

Collect Once, Use Many

Enabling the Reuse of Clinical Data through Controlled Terminologies

Capturing patient information with controlled terminologies can enable its reuse for a wide variety of purposes, from bed assignments to reporting to clinical alerts.

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The requirements for collecting information about patients and the process of their care have grown constantly since Florence Nightingale bemoaned the lack of adequate health records, through Larry Weed's promotion of the problem-oriented medical record, and into the age of documentation for prospective payment, utilization review, and healthcare report cards.

Despite the corresponding increase in the use of computers to capture, store, and retrieve the information to meet these requirements, a great deal of redundancy exists in the process of the actual collection, while the goal of reusing the data for multiple purposes remains elusive.

For example, clinicians dutifully record histories, physicals, impressions, and plans in their patients' medical records, but they must then take time to fill out additional forms to report medication lists, problem lists, and reasons for visits. Healthcare institutions employ entire departments devoted to abstracting records to provide documentation for reimbursement.

Computers can best help us with reuse of data when data are represented in meaningful ways. The mere appearance of the word "pneumonia" in a health record does not tell us if the patient carries the diagnosis or has had the diagnosis excluded, and the absence of the word does not guarantee the absence of the diagnosis. Instead of relying on the textual portion of the record, computer systems make use of data coded with controlled terminologies, the International Classification of Diseases, Ninth Revision, Clinical Modification

Sample Case Record

The patient is a 50-year-old woman who presents to the emergency room with the chief complaints of fever, cough, and chest pain.

The patient has a history of hypertension and diabetes mellitus, with a 70 pack-year smoking history, and was in her usual state of good health until four days prior to admission, when she noted the onset of fever, chills, and cough productive of green sputum. These symptoms continued until the day of admission, when the patient noted the onset of dull, retrosternal chest pain, made worse with exertion, so she came to the emergency room. The patient reports that she takes a pill for blood pressure and a pill for diabetes but does not recall the names. She states that she once got a rash after taking Bufferin.

On arrival to the emergency room, physical examination revealed a well-developed, well-nourished woman in moderate respiratory distress. Vital signs showed a pulse of 80 and regular, a blood pressure of 160/100, a respiratory rate of 22 breaths per minute, and an oral temperature of 100.8°F. Examination of her chest revealed rales and rhonchi on the right side. The remainder of the examination was normal.

Laboratory examination included a serum sodium of 125 mEq/L (normal [136–146]); serum glucose of 200 mg/dL (normal [70–105]), a positive serum troponin, and a negative urine glucose. An electrocardiogram showed ST segment depression in the anterior leads. A chest x-ray showed an infiltrate in the right lower lobe. The patient was admitted to the hospital.

A sample case record showing a variety of typical clinical data.
Examples of the information's reuse appear in the text.

(ICD-9-CM) being the most widely used example. This article illustrates how capturing patient data with such controlled terminologies can support the reuse of patient data for a wide variety of purposes.

Case Study

Consider the abbreviated patient record above. This short record contains a wealth of data that can be used to understand the patient's condition and guide her care. Humans reading this case would have no trouble deciding which room the patient should be admitted to or picking out her blood sugar results. With a little additional medical knowledge, humans can also suggest that the patient should be given prophylactic aspirin therapy because of evidence of an acute myocardial infarction.¹ This would be advised with caution, owing to a possible aspirin allergy. A computer, on the other hand, would be hard pressed to find the specific words it might expect for such tasks in the record.

An Example: Bed Allocation

One of the simplest examples of data reuse is extracting the patient's age and gender from her record and providing it

to the hospital's admission/discharge/transfer (ADT) system to automate the process of assigning the patient to a hospital bed. However, if the system has a rule in the form:

If PATIENT.GENDER = "FEMALE" Then Assign Patient to EMPTY.FEMALE.BED

it will fail if the patient's gender is recorded as (in our case) "woman."

