Identifying Engineering Ambiguity in Laws and Regulations

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Introduction

Software engineers are building software systems for an increasingly regulated environment. Software in the Healthcare Information Technology sector serves as a particularly good example of this trend. In 1996, the United States Congress passed the Health Insurance Portability and Accountability Act (HIPAA)$^1$, which regulates Electronic Health Records (EHR) systems. Our prior research has discussed the importance of complying with HIPAA [4, 6]. Fines of $25,000 per year per violation could result from unintentional, non-criminal compliance failures.

In 2009, Congress amended HIPAA with the HITECH Act, which was passed as a part of the American Recovery and Reinvestment Act$^2$. HITECH outlines a set of objectives that incentivize EHR development by providing payments to healthcare providers using EHRs with certain “meaningful uses.” These meaningful use objectives are further detailed by the U.S. Department of Health and Human Services (HHS), which is the federal agency charged with regulating healthcare in the United States. On July 28th, 2010, HHS published their final ruling on the initial compliance deadlines for the first set of these amendments, known as the Meaningful Use Final Rule [1]. The compliance deadlines granted providers two years to comply with the first stage of objectives.

The first step for engineers building systems that must comply with these regulations is examining the text of the regulation and extracting requirements from it for the system under development. Unfortunately, regulations are ambiguous, often intentionally [7]. Extracting software requirements from regulations is extremely challenging [2, 8, 9]. Even reading and understanding these documents may be beyond the capability of professional engineers [3, 5, 8].

References


Tutorial

In this study, participants will read and examine five paragraphs from the HITECH act. After reading each paragraph, participants will answer questions about possible ambiguities in the text. We will direct all participants through this tutorial together to better understand different types of ambiguity and to discuss an example of the analysis participants will be doing.

Ambiguity takes several possible forms, some of these are explicitly tied to language, but others may be more context dependent, including engineering ambiguity. The IEEE\(^3\) states that a requirements specification is unambiguous only when each requirement has a single interpretation. Lawyers, on the other hand, depend on ambiguity to ensure that laws and regulations are not dependent on temporary standards. For example, lawyers might require “reasonable” encryption practices rather than specifying a particular encryption algorithm or standard that might be outdated in a few years.

To aid you in this identifying ambiguities, we define and present six types of ambiguity in Table 2, titled “Types of Ambiguity.” Each type of ambiguity is defined in more detail and with additional examples following the table. The types of ambiguities outlined in the table are not mutually exclusive. It is possible for a single sentence to exhibit more than one type of ambiguity. Although this classification of ambiguities is designed to be broadly applicable, it is not guaranteed to be comprehensive. It is possible for a sentence to be ambiguous in a way that doesn’t fall into one of these six categories of times. In addition, the selected text was not chosen with the intent to ensure that all types of ambiguity defined are represented. For example, it is possible that one or more types of ambiguity do not appear in the text under analysis. Please keep these considerations in mind as we examine each type of ambiguity in detail.

Lexical Ambiguity

Lexical ambiguity occurs when a word or phrase has multiple valid meanings. Consider the sentence: “John saw Jessica kick the bucket.” This could mean that John saw Jessica pass away or that John saw Jessica literally kick a bucket. Another example is the sentence: “Melissa walked to the bank.” That could mean that Melissa walked to a financial institution or she walked to the edge of a river.

Syntactic Ambiguity

Syntactic ambiguity occurs when a sequence of words has multiple valid grammatical parsings. Consider this sentence: “The grad student destroyed the computer with the broken keyboard.” This sentence could mean that there was a computer with a broken keyboard and a grad student destroyed it. However, it could also mean that a grad student used a broken keyboard to destroy some

\(^3\)The IEEE is the world’s largest technical professional organization. It serves professionals in electrical, electronic, and computing fields. More information about the IEEE is available on their website: http://www.ieee.org/
### Types of Ambiguity

