Representing Negated Information in Healthcare Data Standards

**Draft for Ballot, May 2017**

**Sponsored by:**

**Patient Care Work Group**

**Vocabulary Work Group**

**Clinical Quality Information Work Group**

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| --- | --- |
| Primary Editor / Co-Chair | Jay Lyle, JP Systems  [jay.lyle@jpsys.com](mailto:Jay.Lyle@jpsys.com) |
| Primary Editor / Co-Chair | Rob Hausam  rrhausam@gmail.com |

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## Introduction

The concept of negation raises complex questions in the world of information architecture. These questions include

* **Repetition**: whether a negation of a negation is an involution that cancels itself out, as in algebra, or an intensifier, as is common in natural language,
* **Explicitness**: whether absence of a statement of presence is ever equivalent to a statement of absence,
* **Scope**: how to establish the boundary of what is negated—i.e., when negation is predicated of a class, which class properties are asserted to be absent, and which ones contextualize that assertion,
* **Implication**: the degree to which one assertion may necessarily preclude another,
* **Modification**: the problem of changing the underlying meaning of a class, and the need to ensure that such “modified” classes are understood by other parties, and
* **Transformation**: how can a negated concept be transformed from one formalism into another.

When these issues arise in natural language, as in a clinical note, patterns developed over the history of natural language generally provide tactics for addressing them, often in ways specific to an interpretive community. However, when representing information in a form intended to support automated processing, it is important to specify semantics in consistent ways that support predictable processing results.

All of these questions have arisen in discussions of standards for the representation of clinical data, and they have done so in diverse contexts. These efforts have produced divergent solutions. It is not always obvious how to transform data formed in one syntax into another syntax—or even that such transformations can always be performed reliably.

This project aims to provide a foundation for harmonization of these efforts by

* providing a compendium of data instances regarded as “negations” in order to identify the specific semantics to be addressed,
* assessing the uses of these instances in order to clarify the specific semantic function of the negation,
* and stating principles for information design that support the identified functions without introducing unnecessary complexity.

These principles should allow specification designers to produce designs that

* Ensure they have addressed identified cases of negation,
* Avoid the issues listed above, to the extent possible, and
* Support forward and backward compatibility with other specifications that follow the principles.

We also considered another benefit:

* Recommended patterns to ensure future solutions can be harmonized more easily.

However, it was deemed better to leave these patterns in the hands of the respective specification designers. Instead, it is hoped that this analysis model may provide the basis for a policy to support the creation of such patterns.

The team is under no illusion that any effort “to develop one universal standard that covers everyone’s use cases”[[1]](#footnote-1) will cause stakeholders to subjugate their local and emergent needs to the dictates of a document. We do hope that, by engaging known design specification teams and by providing the result as a living document, we can provide a tool that design teams may find useful, and that this usefulness may conduce to more commensurable patterns in the future.

## Approach

The analysis was conducted in stages.

### Examples

The first task was to confirm scope. We solicited examples and sources of examples of negated information from the participants, and include examples from

* FHIR change requests & chat threads
* Natural Language Processing specifications
* US Veterans Administration use cases
* Team meetings.

We compiled a list of these examples, provided in Appendix A. Many of the items in this list are deemed out of scope for various reasons.

### Scope Boundaries

We identify several related topics here in order to clarify that they are out of scope.

* There are other **Modifiers** that may affect the semantics of a data element. Risks and family history modifiers, e.g., may require handling similar to that recommended here.
* **Certainty** is an assessment of the confidence with which an assertion is stated. Degrees of certainty may imply complementary degrees of negation. SNOMED CT specifies flavors of “known present” including “confirmed present,” “definitely present,” and “probably present,” but “probably present” also shows up in the “known possible” branch alongside “probably not present,” which also appears in the “known absent” branch. This suggests that, were these concepts fully defined, they would contain distinct properties for presence and certainty.
* **Likelihood** refers to the probability that something is true. This may be distinguished from Certainty, which is a kind of Data Quality, and has to do with how well the evidence supports a conclusion. Likelihood values do actually impinge on presence/absence semantics: a likelihood of zero is equivalent to absence
* **Data quality** concerns seem to some to be related to negation. The knowledge that a certain percentage of assertions are incorrect invites comparison to negation of that cohort. However, as the cohort is unknown, no negative assertions can be made. Possible solutions may focus on processes of data capture and maintenance: the topic is not our focus here.
* **Provenance** has been suggested as another dimension of potential negation, however the concern has been with quality and certainty, addressed above.
* **Null values** represent a special case. While we maintain that null values in general are a separate topic from negation, the degree of interest in “no known allergies” makes it a key use case for our project.

### Classification

We reduced the compiled list to a shorter list of kinds of negation. Any item in the first list should be represented by an example in the second. For example, “absent spleen” and “absent carotid artery” are both instances of assertions of the absence of normal anatomical features. We were able to reduce a list of 151 examples to 37 kinds of negation.

### Analysis

We analyzed this shorter list in three steps.

First, in order to characterize the semantics of negation consistently, we modeled the examples in the SNOMED CT concept model for Situation with Explicit Context. This provided a clear division between the phenomena of interest and the negating operations.

Second, we represented the classes in UML in order to identify common features.

And third, we built UML use cases to assess the utility of the classes.

The cases, some based on known quality measures and decision support scenarios, provide ways to assess the impact of negation on the model and the need for negation to be explicit.

The classes so identified are represented in Appendix B, their representation in UML in appendix C.

### Guidelines

Finally, we used these representations to assemble a set of design guidelines for representing negation in clinical information models. While **subject matter expert workgroups** are needed to ensure the lists and classifications are complete and correct, **standards development workgroups** can use the resulting guidelines to

* + confirm that their designs support the needs of the clinical community,
  + demonstrate recommended patterns for their specification,
  + identify out-of-specification patterns, and
  + demonstrate transformations between their designs and other widely adopted specifications.

We frame these guidelines to support the development of a policy that could be adopted to guide future standards development.

## Analysis

We address several issues and identify several kinds of patterns.

### Issues

**Abstraction**

We find the term “negation” useful as a keyword for collecting related concepts.

However, the things we collect under that heading are, in healthcare, observations of *absence* or records that things were *not done* (as well as some edge cases, such as “goal not held” or “risk not present”). They do not tend to be represented in the domain as “negation.”

The logical negation operator and its Boolean values are abstractions. These abstractions have their uses, but where they are not required, they introduce vagueness. This vagueness is responsible for substantial confusion in applications of the HL7 V3 Reference Information Model (viz., CDA).

While most examples we found represented absence or actions not done, two cases could be seen to align more closely with the semantics of negation: goals not held and refuted diagnoses. Because goals are mental constructs, their denial seems close to a negation of their assertion; the same is true of diagnoses (whether previously made or only suspected). It seems reasonable to represent these statements as negations of their affirmatives. If a case can be made for establishing an abstract pattern for representing negation in information models, it can be made here. Still, both cases have existing vocabularies: such a pattern might inform processing, but would not change the terms used in the clinical process.

**Consistency**

The primary value of establishing an abstract pattern for negation would be to support consistency, which provides the ability to find and analyze information more reliably and less expensively. The challenge is to find a level of abstraction that supports optimal consistency without impairing other desiderata, such as support for specific clinical requirements.

Consistency has two faces: within models and across models.

For the first, models should not allow different properties to represent overlapping semantics. E.g., if a model has a way (e.g., the FHIR procedure “status”) to specify whether an activity is completed, it is unclear what information a Boolean “not done” flag provides. Rather than adding another element, it seems that the addition of a “not done” value to the status range meets the need without creating an opportunity for contradictory information.

