present, probably not present, etc.
* AdverseReaction.exposure.causalityExpection to indicate the degree of confidence that an exposure caused the reaction, with values likely, unlikely, confirmed, unknown
* AllergyIntolerance.status to indicate the status of sensitivity, with values suspected, confirmed, refuted, or resolved

Overall, it is difficult to align the two models in terms of their treatment of “unknown” in either sense discussed here, because neither model is particularly systematic.

## Attribute-Level Mapping

In this section, we use examples of QIDAM classes and FHIR resources to explore attribute-level mapping.

### Clinical Statement Attributes

Certain attributes are common to all clinical statements in QIDAM. The mapping of these shared clinical statement attributes to FHIR is given in Table 4.

Table 4. Attribute-Level Mapping of QIDAM ClinicalStatement to FHIR

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| QIDAM Attribute (type) | QIDAM Definition | FHIR Data Element | FHIR Definition | Comment |
| additionalText (text) | Details not captured by other attributes | text (in resource metadata) | Human-readable narrative that contains a summary of the resource |  |
| predecessorStatement (ClinicalStatement) | The statements about the clinical actions that caused this action or observation. | no mapping |  |  |
| semanticType (code) | Maps this clinical statement type to a type specified in an external ontology or taxonomy of clinical concept types | no mapping |  |  |
| statementDateTime (TimePoint) | The time at which the statement was made/recorded | Last modified date (in resource metadata) or recordedDate (in some resources) | Changes each time the content; a version history is maintained | The first version of the resource indicates the statement dateTime |
| statementSource (Entity) | The person, device, or other system that was the source of this statement |  |  | Treated in FHIR on a resource-by-resource basis |
| subject (Patient) | The subject of the clinical statement | patient or subject | The subject or patient for the clinical resource | All clinical resources in FHIR contain a reference to the patient or subject |
| successorStatement (ClinicalStatement) | The actions or observations that were caused by this clinical statement. | no mapping |  |  |

### Example 1: Adverse Event

The FDA defines an adverse event as “any untoward medical occurrence associated with the use of a drug in humans, *whether or not considered drug related*” whereas a suspected adverse reaction is “any adverse event for which there is a reasonable possibility that the drug caused the adverse event.” [10]. By FDA’s definition, all adverse reactions are adverse events, but not all adverse events are adverse reactions. Nonetheless, the closest mapping to QIDAM’s AdverseEvent class is FHIR’s AdverseReaction.

Table 5 shows an alignment of QIDAM and FHIR attributes for these classes. Cardinality is 1..1 unless otherwise noted. Data types are given in parentheses after the attribute name. Many of the attributes of QIDAM have no mapping in FHIR, including bodySite, effectiveTime (the time period from onset to abatement), and observedTime.

FHIR data elements with no corresponding QIDAM attribute include exposure.causalityExpectation (how confident the recorder was that this exposure caused the reaction), symptom.severity (the severity of the reaction), didNotOccurFlag (indicates no reaction occurred if true).

Table 5. Mapping from QIDAM AdverseEvent to FHIR AdverseReaction

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| QIDAM Attribute | QIDAM Definition | FHIR Data Element | FHIR Definition | Comment |
| agent (code) | Suspected causative agent | exposure.substance (Substance, 0..\*) | Substance that is presumed to have caused the adverse reaction | Cardinality difference; FHIR supports a richer description of the substance(s) involved |
| bodySite (BodySite) | Location of the symptom on the subject's body | no mapping |  | FHIR lacks a full description of the symptom |
| category (code) | A category assigned to the condition. E.g. finding | diagnosis | concern | symptom | no mapping |  | In QIDAM, this should always be ‘symptom’ so no FHIR mapping should be required |
| effectiveTime (TimePeriod) | The time period during which the allergy or intolerance is effective | date (0..1) | Date when the reaction began | FHIR omits the time when symptoms abate |
| name (code) | Identification of the condition | symptom.code | The specific sign or symptom that was observed | In FHIR, 0..\* symptoms can be recorded |
| observedAtTime (TimePoint) | The time at which the observation was made | no mapping |  |  |
| precedingExposure (ActionPerformance[[9]](#footnote-10)) | Action that led to the adverse event | exposure.type (code, 0..\*) | The type of exposure, e.g., immunization, drug administration coincidental | Cardinality difference; QIDAM supports a richer description of the action associated with the adverse event |
| statementSource (Entity) | The person, device, or other system that was the source of this statement | recorder(0..1) | The individual (Patient, Practitioner) responsible for the information in the reaction record | FHIR ‘recorder’ cannot be another system or a device |
| status (code) | The state of the condition at the time of the observation | no mapping |  |  |

### Example 2: AllergyIntolerance

QIDAM and FHIR share similar but not identical concepts of AllergyIntolerance. In QIDAM, a patient can have an intolerance to a device, procedure, or substance, whereas an intolerance in FHIR only applies to substance. The detailed attribute-level mapping is given in Table 6.