<table>
<thead>
<tr>
<th>Ambiguity Type</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lexical</td>
<td>A word or phrase with multiple valid meanings</td>
<td>Melissa walked to the bank.</td>
</tr>
<tr>
<td>Syntactic</td>
<td>A sequence of words with multiple valid grammatical interpretations regardless of context</td>
<td>Quickly read and discuss this tutorial.</td>
</tr>
<tr>
<td>Semantic</td>
<td>A sentence with more than one interpretation in its provided context</td>
<td>Fred and Ethel are married.</td>
</tr>
<tr>
<td>Vagueness</td>
<td>A statement that admits borderline cases or relative interpretation</td>
<td>Fred is tall.</td>
</tr>
<tr>
<td>Incompleteness</td>
<td>A grammatically correct sentence that provides too little detail to convey a specific or needed meaning</td>
<td>Combine flour, eggs, and salt to make fresh pasta.</td>
</tr>
<tr>
<td>Referential</td>
<td>A grammatically correct sentence with a reference that confuses the reader based on the context</td>
<td>The boy told his father about the damage. He was very upset.</td>
</tr>
</tbody>
</table>

Computer. Notice that no individual word or phrase contributes to this ambiguity. It occurs only as a result of parsing the sentence as a whole. Another example: “Quickly read and discuss this paragraph.” The adverb “quickly” could modify either the single verb “read” or the compound verb “read and discuss.”

### Semantic Ambiguity

Semantic ambiguity occurs when a sentence has more than one interpretation based entirely on the context in which it occurs. Each word in the sentence has a distinct meaning and the sentence has a single parse tree, but the correct interpretation of the sentence requires more context. For example, if someone asked you, “Would you like to go to the ocean?” the particular ocean might mean the Atlantic if you were both in South Carolina at the time you were asked. Or it could mean the Pacific if you were both in San Francisco. The sentence may also be interpreted in a conceptual context to mean something closer to: “Would you like to go to some ocean?” In that context, the specific ocean does not matter as much as the general concept of the ocean or the beach. Other examples include, “Fred and Ethel are married.” and “Fred kissed his
wife, and so did Bob." Further context is needed to determine if Fred and Ethel are married to each other or separately. Nor do we yet know if Fred has cause to be annoyed.

**Vagueness**

Vagueness occurs when a term or statement admits borderline cases or relative interpretation. Consider the sentence: “She responded to my email quickly.” What constitutes the difference between responding quickly and responding slowly? One person’s “slow” response may be another’s “quick” response. Similarly, consider the sentence: “Fred is tall.” If Fred was a North American male and 5’2” in height, then the claim is not true. If Fred was 6’9” in height, then the claim is supported. Somewhere in between lie heights that reasonable people might disagree as to constituting “tall”. There are many terms in the same category as tall: short, skinny, fat, beautiful, ugly, etc.

**Incompleteness**

Incompleteness occurs when a statement fails to provide enough information to have a single clear interpretation. Consider the sentence: “Call Jessica, the widget is broken.” The speaker expects that widget is an understood term, but it may not be defined at all. The incompleteness results from not having a definition. Similarly, the sentence “Combine flour, eggs, and salt to make fresh pasta.” omits some necessary information such as quantity of materials and techniques to be employed. Incompleteness is common in software requirements specification under development, and it can be tolerated to some extent. However, incompleteness must be resolved for the requirements to make sense prior to implementation.

**Referential Ambiguity**

Referential ambiguity occurs when a word or phrase in a sentence cannot be said to have a clear reference. Several forms of referential ambiguity exist. For example, there is no Appendix Z to this document, so a sentence that reads “Appendix Z details our cold fusion equations” would be referentially ambiguous. Other examples include pronouns and their antecedents. “The boy told his father about the damage. He was very upset.” The pronoun ‘he’ could refer to either the boy or the father.

**Other Ambiguities**

As previously mentioned, the six types of ambiguity outlined above are not comprehensive. If you believe you have found a word, phrase, sentence, or paragraph that has more than one meaning and does not fit within any of the other categories, this sentence should be classified as the “Other” type of ambiguity.
Unambiguous Statements

We have chosen a section of legal text from the HITECH Act primarily because of its important implications for software development. This study was not designed to guarantee that all types of ambiguities appear in the legal text. Paragraphs from this legal text may fail to contain ambiguities. For example, there may well be no referential ambiguity in the legal text. If, for some paragraphs of the legal text, you believe there is a single, clear interpretation, please do not underline any text and circle “None” on the provided list.
Example Text

Let’s walk through an example that’s as similar to the study questions as possible together. The goal of this study is for each participant to read a paragraph from the HITECH Act, classify the ambiguities found therein (if any), and agree with or disagree with a statement about how that paragraph should be viewed from a software engineering perspective.