Instead of relying on the ability of the ADT system to pick the gender information from the text, we can record our data using a controlled terminology. In this case, we can imagine a very simple terminology consisting of two terms, *male* and *female*, each of which is represented by a unique identifier. (This example ignores situations of ambiguous gender, transgender, and other deviations from the male-female dichotomy.)

Instead of recording the patient's gender in the text, we would record it using a choice from the terminology, perhaps using a pick list or other data-entry mechanism. The ADT system can then use its logic to match the appropriate unique identifier unambiguously with an appropriate bed assignment.

Solutions Using Controlled Terminology

Even the simple example of reuse of gender information illustrates some of the challenges in using controlled terminologies: coverage of the domain and capturing data in a coded form.

We can consider other, more complex examples for which the payoff is even greater than automated bed assignment.

Laboratory Data Summarization

The primary use of laboratory data is to report results to clinicians and patients; the most common reuse is the summarization of those data to show patterns and trends. If we wished to summarize our patient's blood sugar results, we would want to extract "serum glucose" and "plasma glucose" from the record but exclude "urine glucose."

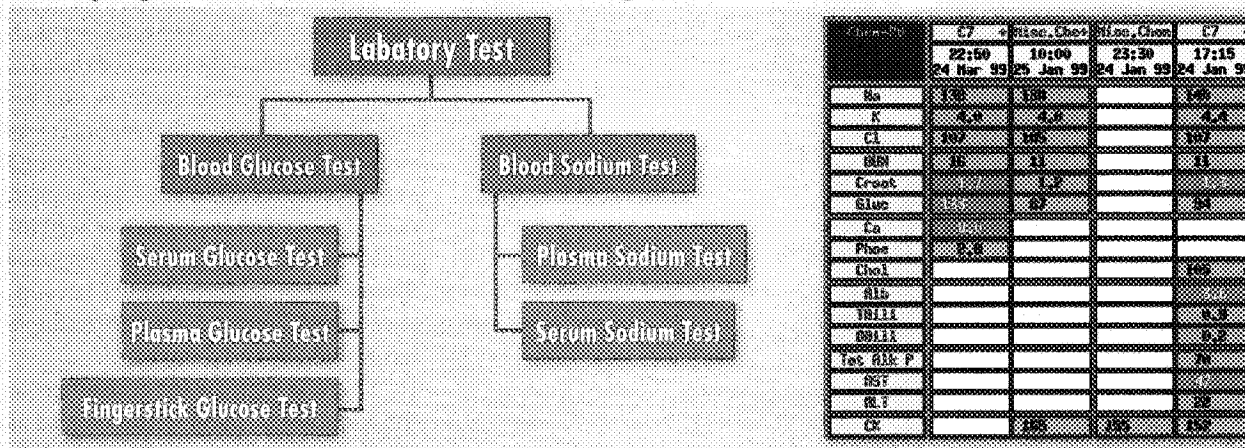
The good news is that laboratory systems generally use controlled terminologies to report their data. The bad news is that the appropriate summarization of results often requires including multiple term codes in each category, so the summarization programs need to know which codes to aggregate. Furthermore, laboratories often make changes to their terminologies, requiring the summarization programs to stay current with these changes.

Controlled terminologies can help with these tasks when they include classification systems that identify how individual coded terms can be grouped. The figure at right depicts a sample of terms from a laboratory terminology and shows how classification can support summarization of patient data by creating hierarchical relationships of the test terms. Controlled terms for new tests can be added to the hierarchy, allowing results to be aggregated automatically.

Clinical Guidelines

Computerized clinical guidelines are often cited as the

Grouping Individual Terms for Summarizing Patient Data



A controlled terminology (left) showing hierarchical relationships among laboratory test terms. The hierarchy can be used to aggregate patient data for the summary displays on the right. For example, results for plasma glucose tests, serum glucose tests, and fingerstick glucose tests can be organized into a single row of a display, as shown on the right. If the laboratory decides to add a new test (e.g., whole blood glucose), the controlled term for the test can be added to the terminology as a child of blood glucose test, and the test's results will automatically be aggregated into the appropriate row of the display.

tools that will help deliver evidence-based patient care, and electronic medical records are held out as the means to enable the delivery of appropriate guidelines to the point of care.² However, guidelines depend on the availability of coded patient data to satisfy their criteria.