Not shown in the table are FHIR attributes that have no QIDAM equivalent: status (suspected, confirmed, refuted, or resolved), reaction (indicating the reaction(s) associated with the sensitivity), and sensitivityTest (observation(s) that confirm or refute the allergy or intolerance).

Table 6. Attribute-level mapping of QIDAM AllergyIntolerance to FHIR

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| QIDAM Attribute | QIDAM Definition | FHIR Data Element | FHIR Definition | Comment |
| criticality (code) | The potential seriousness of a future reaction. | criticality | Criticality of the sensitivity |  |
| effectiveTime (TimePeriod) | The time period during which the condition is effective. | no mapping |  | FHIR status=’resolved’ and the upper limit of the effectiveTime are related |
| observedAtTime (TimePoint) | The time at which the observation was made. | recordedDate | Date when the sensitivity was recorded. | A poor match, since the time of recording and observation may differ. |
| reaction (code) | The possible reactions to the stimulus, e.g., respiratory distress. | reaction (0..\*) | Reactions associated with the sensitivity | Cardinality mismatch |
| sensitivityType (code) | A code that indicates whether this sensitivity is of an allergic nature or an intolerance to a substance | sensitivityType | Type of the sensitivity (allergy, intolerance, unknown) |  |
| statementSource (Entity) | The person, device, or other system that was the source of this statement. | recorder(0..1) | The individual (Patient, Practitioner) responsible for the information in the reaction record | FHIR ‘recorder’ cannot be another system or a device |
| substance (code) | A substance is a physical entity and for purposes of this aspect of the model can mean a drug or biologic, food, chemical agent, plants, animals, plastics etc. | substance | The substance that causes the sensitivity. |  |

### 

### Example 3: Communication Order

QIDAM’s CommunicationOrder maps to FHIR as an Order resource whose detail is an Encounter whose type element corresponds to a type of communication (e.g. email). Despite the structural difference, the semantics of QIDAM and FHIR are quite close. One semantic difference is that QIDAM CommunicationOrder can be negated by specifying a negative reason code (meaning that the communication should not take place), but FHIR does not support negation. Table 7 gives a mapping from QIDAM to FHIR for CommunicationOrder.

Table 7. Attribute-Level Mapping of QIDAM CommunicationOrder to FHIR

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| QIDAM Attribute | QIDAM Definition | FHIR Data Element | FHIR Definition | Comment |
| actionParticipant (Participant) | A participant in the action, e.g., the attending physician, the performer of a procedure, etc. | Order.source (Practitioner),  Order.target (Organization|Device| Practitioner), Encounter.participant | Source:Who initiated the order  Target: Who is intended to fulfill the order. | FHIR is less general about the role of the participant |
| occurredDuring (EncounterEvent) | The encounter within which the (ordering) action occurs. | no mapping |  |  |
| reason (Code) | Justification for proposing or for not proposing the performance of an action. | Order.reason (code|Resource), Encounter.reason | Why the order was made. | FHIR does not use the reason for a negation code, and has two places where the reason might be expressed |
| expectedPerformanceTime (TimePeriod) | The time when the action is expected to be performed. | Order.when.schedule | When order should be fulfilled |  |
| status (ActionStatus) | The status of an action. | Encounter.status | planned | in progress | onleave | finished | cancelled |  |
| medium (Code) | The communication medium, e.g., email, fax | Encounter.type | Specific type of encounter (e.g. e-mail consultation, surgical day-care, skilled nursing, rehabilitation). |  |
| message (Text) | Text and other information to be communicated to the recipient | Encounter.text | Narrative of the Encounter resource |  |
| recipient (Entity) | The entity (e.g., person, organization, clinical information system, or device) which is the intended target of the communication | Encounter.serviceProvider (Organization), Encounter.participant, or Order.target |  | Not clear what is the best mapping |
| sender (Entity) | The entity (e.g., person, organization, clinical information system, or device) which is the source of the communication | Order.source or Encounter.participant |  |  |
| topic (ClinicalStatement) | Any statement that is pertinent to the message | no mapping |  |  |
| orderedAtTime (TimePoint) | The time at which the order was created. | Order.date (dateTime) | When the order was made |  |
| originationMode (Code) | The mode the order was received (such as by telephone, electronic, verbal, written). | no mapping |  |  |
| urgency (Code) | Characterizes how quickly the action must be initiated. Includes concepts such as stat, urgent, routine | Order.when (code) | Priority code, e.g. STAT, daily, evenings |  |