First, let’s focus on reading the legal text. Each legal text is presented in a shadowed box with a centered identifier as one or more lines of monospaced text. If that section of the legal text contains a cross reference, the text of the cross reference will follow the legal text under analysis, but it will not be in a shadowed box. Only the paragraph under examination (i.e. in a shadowed box) should be classified. The text of the cross reference is provided only as context to help disambiguate the paragraph under examination.

The example below is a section from the Health Insurance Portability and Accountability Act, which is modified and amended by the HITECH Act. After reading it, you will be asked to identify the types of ambiguities found therein. For each ambiguity found, please signify it by underlining the words, phrases, or sentences that comprise the ambiguity in one and only one of the five provided response copies of the regulatory text. You should underline the smallest set of words that still completely contains the detected ambiguity. For example, **Lexical ambiguity** may concern a single word. Only a single word would be underlined. In contrast, **Syntactic ambiguity** entails the entire sentence. In this case, the entire sentence would be underlined. Finally, **Semantic ambiguity** could potentially be applied to the entire passage. The entire paragraph would need to be underlined.

Limit your analysis to only the text in § 164.312(a). If you believe an ambiguity you’ve found is intentional, meaning that the author of the legal text explicitly wanted it to have that type of ambiguity and was aware that they were including it in the final version of the text, please indicated this by circling “Intentional” below the paragraph. If you believe the ambiguity you identified was not the author’s intent, please indicate this by circling “Unintentional” below the paragraph.
45 CFR Subtitle A, § 164.312(a)

(a)(1) Standard: Access control. Implement technical policies and procedures for electronic information systems that maintain electronic protected health information to allow access only to those persons or software programs that have been granted access rights as specified in § 164.308(a)(4).

(2) Implementation specifications:

(i) Unique user identification (Required). Assign a unique name and/or number for identifying and tracking user identity.

(ii) Emergency access procedure (Required). Establish (and implement as needed) procedures for obtaining necessary electronic protected health information during an emergency.

(iii) Automatic logoff (Addressable). Implement electronic procedures that terminate an electronic session after a predetermined time of inactivity.

(iv) Encryption and decryption (Addressable). Implement a mechanism to encrypt and decrypt electronic protected health information.

This legal text has one cross reference, which is provided below in the same format that will be used in the study. Note that the paragraph under examination has line numbers, whereas the cross reference text does not.

45 CFR Subtitle A, § 164.308(a)(4)

(4)(i) Standard: Information access management. Implement policies and procedures for authorizing access to electronic protected health information that are consistent with the applicable requirements of subpart E of this part.

(ii) Implementation specifications:

(A) Isolating health care clearinghouse functions (Required). If a health care clearinghouse is part of a larger organization, the clearinghouse must implement policies and procedures that protect the electronic protected health information of the clearinghouse from unauthorized access by the larger organization.

(B) Access authorization (Addressable). Implement policies and procedures for granting access to electronic protected health information, for example, through access to a workstation, transaction, program, process, or other mechanism.

(C) Access establishment and modification (Addressable). Implement policies and procedures that, based upon the covered entity's or the business associate's access authorization policies, establish, document, review, and modify a user's right of access to a workstation, transaction, program, or process.
After reading the legal text, each participant will classify the types of ambiguity found in the text by circling the type from the list provided. For example, if you believe the phrase “obtaining necessary electronic protected health information during an emergency” is an example of incomplete ambiguity because the information needed to determine what constitutes an emergency is missing, then you should underline the phrase “obtaining necessary electronic protected health information during an emergency” and circle “Incompleteness” from the list provided. If you believe there are no ambiguities in the paragraph under examination, signify this by not underlining any text and circling “None” from the list provided. Please write a few sentences providing your rationale for identifying any ambiguities found and for classifying any ambiguities found as responses to the questions “Why is this phrase ambiguous?” and “Why do you believe the ambiguity to be of this type?”

