Standards in Medical Informatics

Article · January 2001

DOI: 10.1007/978-0-387-21721-5_6

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Chapter 6

Standards in Medical Informatics

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After reading this chapter, you should know the answers to these questions:

- Why are standards important in medical informatics?
- What organizations are active in standards development?
- What aspects of medical information management are supported today by standards?
- What is the process for creating consensus standards?
- What factors and organizations influence the creation of standards?

6.1 The Notion of Standards

Ever since Eli Whitney developed interchangeable parts for rifle assembly, standards have been created and used to make things or processes work more easily and economically—or, sometimes, to work at all. A standard can be defined in many physical forms, but essentially it comprises a set of rules and definitions that specify how to carry out a process or produce a product. Sometimes, a standard is useful because it provides a way to solve a problem that other people can use without having to start from scratch. Generally, though, a standard is useful because it permits two or more disassociated people to work in some cooperative way. Every time you screw in a light bulb or play a music cassette, you are taking advantage of a standard. Some standards evolve over time;[1] others are developed deliberately.

The first computers were built without standards, but hardware and software standards quickly became a necessity. Although computers work with values such as 1 or 0, and with "words" such as 10101100, humans need a more readable language (see Chapter 4). Thus, standard character sets, such as ASCII and EBCDIC, were developed. The first standard computer language,

[1] The current standard for railroad-track gauge originated with Roman chariot builders, who set the axle length based on the width of two horses. This axle length became a standard as road ruts developed, requiring that the wheels of chariots—and all subsequent carriages—be the right distance apart to drive in the ruts. When carriage makers were called on to develop railway rolling stock, they continued to use the same axle standard.

COBOL, was written originally to simplify program development, but was soon adopted as a way to allow sharing of code and development of software components that could be integrated. As a result, COBOL was given official standard status by the American National Standards Institute (ANSI).[2] In like manner, hardware components depend on standards for exchanging information to make them as interchangeable as were Whitney's gun barrels.

A 1987 technical report from the International Standards Organization states that "Any meaningful exchange of utterances depends upon the prior existence of an agreed upon set of semantic and syntactic rules" [International Standards Organization, 1987]. In medical informatics, where the emphasis is on collection, manipulation, and transmission of information, standards are greatly needed, but have only recently begun to be available. At present, the standards scene is evolving so rapidly that any description is inevitably outdated within a few months. In this chapter we therefore emphasize the need for standards in general, standards-development processes, current active areas of standards development, and key participating organizations that are making progress in the development of usable standards.

6.2 The Need for Health-Informatics Standards

Standards are generally required when excessive diversity creates inefficiencies or impedes effectiveness. The health-care environment has traditionally consisted of a set of loosely connected, organizationally independent units. Patients receive care across primary, secondary, and tertiary care settings, with little bidirectional communication and coordination among the services. Patients are cared for by one or more primary physicians, as well as by specialists. There is little coordination and sharing of data between inpatient care and outpatient care. Both the system and patients, by choice, create this diversity in care. Within the inpatient setting, the clinical environment is divided into clinical specialties that frequently treat the patient without regard to what other specialities have done. Ancillary departments function as detached units, performing their tasks as separate service units, reporting results without followup about how those results are used or whether they are even seen by the ordering physician. Reimbursement requires patient information that is often derived through a totally separate process, based on the fragmented data collected in the patient's medical record and abstracted specifically for billing purposes. The resulting set of diagnosis and procedure codes often correlates poorly with the patient's original information [Jollis et al., 1993].

Early hospital information systems (HISs) for billing and accounting purposes were developed on large, monolithic mainframe computers (see Chapter 10); they followed a pattern of diversity similar to that seen in the health-care system itself. As new functions were added in the 1970s, they were implemented on mainframe computers and were managed by a data-processing staff that usually was independent of the clinical, and even of the administrative, staff. The advent of the minicomputer supported the development of departmental systems, such as those for the clinical laboratory, radiology, or pharmacy. This model of the central mainframe coupled with independent minicomputer-based departmental systems is still common in installed systems today. Clinical systems, as they have developed, continue to focus on dedicated departmental operations,

[2] Interestingly, medical informaticians were responsible for the second ANSI standard language: MUMPS (now known as M).

and clinical-specialty systems thus do not permit the practicing physician to see a unified view of the patient.

There are many pressures on health-care information systems to change the status quo such that data collected for a primary purpose can be reused in a multitude of ways. Newer models for health-care delivery, such as integrated delivery networks, health maintenance organizations (HMOs) and preferred provider organizations (PPOs), have increased the need for coordinated, integrated, and consolidated information (see Chapters 10 and 19), even though the information comes from disparate departments and institutions. Various management techniques, such as continuous quality improvement and case management, require up-to-date, accurate abstracts of patient data. Post-hoc analyses for clinical and outcomes research require comprehensive summaries across patient populations. Advanced tools, such as clinical workstations (Chapter 9) and decision-support systems (Chapter 16), require ways to translate raw patient data into generic forms for tasks as simple as summary reporting and as complex as automated medical diagnosis. All these needs must be met in the existing setting of diverse, interconnected information systems—an environment that cries out for implementation of standards.

One obvious need is for standardized identifiers for individuals, health-care providers, health plans, and employers so that such individuals can be recognized across systems. Choosing such an identifier is much more complicated than simply deciding how many digits the identifier should have. Ideal attributes for these sets of identifiers have been described in a publication from the American Society for Testing and Materials (ASTM) [American Society for Testing and Materials, 1999]. The identifier must include a check digit to ensure accuracy when the identifier is entered by a human being into a system. A standardized solution must also determine mechanisms for issuing identifiers to individuals, facilities, and organizations; for maintaining databases of identifying information; and for authorizing access to such information (also see Chapter 10).

The Health Care Financing Administration (HCFA) has defined a National Provider Identifier (NPI) that will likely become the national standard. This number is a seven-character alphanumeric base identifier plus a one-character check digit. No meaning is built into the number, each number is unique and is never reissued, and alpha characters that might be confused with numeric characters (for example, 0, 1, 2, 4, and 5 can be confused with O, I or L, Z , Y, and S) have been eliminated. HCFA has also defined a Payor ID for identifying health-care plans. A proposal has been made to use the Internal Revenue Service's employer-identification number for employers.

The most controversial issue is identifying each individual or patient. Many people consider assignment and use of such a number to be an invasion of privacy and are concerned that it could be easily linked to other databases. Public Law 104-191, passed in August 1996 (see Section 6.3.3) requires that Congress formally define suitable identifiers. The Department of Health and Human Services has recommended the identifiers discussed above, except for the person identifier. The decision was made to postpone that recommendation until privacy legislation is in place (see Chapter 7).

We also need standards for encoding data about the patient that are collected by one system and used by another. A hospital-admissions system records that a patient has the diagnosis of diabetes mellitus, a pharmacy system records that the patient has been dispensed gentamicin, a laboratory system records that the patient had certain results on kidney-function tests, and a radiology system records that a doctor has ordered an X-ray examination for the patient that requires

intravenous iodine dye. Other systems need ways to store these data, to present the data to clinical users, to send warnings about possible disease–drug interactions, to recommend dosage changes, and to follow the patient's outcome. A standard for coding patient data is nontrivial when one considers the need for agreed-on definitions, use of qualifiers, differing (application-specific) levels of granularity in the data, and synonymy, not to mention the breadth and depth that such a standard would need to have.

The inclusion of medical knowledge in clinical systems is becoming increasingly important and commonplace. Sometimes, the knowledge is in the form of simple facts, such as the maximum safe dose of a medication or the normal range of results for a laboratory test. Much medical knowledge is more complex, however. It is challenging to encode such knowledge in ways that computer systems can use (see Chapter 2), especially if one needs to avoid ambiguity and to express logical relations consistently. Thus the encoding of clinical knowledge using an accepted standard would allow many people and institutions to share the work done by others. One standard designed for this purpose is the Arden Syntax, discussed in Chapter 16.

Because the tasks we have described require coordination of systems, methods are needed for transferring information from one system to another. Such transfers were traditionally accomplished through custom-tailored point-to-point interfaces, but this technique has become unworkable as the number of systems and the resulting permutations of necessary connections have grown. A current approach to solving the multiple-interface problem is through the development of messaging standards. Such messages must depend on the pre-existence of standards for patient identification and data encoding.

Although the technical challenges are daunting, methods for encoding patient data and shipping those data from system to system are not sufficient for developing practical systems. Security must also be addressed before such exchanges can be allowed to take place. Before a system can divulge patient information, it must ensure that requesters are who they say they are and are permitted access to the requested information (see Chapter 4). Although each clinical system can have its own security features, system builders would rather draw on available standards and avoid reinventing the wheel. Besides, the secure exchange of information requires that interacting systems use standard technologies. Fortunately, many researchers are busy developing such standards.

6.3 Standards Undertakings and Organizations

It is helpful to separate our discussion of the general process by which standards are created from our discussion of the specific organizations and the standards that they produce. The process is relatively constant, whereas the organizations form, evolve, merge and are disbanded. Let us consider, for purposes of illustration, how a standard might be developed for sending laboratory data, in electronic form, from one computer system to another in the form of a message.

6.3.1 The Standards-Development Process

There are four ways in which a standard can be produced:

1. *Ad hoc method:* A group of interested people and organizations (for example, laboratory-system and hospital-system vendors) agree on a standard specification. These specifications are informal and are accepted as standards through mutual agreement of the participating groups. An example produced by this method is the American College of Radiology/National Electrical Manufacturers Association (ACR/NEMA) DICOM standard for medical imaging.

2. *De facto method:* A single vendor controls a large enough portion of the market to make its product the market standard. An example is Microsoft's Windows.
3. *Government-mandate method:* A government agency, such as the Health-Care Financing Administration (HCFA) or the National Institute for Standards and Technology (NIST) creates a standard and legislates its use. An example is HCFA's UB92 insurance-claim form.
4. *Consensus method:* A group of volunteers representing interested parties work in an open process to create a standard. Most health-care standards are produced by this method. An example is the Health Level 7 (HL7) standard for clinical-data interchange (Figure 6.1).