Similarly, the SNOMED CT concept model provides potentially conflicting ways to represent observation results. The model supports the association of observable entities with the findings that interpret them, but is also supports the assertion of “presence” in the situation model.

For the second, the difficulty is in defining when things are similar enough in clinical practice to merit leverage of similar data structures in different models, and when they are not. For instance, the concept of a refuted condition is semantically similar to that of an absent finding.

The use cases of managing “conditions” and recording “observations” may be sufficiently distinct to merit different information structures, but there are edge cases that are difficult to distinguish, so these structures should at the very least be clearly transformable.

**Double negatives**

The semantics of double negatives are ambiguous. Where possible, multiple negations should be avoided. Where multiple negation is unavoidable, its meaning should be specified clearly and explicitly.

Note that the issue of implication means that semantically, the number of negations in a statement may be uncountable. A “closed head injury without loss of consciousness” might be represented as a compound statement, but the “without loss” clause could be understood as either one or two negations. Any analysis of “double” (or multiple) negation is only meaningful for the case of explicit negation; for information modeling, the goal should be simply to minimize complexity.

**Transformation**

Transformation introduces risk and cost, and should be avoided, all else being equal. One approach to the principle articulated by the NPfIT project is to store data in a form as “close to user” as possible. This preserves the intended semantics of the user most clearly, and may be useful for future modifications (or even corrections) to any automated transformations.

Transformations will still be necessary, but, of the many guidelines and heuristics for determining where to perform them, this one militates for storing closer to capture and transforming closer to point of use.

**Explicit representation**

Re-using information is easier when the information uses structured semantics. When negation is expected to be needed for specific secondary uses, representing it explicitly supports those uses more reliably. Where negation is used for computation, it can be expressed in a “model-coordinated” fashion (e.g., with a separate field for “present” or “absent”) or in a “terminology-coordinated” fashion (e.g., a single field to contain both “present X” and “absent X”). The former requires less terminology maintenance and supports computation more directly; the latter is likely to be more often found in “close to user” forms.

Note that explicit representation as a desideratum conflicts with the minimal transformation idea: a close-to-user form is likely to make use of pre-coordinated concepts, whereas a fully articulated model is not. One method of managing this difficulty is to allow a “close-to-user” form for user interfaces, storage, and interoperability as long as such a form can be logically disaggregated into constituent parts for processing. E.g., a “No allergy to latex” concept may be a “fully defined” situation, where the “absent” finding context can be dereferenced when needed for calculation. This approach implies a requirement for accessible terminology services.

Further, the re-use that explicit representation aims to support may be difficult to predict. An assertion of no loss of consciousness might seem more clinically reliable than a record of a head injury that simply has no affirmative statement of loss of consciousness. However, it may be just as clinically significant that the patient did not vomit or experience vision problems. A clinician may record, after an examination, only those symptoms that are both relevant and present; subsequent providers may need to rely on the professional capacity of the first, just as a system may infer absences of findings not specified by a radiologist reading an image in a specific modality.

**Implication and its Implications**

For the cases outlined above, explicit semantic negation is either not necessary (deficit, safety check) or it is a simple matter of tagging an existing artifact with a value that refutes it (“refuted,” “not done,” “not to be done”).

Negation becomes a much more difficult problem when we consider examples where implication is important. Positive assertions often imply negation; e.g., “left hemiplegia present” implies “right hemiplegia absent.” How these facts may interrelate in a query or rule that has not yet been written is difficult to predict, but it means that when we add negated facts to our realm of analysis, we leave the door open to the relevance of facts that we have not anticipated.

When those implications are well understood, we can build systems that manage them, as in the chart by exception rules that follow protocols for what can be negated by a normal finding in a specific image modality. But we cannot design rules without a deep and thorough understanding of the potential implications of the concepts permitted in the rules. This problem is particularly acute given the “open world” assumption of the ontologies used in description logic rules. One of our examples states “the patient has no problems.” The RIM negation pattern would represent this by instantiating a notional “observation” class and using a negation indicator to assert that no instance of that observation exists. But in description logic, such an assertion only means that there is at least one instance of observation that is not of the identified type; there may be others that are.

The implication is that medical records are closer to a closed world conceptualization, where absence of evidence does indeed serve as evidence of absence, than to an open world conceptualization. It is a commonplace that absence of evidence is not evidence of absence. No specific information (viz., absence) can be derived from the results of an empty query other than that it is empty.

The obvious exception is Clinical Quality Measures (CQMs). A rule may infer that a procedure was not done for the sake of calculating the measure and its financial impact, but such an inference should not be used for clinical purposes. There may be a need to record the inference of absence, but if such a record is made, it must be made in a way that cannot be mistaken for a positive absence; e.g., a measure may represent a procedure as “not found.”

But the exceptions to this statement are broader. Many clinical decision support rules infer absence from empty queries. Take, e.g., instructions to give aspirin to patients presenting to the Emergency Department with chest pain. Such rules tend to have exclusions for patients with bleeding disorders, but they do not expect to be able to identify explicit negation of bleeding disorders; rather, they check for patients with bleeding disorders. In the absence of such a record, the rule suggests aspirin. The clinician may follow a safety protocol to ask before administering, but this protocol is a safety check, and a negative answer is unlikely to be usefully persisted for purposes beyond the protocol.

It seems that the reason we repeat this rule is that absence of evidence is often used as evidence of absence, and we must be mindful to guard such conclusions with safety checks.

### Patterns of Content

To the extent that absence of findings or procedures not done can be fit into a consistent model, the model is trivial. We fit the example negation statements to the SNOMED CT situation with explicit context model, and found no cases for which the finding or procedure context could not be assigned. Where there were issues, they were with timing (e.g., for procedures contraindicated for the future, or medications habitually not taken).

The primary issue with finding a pattern to fit the context model is not of too few but of too many options. E.g., asplenia could be represented in at least three ways (leaving aside functional asplenia):

* Spleen observable / absent / current / patient
* Asplenia / present / current / patient
* Splenectomy / done / past / patient

Selecting the appropriate pattern is properly a question of use, not semantics

### Patterns of Use

The case of asplenia suggests some axioms. It seems useful to capture absences of normal anatomical features (e.g., asplenia) or normal physiological functions (e.g., no menses) as disorders. Such disorders appear on a concern list (or problem list), where subsequent providers are made aware of this important and persistent feature of the patient’s clinical state.

It is not clear that it is useful to capture them as negated assertions of presence. There are cases where such absence is explicitly queried; e.g., “Do you have a spleen?” as a contraindication for live vaccine. However, this question is used as a safety check for an imminent procedure. It can support providers who do not have access to the patient’s record and can neither identify previously recorded asplenia nor to record newly discovered asplenia; in cases where providers do have such access, the information is important enough to be added as a disorder.

One pattern of use for negation, then, is **deficit**. This pattern seems to be most usefully captured as positively asserted problems rather than as negations of normal assets. This includes absences outside of physiology, such as homelessness and lack of family.

The case of pregnancy seems similar, but is inverted. Here, the question is asked for reasons similar to those for asplenia, but it is the positive response that is of interest, and might prompt an addition to the concern list. The negation is only captured as evidence that the safety protocol was followed.

The distinction has implications for design. If the negation has only that one use, then it can be captured in a “close-to-user” form, without spending resources on detailed logical decomposition and the operational rules required to manage such a decomposed statement.