Participants are also asked to note the difference between intentional ambiguities and unintentional ambiguities. Intentional ambiguities are explicitly included in the text by the author because multiple interpretations are desired. For example, a lawyer may prefer to use ambiguous language like “reasonable security measures” to allow the law to be interpreted over several generations of technology. If a specific set of encryption protocols or procedures were enshrined into law, then that law would have to be updated when those protocols or procedures became broken or outdated. If you believe an ambiguity you’ve identified accurately represents the intent of the author, circle “Intentional” on your response for that ambiguity. For our previous example, you might believe that the criteria detailing what constitutes an emergency was intentionally left out so that unforeseeable emergency circumstances would still allow healthcare providers covered by this law to justify giving employees access to otherwise protected healthcare records.

Finally, after reading the paragraph and identifying ambiguities within it, each participant will either agree with or disagree with the following statement:

Software engineers should be able to build software that complies with this legal text.

Essentially, we are interested in knowing whether the paragraph as a whole is written in a way that the average software engineer could be relied upon to implement a software system that complies with this legal text. If you agree with the statement, circle “Agree.” If you disagree, circle “Disagree.” Please note that the identification of any unintentional ambiguities within the paragraph may not preclude the ability to implement compliant software. Please also provide your rational for this determination in a few sentences as a response to the question “Why or why not?” Consider the type and severity of any ambiguities identified and give us your opinion as to whether it is reasonable to expect that an average software engineer can build software to comply with the intent of the paragraph.

A single response paragraph and its associated questions appears on the next page in exactly the same format be used in the study.
45 CFR Subtitle A, § 164.312(a)

(a) (1) Standard: Access control. Implement technical policies and procedures for electronic information systems that maintain electronic protected health information to allow access only to those persons or software programs that have been granted access rights as specified in § 164.308(a)(4).

(2) Implementation specifications:
   (i) Unique user identification (Required). Assign a unique name and/or number for identifying and tracking user identity.
   (ii) Emergency access procedure (Required). Establish (and implement as needed) procedures for obtaining necessary electronic protected health information during an emergency.
   (iii) Automatic logoff (Addressable). Implement electronic procedures that terminate an electronic session after a predetermined time of inactivity.
   (iv) Encryption and decryption (Addressable). Implement a mechanism to encrypt and decrypt electronic protected health information.

If you have underlined any words, phrases, or sentences to indicate an ambiguity, please provide your rationale for identifying these words, phrases, or sentences as ambiguous in a few sentences here:

Please circle the type of ambiguity identified in the paragraph above.

Lexical Syntactic Semantic Vagueness
Incompleteness Referential Other Unambiguous

Please provide your rationale for your choice of Ambiguity Type here:

Please indicate whether this ambiguity was intentional or unintentional.

Circle one: Intentional Unintentional

Software engineers should be able to build software that complies with this legal text.

Circle one: Agree Disagree

Why or why not?
This is the end of the tutorial.

Do not proceed to the next page until instructed.
Which of the following best describes you (circle one statement):

I am a **technologist**, and I am more interested in creating, building, or engineering software systems than I am in legal compliance or business analysis.

I am a **policy analyst**, and I am more interested in regulatory compliance and building a business than I am in building technologies.
In this study, you are asked to examine five paragraphs of § 170.302 for possible ambiguities. For context, we have provided the complete text of this section below. The five paragraphs are reprinted on separate pages for your analysis after the full text. Cross-references are provided for the paragraphs under analysis.

45 CFR Subtitle A, § 170.302(a)-(w)

§ 170.302 General certification criteria for Complete EHRs or EHR Modules.

The Secretary adopts the following general certification criteria for Complete EHRs or EHR Modules. Complete EHRs or EHR Modules must include the capability to perform the following functions electronically, unless designated as optional, and in accordance with all applicable standards and implementation specifications adopted in this part:

(a) Drug-drug, drug-allergy interaction checks-(1) Notifications. Automatically and electronically generate and indicate in real-time, notifications at the point of care for drug-drug and drug-allergy contraindications based on medication list, medication allergy list, and computerized provider order entry (CPOE).

(2) Adjustments. Provide certain users with the ability to adjust notifications provided for drug-drug and drug-allergy interaction checks.

(b) Drug-formulary checks. Enable a user to electronically check if drugs are in a formulary or preferred drug list.

(c) Maintain up-to-date problem list. Enable a user to electronically record, modify, and retrieve a patient's problem list for longitudinal care in accordance with:

(1) The standard specified in § 170.207(a)(1); or

(2) At a minimum, the version of the standard specified in § 170.207(a)(2).