# Applying FHIR to CDS and CQM

The processes for authoring, sharing, and evaluating CQM and CDS artifacts are shown in Figure 2. Both processes begin with the measure or rule creator using an authoring tool to produce an exchangeable representation of the artifact. The artifact is subsequently executed by an evaluation engine that uses data either extracted from an EHR system in advance, or interacting with an EHR in real time, to produce a result. In CQM, the result is a quality measurement, while in CDS the result is usually information provided in real time to the clinician.

In this framework, there are three places that FHIR could be used: in the authoring tool, the shareable artifact, or the execution engine (including input and output data formats). We will reduce the space of possibilities by assuming that once information is in the FHIR format, it will stay in FHIR format. That is, if FHIR is used in the authoring tool we assume it will also be used in the shareable artifact and the execution engine. This gives us three scenarios for using FHIR.

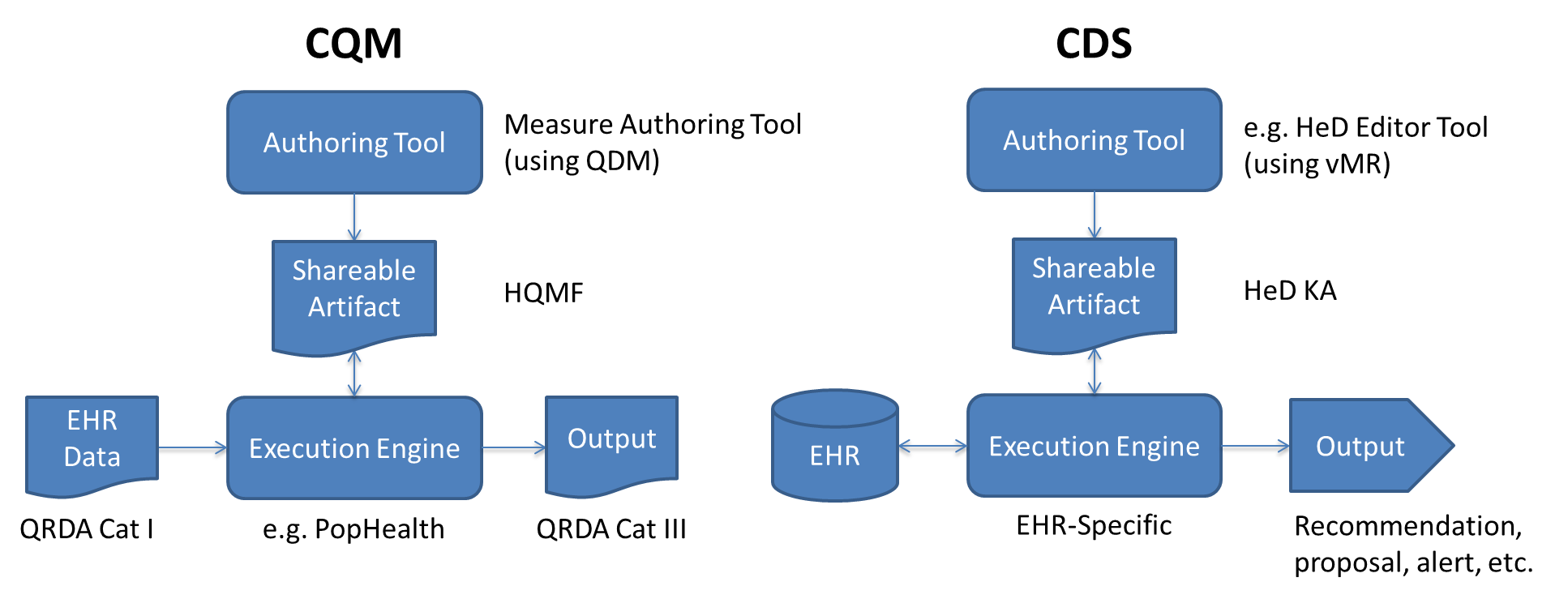


Figure 2. High-Level Information Flows for CQM and CDS

## FHIR in the Execution Engine

This represents the most limited scenario, where FHIR is used only at the bottom of the stacks shown in Figure 2. This scenario assumes the authoring tool and the shareable artifacts will be expressed in terms of a logical model other than FHIR, either as they are currently with QDM and VMR, or using QIDAM.