A second pattern of use for negation, then, is the **safety check**: a question asked in order to rule out contraindications or other procedural issues (e.g., permission) before taking action. The asplenia question is both a deficit and a safety check; the pregnancy question is only a safety check.

A third pattern is **refutation**. The obvious example of Refutation is ruled-out diagnoses and suspicions. It may be useful to record explicit negations for these cases; if the condition was suspected, there may be reason to continue to suspect, and the negation may help providers understand what not to be concerned about.

Refutations also include findings that are negated by diagnostic protocol, whether actually suspected or not. A key category is the “chart by exception” case, where record of “normal” or “within normal limits” may be taken to refute a set of findings that might reasonably be expected to be found by the diagnostic method used. A “normal” chest x-ray, for instance, implies “No mediastinal widening,” among other things. Whether this negation is explicitly charted or left implicit may vary. As in the vaccination safety check, it may be enough to record that the process was followed. The fact that there is no record of a disorder should be sufficient to inform subsequent providers about the patient’s condition; the fact does not necessarily imply a need to record the negation of the respective disorders.

A sub-category of refutation is the **criterion**: cases where the absence of a fact is looked for in order to control future behavior. Instructions to take an action “until able to complete 10-15 minutes in each session without cardiac symptoms” seem complex enough to make detailed semantic modeling inadvisable, but their completion should be accompanied by explicit record of the absence of cardiac symptoms as a refutation.

Finally, there are negations of procedures, including **omissions** (assertions that a procedure was not done) and **prohibitions** (assertions that it is not to be done). Omissions and prohibitions typically include a rationale. Prohibitions need to be easy to find in order systems in order to inform possible ordering providers about previous thought around why a procedure might not be a good idea. This could be managed by creating inverse procedure orders in order to make them more manageable for order systems.

Omissions are typically recorded in order to provide a rationale for quality measures. Clinically, the fact that a procedure was not done is often evident, and if not, may be inferred from the record, at least within a single facility.

### Contexts

For all of these cases, for **data entry** and **human review**, close-to-user forms are appropriate.

Problem lists may contain refuted problems, or assertions of “no known drug allergies.” It is not clear that modeling in more detail than this provides value.

Safety check questions are part of the protocol checklist; they don’t result in explicit records of absent problems; they only result in records that the questions asked were answered in the negative.

One place where a user interface might benefit from clearly negative semantics is order contraindication. If procedure noted as not to be done for a clinical reason, it is important to provide the ordering system with a way to make that clear to providers ordering that or similar procedures. Negated contraindications, however, tend not to be stored for re-use: safety checks are checked consistently.

Criteria tend to be complex, and attempts to articulate negative semantics may be more difficult than they are worth. The fulfillment of the criterion, however, should be explicit. This does not, however, mean that the explicit fulfillment must articulate negative semantics.

**Storage** form is a system architecture decision. It depends on the specific uses to which data will be put, as well as legal and audit needs.

**Computable rules** do raise the question of whether explicit negation may be of value.

**Quality measure** calculation can be performed *ex post facto* and should have minimal effect on clinical record formats.

To the extent that forms optimized for computation in **query** and **clinical decision support** can be managed in business logic, it can be left to the business designers. To the extent that the analytics may depend on more general and cross-case representations, it becomes important to model logical negation explicitly. However, as noted above, it is typically the case that these rules do take absence of evidence as evidence of absence. Given the infinite number of negative assertions that would be required to turn an open world situation into a closed world query, it could not be any other way. This limitation makes it impossible to use rules to execute treatment decisions: CDS logic can only be used to prompt providers to remember evidence-based guidelines.

To take another illustration, there is a clinical significance to the exclusion in “closed head wound without loss of consciousness.” However, there is also significance to the absence of vomiting. Both absences are proxies for a classification of the criticality of the wound, but, in the absence of assertion to the contrary, both are assumed to be absent on the grounds that if either were present, a competent provider would have documented it.

**Description Logic** is the domain where negation modeling questions are the most difficult. Scenarios supported by relational data, as we have seen, use more specific concepts (refutation, contraindication), and rely on closed-world assumptions. Logical inference, on the other hand, uses the negation operator, and its use brings the problems cataloged above to the fore.

Foremost is the problem of implication. Implication means that any unbounded logical scenario is essentially undecidable, as the assertions that any expression implicitly excludes may include other assertions of interest. As a result, those who wish to use description logic should probably eschew negation altogether. Cases where negation promises value can only be implemented under certain controlled circumstances. These include, at least,

* The concepts in the ontology adequately and unambiguously represent both positive and negative relevant statements. Alternative patterns for representing the same information are recognizably the same.
* The users and designers of the logic understand both the nuances of negation in the data and the constraints on the specific subset of description logic to use.
* The data can be inspected for cases of unanticipated negative implication.

Lastly, cases where description logic supports decision support follow the same constraints as other decision support rules: it cannot cause decisions to be made; it can only remind clinicians of best practice.

## Guidelines

We recommend that specification designers follow these guidelines.

1. Model negation concretely, in ways that are fit for purpose (e.g., “refuted,” “contraindicated”). Resist the temptation to generalize without specific near-term use cases for doing so.
2. Support consistency within models: avoid providing implementers with two ways to say the same thing.
3. Support consistency across models: where models say similar things, use similar patterns. For instance, “vomiting” could be reported as either a condition or an observation: its presence or absence should be searchable by a consistent pattern.
4. Provide explicit instructions for how negated statements in your specification should be transformed from and to other widely adopted specifications. This can be done in a consolidated manner using the classes identified in the analysis model or on a case-by-case basis.
5. For cases intended to support description logics, model negation explicitly; i.e., don’t bury “not” values in a value set with positive values.

One final guideline: When you identify a use case that this analysis does not address, bring it up to the Patient Care or Vocabulary work group.