Like the ADT system, some guidelines require age and gender information to make healthcare maintenance recommendations such as mammograms and Pap smears. A more complex recommendation, such as the suggestion that the patient in our example should be given aspirin, would require coded terms for "exertional chest pain," "ST segment depression," and "positive serum troponin" to determine that the patient meets criteria for possible myocardial infarction. Thus, terminologies must cover not only all the terms in specific domains, such as gender or laboratory tests, but represent multiple domains across the spectrum of patient care data.

Clinical System Alerts

Clinical information systems are effective for going beyond simple recommendations to monitor patient data in real time and trigger alerts to dangerous situations.³ Whether the alert involves worrisome trends in patient data or errors in clinicians' orders, the data must be coded using controlled terminologies to be effective.

If, in our sample case, the responsible physician or nurse practitioner decides that the patient should be given aspirin (perhaps because of a computerized guideline), we would hope that the computerized order entry system would issue a warning about the patient's possible allergy. Although a rule such as:

If ORDER="aspirin" and ALLERGY="Bufferin" Then
Print "Warning!"

might work, trying to include a rule for every order and al-

lergy permutation would be impractical. A more generic rule such as:

If ORDER=ALLERGY Then Print "Warning!"

would fail, since the order for "aspirin" would not match the word "Bufferin" that appears in the text.

However, if we represent the patient's allergies and ordered medications by using a controlled terminology, we can keep track of additional knowledge associated with the terms that can be used by computerized reasoning systems. In this example, we might include drug ingredient information in our terminology, as in the figure on the following page, to support the inference that aspirin should not be ordered for patients with Bufferin allergy. The resulting rule might then be:

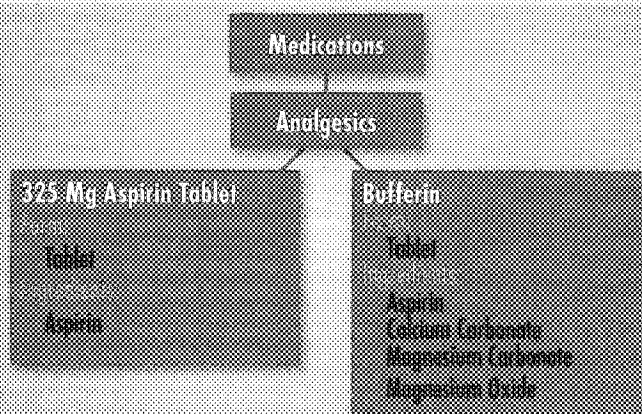
If {any ingredient of ordered drug} = {any ingredient
of allergic drug} = Then Print "Warning!"

Automated Retrieval of Health Information

Besides satisfying information needs, the data in a patient's record can trigger new information needs, such as the need for explanations of the patient findings or appropriate therapies for patient conditions. Although a variety of information resources are available to help resolve such needs, the automated reuse of patient data to help obtain answers from these resources is complicated by the fact that the resources typically do not speak the same language as the patient's record.

In our example, the patient has a serum sodium level of 125 mEq/L and a serum glucose level of 200 mg/dL. Literature databases such as PubMed and diagnostic expert systems such as DXplain can provide information about the causes of such findings.^{4,5} However, they index their information with controlled terms that differ from those in the patient's record.

Increasing Detail for Clinical Alerts



A controlled terminology for medications that includes drug ingredient information.

A terminology such as this could be used for comparing medication orders to patient allergies by using a rule such as:

If {any ingredient of ordered drug} = {any ingredient of allergic drug} Then
Print "Warning!"