In the CDS (real-time) use case, the execution engine will read and interpret the artifact, determine the data needed to evaluate the artifact, and translate the data requirements into standard FHIR data requests (read and search). To fulfill data requests originating from the execution engine, the EHR can expose a standard FHIR server interface, allowing the execution engine to use RESTful read and search operations to obtain the necessary data from the EHR. Note that if the EHR does not provide a FHIR interface, there is little or no reason for the engine to use FHIR.

In the CQM (off-line) use case, the artifact’s data requirements would be surfaced in the form of a FHIR document, instead of the current QRDA Cat 1 document. The execution engine, after translating the data requirements into FHIR terms, would ingest the FHIR documents and extract from them the necessary information to evaluate the artifact.

The benefit of this scenario, especially in the CQM use case, is that the core execution engine could be standardized, because differences between EHR systems would be hidden behind a standards-based interface. Thus, any EHR system with a FHIR interface could be used as a “plug-and-play” data source. The drawback of this approach is that it requires mapping from the logical model using in the artifact to FHIR, potentially introducing errors.

## FHIR in Shareable Artifacts

This scenario involves expressing the shareable artifacts using FHIR terminology. There are two closely-related variations for how these artifacts would be created: (i) by converting existing types of artifacts into FHIR by a process of translation, and (ii) enabling authoring tools to directly produce artifacts using FHIR terminology. The first variation would require a translation/mapping tool that would consume artifacts based on QDM or VMR (or QIDAM), and produce equivalent FHIR-based artifacts. The second variation would embed the mapping functionality in the authoring tool itself, and eliminate the intermediate step of producing artifact in the traditional formats (an authoring tool could do both, of course). Once an artifact is in a FHIR format, the execution engine would read and interpret the artifact, and execute the data requirements against FHIR-enabled data sources, as discussed in Section 3.1.

The benefit of this approach, compared to the one described in Section 3.1, is that the mapping step is separate from artifact execution, making the translation easier to verify. The drawback is that the user creates the artifacts using one logical model, which is then converted to another, potentially introducing semantic mismatches. Another potential drawback (or potential opportunity, depending on your perspective) is the need to change the artifact standards, so FHIR-based artifacts can be standardized and exchanged.

## FHIR Throughout

This is the most comprehensive FHIR-based scenario, involving integration of FHIR into the authoring process, the produced artifacts, and the execution engine. In this case, the user would create artifacts directly using FHIR resources, data elements, and logical structure. As in Section 3.2, the resulting artifacts would incorporate FHIR, and the execution engine would process the artifact by interacting with FHIR-enabled data sources, as in Section 3.1.

The benefit of this approach is that it eliminates the need to translate or map from one logical model to another. The drawback is that the FHIR model may not meet the requirements of CQM or CDS as expressed in QIDAM, and may not be as simple or user-friendly as vMR or QDM. Furthermore, this scenario requires essentially a complete overhaul of the existing standards for CQM and CDS.

# Data References using the FHIR Logical Model

In the scenarios of Sections 3.2 and 3.3, the FHIR logical model becomes visible in artifacts or authoring tools, or both. This section looks at how FHIR may be used in these contexts.

CDS and CQM need a logical model to provide the terminology to specify what data should be collected from data sources to enable evaluation of the artifact. These structured references to clinical data (“data references” for short) are designed to convert into actionable code such as SQL statements or xPaths into XML documents. In the case of FHIR, the actionable code will be in the form of read and search actions carried out through FHIR’s RESTful interface using URLs and the HTTP GET operation. The result of evaluating a data reference is a set or list of items meeting the specified criteria (borrowing from SQL, a “result set”). The result set might be empty (interpreted as “false” in some contexts) or may contain one or more items satisfying the data criteria. Once a result set has been obtained, an expression language can further manipulate the result set, e.g., by filtering through additional criteria such as relative timing of events, applying numerical operations, or joining multiple result sets.

In current CQMs, QDM provides the basis for data references. A QDM element consists of a “category” (similar to a class name), a so-called “dataype” (often specifying a subclass, mood, or status), a named value set (e.g. NSAIDs), and optionally, an expression involving attributes. Here are some typical examples:

* Diagnosis, Active: Pregnancy
* Medication, Administered: NSAIDs
* Diagnosis, Active: hypertension (time: *start date/time*)
* Physical Exam, Documented: diastolic blood pressure (result>= 90 mmHg)
* Physical Exam, Documented: diastolic blood pressure (result >= 90 mmHg; data flow source: blood pressure monitor, recorder: blood pressure monitor, subject: patient; environment: ambulatory office)

This is an example of a computable domain-specific language (DSL), tuned for human readability and compactness.