## Appendix A

List of example requirements,

| ID | **Source** | **Item** | **Category** | **Relevant** | **Note** | **Model class** |
| --- | --- | --- | --- | --- | --- | --- |
| 62 | CIMI CQI project | Absence of assertion of intent to breast feed | absence of assertion | Not relevant | absence of evidence is not evidence of absence | None |
| 64 | PC thread 2/25/16 | 2.       It is not the case (that I do know) that the Patient has problem X, | absence of assertion | Not relevant | null value | None |
| 147 | PQRS 258 | Percent of patients undergoing open repair of small or moderate sized non-ruptured abdominal aortic aneurysms who do not experience a major complication (discharge to home no later than post-operative day #7) i.e., who do not experience a major complication | absence of complication (derived) |  |  | Absence of phenomenon, derived |
| 148 | PQRS 259 | Percent of patients undergoing endovascular repair of small or moderate non-ruptured abdominal aortic aneurysms (AAA) that do not experience a major complication (discharged to home no later than post-operative day #2) | absence of complication (derived) |  |  | Absence of phenomenon, derived |
| 150 | PQRS 384 | Patients aged 18 years and older who had surgery for primary rhegmatogenous retinal detachment who did not require a return to the operating room within 90 days of surgery. | absence of complication (derived) |  |  | Absence of phenomenon, derived |
| 48 | NegEx Lexicon | definiteExistence e.g., obvious | affirmative | Not relevant | affirmative, not negation | None |
| 54 | NegEx Lexicon | probableExistence e.g., evidence for, appears | affirmative | Not relevant | likelihood, not negation | None |
| 57 | NegEx Lexicon | pseudoHistorical e.g., history and examination | affirmative | Not relevant | history, not negation | None |
| 58 | NegEx Lexicon | pseudoNegation e.g., no change | affirmative | Not relevant | consistency, not negation | None |
| 63 | PC thread 2/25 | 1.       It is the case (that I do know) that the Patient has problem X, | affirmative | Not relevant | affirmative, not negation | None |
| 42 | HL7 PC Orlando 1/12/16 | Congenital absence of coronary artery | Anatomical deficit, congenital |  | need to distinguish? | Condition |
| 44 | HL7 PC Orlando 1/12/16 | Left leg amputated (not present) | Anatomical deficit, surgical |  |  | Condition or Procedure (Record of action) |
| 43 | HL7 PC Orlando 1/12/16 | Left kidney resected (absent) | Anatomical deficit, surgical |  |  | Condition or Procedure (Record of action) |
| 100 | invented 5/5/16 | Hand lost in accident | Anatomical deficit, traumatic |  |  | Condition |
| 47 | HL7 PC Orlando 1/12/16 | no spleen | Anatomical deficit, unspecified |  |  | Condition |
| 144 | PQRS 145 | Final reports for procedures using fluoroscopy that document radiation exposure indices, or exposure time and number of fluorographic images (if radiation exposure indices are not available) | backup measure | Not relevant | absence is a condition, not a recorded fact | None |
| 60 | RadLex (Richard Esmond) | Radiology negative findings - get example list for chart by exception | Chart by exception |  |  | Absence of phenomenon |
| 104 | WGM 5/10/16 | [assert that a batch of stuff is absent] | Chart by exception |  |  | Absence of phenomenon |
| 1 | VA Use Case Angina 1 - EDCare 2.20.15 | m.   CXR: Normal. No mediastinal widening, valve disease, or CHF I.e., no CHF | Chart by exception |  |  | Absence of phenomenon |
| 105 | WGM 5/10/16 | [handle context conduction] | Collection (inheritance) | Not relevant | no concrete example found | None |
| 103 | WGM 5/10/16 | Ted: nested negation? See fhir dstu questionnaire | Collection (inheritance) | Not relevant | no concrete example found | None |
| 74 | 20160323 call | does not have diabetes (from MU test data - problem list) - provenance is important to consider i.e., no diabetes | Condition absent |  |  | Absence of phenomenon |
| 92 | Negation call 4/13 | patient not pregnant | Condition absent |  |  | Absence of phenomenon |
| 73 | 20160323 call | not allergic to clindamycin (from MU test data - allergy list) - provenance is important to consider | Condition absent |  |  | Absence of phenomenon |
| 67 | PC thread 2/25/16 | 5.       It is the case (that I do know) that the Patient has no problems (ie none). | Condition absent (generic) |  |  | Absence of phenomenon |
| 112 | openEHR exam pattern | No abnormality detected (BL) | Condition absent (generic) |  |  | Absence of phenomenon |
| 41 | HL7 PC Orlando 1/12/16 | my uncle does not have hemophilia | Condition absent (relation) |  | One might assume this is a risk factor for pt, not a condition for uncle. But some domains might model relation to uncle and absence of a condition. In this case, this is an absent condition like any other, just assigned to a different person. | Absence of phenomenon |
| 69 | PC thread 2/29/16 | clinicianAssertedStatus - confirmed/refuted - "Patient is/isn't allergic to penicillin" | Condition absent (sensitivity) |  |  | Absence of phenomenon |
| 70 | PC thread 3/1/16 | no allergy to latex | Condition absent (sensitivity) |  |  | Absence of phenomenon |
| 128 | FHIR Zulip 9/5 | "patient says that they have never had chicken pox" | Condition historically absent |  |  | Evaluation of characteristic |
| 101 | WGM 5/10/16 | [condition in remission] | Condition in remission | Not relevant | this is a problem status | None |
| 91 |  | Refute the absence of a condition | Condition not absent | Not relevant | no concrete example found | None |
| 102 | WGM 5/10/16 | [condition refuted] | Condition refuted | Not relevant | this is a problem status | None |
| 131 | PC 9/20/16 | healed fracture (no fracture) | Condition resolved | Not relevant | this is a problem status | None |
| 122 | Negation call 8/10 | need example. Probably out of scope, because semantically more like 'risk' or 'possibility,' but need to explain this. And that "rule out" is ambiguous: use "differential" or "not present" | Condition rule-out | Not relevant | differential or rule-out are ambiguous for two problem states: risk/possibility and refuted. Use those. | None |
| 53 | NegEx Lexicon | indication e.g., rule out | Condition rule-out | Not relevant | too abstract to evaluate | None |
| 136 | PQRS 69 | Percentage of patients aged 18 years and older with a diagnosis of multiple myeloma, not in remission, who were prescribed or received intravenous bisphosphonate therapy within the 12-month reporting period [condition not in remission] | Condition status | Not relevant | this is a problem status | None |
| 130 | PC 9/20/16 | Patient does not consent to surgery | Consent |  |  | None |
| 50 | NegEx Lexicon | experiencer e.g., sister's | Context | Not relevant | subject context, not negation | None |
| 51 | NegEx Lexicon | future e.g., at risk for, concern for | Context | Not relevant | risk, not negation | None |
| 143 | PQRS 141 | Percentage of patients aged 18 years and older with a diagnosis of primary open-angle glaucoma (POAG) whose glaucoma treatment has not failed (the most recent IOP was reduced by at least 15% from the pre- intervention level) OR if the most recent IOP was not reduced by at least 15% from the pre- intervention level, a plan of care was documented within 12 months | Criterion | Not relevant | threshold, not negation | None |
| 145 | PQRS 166 | Percentage of patients aged 18 years and older undergoing isolated CABG surgery who have a postoperative stroke (i.e., any confirmed neurological deficit of abrupt onset caused by a disturbance in blood supply to the brain) that did not resolve within 24 hours | Criterion | Not relevant | threshold, not negation | Condition |
| 97 | MM mail 4/5 | “NO KNOWN. CODEINE CAUSES NAUSEA” | criticality |  | combination of negative & criticality | condition |
| 82 | Negation call 3/30/16 | patient did not show up | Encounter not held |  | could be documented on appointment; might be documented as an act that did not occur. | Action not done |
| 39 | VA Use Case DM 4 Care Coordinator Telephone Follow Up 2.20.15 | a.     Patient notes that work has been busy, and that no time has been available to make the appointment | Encounter not to be held + reason |  |  | Action not done |
| 81 | Negation call 3/30/16 | follow up not needed | Encounter not to be held + reason |  |  | Prohibition |
| 55 | NegEx Lexicon | probableNegatedExistence e.g., fails to reveal | Evidence absent | Not relevant |  | Evaluation of characteristic |
| 108 | decomposition of other requirements 6/21 | no evidence of cancer (path) | Evidence absent (Pathology) |  | not condition absent; likely to be a question asked for certain patients | Evaluation of characteristic |
| 56 | NegEx Lexicon | pseudoExperiencer e.g., by her husband | Family member | Not relevant |  | None |
| 133 | VA Use Case CHF - ED 20150305 | 1.     Nothing to eat or drink until respiratory distress dissipates  [respiratory distress absent] | Finding absent |  |  | Absence of phenomenon |
| 71 | Kcampbelll | closed head injury without loss of consciousness i.e., no loss of consciousness | Finding absent (dependent) |  | two observations. Is conjunction in situation relevant? | Absence of phenomenon |