Insert Figure 6.1 (HL-7 group photo) About Here

The process of creating a standard proceeds through several stages [Libicki, 1995]. It begins with an *identification stage*, during which someone becomes aware that there exists a need for a standard in some area and that technology has reached a level that can support such a standard. In our example, suppose there are several laboratory systems sending data to several central hospital systems—a standard message format would allow each laboratory system to talk to all the hospital systems without specific point-to-point interface programs being developed for each possible laboratory-to-laboratory or laboratory-to-hospital combination. If the time for a standard is ripe, then several individuals can be identified and organized to help with the *conceptualization stage*, in which the characteristics of the standard are defined. What must the standard do? What is the scope of the standard? What will be its format? In the laboratory system example above, one key discussion would be on the scope of the standard. Should the standard deal only with the exchange of laboratory data or should the scope be expanded to include other types of data exchange? Should the data elements being exchanged be sent with a tag identifying the data element, or should the data be defined positionally? In the ensuing *discussion stage*, the participants will begin to create an outline that defines content, to identify critical issues, and to produce a time line. In the discussion, the pros and cons of the various concepts are discussed. What will be the specific form for the standard? For example, will it be message-based? Will the data exchange be based on a query or on a trigger event? Will the standard define the message content, the message syntax, the vocabulary, and the network protocol, or will the standard deal with a subset of these issues?

The participants are generally well informed in the domain of the standard, so they appreciate the needs and problems that the standard must address. Basic concepts are usually topics for heated discussion; subsequent details may follow at an accelerated pace. Many of the participants will have experience in solving problems to be addressed by the standard and will protect their own approaches. The meanings of words are often debated. Compromises and loosely defined terms are often accepted to permit the process to move forward. In our example, the likely participants would be vendors of competing laboratory systems and vendors of competing hospital systems. All participants would be familiar with the general problems, but would have their own proprietary approach to solving them. Definitions of basic concepts normally taken for granted, such as what constitutes a test or a result, would need to be clearly stated and agreed on.

The writing of the draft standard is usually the work of a few, dedicated individuals—typically people who represent the vendors in the field. Other people then review that draft; controversial

points are discussed in detail, and solutions are proposed and finally accepted. Writing and refining the standard is further complicated by the introduction of people new to the process who have not been privy to the original discussions and who want to revisit points that have been resolved earlier. The balance between moving forward and being open is a delicate one. Most standards-writing groups have adopted an **open policy**: Anyone can join the process and can be heard. Most standards-development organizations—certainly those by accredited groups—support an open balloting process. A draft standard is made available to all interested parties, inviting comments and recommendations. All comments are considered. Negative ballots must be addressed specifically. If the negative comments are persuasive, the standard is modified. If they are not, the issues are discussed with the submitter in an attempt to convince the person to remove the negative ballot. If neither of these efforts is successful, the comments are sent to the entire balloting group to see whether the group is persuaded to change its vote. The resulting vote then determines the content of the standard. Issues might be general, such as deciding what types of laboratory data to include (pathology? blood bank?), or specific, such as deciding the specific meanings of specific fields (do we include the time the test was ordered? specimen drawn? test performed?).

A standard will generally go through several versions on its path to maturity. The first attempts at implementation are frequently met with frustration as participating vendors interpret the standard differently and as areas not addressed by the standard are encountered. These problems may be dealt with in subsequent versions of the standard. Backward compatibility is a major concern as the standard evolves. How can the standard evolve, over time, and still be economically responsible to both vendors and users? An implementation guide is usually produced to help new vendors profit from the experience of the early implementers.

A critical stage in the life of a standard is *early implementation*, when acceptance and rate of implemention are important to success. This process is influenced by accredited standards bodies, by the federal government, by major vendors, and the marketplace. The maintenance and promulgation of the standard are also important to ensure widespread availability and continued value of the standard. Some form of conformance testing is ultimately necessary to ensure that vendors adhere to the standard and to protect its integrity.

Producing a standard is an expensive process in terms of both time and money. Vendors and users must be willing to support the many hours of work, usually on company time; the travel expense; and the costs of documentation and distribution. In the United States, the production of a consensus standard is voluntary, in contrast to in Europe, where most standards development is funded by governments.

An important aspect of standards is *conformance*, a concept that covers compliance with the standard and also usually includes specific agreements among users of the standard who affirm specific rules will be followed. An example of a group that has defined a conformance specification for HL7 is the Andover Working Group, a consortium of vendors and health-care–provider organizations, which is using HL7 (see Section 6.5.2) and other standards. The conformance document identifies specifically what data elements will be sent, when, and in what form.

A second important concept is *certification*. The use of most standards is enhanced by a certification process in which a neutral body certifies that a vendor's product in fact does comply and conform with the standard.

6.3.2 Information-Standards Organizations

Sometimes, standards are developed by organizations that need the standard to carry out their principal functions; in other cases, coalitions are formed for the express purpose of developing a particular standard. The latter organizations will be discussed later, when we examine the particular standards developed in this way. There are also *standards organizations* that exist for the sole purpose of fostering and promulgating standards. In some cases, they include a membership with expertise in the area where the standard is needed. In other cases, the organization provides the rules and framework for standard development but does not offer the expertise needed to make specific decisions for specific standards, relying instead on participation by knowledgeable experts when a new standard is being studied.

In this section we describe in some detail several of the best-known **Standards Development Organizations (SDOs)**. Our goal has been to familiarize you with the names or organizational and historical aspects of the most influential health-related standards groups. For a detailed understanding of an organization or the standards it has developed, you will need to refer to current primary resources. Many of the organizations maintain web sites with excellent current information on their status.

American National Standards Institute (ANSI)

{**NOTE TO EDITORS: this section reduced in font size to minimize it's emphasis}

The American National Standards Institute (ANSI) is a private, nonprofit membership organization founded in 1918. It originally served to coordinate the U.S. voluntary census standards systems. Today, it is responsible for approving official *American National Standards*. ANSI membership includes over 1100 companies; 30 government agencies; and 250 professional, technical, trade, labor, and consumer organizations.

ANSI does not write standards; rather, it assists standards developers and users from the private sector and from government to reach consensus on the need for standards. It helps them to avoid duplication of work, and it provides a forum for resolution of differences. ANSI administers the only government-recognized system for establishing American National Standards. ANSI also represents U.S. interests in international standardization. ANSI is the U.S. voting representative on the International Standards Organization (ISO) and the International Electrotechnical Commission (IEC). There are three routes for a standards-development body to become ANSI approved so as to produce an American National Standard: Accredited Organization, Accredited Standards Committee, and Accredited Canvass.

An organization that has existing organizational structure and procedures for standards development may be directly accredited by ANSI to publish American National Standards, provided that it can meet the requirements for due process, openness, and consensus. HL7 (discussed in Section 6.5.2) is an example of an ANSI Accredited Organization.

ANSI may also create internal Accredited Standards Committees (ASCs) to meet a need not filled by an existing Accredited Organization. ASC X12 (discussed in Section 6.5.2) is an example of such a committee.

The final route, Accredited Canvass, is available when an organization does not have the formal structure required by ANSI: Through a canvass method that meets the criterion of balanced representation of all interested parties, a standard may be approved as an American National Standard. For example, ACR/NEMA (Section 6.5.2) could choose to use this method to publish its imaging standard as an American National Standard.

Technical Committee 251 (CEN TC 251)

The European Committee for Standardization, (Comité Europeén de Normalisation—CEN), established Technical Committee 251 (TC 251) in 1991 for the development of standards for health-care informatics. The major goal of TC 251 is to develop standards for communication among independent medical information systems so that clinical and management data produced by one system can be transmitted to another system. The organization of TC 251 parallels work in the United States through various Working Groups. These groups similarly deal with a

data-interchange standard; medical-record standards; code and vocabulary standards; imaging standards; and security, privacy, and confidentiality. Both Europe and the United States are working to coordinate all areas of standardization. Draft standards are being shared. Common solutions are being accepted as desirable. Groups are working together at various levels toward a common goal. Standards of interest include EUCLIDES, for interfacing reference laboratory systems to health-care settings, EDIFACT, for transmission of electronic documents, and a message standard developed by Project Team 007 (PT007) for transmitting content of electrocardiogram (ECG) carts to computers (EUCLIDES, EDIFACT and PT007 are further discussed at the end of Section 6.5.2).

Technical Committee 215 (ISO TC 215)

In January 1998, the International Standards Organization (ISO) created a new technical committee (TC 215) for medical informatics. The scope of this TC is standardization in the field of information for health and health information and communications technology to achieve compatibility and interoperability between independent systems. The TC will also address issues required to ensure compatibility of data for comparative statistical purposes and to reduce duplication of effort and redundancies. The U.S. has been assigned the duties of Secretariat, and those duties have been specifically assigned to ASTM (see below). ASTM will also serve as the Technical Advisory Group Administrator.

American Society for Testing and Materials (ASTM)

The American Society for Testing and Materials (ASTM) was founded in 1898 and chartered in 1902 as a scientific and technical organization for the development of standards on characteristics and performance of materials. The original focus of ASTM was standard test methods. The charter was subsequently broadened in 1961 to include products, systems, and services, as well as materials. ASTM is the largest nongovernment source of standards in the United States. It has over 30,000 members who reside in over 90 different countries. ASTM is a charter member of ANSI. ASTM technical committees are assigned 12 ISO committee and subcommittee secretariats and have over 50 assignments to serve as Technical Advisory Groups (TAGs) for developing U.S. positions on international standards. ASTM Committee E31 on Computerized Systems is responsible for the development of the medical-information standards. Table 6.1 shows the domains of its various subcommittees.

Insert Table 6.1 About Here

Healthcare Informatics Standards Board (HISB)

Responding to a request by CEN TC251 to identify a single American organization that represents the standards work in the United States, ANSI formed a Healthcare Informatics Standards Planning Panel (HISPP) in January 1992. This panel had a balanced representation from standards-development groups, health-care vendors, government agencies, and health-care providers.