In vMR, clinical statements involve a class and attribute-based filtering criteria. For example, the statement that a patient has had asthma since before 14 August 2013 could be represented as [6]:

clinicalstatement[xsi:type=“vmr:Problem” and

/templateId[root=“2.16.840.1.113883.3.1829.11.7.2.5”] and

/problemCode[codeSystem=“2.16.840.1.113883.6.96” and code=“195967001”] and

/problemEffectiveTime[/low[value<=“20130814”]] and

/problemStatus[codeSystem=“2.16.840.1.113883.6.96” and code=“55561003”]

]

The same statement can be rendered in XML:

<clinicalStatement xsi:type="vmr:Problem">

<templateId root="2.16.840.1.113883.3.1829.11.7.2.5"/>

<problemCode codeSystem="2.16.840.1.113883.6.96" code="195967001"><displayName

value="Asthma"/></problemCode>

<problemEffectiveTime><low value<=“20130814”/><problemEffectiveTime>

<problemStatus codeSystem="2.16.840.1.113883.6.96" code="55561003"><displayName

value="Active"/></problemStatus>

</clinicalStatement>

Data references using FHIR might be rendered in a user-friendly DSL like QDM, or in XML like vMR, or other forms, such as partial URLs. Because there are many conceivable “surface forms,” we will not attempt to specify the grammar of FHIR data references, but simply illustrate their logical structure using pseudo-code. In the examples, data references are expressed as “Get [resourceType] as [local variable binding] where [logical conditions].”

**Example 1: Active asthma started before 14 August 2013**

In this example, we want to find one or more Condition resources represented by the local variable C. The pseudo-code below could be read as “get all conditions C where C has the follow properties… ”. FHIR conditions do not have a simple active/not active flag, but instead, use the “abatement” data element, which can be a boolean, a date, or an age. Thus, to check if the condition has abated prior to the current time, we have to check several different ways, something that requires a representation of “now” and the patient’s current age, which we represent as #NOW and #CURRENT-SUBJECT-AGE, respectively.

Get Condition C where C.code.system="2.16.840.1.113883.6.96" and C.code.code ="195967001" and C.status=confirmed and C.startDate <= 2013-08-14 and not(C.abatement isA Boolean and C.abatement=true) and not (C.abatement isA date and C.abatement<#NOW) and not(C.abatement isA age and C.abatement<#CURRENT-SUBJECT-AGE)

**Example 2: Medication, Administered: NSAIDs**

In this example, we assume NSAIDs is a pre-defined value set. The “memberOf” operation is not currently supported in FHIR search operations. Currently the list of codes would have to be passed explicitly in a search, e.g., MedicationAdministration.medication.code=a,b,c,d,e,f,g,etc. Note that the negation indicator must be checked to make sure this is a record of an actual MedicationAdministration, rather than one refused or otherwise not given. Also note that ‘wasNotGiven’ is an optional element and may not exist in every instance of a MedicationAdministration, and hence an existence check on the element is added prior to referencing its value.

Get MedicationAdministration M where M.medication memberOf NSAIDs and not(M.wasNotGiven exists and M.wasNotGiven=true)

**Example 3: Laboratory Test, Result: “value set A” (result: “value set B”)**

Laboratory tests are represented in FHIR by Observation resources. Again, we assume the value sets A and B are pre-defined. In an Observation, the value can be quantity, CodeableConcept, Attachment, Ratio, Period, SampledData or string, so before checking membership, we check the type using an ‘isA’ function.

Get Observation O where (O.name.code memberOf A and O.value isA codeableConcept and O.value memberOf B)

**Example 4: Conditions resulting from Procedure A:**

Get Condition C where (C.relatedItem.resourceType=Procedure and C.relatedItem.type=due-to and C.relatedItem.target.code memberOf A);

Note that this only retrieves the list of Conditions. To get the corresponding list of Procedures, we could define an iteration operator, that could go through the list of Conditions and retrieve the related Procedure for each Condition:

Procedure P = forEach(C, C.relatedItem.target)

The following might be a more efficient construct accomplishing the same in one statement:

Get Condition C and Procedure P where (C.relatedItem.resourceType=Procedure and C.relatedItem.type=due-to and C.relatedItem.target.code memberOf A);

There is no read or search operation in FHIR to accomplish the simultaneous retrieval of more than one resource type, so the above DSL statement must be translated into multiple FHIR searches by the execution engine.

**Example 5: Conditions B resulting from Procedure A:**

This example assumes A and B are value sets.