| 4 | VA Use Case Angina 1 - EDCare 2.20.15 | b.    CV: Chest pressure 5 out of 10 after 3 SL-NTG tablets, S1S2, No murmurs or gallop Exam: No murmur | Finding absent (exam) |  |  | Absence of phenomenon |
| 23 | VA Use Case Depression - Outpatient Follow-up 2.26.15 | Extremities: No swelling, pedal pulses strong. I.e., No swelling | Finding absent (exam) |  |  | Absence of phenomenon |
| 33 | VA Use Case DM 2 Follow Up Outpatient Visit 2.20.15 | Extremities: No swelling, bilateral pedal pulses +2, I.e., No swelling | Finding absent (exam) |  |  | Absence of phenomenon |
| 37 | VA Use Case DM 3 - Referral for Annual Podiatry Screening 2.20.15 | 5. Wound assessment: Medial portion of right big toe (approx. 5 mm x 5mm) at top of toenail is slightly red. No breakdown. No sign of infection.  I.e., No breakdown | Finding absent (exam) |  |  | Absence of phenomenon |
| 38 | VA Use Case DM 3 - Referral for Annual Podiatry Screening 2.20.15 | Provider removes ingrown toenail without complications. No infection noted. Skin intact, with slight inflammation. I.e., No infection noted | Finding absent (exam) |  |  | Absence of phenomenon |
| 11 | VA Use Case Angina 2 TelemetryCare 2.20.15 | a.     Begin light exercise (walking on a level surface for 5 minutes, 3 times a day). Add 1 minute to each session, each day until able to complete 10-15 minutes in each session without cardiac symptoms. cardiac symptoms absent | Finding absent (exam) |  | Record "absent"; we do not recommend relying on absence of positive assertion to record achievement of a goal | Absence of phenomenon |
| 24 | VA Use Case Depression - Outpatient Follow-up 2.26.15 | b. Adverse effects from the medication  a. None noted | Finding absent (general) |  |  | Absence of phenomenon |
| 22 | VA Use Case Depression - Outpatient Follow-up 2.26.15 | Abdomen: Soft, benign. No GI/GU issues. I.e., No GI/GU issues | Finding absent (general) |  | this is very similar to chart by exception | Absence of phenomenon |
| 20 | VA Use Case Depression - Outpatient Follow-up 2.26.15 | a.     AUDIT-C - Score: 0 (No symptoms of abuse) | Finding absent (instrument) |  |  | Evaluation of characteristic |
| 32 | VA Use Case DM 1 Diagnosis of Diabetes 2.20.15 | Patient completes alcohol use screening  l. Result: 2 (Negative) | Finding absent (instrument) |  |  | Evaluation of characteristic |
| 31 | VA Use Case DM 1 Diagnosis of Diabetes 2.20.15 | Patient completes PTSD screening k. Results: Negative | Finding absent (instrument) |  |  | Evaluation of characteristic |
| 9 | VA Use Case Angina 2 TelemetryCare 2.20.15 | Cardiologist evaluates the reading and enters the interpreted result in the EHR. Result: Normal echocardiogram. No cardiomegaly or effusion. Good valve function. Ejection Fraction: 58% I.e., No cardiomegaly | Finding absent (interpretation) |  |  | Absence of phenomenon |
| 10 | VA Use Case Angina 2 TelemetryCare 2.20.15 | Reviews ECG reading and enters the interpreted result in the EHR. Result: SR 76. No ectopy. No hypertrophy.  I.e., No hypertrophy | Finding absent (interpretation) |  |  | Absence of phenomenon |
| 8 | VA Use Case Angina 2 TelemetryCare 2.20.15 | a.     Notes cardiac rhythm: Sinus rhythm without ectopy, HR 84 I.e., No ectopy | Finding absent (interpretation) |  |  | Absence of phenomenon |
| 13 | VA Use Case CHF - ED 20150305 | o    Cardiac rhythm (ECG): Sinus tachycardia (ST) without ectopy  I.e., No ectopy | Finding absent (interpretation) |  |  | Absence of phenomenon |
| 108 | decomposition of other requirements 6/21 | no mrsa found (lab) | Finding absent (lab) |  |  | Evaluation of characteristic |
| 7 | VA Use Case Angina 2 TelemetryCare 2.20.15 | a.     History of Tobacco use: No | Finding absent (patient report) |  |  | Evaluation of characteristic |
| 17 | VA Use Case CHF - ED 20150305 | a.     Smoking history: No tobacco use | Finding absent (patient report) |  |  | Evaluation of characteristic |
| 19 | VA Use Case CHF - IMC 20150305 | 1.     History of Tobacco use: No | Finding absent (patient report) |  |  | Evaluation of characteristic |
| 29 | VA Use Case DM 1 Diagnosis of Diabetes 2.20.15 | a.     Smoker: No | Finding absent (patient report) |  |  | Evaluation of characteristic |
| 30 | VA Use Case DM 1 Diagnosis of Diabetes 2.20.15 | a.     Substance Use: No | Finding absent (patient report) |  |  | Evaluation of characteristic |
| 35 | VA Use Case DM 3 - Referral for Annual Podiatry Screening 2.20.15 | a.     Smoker: No | Finding absent (patient report) |  |  | Evaluation of characteristic |
| 36 | VA Use Case DM 3 - Referral for Annual Podiatry Screening 2.20.15 | b.     Alcohol Use: No | Finding absent (patient report) |  |  | Evaluation of characteristic |
| 3 | VA Use Case Angina 1 - EDCare 2.20.15 | d.    Smoking history: No tobacco use | Finding absent (patient report) |  |  | Evaluation of characteristic |
| 5 | VA Use Case Angina 1 - EDCare 2.20.15 | e.     GU: Verbalizes no problems with voiding | Finding absent (patient report) |  |  | Evaluation of characteristic |
| 89 | NEMSIS | No bleeding disorders | Finding absent (patient report) |  | safety process; not on condition list | Evaluation of characteristic |
| 45 | HL7 PC Orlando 1/12/16 | No vision in right eye | Functional deficit |  |  | Condition |
| 46 | HL7 PC Orlando 1/12/16 | no menses | Functional deficit |  |  | Condition |
| 49 | NegEx Lexicon | definiteNegatedExistence e.g., patient was not | general | Not relevant | too abstract to evaluate | None |
| 80 | Negation call 3/30/16 | 5-year survival is not my goal | Goal not held |  |  | Evaluation of characteristic |
| 79 | Negation call 3/30/16 | Quitting smoking is not my goal | Goal not held |  |  | Evaluation of characteristic |
| 76 | Negation call 3/23 | Goal was not met | Goal status | Not relevant | status of tracked goal | None |
| 14 | VA Use Case CHF - ED 20150305 | 1.     Sinus tachycardia (ST) Q waves in the inferior leads, inferolateral ST- and T-wave changes (This is unchanged from the previous admission-3 months ago). | Inference | Not relevant | 'no change' can be inferred from any pair of items | None |
| 52 | NegEx Lexicon | historical e.g., changing, previous | Inference | Not relevant | prior change is not a negation | None |
| 25 | VA Use Case Depression - Outpatient Follow-up 2.26.15 | i.    Provider notices that the patient did not tolerate Prazosin in the past (which was started to address difficulty sleeping) | Intolerance | Not relevant | intolerance is a condition | Condition |
| 12 | VA Use Case CHF - ED 20150305 | Allergies: No known drug allergy | No known allergy |  |  | Absence of phenomenon |
| 16 | VA Use Case CHF - ED 20150305 | a.     Confirms allergies: No known drug allergy | No known allergy |  |  | Absence of phenomenon |
| 93 | MM mail 4/5 | “No Known Medicine Allergies, mom sts food Allergies” | No known allergy |  |  | Absence of phenomenon |
| 94 | MM mail 4/5 | “no known med allergies but has food other allergies” | No known allergy |  |  | Absence of phenomenon |
| 2 | VA Use Case Angina 1 - EDCare 2.20.15 | b.    Confirms allergies: No known drug allergy | No known allergy |  |  | Absence of phenomenon |
| 95 | MM mail 4/5 | “Father states pt has no known allergies, but states close family members have had severe reactions to:  PCN, succinylcholine chloride, anectine, and quelizine” | No known allergy with FH |  |  | Absence of phenomenon |
| 21 | VA Use Case Depression - Outpatient Follow-up 2.26.15 | Head/Neuro: WNL Heart: S1S2, BP normal | Normal | Not relevant | WNL can be used to support chart by exception, but is not here | Evaluation of characteristic |
| 34 | VA Use Case DM 2 Follow Up Outpatient Visit 2.20.15 | Head/Neuro: WNL | Normal | Not relevant |  | Evaluation of characteristic |
| 129 | FHIR Zulip 9/5 | not currently taking | Not on medication |  |  | Not currently taking medication |
| 90 | NEMSIS | Not on anticoagulants or thinners | Not on medication (patient report) |  |  | Not currently taking medication |
| 6 | VA Use Case Angina 1 - EDCare 2.20.15 | b.    Since chest pain started 45 minutes ago, it is too early to see any elevation in cardiac enzymes (Troponin, CK-MB) | Null flavor | Not relevant | null value | None |
| 40 | HL7 PC Orlando 1/12/16 | do not know whether uncle has/had colon cancer | Null flavor | Not relevant | null value | None |
| 65 | PC thread 2/25 | 3.       It is the case that I don’t know if the Patient has problem X, | Null flavor | Not relevant | null value | None |
| 66 | PC thread 2/25 | 4.       It is the case that I don’t know if the Patient has any problems (ie any). | Null flavor | Not relevant | null value | None |
| 96 | MM mail 4/5 | “no known allergies but has problems with ingesting some meds” | Null flavor | Not relevant | null value | None |
| 59 | NegEx Lexicon | uncertain e.g., either | Null flavor | Not relevant | null value | None |
| 107 | decomposition of other requirements 6/21 | No next of kin | Party absent (persistent) |  | could be n/a or negated or a second question with "no" or "none" as the answer | Evaluation of characteristic |
| 106 | WGM 5/10/16 | no family; no home; transportation; POA I.e., no family | Party absent (persistent) |  |  | Evaluation of characteristic |