One of the charter goals of the HISPP was to coordinate the work of the message-standards group for health-care data interchange and health-care informatics to achieve the evolution of a unified set of nonredundant, nonconflicting standards that is compatible with ISO and non-ISO communications environments. In addition, a balanced subcommittee of the planning panel was formed to interact with and to provide input to CEN TC 251 in a coordinated fashion, and to explore avenues of international standards development. A second subcommittee, with the specific objective of coordinating HISPP activities with TC 251, met in November 1992 and agreed to basic rules in the distribution of working documents (once approved by HISPP) to TC 251.

As work progressed, and more organizations became actively interested in health-care standards, ANSI and the members of HISPP recognized the need for a permanent body to coordinate the health-care–standards activities. The ANSI Board was petitioned to form a Health-Care Informatics Board. In December 1995, the HISPP was dissolved and the Health-Care Informatics Standards Board (HISB) was created.

The scope of the HISB includes standards for

1. Health-care models and electronic health-care records

2. Interchange of health-care data, images, sounds, and signals within and between organizations and practices
3. Health-care codes and terminology
4. Communication with diagnostic instruments and health-care devices
5. Representation and communication of health-care protocols, knowledge, and statistical databases
6. Privacy, confidentiality, and security of medical information
7. Additional areas of concern or interest with regard to health-care information

A major contribution of the HISB has been the creation and maintenance of an Inventory of Health Care Information Standards pertaining to the Health Insurance Portability and Accountability Act of 1996 (discussed in Section 6.3.3).

Computer-Based Patient Record Institute (CPRI)

The Computer-Based Patient Record Institute (CPRI) has been an active proponent of standards activities since its inception in 1992. Although not a standards developer, CPRI has made major contributions in the area of content of the computer-based patient record; security, privacy, and confidentiality; the universal health identifier; and vocabulary and terminology.

6.3.3 Health Insurance Portability and Accountability Act of 1996

The Health Insurance Portability and Accountability Act of 1996 (HIPAA) was signed into law on August 21, 1996. The administrative-simplification portion of HIPAA requires that the Secretary of Health and Human Services (HHS) adopt standards for the electronic transmission of specific administrative transactions. These standards will apply to health plans, health-care clearinghouses, and health-care providers who transmit any health information in electronic form; Figure 6.2 shows the kinds of transactions covered. Recommendations made thus far include the use of X12N standards for health claims.

Insert Figure 6.2 About Here

6.4 Coded Terminologies, Vocabularies, and Nomenclatures

As we discussed in Chapter 2, the capture, storage, and use of clinical data in computer systems is complicated by lack of agreement on terms and meanings. The many terminologies discussed in this section have been developed to ease the communication of coded medical information.

6.4.1 Motivation for Controlled Terminologies

The encoding of medical information is a basic function of most clinical systems. Standards for such encoding can serve two purposes. First, they can save system developers from reinventing the wheel. For example, if an application allows caregivers to compile problem lists about their patients, using a standard vocabulary saves developers from having to create their own. Second, using commonly accepted standards can facilitate exchange of data among systems. For example, if a central database is accepting clinical data from many sources, the task is greatly simplified if each source is using the same coding scheme. System developers often ignore available standards and continue to develop their own solutions. It is easy to believe that the developers have resisted adoption of standards because it is too much work to understand and adapt to any system that

was "not invented here." The reality, however, is that the available standards are often inadequate for the needs of the users (in this case, system developers). As a result, no standard terminology enjoys the wide acceptance sufficient to facilitate the second function: exchange of coded clinical information.

In discussing coding systems, the first step is to clarify the differences among a **terminology**, a **vocabulary**, and a **nomenclature**. These terms are often used interchangeably by creators of coding systems and by authors discussing the subject. Fortunately, although there are few accepted standard terminologies, there is a generally accepted standard *about* terminology: ISO Standard 1087 (Terminology - Vocabulary). Figure 6.3 lists the various definitions for these terms. For our purposes, we consider the currently available standards from the viewpoint of their being terminologies.

Insert Figure 6.3 About Here

The next step in the discussion is to determine the basic use of the terminology. In general, there are two different levels relevant to medical data encoding: abstraction and representation. **Abstraction** entails examination of the recorded data, and then selection of an item from a terminology with which to label the data. For example, a patient might be admitted to the hospital and have a long and complex course; for the purposes of billing, however, it might be relevant only that the patient was diagnosed as having had a myocardial infarction. Someone charged with abstracting the record to generate a bill might then reduce the entire set of information to a single code. **Representation**, on the other hand, is the process by which as much detail as possible is coded. So, for our medical-record example, the representation might include codes for each physical finding noted, laboratory test performed, and medication administered.

When we discuss a controlled terminology, we should consider the domain of discourse. Virtually any subject matter can be coded, but there must be a good match with any standard selected for the purpose. For example, a terminology used to code disease information might be a poor choice for coding entries on a problem list, since it might lack items such as "Abdominal Pain," "Cigarette Smoker," or "Health Maintenance."

The next consideration is the content of the standard itself. There are many issues, including the degree to which the standard covers the terminology of the intended domain; the degree to which data are coded by assembly of terms into descriptive phrases (postcoordination) versus selection of a single, precoordinated term; and the overall structure of the terminology (list, strict hierarchy, multiple hierarchy, semantic network, and so on). There are also many qualitative issues to consider, including the availability of synonyms and the possibility of redundant terms (that is, more than one way to encode the same information).

Finally, we should consider the methods by which the terminology is maintained. Every standard terminology must have an ongoing maintenance process or it will become obsolete rapidly. The process must be timely, and must not be disruptive to people using an older version of the terminology. For example, if the creators of the terminology choose to rename a code, what happens to the data previously recorded with that code?

6.4.2 Specific Terminologies

With these considerations in mind, let us survey some of the several popular, available controlled terminologies. People often say, tongue in cheek, that the best thing about standards is that there are so many from which to choose. We give introductory descriptions of a few current and common terminologies. New terminologies appear annually, and existing proprietary terminologies often become publicly available. When reviewing the following descriptions, try to keep in mind the background motivation for a development effort. All these standards are evolving rapidly and you should consult their web sites or other primary sources for the most recent information.

International Classification of Diseases and Its Clinical Modifications

{**NOTE TO EDITORS: this section reduced in font size to minimize it's emphasis}

One of the best-known terminologies is the *International Classification of Diseases* (ICD). First published in 1983, it has been revised at roughly 10-year intervals, first by the Statistical International Institute, and later by the World Health Organization (WHO). The *Ninth Edition* (ICD-9) was published in 1977 [World Health Organization, 1977], and the *Tenth Edition* (ICD-10) in 1992 [World Health Organization, 1992]. The coding system consists of a *core classification* of three-digit codes that are the minimum required for reporting mortality statistics to WHO. A fourth digit (in the first decimal place) provides an additional level of detail; usually .0 to .7 are used for more specific forms of the core term, .8 is usually "other," and .9 is "unspecified." Terms are arranged in a strict hierarchy, based on the digits in the code. For example, bacterial pneumonias are classified as shown in Figure 6.4. In addition to diseases, ICD also includes several "families" of terms for medical-specialty diagnoses, health status, disablements, procedures, and reasons for contact with health-care providers.

Insert Figure 6.4 About Here

ICD-9 has generally been perceived as inadequate for the level of detail desired for statistical reporting in the United States [Kurtzke, 1979]. In response, the United States National Center for Health Statistics published a set of **clinical modifications** [Commission on Professional and Hospital Activites, 1978]. **ICD-9-CM**, as it is known, is compatible with ICD-9, and provides extra levels of detail in many places by adding fourth- and fifth-digit codes. Figure 6.5 shows a sample additional detail. Most of the diagnoses assigned in the United States are coded in ICD-9-CM, allowing compliance with international treaty (by conversion to ICD-9) and supporting billing requirements (by conversion to *diagnosis-related groups*, or DRGs). A clinical modification for ICD-10 has not yet been produced.

Insert Figure 6.5 About Here

Diagnosis-Related Groups

Another U.S. creation for the purpose of abstracting medical records is the *diagnosis-related groups* (DRGs), developed initially at Yale University for use in prospective payment in the Medicare program [3M Health Information System, updated annually]. In this case, the coding system is an abstraction of an abstraction: It is applied to lists of ICD-9-CM codes that are themselves derived from medical records. The purpose of DRG coding is to provide a relatively small number of codes for classifying patient hospitalizations, while also providing some separation of cases based on severity of illness. The principal bases for the groupings are factors that affect cost and length of stay. Thus, a medical record containing the ICD-9-CM *primary* diagnosis of Pneumococcal Pneumonia (481) might be coded with one of 18 codes (Figure 6.6), depending on associated conditions and procedures; additional codes are possible if the pneumonia is a secondary diagnosis.

Insert Figure 6.6 About Here

International Classification of Primary Care

The World Organization of National Colleges, Academies and Academic Associations of General Practitioners/Family Physicians (WONCA) publishes the International Classification of Primary Care (ICPC) with the World Health Organization. ICPC is a classification of some 800 diagnostic concepts that are partially mapped into ICD-9. ICPC contains all 380 concepts of the *International Classification of Health Problems in Primary Care (ICHPPC), Third Edition*, including reasons for an encounter. ICPC provides seven axes of terms and a structure to combine them to represent clinical encounters. Although the granularity of the terms is generally larger than that of other classifications schemes (for example, all pneumonias are coded as R81), the ability to represent the interactions of the concepts found in a medical record is much greater through the *postcoordination* of atomic terms. In postcoordination, the coding is accomplished through the use of multiple codes as needed to describe the data. So, for example, a case of bacterial pneumonia would be coded in ICPC as a combination of the code R81 and the code for the particular test result that identifies the causative agent. This method is in contrast to the *precoordination* approach, in which every type of pneumonia is assigned its own code.