Controlled terminologies from different systems can be integrated with each other, as they are in the National Library of Medicine's Unified Medical Language System.⁶ Automated translation then can be brought to bear to support reuse of patient data for automated knowledge retrieval. The figure at right shows an example of how automated terminology translation is used by automated links, called *infobuttons*, to carry out such retrievals.⁷

A Look Ahead

The examples of data reuse described here are a small sample of the ways in which computer systems can use available information to improve the healthcare process without redundant data collection. In each case, the key to success is the representation of the information using controlled terms. Without such representation, the data are merely strings of letters and numbers to be stored and displayed; with such representation, the terms used to code the data convey semantic information that can support reasoning about the data and the patient to whom they relate.

There are significant challenges to representing patient data with controlled terminologies, including lack of availability of high-quality terminologies, resistance to the adoption of standards for representation, and inadequate mechanisms for capturing the data in coded form. Although ICD-9-CM is a widely adopted standard, it suffers from a number of technical limitations that render it unfit for capturing data suitable for reuse, including its inability to allow multiple classifications of terms and its lack of semantic knowledge beyond term names and codes.⁸

Fortunately, several standards efforts have begun to produce terminologies that can support data reuse, including the Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) for clinical findings, Logical Observation

Identifiers Names and Codes (LOINC) for laboratory tests, and RxNorm for medications.^{9,10,11} Terminologies such as these address the issues of domain coverage, multiple hierarchies, and semantic representation that support tasks such as the reuse examples described above. Besides their intrinsic properties, each of these terminologies has been included in the Unified Medical Language System Metathesaurus, which can support translation of terms across multiple terminologies and domains.¹²

There is significant resistance to the adoption of these terminologies as standards; controversy and opposition currently impede the adoption of even ICD-10-CM over ICD-9-CM.¹³ However, HIPAA mandates the use of standards for the transmission of health information, and the National Committee on

Vital and Health Statistics is in the process of making standards recommendations to the secretary of Health and Human Services, indicating that standards adoption is inevitable.^{14,15}

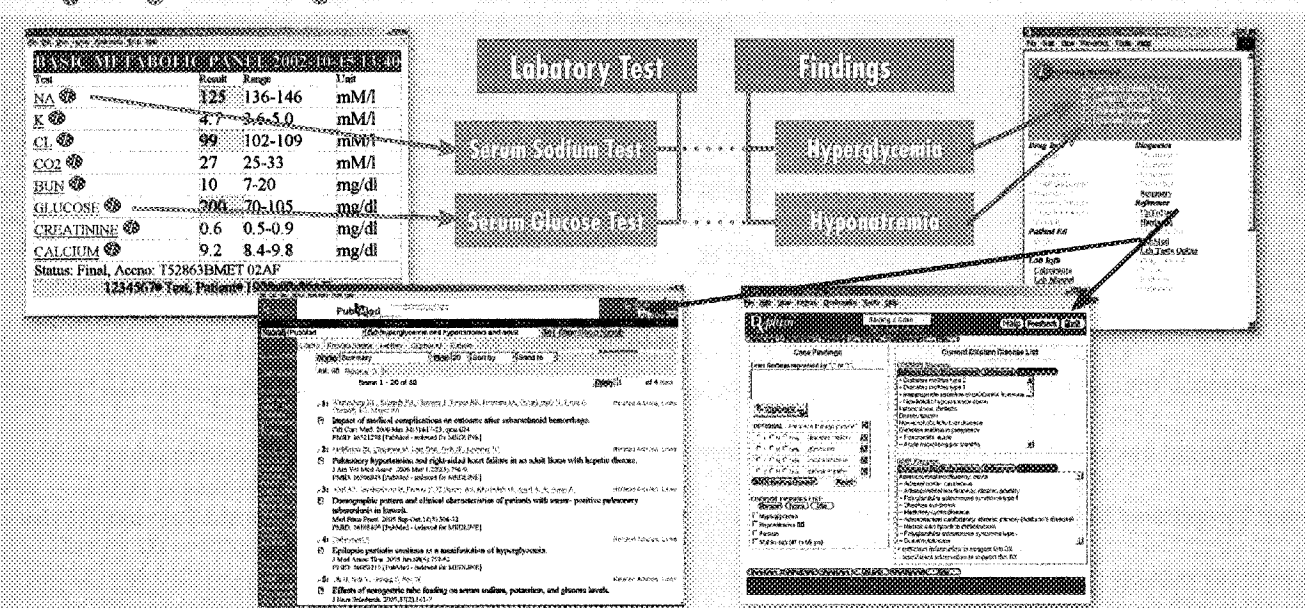
The ability to capture patient information with controlled terms remains difficult, but user interface design and natural language processing are reducing some of the barriers to system adoption.^{16,17} The currently increasing use of clinician order entry systems is one way in which important clinical data (diagnostic tests and medications) are being captured in coded, if not yet standard, form.