| 72 | Unknown | mother not present | Party absent (point) | Not relevant | Provenance | None |
| 61 | CIMI CQI project | Assertion of intention not to breast feed | Patient intent to abstain |  |  | Evaluation of characteristic |
| 75 | Negation call 3/23 | Preference that an action not be done: [Margaret] | Patient preference to abstain |  |  | Evaluation of characteristic |
| 132 | PC 9/20/16 | Patient is not NPO | Precondition not met |  |  | Evaluation of characteristic |
| 78 | Negation call 3/30/16 | reason for discontinuing medication | Procedure discontinued + reason |  |  | Action aborted |
| 27 | VA Use Case Depression - Outpatient Follow-up 2.26.15 | and was discontinued due to irregular heartbeats and restlessness | Procedure discontinued + reason |  |  | Action aborted |
| 115 | CQI - The Joint Commission Measure VTE-3 | Reason for discontinuation of parenteral anticoagulation therapy | Procedure discontinued + reason |  |  | Action aborted |
| 26 | VA Use Case Depression - Outpatient Follow-up 2.26.15 | *xxxx* and was discontinued due to irregular heartbeats and hyperventilation | Procedure discontinued + reason |  |  | Action aborted |
| 135 | PQRS 65 | Percentage of children 3 months through 18 years of age who were diagnosed with upper respiratory infection (URI) and were not dispensed an antibiotic prescription on or three days after the episode | procedure not done |  |  | Action not done |
| 137 | PQRS 93 | Percentage of patients aged 2 years and older with a diagnosis of AOE who were not prescribed systemic antimicrobial therapy | procedure not done |  |  | Action not done |
| 138 | PQRS 102 | Percentage of patients, regardless of age, with a diagnosis of prostate cancer at low risk of recurrence receiving interstitial prostate brachytherapy, OR external beam radiotherapy to the prostate, OR radical prostatectomy, OR cryotherapy who did not have a bone scan performed at any time since diagnosis of prostate cancer | procedure not done |  |  | Action not done |
| 139 | PQRS 116 | Percentage of adults 18 through 64 years of age with a diagnosis of acute bronchitis who were not prescribed or dispensed an antibiotic prescription on or 3 days after the episode | procedure not done |  |  | Action not done |
| 140 | PQRS 121 | Percentage of patients aged 18 years and older with a diagnosis of chronic kidney disease (CKD) (stage 3, 4, or 5, not receiving Renal Replacement Therapy [RRT]) who had a fasting lipid profile performed at least once within a 12-month period | procedure not done |  |  | Action not done |
| 141 | PQRS 122 | Percentage of patient visits for those patients aged 18 years and older with a diagnosis of chronic kidney disease (CKD) (stage 3, 4, or 5, not receiving Renal Replacement Therapy [RRT]) with a blood pressure < 140/90 mmHg OR ≥ 140/90 mmHg with a documented plan of care | procedure not done |  |  | Action not done |
| 146 | PQRS 243 | Percentage of patients evaluated in an outpatient setting who within the previous 12 months have experienced an acute myocardial infarction (MI), coronary artery bypass graft (CABG) surgery, a percutaneous coronary intervention (PCI), cardiac valve surgery, or cardiac transplantation, or who have chronic stable angina (CSA) and have not already participated in an early outpatient cardiac rehabilitation/secondary prevention (CR) program for the qualifying event/diagnosis who were referred to a CR program | procedure not done |  |  | Action not done |
| 149 | PQRS 312 | Percentage of patients 18-50 years of age with a diagnosis of low back pain who did not have an imaging study (plain X-ray, MRI, CT scan) within 28 days of the diagnosis. | procedure not done |  |  | Action not done |
| 151 | PQRS 419 | Percentage of patients with a diagnosis of primary headache disorder for whom advanced brain imaging was not ordered. | procedure not done |  |  | Action not done |
| 99 | Negation call 4/20 | hearing screening not done - needed for quality measure | Procedure not done |  |  | Action not done |
| 113 | CQI call 8/5 | Represent inference of "absence" from empty query - specific use not yet determined, but, e.g., CDS logging | Procedure not done - inference |  |  | Action not done (derived) |
| 28 | VA Use Case Depression - Outpatient Follow-up 2.26.15 | Patient still refuses cessation treatment despite motivational interventions | Procedure not done + reason |  |  | Action not done |
| 87 | FHIM call 4/1/16 | did not do a variety of things for reason X | Procedure not done + reason |  |  | Action not done |
| 114 | CQI - The Joint Commission Measure AMI-7a | Reason for delay in fibrinolytic therapy | Procedure not done + reason |  |  | Action not done |
| 116 | CQI - The Joint Commission Measure STK-4 | Reason for delay in initiation of IV thrombolytic | Procedure not done + reason |  |  | Action not done |
| 117 | CQI - The Joint Commission Measure VTE-3 | Reason for not providing overlap medication (IV or subcutaneous anticoagulation therapy and warfarin on the same day) | Procedure not done + reason |  |  | Action not done |
| 118 | CQI - The Joint Commission Measure TOB-2, TOB-3 | Reason for not providing tobacco cessation medication at discharege | Procedure not done + reason |  |  | Action not done |
| 119 | CQI - The Joint Commission Measures STK-1, VTE-1, VTE-6 | Reason for not providing Venous thromboembolism therapy or prophylaxis (medication or antithrombotic device use | Procedure not done + reason |  |  | Action not done |
| 120 | CQI - The Joint Commission Measure STK-6 | Reason for not providing statin medication at discharge | Procedure not done + reason |  |  | Action not done |
| 121 | CQI - The Joint Commission Measure PC-03 | Reason for not initiating antenatal steroids | Procedure not done + reason |  |  | Action not done |
| 77 | Negation call 3/30/16 | won't admin flu vaccine due to egg allergy | Procedure not done + reason |  |  | Action not done |
| 83 | Negation call 3/30/16 | procedure not done because patient ate | Procedure not done + reason |  |  | Action not done |
| 86 | Negation call 3/30/16 | did not provide vaccine because out of stock | Procedure not done + reason |  |  | Action not done |
| 134 | PQRS 47 | Percentage of patients aged 65 years and older who have an advance care plan or surrogate decision maker documented in the medical record or documentation in the medical record that an advance care plan was discussed but the patient did not wish or was not able to name a surrogate decision maker or provide an advance care plan. | Procedure not done + reason |  |  | Action not done |
| 124 | FHIR Gforge comment | [do not turn patient](http://gforge.hl7.org/gf/project/fhir/tracker/?action=TrackerItemEdit&tracker_item_id=9335) | Procedure not to be done |  |  | Prohibition |
| 126 | FHIR Gforge comment | do not flush central line | Procedure not to be done |  |  | Prohibition |
| 127 | FHIR Gforge comment | do not take blood pressure on left arm | Procedure not to be done |  |  | Prohibition |
| 18 | VA Use Case CHF - ED 20150305 | 1.     Nothing to eat or drink until respiratory distress dissipates | Procedure not to be done |  |  | Prohibition |
| 125 | FHIR Gforge comment | do not give blood or blood products | Procedure not to be done |  |  | Prohibition |
| 68 | PC thread 2/29/16 | patientAssertedStatus - unconfirmed/excluded - scope of "I'm allergic to penicillin" | Provenance | Not relevant | How to interpret the focal concept (drug, product, class) is orthogonal to negation | None |
| 123 | FHIR list, 8/23 | to exclude a search result for specific code system | Query | Not relevant |  | None |
| 85 | Negation call 3/30/16 | did not supply electric wheelchair | Supply not provided |  | consider pattern of process status - GF | Action not done |
| 84 | Negation call 3/30/16 | did not use antithrombotic device on legs (supply) | Supply not provided |  |  | Action not done |
| 110 | decomposition of other requirements 6/21 | no family; no home; transportation; POA | Support deficit |  |  | Evaluation of characteristic |
| 111 | decomposition of other requirements 6/21 | no family; no home; transportation; POA | Support deficit |  |  | Evaluation of characteristic |
| 109 | decomposition of other requirements 6/21 | no family; no home; transportation; POA | Support deficit |  |  | Evaluation of characteristic |
| 142 | PQRS 137 | Percentage of patients, regardless of age, with a current diagnosis of melanoma or a history of melanoma whose information was entered, at least once within a 12 month period, into a recall system that includes:  • A target date for the next complete physical skin exam, AND  • A process to follow up with patients who either did not make an appointment within the specified timeframe or who missed a scheduled appointment | system characteristic | Not relevant |  | None |
| 15 | VA Use Case CHF - ED 20150305 | i.    If the patient does not produce 250ml urine in first 30 minutes, furosemide 40mg IV x1 should be administered | Threshold | Not relevant |  | None |
| 98 | MM mail 4/5 | “Allergic to antibiotics but no known which class” | Vague |  | question | None |