Current Procedural Terminology

The American Medical Association developed the *Current Procedural Terminology* (CPT) in 1966 [American Medical Association, updated annually] to provide a precoordinated coding scheme for diagnostic and therapeutic procedures that has since been adopted in the United States for billing and reimbursement. Like the DRG codes, CPT codes specify information that differentiates the codes based on cost. For example, there are different codes for pacemaker insertions, depending on whether the leads are "epicardial, by thoracotomy" (33200), "epicardial, by xiphoid approach" (33201), "transvenous, atrial" (33206), "transvenous, ventricular" (33207), or "transvenous, AV sequential" (33208). CPT also provides information about the reasons for a procedure. For example, there are codes for arterial punctures for "withdrawal of blood for diagnosis" (36600), "monitoring" (36620), "infusion therapy" (36640), and "occlusion therapy" (75894). Although limited in scope and depth, the CPT-4 is the most widely accepted nomenclature in the United States for reporting physician procedures and services for federal and private-insurance third-party reimbursement.

Diagnostic and Statistical Manual of Mental Disorders

The American Psychiatric Association published its *Diagnostic and Statistical Manual of Mental Disorders, Revised Third Edition* (DSM-III-R) in 1987 [American Psychiatric Association, 1987], and the *Fourth Edition* (DSM-IV) in 1994 [American Psychiatric Association, 1994], revised in 1996 (DSM-IV-R). The DSM nomenclature provides definitions of psychiatric disorders and includes specific diagnostic criteria. Thus, it is used not only for coding patient data, but also as a tool for assigning diagnoses. Each edition of DSM has been coordinated with corresponding editions of ICD; DSM-IV is coordinated with ICD-10.

Systematized Nomenclature of Medicine and Its Predecessors

Drawing from the New York Academy of Medicine's *Standard Nomenclature of Diseases and Operations* (SNDO)[New York Academy of Medicine, 1961], the College of American Pathologists developed the *Standard Nomenclature of Pathology* (SNOP) as a multiaxial system for describing pathologic findings [College of American Pathologists, 1971] through postcoordination of topographic (anatomic), morphologic, etiologic, and functional terms. SNOP has been used widely in pathology systems in the United States; its successor, the *Systematized Nomenclature of Medicine* (SNOMED) has evolved beyond an abstracting scheme to become a comprehensive coding system.

Largely the work of Roger Côté and David Rothwell, SNOMED was first published in 1975, then was revised as SNOMED II in 1979. SNOMED 3 is a greatly expanded version: the *Systematized Nomenclature of Human and Veterinary Medicine—SNOMED International* [Côté et al., 1993]. SNOMED consists of a set of axes (now 11), each of which serves as a taxonomy for a specific set of concepts (organisms, diseases, procedures, and so on),

containing a total of over 130,000 terms. Coding of patient information is accomplished through the postcoordination of terms from multiple axes to represent complex terms that may be desired but do not exist in SNOMED. For example, although many of the various bacterial pneumonia terms seen in other terminologies are in SNOMED (Figure 6.7), a user can construct additional terms by pairing a generic pneumonia term with a bacteria term taken from the Living Organism axis.

Insert Figure 6.7 About Here

Despite its long history and extensive efforts to provide the codes needed for coding in electronic medical records, SNOMED has not been widely embraced. The latest version goes a long way toward addressing past complaints about missing terms; however, the structure of previous versions, also found to be an impediment to use, has persisted in SNOMED International. The main problem with using SNOMED for coding patient information is that it is *too* expressive. Because there are few rules about how the postcoordination coding should be done, the same expression might end up being represented differently by different coders. For example, "acute appendicitis" can be coded as a single disease term, as a combination of a modifier ("acute") and a disease term ("appendicitis"), or as a combination of a modifier ("acute"), a morphology term ("inflammation") and a topography term ("vermiform appendix"). Each of these codings is correct, yet there is no formal way, in SNOMED, to know that they have equivalent meaning. Such freedom of expression may be welcome to people who must encode human utterances, but it is frustrating to system developers who must make sure that their applications can recognize medical concepts.

A recent development in the evolution of SNOMED is the creation of a "reference terminology" (SNOMED-RT) that is designed to encourage consistent use of the terms by defining explicitly the relationships among them. Some of the problems with earlier versions of SNOMED are being resolved in this process [Campbell et al., 1998].

Read Clinical Codes

The *Read Clinical Codes* comprise a set of codes designed specifically for use in coding electronic medical records. Developed by James Read in the 1980s [Read, 1990; Read & Benson, 1986], the first version was adopted by the British National Health Service in 1990. Version 2 was developed to meet the needs of hospitals for cross-mapping their data to ICD-9. Version 3 [NHS Centre, 1994a] was developed to support not only medical-record summarization, but also patient-care applications directly. Whereas previous versions of the Read Codes were organized in a strict hierarchy, Version 3 took an important step by allowing terms to have multiple parents in the hierarchy; that is, the hierarchy became that of a directed acyclic graph. Figure 6.8 shows the hierarchy for bacterial pneumonia. Version 3.1 added the ability to make use of term modifiers through a set of templates for combining terms in specific, controlled ways so that both precoordination and postcoordination is used. Finally, the NHS has undertaken a series of *terms projects* that are expanding the content of the Read Codes to ensure that the terms needed by practitioners are represented in the Codes [NHS, 1994b].[3]

Insert Figure 6.8 About Here

Gabrieli Medical Nomenclature

Also in the 1980s, Elmer Gabrieli developed the *Gabrieli Medical Nomenclature* [Gabrieli, 1989] at the University of Buffalo. The system was then adopted for use in a proprietary system. It consists of a single, large hierarchy that contains successively more complex expressions as you move down through the hierarchy. The aim

[3] In 1999, the developers and maintainers of SNOMED and the Read Codes announced that they had reached an agreement to merge their efforts and to produce a single joint clinical terminology. This promising development suggests that a single terminology suitable for clinical patient records may be in sight.

of this system is to take precoordination to the extreme, providing a code for every utterance that might be found in a medical record (Figure 6.9). Although initially available as a commercial product, the developers have used it as the basis for nomenclature work under the ASTM [ASTM, 1989]. The ASTM is currently working to move this nomenclature through the standards-development process.

Insert Figure 6.9 About Here

Nursing Terminologies

Nursing organizations have been extremely active in the development of standard coding systems for abstracting patient records. One review counted a total of 13 separate projects worldwide [Wake et al., 1993]. These projects have arisen because general medical terminologies fail to represent the kind of clinical concepts needed in nursing care. For example, the kinds of problems that appear in a physician's problem list (for example, "myocardial infarction" and "diabetes mellitus") are relatively well represented in the many of the terminologies that we have described, but the kinds of problems that appear in a nurse's assessment (for example, "activity intolerance" and "knowledge deficit related to myocardial infarction") are not (also see Chapter 12). Preeminent nursing terminologies include the *Nursing Intervention Classification System* (NIC), the *Nursing Outcomes Classification* (NOC), the *Georgetown Home Health Care Classification* (HHCC), and the Omaha System (which covers problems, interventions, and outcomes). Despite the proliferation of standards for nursing terminologies, gaps remain in the coverage of this domain [Henry & Mead, 1997].

GALEN

In Europe, a consortium of universities, agencies and vendors, with funding from the Advanced Informatics in Medicine initiative (AIM), has formed the GALEN project to develop standards for representing coded patient information [Rector et al., 1995]. GALEN is developing a reference model for medical concepts using a formalism called Structured Meta Knowledge (SMK). In SMK, terms are defined through relationships to other terms, and grammars are provided to allow combinations of terms into sensible phrases. The reference model is intended to allow representation of patient information in a way that is independent of the language being recorded and of the data model used by an electronic medical record system. The GALEN developers are working closely with CEN TC 251 (see Section 6.2.2) to develop the content that will populate the reference model with actual terms.

Logical Observations, Identifiers, Names and Codes

An independent consortium, led by Clement J. McDonald and Stanley M. Huff, has created a naming system for tests and observations. Originally called *Laboratory Observations, Identifiers, Names and Codes* (LOINC), the system is being extended to include nonlaboratory observations (vital signs, electrocardiograms, and so on), so *Logical* has replaced *Laboratory* to reflect the change [ASTM, 1994]. Figure 6.10 shows some typical *fully specified names* for common laboratory tests. The standard specifies structured coded semantic information about each test, such as the substance measured and the analytical method used. Using this system, a person can code new names for new tests, which can be recognized by other users of the coded information; however, officially recognized names (such as those in the Figure 6.10) are given more compact LOINC codes. The LOINC committee is collaborating with CEN to coordinate their work with the similar EUCLIDES work in Europe [EUCLIDES Foundation International, 1994].

Insert Figure 6.10 About Here

National Drug Codes

The *National Drug Codes* (NDC), produced by the Food and Drug Administration (FDA), is applied to all drug packages. It is widely used in the United States but it is not as comprehensive as the WHO codes described below.

The FDA designates part of the code based on drug manufacturer, and each manufacturer defines the specific codes for their own products. As a result, there is no uniform class hierarchy for the codes, and codes may be reused at the manufacturer's discretion.

World Health Organization Drug Dictionary and the Anatomical-Therapeutic-Chemical Index

The World Health Organization (WHO) Drug Dictionary is an international classification of drugs that provides proprietary drug names used in different countries, as well as all active ingredients and the chemical substances, with Chemical Abstract numbers. Drugs are classified according to the Anatomical-Therapeutic-Chemical (ATC) classification, with cross-references to manufacturers and reference sources. The current dictionary contains 24,300 proprietary drug names, 14,700 single ingredient drugs, 9500 multiple ingredient drugs, and 6900 chemical substances. The dictionary now covers drugs from 34 countries and grows at a rate of about 2000 new entries per year.

Medical Subject Headings

The *Medical Subject Headings* (MeSH), maintained by the United States' National Library of Medicine (NLM) [National Library of Medicine, updated annually], is the vocabulary by which the world medical literature is indexed. MeSH arranges terms in a structure that breaks from the strict hierarchy used by most other coding schemes. Terms are organized into hierarchies and may appear in multiple places in the hierarchy (Figure 6.11). Although it is not generally used as a direct coding scheme for patient information, it plays a central role in the Unified Medical Language System.