(d) Maintain active medication list. Enable a user to electronically record, modify, and retrieve a patient's active medication list as well as medication history for longitudinal care.

(e) Maintain active medication allergy list. Enable a user to electronically record, modify, and retrieve a patient's active medication allergy list as well as medication allergy history for longitudinal care.
(f) Record and chart vital signs—(1) Vital signs. Enable a user to electronically record, modify, and retrieve a patient's vital signs including, at a minimum, height, weight, and blood pressure.

(2) Calculate body mass index. Automatically calculate and display body mass index (BMI) based on a patient's height and weight.

(3) Plot and display growth charts. Plot and electronically display, upon request, growth charts for patients 2-20 years old.

(g) Smoking status. Enable a user to electronically record, modify, and retrieve the smoking status of a patient. Smoking status types must include: current every day smoker; current some day smoker; former smoker; never smoker; smoker, current status unknown; and unknown if ever smoked.

(h) Incorporate laboratory test results—(1) Receive results. Electronically receive clinical laboratory test results in a structured format and display such results in human readable format.

(2) Display test report information. Electronically display all the information for a test report specified at 42 CFR 493.1291(c)(1) through (7).

(3) Incorporate results. Electronically attribute, associate, or link a laboratory test result to a laboratory order or patient record.

(i) Generate patient lists. Enable a user to electronically select, sort, retrieve, and generate lists of patients according to, at a minimum, the data elements included in:

(1) Problem list;
(2) Medication list;
(3) Demographics; and
(4) Laboratory test results.

(j) Medication reconciliation. Enable a user to electronically compare two or more medication lists.

(k) Submission to immunization registries. Electronically record, modify, retrieve, and submit immunization information in accordance with:

(1) The standard (and applicable implementation specifications) specified in § 170.205(e)(1) or § 170.205(e)(2); and
(2) At a minimum, the version of the standard specified in § 170.207(e).

(l) Public health surveillance. Electronically record, modify,
retrieve, and submit syndrome-based public health surveillance
information in accordance with the standard specified in
§ 170.205(d)(1) or § 170.205(d)(2).

(m) Patient-specific education resources. Enable a user to
electronically identify and provide patient-specific education
resources according to, at a minimum, the data elements included
in the patient's: problem list; medication list; and laboratory
test results; as well as provide such resources to the patient.

(n) Automated measure calculation. For each meaningful use
objective with a percentage-based measure, electronically record
the numerator and denominator and generate a report including the
numerator, denominator, and resulting percentage associated with
each applicable meaningful use measure.

(o) Access control. Assign a unique name and/or number for
identifying and tracking user identity and establish controls
that permit only authorized users to access electronic health
information.

(p) Emergency access. Permit authorized users (who are
authorized for emergency situations) to access electronic health
information during an emergency.

(q) Automatic log-off. Terminate an electronic session after a
predetermined time of inactivity.

(r) Audit log-(1) Record actions. Record actions related to
electronic health information in accordance with the standard
specified in § 170.210(b).
(2) Generate audit log. Enable a user to generate an audit log
for a specific time period and to sort entries in the audit log
according to any of the elements specified in the standard at
§ 170.210(b).

(s) Integrity. (1) Create a message digest in accordance with
the standard specified in § 170.210(c).
(2) Verify in accordance with the standard specified in
§ 170.210(c) upon receipt of electronically exchanged health
information that such information has not been altered.
(3) Detection. Detect the alteration of audit logs.

(t) Authentication. Verify that a person or entity seeking
access to electronic health information is the one claimed and is
authorized to access such information.
(u) General encryption. Encrypt and decrypt electronic health information in accordance with the standard specified in § 170.210(a)(1), unless the Secretary determines that the use of such algorithm would pose a significant security risk for Certified EHR Technology.

(v) Encryption when exchanging electronic health information. Encrypt and decrypt electronic health information when exchanged in accordance with the standard specified in § 170.210(a)(2).

(w) Optional. Accounting of disclosures. Record disclosures made for treatment, payment, and health care operations in accordance with the standard specified in § 170.210(d).

On the following pages, you will be asked to examine paragraphs (c), (d), (f), (o), and (p). Please identify each recognized ambiguity on a separate response page. If you need additional response pages for a paragraph, please contact a proctor and they will be provided. A table detailing the ambiguity types is provided at the end of this packet.
(c) Maintain up-to-date problem list. Enable a user to electronically record, modify, and retrieve a patient’s problem list for longitudinal care in accordance with:

(1) The standard specified in § 170.207(a)(1); or

(2) At a minimum, the version of the standard specified in § 170.207(a)(2).