## Appendix B

List of requirement kinds, with proposed “situation” model representations

| ID | **Item** | **Category** | **Associated finding/procedure** | **Timing** | **context** | **subject** |
| --- | --- | --- | --- | --- | --- | --- |
| 150 | Patients aged 18 years and older who had surgery for primary rhegmatogenous retinal detachment who did not require a return to the operating room within 90 days of surgery. | absence of complication (derived) |  |  |  |  |
| 42 | Congenital absence of coronary artery | Anatomical deficit, congenital | Finding | Current | Present | Patient |
| 44 | Left leg amputated (not present) | Anatomical deficit, surgical | Finding | Current | Present | Patient |
| 1 | m.   CXR: Normal. No mediastinal widening, valve disease, or CHF I.e., no CHF | Chart by exception | Finding | Current | Absent | Patient |
| 92 | patient not pregnant | Condition absent | Finding | Current | Absent | Patient |
| 67 | 5.       It is the case (that I do know) that the Patient has no problems (ie none). | Condition absent (generic) | Finding | Current | Absent | Patient |
| 70 | no allergy to latex | Condition absent (sensitivity) | Finding | Current | Absent |  |
| 128 | "patient says that they have never had chicken pox" | Condition historically absent | Finding | Current | Absent | Patient |
| 82 | patient did not show up | Encounter not held | Encounter | Current | Not done | Patient |
| 81 | follow up not needed | Encounter not to be held + reason | Encounter | TBD | Not to be done | Patient |
| 108 | no evidence of cancer (path) | Evidence absent (Pathology) | Finding | Current | Absent | Patient |
| 133 | 1.     Nothing to eat or drink until respiratory distress dissipates  [respiratory distress absent] | Finding absent | Finding | TBD | Absent | Patient |
| 71 | closed head injury without loss of consciousness i.e., no loss of consciousness | Finding absent (dependent) | Finding | Specified time | Absent | Patient |
| 23 | Extremities: No swelling, pedal pulses strong. I.e., No swelling | Finding absent (exam) | Finding | Current | Absent | Patient |
| 24 | b. Adverse effects from the medication  a. None noted | Finding absent (general) | Finding | Current | Absent | Patient |
| 20 | a.     AUDIT-C - Score: 0 (No symptoms of abuse) | Finding absent (instrument) | Finding | Current | Absent | Patient |
| 10 | Reviews ECG reading and enters the interpreted result in the EHR. Result: SR 76. No ectopy. No hypertrophy.  I.e., No hypertrophy | Finding absent (interpretation) | Finding | Current | Absent | Patient |
| 108 | no mrsa found (lab) | Finding absent (lab) | Finding | Current | Absent | Patient |
| 7 | a.     History of Tobacco use: No | Finding absent (patient report) | Finding | Current | Absent | Patient |
| 89 | No bleeding disorders | Finding absent (patient report) | Finding | Current | Absent | Patient |
| 46 | no menses | Functional deficit | Condition | Current | Present | Patient |
| 79 | Quitting smoking is not my goal | Goal not held | Goal | Current | Absent | Patient |
| 25 | i.    Provider notices that the patient did not tolerate Prazosin in the past (which was started to address difficulty sleeping) | Intolerance | Condition | Current | Present | Patient |
| 12 | Allergies: No known drug allergy | No known allergy | Condition | Current | Absent | Patient |
| 34 | Head/Neuro: WNL | Normal |  |  |  |  |
| 129 | not currently taking | Not on medication | Procedure | Current or past | Not done | Patient |
| 106 | no family; no home; transportation; POA I.e., no family | Party absent (persistent) | Finding | Current | Absent | Patient |
| 61 | Assertion of intention not to breast feed | Patient intent to abstain | Goal | Current | Absent | Patient |
| 75 | Preference that an action not be done: [Margaret] | Patient preference to abstain | Goal | Current | Absent | Patient |
| 132 | Patient is not NPO | Precondition not met | Finding | Current | Present | Patient |
| 27 | and was discontinued due to irregular heartbeats and restlessness | Procedure discontinued + reason | Procedure | Current | Discontinued | Patient |
| 137 | Percentage of patients aged 2 years and older with a diagnosis of AOE who were not prescribed systemic antimicrobial therapy | procedure not done | Procedure | Current | Not Done | Patient |
| 113 | Represent inference of "absence" from empty query - specific use not yet determined, but, e.g., CDS logging | Procedure not done - inference | Not for inference | | | |
| 28 | Patient still refuses cessation treatment despite motivational interventions | Procedure not done + reason | Procedure | Current | Not done | Patient |
| 124 | [do not turn patient](http://gforge.hl7.org/gf/project/fhir/tracker/?action=TrackerItemEdit&tracker_item_id=9335) | Procedure not to be done | Procedure | Current | Not to be done | Patient |
| 85 | did not supply electric wheelchair | Supply not provided | Procedure | In the past | Not done | Patient |
| 110 | no family; no home; transportation; POA | Support deficit | Finding | Current | Absent | Patient |