Insert Figure 6.11 About Here

Unified Medical Language System

In 1986, Donald Lindberg and Betsy Humphreys, at the NLM, began consulting contractors to identify ways to construct a resource that would bring together and disseminate controlled medical vocabularies. An experimental version of the *Unified Medical Language System* (UMLS), was first published in 1989 [Humphreys, 1990]; the UMLS has been updated annually since then. Its principal component is the Metathesaurus, which contains over 331,000 terms collected from over 40 different sources (including many of those that we have discussed), and attempts to relate synonymous and similar terms from across the different sources (Figure 6.12). Figure 6.13 lists the preferred names for all pneumonia concepts in the Metathesaurus; Figure 6.14 shows how like terms are grouped into concepts and are tied to other concepts through semantic relationships.

Insert Figure 6.12 About Here

Insert Figure 6.13 About Here

Insert Figure 6.14 About Here

Interchange Registration of Coding Schemes

To accommodate the many coding schemes that are in use (and are likely to persist) in health-care applications today, the CEN Project Team PT005 has defined a draft standard that describes procedures for international registration of coding schemes used in health care [Health Care Financial Management Association,

1992]. The protocol specifies the allocation of a unique six-character Health Care Coding Scheme Designator (HCD) to each registered coding scheme. A code value can then be assigned an unambiguous meaning in association with an HCD.

6.5 Data-Interchange Standards

The recognition of the need to interconnect health-care applications led to the development and enforcement of **data-interchange standards**. The conceptualization stage began in 1980 with discussions among individuals in an organization called the American Association for Medical Systems and Informatics (AAMSI). In 1983, an AAMSI task force was established to pursue those interests in developing standards. The discussions were far ranging in topics and focus. Some members wanted to write standards for everything, including a standard medical vocabulary, standards for hospital information systems, standards for the computer-based patient record, and standards for data interchange. Citing the need for data interchange between commercial laboratories and health-care providers, the task force agreed to focus on data-interchange standards for clinical laboratory data. Early activities were directed mainly toward increasing interest of AAMSI members in working to create health-care standards.

The development phase was multifaceted. The AAMSI task force became subcommittee E31.11 of the ASTM, and developed and published ASTM standard 1238 for the exchange of clinical-laboratory data. Two other groups—many members of which had participated in the earlier AAMSI task force—were formed to develop standards, each with a slightly different emphasis: HL7 and MEDIX. The American College of Radiology (ACR) joined with the National Electronic Manufacturers Association (NEMA) to develop a standard for the transfer of image data. Two other groups developed related standards independent of the medical-informatics community: ANSI X12 for the transmission of commonly used business transactions, including health-care claims and benefit data, and the National Council for Prescription Drug Programs (NCPDP) for the transmission of third-party drug claims. Development was further complicated by the independent creation of standards by several groups in Europe including EUCLIDES and EDIFACT.

6.5.1 General Concepts and Requirements

The purpose of a data-interchange standard is to permit one system, the **sender**, to transmit to another system, the **receiver**, all the data required to accomplish a specific communication, or **transaction set**, in a precise, unambiguous fashion. To complete this task successfully, both systems must know what format and content is being sent and must understand the words or vocabulary, as well as the delivery mode. When you order merchandise, you fill out a form that includes your name and address, desired items, quantities, colors, sizes, and so on. You might put the order form in an envelope and mail it to the supplier at a specified address. There are standard requirements, such as where and how to write the receiver's (supplier’s) address, your (the sender's) address, and the payment for delivery (the postage stamp). The receiver must have a mailroom, a post-office box, or a mailbox to receive the mail.

A communications model, called the Open Systems Interconnection (OSI) reference model (ISO 7498-1), has been defined by the International Standards Organization (ISO) (see Section 4.1.2 and the discussion of software for network communications). It describes seven levels of requirements or specifications for a communications exchange: Physical, Data Link, Network, Transport, Session, Presentation and Application [Rose, 1989; Stallings, 1987a; Tanenbaum, 1987]. Level 7, the application level, deals primarily with the semantics or data-content

specification of the transaction set or message. For the data-interchange standard, Health Level 7 requires the definition of all the data elements to be sent in response to a specific task, such as the admission of a patient to a hospital. In many cases, the data content requires a specific vocabulary that can be understood by both sender and receiver. For example, if a physician orders a laboratory test that is to be processed by a commercial laboratory, the ordering system must ensure that the name of the test on the order is the same as the name that the laboratory uses. When a panel of tests is ordered, both systems must share a common understanding of the panel composition. This vocabulary understanding is best ensured through use of a vocabulary table that contains both the test name and a unique code. Unfortunately, several code sets exist for each data group, and none are complete. An immediate challenge to the medical-informatics community is to generate one complete set. In other cases, the vocabulary requires a definition of the domain of the set, such as what are the possible answers to the data parameter "ethnic origin."

The sixth level, presentation, deals with what the syntax of the message is, or how the data are formatted. There are both similarities and differences at this level across the various standards bodies. Two philosophies are used for defining syntax: one proposes a *position-dependent* format; the other uses a *tagged-field* format. In the position-dependent format, the data content is specified and defined by position. For example, the sixth field delimited by "|" is the gender of the patient and contains a M, F, U or is empty. A tagged field representation is "SEX = M".

The remaining OSI levels—session, transport, network, data link, and physical—govern the communications and networking protocols and the physical connections made to the system. Obviously, some understanding at these lower levels is necessary before a linkage between two systems can be successful. Increasingly, standards groups are defining scenarios and rules for using various protocols at these levels, such as TCP/IP (Section 4.1.2). Much of the labor in making existing standards work lies in these lower levels.

Typically, a transaction set or message is defined for a particular event, called a **trigger event**. The message is composed of several data segments; each data segment consists of one or more data fields. Data fields, in turn, consist of data elements that may be one of several data types. The message must identify the sender and the receiver, the message number for subsequent referral, the type of message, special rules or flags, and any security requirements. If a patient is involved, a data segment must identify the patient, the circumstances of the encounter, and additional information as required. A reply from the receiving system to the sending system is mandatory in most circumstances and completes the communications set.

It is important to understand that the sole purpose of the data-interchange standard is to allow data to be sent from the sending system to the receiving system; the standard does not in any manner constrain the application system that uses those data. Application independence permits the data-interchange standard to be used for a wide variety of applications. However, the standard must ensure that it accommodates all data elements required by the complete application set.

6.5.2 Specific Data-Interchange Standards

As health care increasingly depends on the connectivity within an institution, an enterprise, an integrated delivery system, a geographical system, or even a national integrated system, the ability to interchange data in a seamless manner becomes critically important. The economic benefits of data-interchange standards are immediate and obvious. Consequently, it is in this area of health-

care standards that most effort has been expended at this time. All of the Standards Development Organizations in health care have some development activity in data-interchange standards.

In the following sections we summarize many of the current standards for data-interchange. Examples are provided to give you a sense of the technical issues that arise in defining a data-exchange standard, but details are beyond the scope of this book. For more information, consult the primary resources or the web sites for the relevant organizations.

ACR/NEMA

{**NOTE TO EDITORS: this section reduced in font size to minimize it's emphasis}

With the introduction of computed tomography and other digital diagnostic imaging modalities, people needed a standard method for transferring images and associated information between devices, manufactured by different vendors, that display a variety of digital image formats. The American College of Radiology formed a relationship with the National Electronic Manufacturers Association in 1983 to develop such a standard for exchanging radiographic images, creating a unique professional/vendor group. The purposes of the ACR/NEMA standard were to promote a generic digital-image communication format, to facilitate the development and expansion of picturing-archiving and communication systems (PACSs; see Chapter 14), to allow the creation of diagnostic databases for remote access, and to enhance the ability to integrate new equipment with existing systems.

Version 1 of the ACR/NEMA standard, published in 1985, specified a hardware interface, a data dictionary, and a set of commands. This standard supported only point-to-point communications. Version 2, published in 1988, introduced a message structure that consisted of a command segment for display devices, a new hierarchy scheme to identify an image, and a data segment for increased specificity in the description of an image (for example, the details of how the image was made, and the settings).

In the ACR/NEMA standard, individual units of information, called *data elements* are organized within the data dictionary into related groups. Groups and elements are numbered. Each individual data element, as contained within a message, consists of its group-element tag, its length, and its value. Groups include Command, Identifying, Patient, Acquisition, Relationship, Image Presentation, Text, Overlay, and Pixel Data.

The latest version of the ACR/NEMA Standard is the Digital Imaging and Communications in Medicine (DICOM) Version 3.0. It incorporates an object-oriented data model and adds support for ISO standard communications. DICOM provides full networking capability; specifies levels of conformance; is structured as a nine-part document to accommodate evolution of the standard; introduces explicit information objects for images, graphics, and text reports; introduces service classes to specify well-defined operations across the network; and specifies an established technique for identifying uniquely any information object. DICOM also specifies image-related management-information exchange, with the potential to interface to hospital information systems and radiology information systems.

The general syntax used by DICOM in representing data elements includes a data tag, a data-length specification, and the data value. That syntax is preserved over a hierarchical nested data structure of items, elements, and groups. Data elements are defined in a data dictionary and are organized into groups. A data set consists of the structured set of attributes or data elements and the values related to an information object. Data-set types include images, graphics, and text. A multivendor demonstration of DICOM Version 3.0 was first demonstrated at the Radiological Society of North America (RSNA) meeting in Chicago in November 1992.

The protocol architecture for DICOM Version 3.0 is shown in Figure 6.15. The bold line indicates the OSI upper-layer service boundary. This figure, which illustrates the communication services for a point-to-point environment and for a networked environment, identifies the communication services and the upper-level protocols necessary to support communication between DICOM Application Entities. The upper-layer service supports the use of a fully conformant stack of OSI protocols to achieve effective communication. It supports a wide variety of international standards-based network technologies using a choice of physical networks such as Ethernet, FDDI, ISDN, X.25, dedicated digital circuits, and other local area network (LAN) and wide area network (WAN) technologies. In addition, the same upper-layer service can be used in conjunction with TCP/IP transport protocols.