Get Condition C and Procedure P where (C.code memberOf B and C.relatedItem.resourceType=Procedure and C.relatedItem.type=due-to and C.relatedItem.target.code memberOf A);

# Conclusions

In this paper, we explored whether FHIR could be used as the logical model in CDS and CQM. To determine this, we created a class-by-class mapping of QIDAM to FHIR.

Of the approximately 70 classes in QIDAM, only 20 have direct mappings to FHIR resources. These include some of the most frequently-used classes, such as EncounterEvent, MedicationAdministration, ObservationResult, and Procedure. Another 11 QIDAM classes have good mappings to FHIR resources, but require attribute-based filtering to identify the correct resources. An additional 11 classes map to FHIR resources only with significant semantic differences. Almost 20 QIDAM classes have no FHIR equivalent.

The unmapped classes from QIDAM fall into three main categories: proposals for various actions (and non-actions), statements related to diet and nutrition, and classes representing negatives and unknowns. Both QIDAM and FHIR have inconsistent treatments of negation, neither of which are wholly consistent with vMR’s use of negation classes. QIDAM sometimes has explicit classes for negations, but also relies on negation flags. FHIR has no explicit negation classes, and only some resources provide negation flags. Inconsistent naming of FHIR’s negation elements could present a challenge for measure and rule authors. Similar problems in modeling uncertainty and missing information affect both QIDAM and FHIR.

Focusing at the attribute level, using a small sample of classes with acceptable class-level FHIR counterparts, we determined that approximately 1/3 of QIDAM attributes do not map to FHIR, another 1/3 number have questionable mappings (significant semantic differences, cardinality differences, or multiple choices), and the remaining 1/3 have satisfactory mappings.

Based on these results, we conclude that mapping QIDAM to FHIR cannot be accomplished with an acceptable level of fidelity, where the semantics of a QIDAM clinical data reference is preserved upon mapping to FHIR.

We identified three ways that FHIR might be employed in CQM and CDS: (i) in the execution engine only, (ii) in the shareable artifact and the execution engine, and (iii) in the authoring tool, shareable artifact, and execution engine. The first two of these appear infeasible at the present time, because they would require mapping from QIDAM to FHIR, which cannot be accomplished with an acceptable level of fidelity. The last scenario, which uses FHIR throughout the process of creating and applying CDS and CQM rules, could be feasible if FHIR is able to express more of the necessary concepts in these domains.

We also explored how references to clinical data might appear, if FHIR were the logical model used in an authoring tool or CQM/CDS artifact. Based on a few examples, creating clinical data references in FHIR seems feasible, but complicated by negations, optional elements, and data elements that can take multiple data types.

# Recommendations

As a result of this study, the authors make the following recommendations relative to FHIR:

1. FHIR would benefit from “proposal”, “goal” and “recommendation” resources to additional action moods, using an approach similar to the current Order resource.
2. FHIR developers should examine the list of missing or poorly mapped QIDAM classes, and consider whether additional FHIR classes are needed.
3. FHIR should introduce a class that represents adverse events.
4. Although we did not analyze every class, it appears that FHIR resources are missing some attributes that are important for CDS and CQM. A class-by-class analysis should be undertaken to identify those missing attributes.
5. FHIR should investigate the feasability of a search operation that would search within a externally-defined value sets, without having to pass all codes individually in a list.

Although the objective of this study was not to critique QIDAM, several issues in QIDAM became apparent:

1. QIDAM should take a consistent approach to negation: either negation classes and no negation attributes, or negation attributes and no negation classes.
2. A class-by-class analysis should be undertaken to identify if QIDAM is missing any important attributes included in FHIR.
3. QIDAM should take a closer look at the cardinality of its attributes. FHIR allows multiple cardinality more often than QIDAM, and in many cases the FHIR design seems to be justified.

In terms of moving towards convergence, if the path forward involves FHIR, a considerable amount of work to harmonize FHIR with QIDAM will be required. Because the requirements of QIDAM have been validated (albeit indirectly) through the use of vMR and QDM, FHIR is likely to benefit from this analysis in terms of completeness and maturity. Ultimately, adoption of FHIR in this area will require reworking on several levels, authoring tools, artifact formats, and execution engines. Whether this investment is worthwhile remains to be seen.

# Glossary (Non-Normative)

**Fast Healthcare Interoperability Resources (FHIR)** [2]- An HL7 initiative that defines a set of granular objects (“resources”) that represent the basic elements of healthcare, such as patients, problems, medications, and the like, and defines REST services for exchanging these objects.