This text has two cross references: one to § 170.207(a)(1) and one to § 170.207(a)(2), both of which are shown below:


The Secretary adopts the following code sets, terminology, and nomenclature as the vocabulary standards for the purpose of representing electronic health information:

(a) Problems—(1) Standard. The code set specified at 45 CFR 162.1002(a)(1) for the indicated conditions.

Please underline at most one ambiguity found in the paragraph below. Additional ambiguities should be underlined on separate pages. If you need additional pages, please contact a proctor.

45 CFR Subtitle A, § 170.302(c)
(c) Maintain up-to-date problem list. Enable a user to electronically record, modify, and retrieve a patient’s problem list for longitudinal care in accordance with:

(1) The standard specified in § 170.207(a)(1); or

(2) At a minimum, the version of the standard specified in § 170.207(a)(2).

If you have underlined any words, phrases, or sentences to indicate an ambiguity, please provide your rationale for identifying these words, phrases, or sentences as ambiguous in a few sentences here:

Please circle the type of ambiguity identified in the paragraph above.

Lexical Syntactic Semantic Vagueness
Incompleteness Referential Other Unambiguous

Please provide your rationale for your choice of Ambiguity Type here:

Please indicate whether this ambiguity was intentional or unintentional.

Circle one: Intentional Unintentional

Software engineers should be able to build software that complies with this legal text.

Circle one: Agree Disagree

Why or why not?
45 CFR Subtitle A, § 170.302(c)

(c) Maintain up-to-date problem list. Enable a user to electronically record, modify, and retrieve a patient’s problem list for longitudinal care in accordance with:

(1) The standard specified in § 170.207(a)(1); or

(2) At a minimum, the version of the standard specified in § 170.207(a)(2).

If you have underlined any words, phrases, or sentences to indicate an ambiguity, please provide your rationale for identifying these words, phrases, or sentences as ambiguous in a few sentences here:

Please circle the type of ambiguity identified in the paragraph above.

- Lexical
- Syntactic
- Semantic
- Vagueness
- Incompleteness
- Referential
- Other
- Unambiguous

Please provide your rationale for your choice of Ambiguity Type here:

Please indicate whether this ambiguity was intentional or unintentional.

Circle one: Intentional Unintentional

Software engineers should be able to build software that complies with this legal text.

Circle one: Agree Disagree

Why or why not?
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If you have underlined any words, phrases, or sentences to indicate an ambiguity, please provide your rationale for identifying these words, phrases, or sentences as ambiguous in a few sentences here:

Please circle the type of ambiguity identified in the paragraph above.

Lexical  Syntactic  Semantic  Vagueness

Incompleteness  Referential  Other  Unambiguous

Please provide your rationale for your choice of Ambiguity Type here:

Please indicate whether this ambiguity was intentional or unintentional.

Circle one:  Intentional  Unintentional

Software engineers should be able to build software that complies with this legal text.

Circle one:  Agree  Disagree

Why or why not?
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Circle one: Intentional  Unintentional

Software engineers should be able to build software that complies with this legal text.

Circle one: Agree  Disagree

Why or why not?
Please underline at most one ambiguity found in the paragraph below. Additional ambiguities should be underlined on separate pages. If you need additional pages, please contact a proctor.

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(c) Maintain up-to-date problem list. Enable a user to electronically record, modify, and retrieve a patient’s problem list for longitudinal care in accordance with:

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Lexical     Syntactic     Semantic     Vagueness
Incompleteness    Referential   Other    Unambiguous

Please provide your rationale for your choice of Ambiguity Type here:

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Circle one: Intentional     Unintentional

Software engineers should be able to build software that complies with this legal text.

Circle one: Agree     Disagree

Why or why not?
(d) Maintain active medication list. Enable a user to electronically record, modify, and retrieve a patient’s active medication list as well as medication history for longitudinal care.
45 CFR Subtitle A, § 170.302(d)
(d) Maintain active medication list. Enable a user to electronically record, modify, and retrieve a patient’s active medication list as well as medication history for longitudinal care.