Insert Figure 6.15 About Here

ASTM E31

In 1984, the first ASTM health-care data-interchange standard was published: E1238, Standard Specification for Transferring Clinical Observations Between Independent Systems. This standard is used in large commercial and reference clinical laboratories in the United States, and has been adopted by a consortium of French laboratory system vendors who serve 95 percent of the laboratory volume in France. The ASTM E1238 standard is message based; it uses position-defined syntax and is similar to the HL7 standard (see next section). Related data-interchange standards include E1394 (from Subcommittee E31.13), Standard Specification for Transferring Information Between Clinical Instruments and Computer Systems, and E1467 (from Subcommittee E31.16), Specification for Transferring Digital Neurophysiological Data Between Independent Computer Systems. Another important ASTM standard is E1460 (from Subcommittee E31.15), Defining and Sharing Modular Health Knowledge Bases (Arden Syntax for Medical Logic Modules; see Chapter 16). In 1998, ownership of the Arden Syntax was transferred to HL7 where it will be developed by the Arden Syntax and Clinical Decision Support Technical Committee. An example of the ASTM 1238 standard describing a message transmitted between a clinic and a commercial clinical laboratory is shown in Figure 6.16.

Insert Figure 6.16 About Here

HL7

An ad hoc standards group was formed in March 1987 as a result of efforts to develop an integrated hospital information system by interconnecting function-specific systems. That group adopted the name Health Level 7 (HL7) to reflect the applications (seventh) level of the OSI reference model.[4] The original primary goal of HL7 was to provide a standard for the exchange of data among hospital-computer applications that eliminated, or substantially reduced, the hospital-specific interface programming and program maintenance that was required at that time. The standard was designed to support single, as well as batch, exchanges of transactions among the systems implemented in a wide variety of technical environments. Today, HL7 has over 500 organizational members and over 1800 individual members; HL7 is the most widely implemented health-care data-messaging standard and is in use at over 1500 health-care facilities.

The standard was built on existing production protocols—particularly ASTM 1238. The HL7 standard is message based and uses an event trigger model that causes the sending system to transmit a specified message to the receiving unit, with a subsequent response by the receiving unit. Messages are defined for various trigger events. Version 1.0 was published in September 1987 and served mainly to define the scope and format of standard. Version 2.0, September 1988, was the basis for several data-interchange demonstrations involving more than 10 vendors. Version 2.1, June 1990, was widely implemented in the United States and abroad. In 1991, HL7 became a charter member of ANSI; on June 12, 1994, it became an ANSI accredited Standards Development Organization. Version 2.2 was published in December 1994; on February 8, 1996 it was approved by ANSI as the first health-care data-interchange American National Standard. Version 2.3, March 1997, considerably expanded the scope by providing standards for the interchange of data relating to patient administration (admission, discharge, transfer, and outpatient registration), patient accounting (billing), order entry, clinical-observation data, medical information management, patient and resource scheduling, patient-referral messages, patient-care messages that support communication for problem-oriented records, adverse-event reporting, immunization reporting, and clinical trials, as well as a generalized interface for synchronizing common reference files.

Figure 6.17 illustrates the exchange that occurs when a patient is transferred from the operating room (which uses a system called DHIS) to the surgical intensive-care unit (which uses a system called TMR). Note the similarity between these messages and the ASTM example.

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[4] see http://www.hl7.org/ for current information about HL7 and its evolution.

Insert Figure 6.17 About Here

Version 3 of the standard (1999) is object oriented and based on a Reference Information Model (RIM) being developed by HL7. The RIM has evolved from a number of commercial and academic health-care data models, and it accommodates the data elements defined in the current (Version 2.3) HL7 standard.

This RIM is a collection of subject areas, scenarios, classes, attributes, use cases, actors, trigger events, interactions, and so on that depict the information needed to specify HL7 messages. In this sense it is more than a data-interchange standard, seeking to merge standards notions that include terminology and representation as well as data exchange. The stated purpose of the RIM is to provide a model for the creation of message specifications and messages for HL7. The RIM is not intended as a general purpose health-care data model, although it might become that in time.

IEEE MEDIX

The Institute of Electrical and Electronics Engineers (IEEE) is an international organization that is a member of both ANSI and ISO. Through IEEE, many of the world's standards in telecommunications, electronics, electrical applications, and computers have been developed. There are two major IEEE standards projects in health care. IEEE P1157 Medical Data Interchange Standard (MEDIX) was organized in November 1987 to draft a standard for the exchange of data between hospital computer systems. The MEDIX committee, in formation, was committed to developing a standard set of hospital-system interface transactions based on the ISO standards for all seven layers of the OSI reference model. Its work has produced a family of documents that defines the communications models for medical data interchange among diverse systems.

IEEE 1073, Standard for Medical Device Communications, has produced a family of documents that defines the entire seven-layer communications requirements for the **medical information bus** (MIB). The MIB is a robust, reliable communication service designed for bedside devices in the intensive-care unit, operating room, and emergency room (see Chapter 13 for further discussion of the MIB in patient-monitoring settings).

The National Council for Prescription Drug Programs (NCPDP)

The National Council for Prescription Drug Programs (NCPDP) is a trade organization. The Standardization Committee within the NCPDP has developed a standard format for the electronic submission of third-party drug claims. The standard was developed to accommodate the eligibility verification process at the point of sale, and to provide a consistent format for electronic claims processing. Primarily pharmacy providers, insurance carriers, third-party administrators, and other responsible parties use the standard. This standard addresses the data format and content, transmission protocol, and other appropriate telecommunication requirements.

Version 1, released in 1988, used formats with fixed fields only. Version 2 added only typographical corrections to the Version 1 standard. The major thrust of the change in Versions 3.0 and 3.1, in 1989, was the change from fixed-field transactions to a hybrid or variable format, in which the fields can be tailored to the required content of the message. The current release is Version 3.2 (February 1992): it introduces the fixed-length Recommended Transaction Data Sets (RTDS) that define three different message types, and a separate Data Dictionary format. The Data Dictionary defines permissable values and default values for fields contained in the specification.

The standard uses defined separator characters at a group and a field level. The telecommunications specifications for sending two prescriptions includes three required sections (Transaction Header; Group Separator, First-Claim Information; and Group Separator, Second-Claim Information (R)) and three optional sections (Header Information, First-Claim Information, and Second-Claim Information (O)). The NCPDP communication standard is used in more than 60 percent of the nation's total prescription volume.

ANSI X12

Accredited Standards Committee (ASC) X12, an independent organization accredited by ANSI, has developed message standards for purchase-order data, invoice data, and other commonly used business documents. The subcommittee X12N has developed a group of standards related to providing claim, benefits, and claim payment or advice. The specific standards that strongly relate to the health-care industry are shown in Table 6.2.

Insert Table 6.2 About Here

The X12 standards define commonly used business transactions in a formal, structured manner called transaction sets. A **transaction set** is composed of a transaction-set header control segment, one or more data segments, and a transaction-set trailer control segment. Each segment is composed of a unique segment ID; one or more logically related simple data elements or composite data structures, each preceded by a data element separator; and a segment terminator. Data segments are defined in a data-segment directory; data elements are defined in a data-element directory; composite data structures are defined in a composite data structure directory; control segments and the binary segment are defined in a data-segment directory.

A sample 835 Interchange Document is shown in Figure 6.18. This standard is similar to ASTM and HL7 in that it uses labeled segments with positionally defined components.

Insert Figure 6.18 About Here

There are several additional organizations that either create standards related to health care or have influence on the creation of standards.

American Dental Association (ADA)

In 1983, the American Dental Association (ADA) committee MD156, became an ANSI accredited committee responsible for all specifications for dental materials, instruments, and equipment. In 1992, a Task Group of the ASC MD156 was established to initiate the development of technical reports, guidelines, and standards on electronic technologies used in dental practice. Five working groups promote the concept of a dental computer-based clinical workstation and allow the integration of different software and hardware components into one system. Areas of interest include digital radiography, digital intraoral video cameras, digital voice-text-image transfer, periodontal probing devices, and CAD/CAM. Proposed standards include Digital Image Capture in Dentistry, Infection Control in Dental Informatics, Digital Data Formats for Dentistry, Construction and Safety for Dental Informatics, Periodontal Probe Standard Interface, Computer Oral Health Record, and Specification for the Structure and Content of the Computer-Based Patient Record.

Uniform Code Council (UCC)

The Uniform Code Council (UCC) is an ANSI approved organization which defines the universal product code. Standards include specifications for the printing of machine-readable representations (bar codes).

Health Industry Business Communications Council (HIBCC)

The Health Industry Business Communications Council (HIBCC) has developed the Health Industry Bar Code (HIBC) Standard, composed of two parts. The HIBC Supplier Labeling Standard describes the data structures and bar-code symbols for bar coding of health-care products. The HIBC Provider Applications Standard describes data structures and bar-code symbols for bar coding of identification data in a health-care–provider setting. HIBCC also issues and maintains Labeler Identification Codes that identify individual manufacturers. The HIBCC administers the Health Industry Number System, which provides a unique identifier number and location information for every health-care facility and provider in the United States The HIBCC also administers the Universal Product Number Repository, which identifies specific products and is recognized internationally.

Workgroup for Electronic Data Interchange (WEDI)

The Workgroup for Electronic Data Interchange (WEDI) was formed in 1991 as a broad health-care coalition to promote greater health care electronic commerce and connectivity in response to a challenge by then-Secretary of Health and Human Services, Louis Sullivan, M.D. The challenge was to bring together industry leaders to identify ways to reduce administrative costs in health care through thoughtful implementation of Electronic Data Interchange (EDI).

Specifically, the goals of WEDI are

- To define, prioritize, and reach consensus on critical issues affecting the acceptance of electronic commerce by the health-care community
- To serve as a primary resource for identifying and removing obstacles that impede implementation of electronic commerce
- To educate and promote action by providing information resources on the benefits and effective use of electronic commerce, and on the implementation products and services available

WEDI incorporated as a formal organization in 1995. It has developed action plans to promote EDI standards, architectures, confidentiality, identifiers, health cards, legislation, and publicity. WEDI is one of four organizations named specifically in the HIPAA law to be consulted in the development of health-care standards that would be selected to meet HIPAA requirements.