**Representational State Transfer (REST)** [5] - A popular web-oriented style of stateless client-server interaction that uniquely identifies a set of resources by URIs and provides basic create, read, update, and delete operations, most often implemented using HTTP.

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# Appendix A: Detailed Class-Level Mapping from QIDAM to FHIR

|  |  |  |  |
| --- | --- | --- | --- |
| QIDAM | FHIR | Grade | Notes |
| AdverseEvent | AdverseReaction | A- | Significant semantic distinction between these classes. See Section 2.6.2 |
| AllergyIntolerance | AllergyIntolerance | A- | FHIR can only represent intolerances to substances, while QIDAM includes intolerances to devices, tests, and procedures. |
| AllergyIntoleranceUnknown | Unknown if an AllergyIntolerance is not present or absent | C | FHIR can express unknown only by the absence of an AllergyIntolerance resource. See Section 2.5 |
| BodySite | http://hl7.org/fhir/vs/body-site (value set) | A | Maps to a FHIR value set |
| CareExperience | none | E |  |
| CommunicationEvent | Encounter (with type email, telephone, etc.) | B | FHIR represents a communication as a type of Encounter |
| CommunicationOrder | Order.detail.resourceType=Encounter | B | FHIR represents orders using the Order resource, specifying what is being ordered using the Order.detail (1..\*). |
| CommunicationProposal | none | E | Differential semantics of proposal versus order are not supported in FHIR |
| ConditionAbsent | Condition.certainty=(known absent, definitely not present) OR Condition.status=refuted | B- | FHIR Conditions combine multiple status and certainty values, making the mapping to the three QIDAM condition classes unclear. |
| ConditionPresenceUnknown | Unknown if Condition is not present or absent | C | See ConditionAbsent and CondtionPresent |
| ConditionPresent | Condition.status!=refuted AND Condition.certainty!=(known absent, definitely not present) | B- | Not clear how to handle other (un)certainty values |
| ContraindicationToMedication | none | E | Nothing to directly indicate a contraindication. Closest match might be MedicationStatement.reasonNotGiven |
| ContraindicationToProcedure | none | E |  |
| Cycle | schedule (complex type) | A |  |
| Device | Device | A |  |
| DeviceApplicationNotPerformed | OrderResponse.code=(rejected, error, cancelled, replaced, aborted) AND OrderResponse.request.detail.resourceType =Device | B- | OrderResponse can be used only if the device application was the result of an Order |
| DeviceApplicationOrder | Order.detail.resourceType=Device | B |  |
| DeviceApplicationPerformed | OrderResponse.code=complete AND OrderResponse.request.detail.resourceType =Device | B- | Can only be used if the device application was the result of an Order |
| DeviceApplicationProposal | none | E |  |
| DietAdministration | none | E |  |
| DietOrder | none | E |  |
| DietProposal | none | E |  |
| EncounterCondition | Condition.encounter | B- | Only class in QIDAM that specifies a “typed” relationship, conveying the role of the condition within this encounter, e.g. chief complaint, admission diagnosis, discharge diagnosis, comorbidity. The FHIR relationship cannot express the role information. |
| EncounterEvent | Encounter | A |  |
| EncounterProposal | none | E |  |
| EncounterRequest | Order.detail.resourceType=Encounter | B | HL7 v3 makes no distinction between an order and a request |
| EntityCharacteristic | ??? |  |  |
| FamilyHistoryConditionAbsent | none | E | No way to negate a FamilyHistory.relation.condition |
| FamilyHistoryConditionPresent | FamilyHistory.relation.condition | A |  |
| FamilyHistoryConditionUnknown | none | E | FHIR has no way to indicate that "don't know" or "won't say" was the answer to a family history question. See Section xxx |
| GoalPerformance | CarePlan.activity | B |  |
| GoalProposal | CarePlan.goal | B |  |
| ImmunizationDoseAdministration | Immunization | A |  |
| ImmunizationOrder | Order.detail.resourceType=Immunization | B |  |
| ImmunizationProposal | ImmunizationRecommendation | A- | Semantic difference between a proposal and a recommendation |
| Location | Location | A | QIDAM Location class is not yet developed |
| ManufacturedProduct |  |  |  |
| Medication | Medication | A |  |
| MedicationAdministrationProposal | none | E | No proposal mood in FHIR |
| MedicationDispense | MedicationDispense | A |  |
| MedicationDoseAdministration | MedicationAdministration | A |  |
| MedicationIngredient |  |  |  |
| MedicationPrescription | MedicationPrescription | A |  |
| MedicationStatement | MedicationStatement | A |  |
| NoAdverseEvent | AdverseReaction.didNotOccurFlag=true | B- | FHIR AdverseReaction has a negation flag, allowing that resource to be used to express the concept NoAdverseEvent. |
| NoAllergyIntolerance | AllergyIntolerance[status=refuted,resolved] | B- | Semantic difference between QIDAM's "not known to have" versus FHIR's "known **not** to have" or "used to have, but not anymore" |
| NoKnownAllergy | Could be represented by an empty FHIR list | C | Supposed to represent “An assertion that a patient does not have allergies to broad classes of stimuli,” e.g.” no known allergies” |
| NutritionProduct | none | E | FHIR Substance cannot be used because the associated value set is SNOMED |
| ObservationResult | Observation | A |  |
| Organization | Organization | A |  |
| Participant | Practitioner OR RelatedPerson | D | QIDAM semantics are "the healthcare professional or related person participating in the encounter" |
| Patient | Patient | A |  |
| ParticipationInProgram | CarePlan.Activity.Status=(in progress, completed) | B |  |
| Practitioner | Practitioner | A |  |
| ProcedureEvent | Procedure | A |  |
| ProcedureNotPerformed | OrderResponse.code=rejected, cancelled, replaced, aborted | E |  |
| ProcedureOrder | Order.detail.resourceType=Procedure | B |  |
| ProcedureProposal | none | E |  |
| Prognosis | none | E | FHIR Condition doesn't mention prognosis |
| ProgramParticipationOrder | Order.detail.resourceType=CarePlan | B |  |
| ProgramParticipationProposal | none | E |  |
| ProposalToNotPerformProcedure | none | E |  |
| RelatedPerson | RelatedPerson | A |  |
| Schedule | schedule (complex data type) | A |  |
| ScheduledEncounter | Encounter.status=planned | B |  |
| ScheduledProcedure | none | E | Unlike Encouter above, FHIR Procedure does not have a status, so cannot indicate "planned" |
| Specimen | Specimen | A |  |
| Vaccine | Immunization.vaccineType | B- | Not a separate resource in FHIR; a vaccine cannot be represented outside the context of an immunization resource |