If you have underlined any words, phrases, or sentences to indicate an ambiguity, please provide your rationale for identifying these words, phrases, or sentences as ambiguous in a few sentences here:

Please circle the type of ambiguity identified in the paragraph above.

Lexical  Syntactic  Semantic  Vagueness
Incompleteness  Referential  Other  Unambiguous

Please provide your rationale for your choice of Ambiguity Type here:

Please indicate whether this ambiguity was intentional or unintentional.

Circle one:  Intentional  Unintentional

Software engineers should be able to build software that complies with this legal text.

Circle one:  Agree  Disagree

Why or why not?
45 CFR Subtitle A, § 170.302(d)
(d) Maintain active medication list. Enable a user to electronically record, modify, and retrieve a patient’s active medication list as well as medication history for longitudinal care.

If you have underlined any words, phrases, or sentences to indicate an ambiguity, please provide your rationale for identifying these words, phrases, or sentences as ambiguous in a few sentences here:

Please circle the type of ambiguity identified in the paragraph above.

Lexical     Syntactic     Semantic     Vagueness
Incompleteness     Referential     Other     Unambiguous

Please provide your rationale for your choice of Ambiguity Type here:

Please indicate whether this ambiguity was intentional or unintentional.
Circle one: Intentional     Unintentional

Software engineers should be able to build software that complies with this legal text.
Circle one: Agree     Disagree

Why or why not?
45 CFR Subtitle A, § 170.302(d)
(d) Maintain active medication list. Enable a user to electronically record, modify, and retrieve a patient’s active medication list as well as medication history for longitudinal care.

If you have underlined any words, phrases, or sentences to indicate an ambiguity, please provide your rationale for identifying these words, phrases, or sentences as ambiguous in a few sentences here:

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Lexical  Syntactic  Semantic  Vagueness
Incompleteness  Referential  Other  Unambiguous

Please provide your rationale for your choice of Ambiguity Type here:

Please indicate whether this ambiguity was intentional or unintentional.
Circle one:  Intentional  Unintentional

Software engineers should be able to build software that complies with this legal text.
Circle one:  Agree  Disagree

Why or why not?
45 CFR Subtitle A, § 170.302(d)
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Lexical Syntactic Semantic Vagueness
Incompleteness Referential Other Unambiguous

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Circle one: Agree Disagree

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Why or why not?
45 CFR Subtitle A, § 170.302(f)

(f) Record and chart vital signs—

(1) Vital signs. Enable a user to electronically record, modify, and retrieve a patient’s vital signs including, at a minimum, height, weight, and blood pressure.

(2) Calculate body mass index. Automatically calculate and display body mass index (BMI) based on a patient’s height and weight.

(3) Plot and display growth charts. Plot and electronically display, upon request, growth charts for patients 2-20 years old.
45 CFR Subtitle A, § 170.302(f)
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45 CFR Subtitle A, § 170.302(o)

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Why or why not?
## Types of Ambiguity

<table>
<thead>
<tr>
<th>Ambiguity Type</th>
<th>Definition</th>
<th>Examples</th>
</tr>
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</table>
| Lexical        | A word or phrase with multiple valid meanings | • Melissa walked to the bank.  
• John saw Jessica kick the bucket. |
| Syntactic      | A sequence of words with multiple valid grammatical interpretations regardless of context | • Quickly read and discuss this tutorial.  
• The student destroyed the computer with the broken keyboard. |
| Semantic       | A sentence with more than one interpretation in its provided context | • Would you like to go to the ocean?  
• Fred and Ethel are married. |
| Vagueness      | A statement that admits borderline cases or relative interpretation | • She responded to my email quickly.  
• Fred is tall. |
| Incompleteness | A grammatically correct sentence that provides too little detail to convey a specific or needed meaning | • Call Jessica, the widget is broken.  
• Combine flour, eggs, and salt to make fresh pasta. |
| Referential    | A grammatically correct sentence with a reference that confuses the reader based on the context | • Appendix Z details our cold fusion equations.  
• The boy told his father about the damage. He was very upset. |
| Other Ambiguity| Any ambiguous statement that doesn't fit in the previous six categories. | N/A |
| Unambiguous Statements | Any paragraph that does not contain any ambiguities of any kind. (Denote these by marking an 'X' in the box labeled ‘None.’) | N/A |