The European Clinical Data Exchange Standard (EUCLIDES)

The European Clinical Data Exchange Standard (EUCLIDES), provides a standard for clinical laboratory-data interchange between independent and heterogeneous medical information systems [NCPDP Telecommunication, 1992, ; Draft Application Protocol, 1993, ; Standard for Health Care Interchange, 1993,]. EUCLIDES is being supported by the Commission of the European Communities within the framework of the Advanced Informatics in Medicine (AIM) program.

A three-pronged approach to standardizing data interchange was adopted by EUCLIDES: semantics (nomenclature and coding), syntax, and message transfer. EUCLIDES has made a significant contribution to data-interchange standards through the development of the EUCLIDES Coding System. This coding system provides a multilingual, multiaxial, coded nomenclature designed for the unambiguous transfer of laboratory data between sites that does not disturb local usage of terminology at different sites. Coding lists contain all terms, including synonyms, that are in routine use in Europe in all branches of laboratory medicine.

The Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT)

The Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT) is a set of international standards, projects, and guidelines for the electronic interchange of structured data related to trade in goods and services between independent computer-based information systems [NCPDP Data Dictionary, 1994,]. The standard includes application-level syntax rules, message-design guidelines, syntax-implementation guidelines, data-element dictionary, code list, composite data-elements dictionary, standard message dictionary, uniform rules of conduct for the interchange of trade data by transmission, and explanatory material.

The basic EDIFACT (ISO 9735) syntax standard was formally adopted in September 1987 and has undergone several updates. In addition to the common syntax, EDIFACT specifies standard messages (identified and structured sets of statements covering the requirements of specific transactions), segments (the groupings of functionally related data elements), data elements (the smallest items in a message that can convey data), and code sets (lists of codes for data elements). The ANSI ASC X12 standard is similar in purpose to EDIFACT, and work is underway to coordinate and merge the two standards.

EDIFACT is concerned not with the actual communications protocol, but rather with the structuring of the data that are sent. EDIFACT is independent of the machine, media, system, and application, and can be used with any communications protocol or with physical magnetic tape.

Standard Communications Protocol for Computer-Assisted Electrocardiography (SCP-ECG)

Project Team PT007 of TC 251 produced a prestandard for ECG cart-to-host communication [Health Care Financial Management Association, 1993]. The primary aim of this Standard Communications Protocol for Computer-Assisted Electrocardiography (SCP-ECG) is to ensure that Electrocardiography (ECG) reports and data from any vendor's computer-based ECG recorder can be transmitted on a direct connected serial line to any other vendor's central ECG management system. The same standard would also allow standardized transmission of digitized ECG data and results between various computer systems. The standard supports the conventional 12-lead

ECG and the vectorcardiogram. The current version does not accommodate body-surface mapping potentials, recordings of intracardiac potentials, Holter monitoring, or exercise ECG recordings.

The SPC-ECG specifies the content and structure of the information to be interchanged. Data-encoding and data-compression methodologies are defined. A minimum set of control and query messages for cart-to-cart and cart-to-host interchange is included. A low-level transport protocol between an ECG cart and a host based on an enhanced X-Modem protocol is specified. The message structure is based on a field tag, length, value format. The ECG data-interchange message includes patient identification, diagnoses, physician data, drugs, machine data, parameter measurements, and ECG data.

6.6 Today's Reality and Tomorrow's Directions

The development of standards is driven by perceived need and is influenced by the user community, vendors, consultants, and government. If a standard is developed as an academic exercise and is before its time, the standard is often unused. If a standard is too late in development, it is difficult to change the patterns of what people do. The pace of standards development is controlled by the rate at which vendors and users are willing to change. New technology often makes the acceptance of standards easier. Clearly, the demand for standards by those who are willing to pay define today's reality. Tomorrow's directions depend on predictions of for what users will be willing to pay.

6.6.1 The Interface: Standards and Workstations

Much of the early work in creating standards for data exchange was in the area of exchanging data between distributed systems, most often in the background and unsolicited. As the online use of information systems by professional users increases, and as the need to bring in data from distributed systems escalates, data-interchange standards requirements will expand to support a request mode, which will allow specific data elements from disparate sources to be integrated at the desktop.

Much of the work to date on data-interchange standards will certainly be useful in connecting health professionals' workstations to the rest of the world. However, we must recognize that data-messaging standards have thus far focused primarily on exchanging medical data in a way that is largely driven by the desired function—to support an admission, test ordering, or results reporting. Only casual work has been done in developing standards for queries from users to such data sources. Queries will tend to return many more data than the workstations need unless new standards are developed. Should queries for workstations be based on the de facto database query standard, SQL (see Chapter 4)? If so, what modifications will be required to support queries from workstations while building on other notions of data exchange?

User queries will need to identify the patient and either to request or transmit data elements to other components of the distributed enviornment. Query methods will be required to support a variety of scenarios: a single test value with date and time, a set of vital signs, a problem list, a list of allergies, a complete data set for an outpatient encounter, a complete data set for a hospitalization, current drugs, or a complete patient record. Invariably, each such exchange of data must control and pass along the patient's rights and wishes regarding access to and use of the data (see Chapter 7).

Standardized access to knowledge systems and bibliographic systems must support scripting and data-entry mechanisms to assure that a data system can properly and accurately provide a response. Workstations typically permit cut and paste from one module to another; the data representation must thus accommodate a standard linkage to enable user-directed transfer

between systems. The global use of decision-support systems will require high-speed query and response for the typically large number of data elements required to execute the decision-logic, as well as high computational speeds to process the information and to provide an acceptable real-time response on the workstation.

Patient information will be retrieved not only by patient name or identification number, but also by patient characteristics. For example, a physician at a workstation may ask for data on all patients who have coronary-artery disease with more than three-vessel involvement, who have had a myocardial infarction (heart attack), who are diabetic, who were treated surgically, and who have lived more than 5 years. The underlying system must use a variety of standards to translate this query into a manageable task, returning the correct data and preserving access constraints.

How good are the standards that are available today? What do users have to do to incorporate today's operational versions of standards into systems that they are implementing? First, much negotiation is necessary among vendors who are interfacing systems. There are two reasons for this need. Different parts of the various standards have different levels of maturity. For example, in HL7, the ADT version of the standard is defined more completely than is the observation-reporting section when the latter is used to transmit complete clinical data. Most of the standards are not complete, except for their support of some well-defined documents, such as insurance-claim forms. Standards are only now beginning to use an object-oriented model of the data to minimize ambiguity and to ensure completeness.[5] Vendors may interpret the use of a field differently, depending on their perspective or orientation. A billing vendor may understand the meaning of a field entirely differently from a clinical system vendor. The incompleteness of the standards—for example, in managing a complex set of trigger events—may lead one vendor to make assumptions not obvious to another vendor. The issue of optionality creates confusion and requires negotiation among vendors for a well-structured interface. Vocabulary standards also are not adequate for seamless interfaces. The second problem faced by vendors lies in the lower levels of the OSI reference model. Most of the standards bodies are now addressing the lower levels by defining strategies and rules for the lower-level protocols, most frequently using TCP/IP, rather than pure OSI protocols.

From a user's perspective, the problem lies in how closely the vendor's implementation adheres to the standard. In many cases, the vendor defines standard compliance loosely, and the user purchases a system that cannot be easily interfaced. The only solution to this problem is certification by some agency—an unpopular task at best. Legal concerns and the difficulty of certifying compliance to the standards are obstacles that must be overcome.

Do today's standards reduce costs? The answer depends on the vendor. Some vendors charge little or nothing for standard interfaces; others charge the same as they do for custom interfaces. Over time, however, the cost of the interface will be driven down considerably by the users. In the case of imaging standards, the standards are necessary to develop the market for displaying images in a variety of settings.

[5] See the HL7 website at http://www.hl7.org for more details.

6.6.2 Future Directions

The General Accounting Office reported in a study from the early 1990s that several hundred standards would be required by the health-care industry [United States General Accounting Office, 1993]. Other authors have estimated the numbers to be in the thousands. We believe that the most probable need will be 20 to 30 standards. One problem in trying to standardize everything is the conflict between a standard and the opportunity for a vendor to use creativity in a product to enhance sales. Standards should not stifle creativity but rather encourage it. For example, standardization of the screen displays for a computer-based patient-record system is unlikely to occur, because individual vendors have different beliefs about the best designs. On the other hand, it is likely that components of the displays may be standardized. The use of the mouse (for example, single and double clicks, right and left clicks) needs to be standardized in function. The use of visual objects also needs to be (and can be) standardized. It is likely that icons that represent functions also will be standardized in time.

At the present time, standards do not exist to support fully the requirements of health-professional workstations. A standard is necessary whenever someone other than the originator of data must understand and use data received electronically. For seamless electronic interchange of clinical data, standard formats need to be defined to include all types of data representation—images, signals and waveforms, sound and voice, and video, including motion video. Other candidate issues where the definition of standards would be helpful include specifying the location of data (both in terms of physical location as well as database characteristics) and defining the rules for the retention of data and for tighter coupling of data.

Core data sets for health-care specialty groups and defined health-care scenarios are likely candidates for standardization. The Centers for Disease Control, for example, has defined a set of standard codes for the emergency department. Forms, such as discharge summaries, operative notes, and so on, can be exchanged meaningfully between organizations if they use a standard format. Decision-support algorithms and clinical guidelines will be more widely used and accepted if they go through a consensus standardization process.

The future of messaging standards seems bright. The prevailing attitude in all the existing standards groups—in Europe and in the United States—favors developing workable standards so that we can solve new problems. Participants favor working together; proprietary and “not-invented-here” concerns are minimal. The willingness to separate data content from syntax is important. The development of a common, global data model is critical. Definitions of vocabulary, coding, and standard data structures are approaching reality. Clearly, the goals of “plug and play” have not yet been realized, but they may be obtainable within the next few years.