The ability to reuse patient data to improve healthcare processes need not await complete encoding of the patient record. A great deal can be done, and is being done, with the data we have coded thus far. As we code additional parts of the record, we will have greater capability to build systems that reuse data.¹⁸ As coding systems become more standardized, the solutions that address these uses can be standardized as well. ♦

Notes

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4. McEntyre, J., and D. Lipman. "PubMed: Bridging the Information Gap." *Canadian Medical Association*

Integrating Terminologies to Link Patient Data to Literature Databases



Automated retrieval of health information from a patient's electronic medical record. Infobuttons in a clinical information system (top left) use controlled terms for the laboratory tests (red arrows) that are related to finding terms in the controlled terminology (top center). The finding terms can be passed (green arrows) to an infobutton manager (top right), which uses the finding terms to retrieve information (blue arrows) from a literature database (PubMed, bottom left) and a diagnostic expert system (DXplain, bottom right).

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HIM Domain Area: Clinical Data Management

Article—"Collect Once, Use Many"

1. Which of the following statements is true?
 - a. Clinical guidelines used in electronic health records depend on the availability of coded data in order to satisfy their criteria for use.
 - b. An "infobutton" could be used to link an EHR with health plans that pay for care, replacing claims attachments as the preferred method for sharing clinical information with payers.
 - c. One of the significant challenges to representing patient data with controlled terminologies is computer processing and storage limitations.
 - d. Laboratories never make changes to their terminologies.
2. Which of the following does not belong in a list of named standards in clinical terminologies?
 - a. SNOMED CT
 - b. LOINC
 - c. RxNorm
 - d. HIPAA
3. Which two areas can reduce barriers to system adoption of controlled terminology use?
 - a. use of macros and templates in document creation
 - b. user interface design and natural language processing
 - c. ICD-10-CM and ICD-10-PCS
 - d. the Continuity of Care Record and Continuity of Care Document standards
4. Classification systems work with controlled terminologies to identify how individual coded items can be grouped.
 - a. true
 - b. false
5. Controlled terminologies are unable to play a role in clinical system alerts.
 - a. true
 - b. false
6. Which of the following statements provides the path to greater reuse of data after capture?
 - a. concentration on one standard terminology for all clinical data representation
 - b. when additional parts of records are encoded, greater capacity to build systems that reuse data is possible
 - c. textual portion of the records are increased to share more information in standard documents
 - d. all of the above
7. Clinical terminologies must _____.
 - a. represent specific domains limited to specific settings of care
 - b. cover payment requirements for health plans
 - c. cover terms in specific domains
 - d. none of the above
8. Which of the following is considered a technical limitation of ICD-9-CM for capture and reuse of data?
 - a. lack of alpha characters in the codes
 - b. it is not included in the UMLS
 - c. it has an inability to allow multiple classification of terms
 - d. all of the above
9. There is significant resistance to adoption of some terminologies as standards.
 - a. true
 - b. false
10. Computers help with reuse of data when the data are represented in meaningful ways.
 - a. true
 - b. false

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Please see the answer form on page 32