PARKING LOT

In CQM, EHR input data is standardized, and therefore a standard execution engine can be used. In CDS, data is not extracted into standard form, and the execution engine is EHR-specific such as the Measure Authoring Tool [11]. The authoring tool, for example, a quality measure expressed in HQMF [12]. The artifact can then be deployed and executed or evaluated by an execution engine, drawing on information in an electronic medical record system, leading to the desired output (e.g. a CDS alert, a QRDA Category III report, etc.). Currently, the authoring tools, artifact formats, execution engines, and standard data formats for CDS and CQM are different.

1. I.e., conceptual, logical, and physical. Conceptual models, created early in the development cycle, deal with high-level business objects and relationships, with limited articulation of attributes, cardinality, data storage or technologies. Logical-level modeling elaborates classes, attributes, relationships, cardinality, optionality, and datatypes, in a manner independent of particular computing technologies. The physical model level deals with actual implementation, specific data storage methods, method signatures, messaging details, information serializations, XML schemas, security, and the like. [↑](#footnote-ref-2)
2. Logical and conceptual models are implicit in FHIR because they could be revealed by *removing* details from FHIR. [↑](#footnote-ref-3)
3. Although Java interfaces have methods, not attributes, in QIDAM, a class is said to “implement” an interface if it inherits the attributes of that interface. [↑](#footnote-ref-4)
4. The parallel to classroom-style letter grades is intentional, but when interpreting the table, bear in mind the “grades” do not form a true Likert scale. For example, the semantic mismatch on AdverseEvent (A-) could be considered worse than not having a mapping for NutritionProduct (E). [↑](#footnote-ref-5)
5. To achieve vMR’s design goal, QIDAM Release 2 could have defined MedicationNotDispensed, inheriting from ActionNonPerformance, instead of introducing negation attributes. [↑](#footnote-ref-6)
6. The use of the phrase of “FHIR cannot…” is explained in Section 1.2. [↑](#footnote-ref-7)
7. A goal could be one of the other actions, for example, the goal to follow a diet. [↑](#footnote-ref-8)
8. Only applicable in limited situations where the OrderResponse is associated with an Order whose detail.resourceType=Device [↑](#footnote-ref-9)
9. The QIDAM ActionPerformance class includes actionParticipant (Participant type), occurredDuring (EncounterEvent), reason (code), additionalText (text), predecessorStatement (ClinicalStatement), semanticType (code), statementDateTime (TimePoint), statementSource (Entity), subject (Patient), and successorStatement (ClinicalStatement). [↑](#footnote-ref-10)