## Appendix C

Domain analysis model representing common negation use cases and classes to support them, based on requirements list.

### Use Cases diagram



1. Use Cases

### Actors

#### Automated Agent

A system that uses record data in an automated fashion.

#### Clinical decision support system

A system designed to recommend clinical advice based on a patient's record data.

#### Initial care provider

A care provider who records information that will be used later.

#### Quality system

A system designed to calculate quality measures based on existing medical record data.

#### Subsequent care provider

A provider who uses information recorded previously.

Note that a subsequent provider may simply be the initial provider at a later point in time.

### Use Cases

#### Confirm checklist

Certain actions require confirmation of appropriateness. Some questions may confirm whether or not there are contraindications to a procedure (pregnancy, latex allergy), and some may confirm the patient's state of mind (goals, permissions). When these questions are answered in the negative, the 'gated' action will typically not proceed.

#### Direct that procedure not be done

Instruction that a procedure not be performed on a specific patient, usually with a reason for the prohibition.

#### Find absent phenomena

Discover phenomena documented as absent in the patient. This case supports both human review and automated processes (CDS and quality measure calculation).

#### Find procedures not done

Discover procedures documented as not performed on the patient. This case supports both human review and automated processes (CDS and quality measure calculation).

#### Order Procedure

Indicate that a procedure should be performed. This is included here in order to demonstrate linkage to the prior assertion that the procedure not be performed.

#### Record absent intent

Intents include goals and permissions. A patient may not share a clinician's concern or statement of goal such as quitting smoking; and the patient may decline to give permission to perform procedures.

#### Record absent phenomenon

Record that a phenomenon is not observed in a patient. This typically implies that the method used to determine the presence of the phenomenon is normally sufficient to do so.

#### Record negative answer to question

A negative value is recorded in response to a specific evaluative question.

Two common cases include negative results (e.g., negative strep test) and questions confirming absence of contraindications to a procedure (e.g., patient not pregnant).

#### Record procedure not done

Document that a specific procedure was not performed on the patient, usually to ensure that other providers understand that the gap is intentional. Such a record implies a scope of time, typically the encounter.

#### View absent phenomenon

View problems or other conditions found to be absent in the patient. This is commonly used in 'chart by exception' cases.

#### View procedure not done

Discover details about a procedure documented as not done, typically with a reason.

### 

### Negation Domain Class Diagram



1. Negation Domain Diagram

#### Indicative statement

A statement of fact, as opposed to an instruction (imperative), possibility (subjunctive), or question (interrogative).

#### Absence of phenomenon

An assertion that a phenomenon is not observed in the patient, implying but not specifying that the observation process used should be sufficient to detect the phenomenon were it present.

This is a common pattern in "chart by exception" scenarios.

Also note that any negative evaluation of presence statement may also be represented as an "absence of phenomenon."

#### Action not done

Actions not done are typically captured in order to explain why they were not done.

#### Action not done derived from 'not found'

Quality measures may need counts of actions done and not done, and they will necessarily count actions not found as not done. These derived facts can be used for quality measure calculation and persisted for audit, but they cannot be relied upon for clinical use.

#### Evaluation of characteristic

A statement of the value of a property or attribute of the patient, typically expressed as a question/answer or name/value pair.

E.g., blood pressure = 120/90, breath sound quality = normal, smoking status = smoker.

Whether the indicative statement should contain the question/name as well as the answer/value (rather than refer to it) is a design question.

Also note that any "absence of phenomenon" statement may also be represented as an evaluation, given a defined question with which to do so.

#### Imperative direction

A request, demand, suggestion or prohibition that an act be performed in the future.

Such direction may include reasons for doing it and reasons for not doing it, whether it is a demand or a prohibition.

#### Indicative statement

A statement of fact, as opposed to an instruction (imperative), possibility (subjunctive), or question (interrogative).

#### Intent absent

Two kinds of intent have been identified.

A patient may grant or withhold permission to conduct a procedure. This is typically captured as the answer to an explicit questions.

A patient may also concur or disagree with a goal assertion. Goal assertions may be captured as independent phenomena, but can be captured in response to care planning questions. Denial of a goal is typically a response to a proposed goal.

#### Interrogative question

A question, typically about a characteristic of a patient, for which the answer is the indicative statement. The question may take the form of the name of a property, implying the question 'what is the value of this property?'

E.g., blood pressure, breath sound quality, smoking status.

#### No known drug allergy

Assertion that no drug allergy is known to be present in the patient. This can be understood as an explicit negation, with the scope of substances to which the patient has been exposed, or as a null value with respect to other substances.

#### Not currently taking medication

Observation that a patient has not recently taken a medication, without reference to any specific administration. This can be a generic statement, as in "not on any medications" or a specific observation, such as "not on any blood thinners."

Does the concept of 'habitual' obtain here, or only recency?

#### Order

Instruction to take action. This class represents an intent that action be taken irrespective of strength or workflow; i.e., it includes suggested and planned as well as ordered procedures.

#### Presence of phenomenon

A statement asserting that a phenomenon is observed in the patient. This is typically used for phenomena understood as 'conditions' -- enduring physiological states about which a patient or caregiver may have appropriate concern.

E.g., diabetes mellitus, pregnancy, hypertension.

Whether these phenomena can be categorically differentiated from "evaluation" values (characteristics to be evaluated, typically as a question/answer or name/value pair) is a vexed question, but usage requires that we address both.

#### Prohibition

Indication that a procedure is to be avoided.

#### Record of action

A statement about an action. The action might be in any state -- performed, planned, prohibited, not done, etc.

An action may have reasons for and against execution. If there is no actual order from which to derive these values, they belong in the record statement itself.

Whether the act is in fact performed cannot be inferred from the pro and con reasons: it must be explicitly stated (whether in an attribute or in a class definition).

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### Out of scope items diagram



1. Out of scope items

1. https://xkcd.com/927/ [↑](#footnote-ref-1)