Suggested Readings

Abbey L.M., Zimmerman J. (Eds). *Dental Informatics, Integrating Technology into the Dental Environment.* New York: Springer-Verlag, 1991.

This text demonstrates that the issues of standards extend throughout the areas of application of medical informatics. The standards issues discussed in this chapter for clinical medicine are shown to be equally pertinent for dentistry.

Chute C.G. *Electronic Medical Record Infrastructures: An Overview of Critical Standards and Classifications*. New York: Springer-Verlag, 1998.

This text provides more in-depth coverage of the structure, content, and issues related to coded terminologies, nomenclatures, and vocabularies in health care.

Stallings W. *Data and Computer Communications*. New Jersey: Prentice Hall, 1997.

This text provides detail on communications architecture and protocols and on local and wide area networks.

Stallings W. *Handbook of Computer-Communications Standards.* New York: Macmillan Publishing Company, 1987.

This text provides excellent detail on the Open Systems Interconnection mode of the International Standards Organizationl.

Steedman D. *Abstract Syntax Notation One: The Tutorial and Reference.* Great Britian: Technology Appraisals Ltd, 1990.

This text is definitive on the definition and content of Abstract Syntax Notation One (ASN.1) and includes illustrative examples.

Questions for Discussion

1. What are five possible approaches to accelerating the creation of standards?
2. Define five health-care standards, not mentioned in the chapter, that might also be needed?
3. What role should the government play in the creation of standards?
4. At what level might a standard interfere with a vendor's ability to produce a unique product?
5. Define a hypothetical standard for one of the areas mentioned in the text for which no current standard exists. Include the conceptualization and discussion points. Specifically state the scope of the standard.

Table 6.1 ASTM E31 Subcommittees

Subcommittee	Medical-Information Standard
E31.01	Terminology
E31.11	Standards for Transferring Clinical Observations Between Independent Computer Systems
E31.12	Disease Data Management
E31.13	Clinical Laboratory Information Management Systems
E31.14	Clinical Laboratory Instrument Interface
E31.15	Medical Knowledge Representation
E31.16	Exchange of Electrophysiological Waveforms and Signals
E31.17	Access, Privacy, and Confidentiality of Medical Records
E31.18	Health Data Cards
E31.19	Vocabulary for Computer-based Health Information
E31.20	Authentication of Computer-based Health Information
E31.21	Health Information Networks
E31.22	Health Information Transcription and Documentation
E31.23	Modeling for Health Informatics

Table 6.2 ANSI X12 standards

Code	Title	Purpose
148	First Report of Injury, Illness or Incident	Facilitate the first report of an injury, incident, or illness
270 271	Health-Care Eligibility/Benefit Inquiry Health-Care Eligibility/Benefit Information	Provide for the exchange of eligibility information, and for response to individuals in a health-care plan
275	Patient Information	Support the exchange of demographic, clinical, and other patient information to support administrative reimbursement processing as it relates to the submission of health-care claims for both health-care products and services
276 277	Health-Care Claim Status Request Health-Care Claim Status Notification	Query the status of a submitted claim and report the status of a submitted claim
278	Health-Care Service Review Information	Provide referral certification and authorization information
811 820	Consolidated Service Invoice/Statement Payment Order/Remittance Advice	Facilitate health-plan premium billing and payment
IHCLME	Interactive Health-Care Claim/ Encounter	Support administrative reimbursement processing as it relates to the submission of health-care claims for both health-care products and services in an interactive environment
IHCE/BI IHCE/BR	Interactive Health-Care Eligibility/Benefit Inquiry Interactive Health-Care Eligibility/Benefit Response	Provide for the exchange of eligibility information, and for response to individuals within a health plan Provide for the exchange of eligibility information, and for response to individuals within a health plan

Legends to Figures

Figure 6.1 A Standards-Development Meeting. The development of effective standards often requires numerous group meetings over many years. Volunteers bring varying expertise and perspectives to the meetings so that consensus can gradually be achieved. Here an HL7 group is shown at one of their meetings (see Section 6.5.2). (Courtesy of HL7, photograph by George Beeler.)

Figure 6.2 Requirements of the Health Insurance Portability and Accountability Act of 1996. These requirements define the first round of standards required to meet the immediate needs of the health-care community.

Figure 6.3 Terminologic terms, adapted from ISO Standard 1087. Terms not defined here—such as "definition," "lexical unit," and "linguistic expression"—are assumed by the Standard to have common meanings.

Figure 6.4 Bacterial pneumonias coded in ICD-9. The extensive set of codes for mycobacterial disease has been omitted for simplicity.

Figure 6.5 Example of fifth-digit codes in the Clinical Modifications of ICD-9 (ICD-9-CM). The four-digit codes are identical to those in ICD-9; the five-digit codes were introduced in ICD-9-CM. Note that Salmonella Pneumonia has been added as a child in the 003 section; it is not included under 482 (Other Bacterial Pneumonia) or 484 (Pneumonia in Infectious Disease Classified Elsewhere).

Figure 6.6 DRG codes assigned to cases of bacterial pneumonia depending on co-occurring conditions or procedures (mycobacterial disease is not shown here except as a co-occurring condition). "Simple Pneumonia" codes are used when the primary bacterial pneumonia corresponds to ICD-9 codes 481, 482.2, 482.3, or 482.9 (refer to Figures 6.4 and 6.5) *and* when there are only minor or no complications. The remaining ICD-9 bacterial pneumonias (482.0, 482.1, 482.2, 482.4, 482.8, 484, and various other codes such as 003.22 (refer to Figure 6.4) are coded as "Respiratory Disease" or "Respiratory Infection." Cases in which pneumonia is a secondary diagnosis may also be assigned other codes (such as 798), depending on the primary condition.

Figure 6.7 SNOMED International codes for pneumonia. The first set of terms are those from the Disease axis, which are included under the Bacterial Infectious Disease hierarchy (excluding several veterinary diseases). "NOS" stands for "not otherwise specified." The codes shown on the right are the SNOMED codes that, when taken together, are the equivalent of the precoordinated bacterial pneumonia terms. For example, "Pneumococcal pneumonia" (DE-13510) is the precoordination of the terms "Lung, NOS" (T-28000), "Inflammation, NOS" (M-40000), and "Streptococcus pneumoniae" (L-25116). The second set of terms shows some of the other pneumonia terms in SNOMED that could be coupled with specific Living Organism terms to allow postcoordinated coding of concepts not coded explicitly in SNOMED.

Figure 6.8 Bacterial pneumonias in the Read Clinical Codes. A user can code additional infections by using Bacterial Pneumonia with one of the prescribed modifiers (Bacteria). Some of these terms also appear in other hierarchy locations; for example, Meningococcal Pneumonia also appears under Meningococcal Infection (which is under Bacterial Disease). The asterisk (*) denotes optional terms that are included for use in classification by epidemiologists or coders, but would not be included in a clinical record. [NOS = not otherwise specified.]

Figure 6.9 Bacterial pneumonias coded in the Gabrieli (ASTM) Medical Nomenclature. (Sixteen descendants of Mycobacterial pneumonia are not shown.) Some terms appear in multiple locations (for example, Staphylococcal Pneumonia, which has additional descendants in one context). Note that Bacterial Pneumonia and Bacteriogenic Pneumonia are not considered synonymous and have different descendants. Similarly, Streptococcus Pneumonia (4-3-3-2-1-7-1-3-1-2) and Streptococcal Pneumonia (4-3-22-1-1-4) are not considered synonymous. Additional bacterial pneumonias can be found elsewhere in the hierarchy, such as Listerial Pneumonia (4-3-22-1-29-6-1), Staphylococcus Aureus Pneumonia in a Granulocytopenic Host (4-3-3-2-1-7-1-1-1-2), its child Staphylococcus Epidermidis Pneumonia in a Granulocytopenic Host, and Staphylococcus Pneumonia in Children (16-10-5-7-2-14-1-3).

Figure 6.10 Examples of common-laboratory test terms as they are encoded in LOINC. The major components of the fully specified name are separated here by ":" and consist of the substance measured, the property (for example, MCNC = mass concentration, SCNC = substance concentration, NFR = numeric fraction, and NCNC = number concentration), the time (PT = point in time), the specimen, and the method (SQ = semiquantitative, QN = quantitative, QL = qualitative).

Figure 6.11 Partial tree structure for the Medical Subject Headings (MeSH) showing pneumonia terms. Note that terms can appear in multiple locations, although they may not always have the same children, implying that they have somewhat different meanings in different contexts. For example, Pneumonia means "lung inflammation" in one context (line 3) and "lung infection" in another (line 16).

Figure 6.12 Sources for the UMLS. The Unified Medical Language System comprises contributed terminologies from a large number of sources, including all the text compendia shown here. (Courtesy National Library of Medicine and Lexical Technolgoy, Inc.)

Figure 6.13 Some of the bacterial pneumonia concepts in the Unified Medical Language System (UMLS) Metathesaurus.

Figure 6.14 Some of the information available in the UMLS about selected pneumonia concepts. Concept's preferred names are shown in italics. Sources are identifiers for the concept in other vocabularies. Synonyms are names other than the preferred name. ATX is an associated MeSH expression that can be used for Medline searches. The remaining fields (Parent, Child, Broader, Narrower, Other, and Semantic) show relationships among concepts in the Metathesaurus. Note that concepts may or may not have hierarchical relations to each other through Parent–Child, Broader–Narrower, and Semantic (is-a and inverse-is-a) relations. Note also that *Pneumonia, Streptococcal* and *Pneumonia due to Streptococcus* are treated as separate concepts, as are *Pneumonia in Anthrax* and *Pneumonia, Anthrax*.

Figure 6.15 DICOM communications-protocol architecture illustrating the different approaches to dealing with the OSI reference model communication levels.

Figure 6.16 An example of message in the ASTM 1238 format. The message consists of the header segment, H, the Patient segment, P, and general order segments, OBR. Primary delimiters are the vertical bars (|); secondary delimiters are the carets (^). Note the similarities of this message to the HL7 message in Figure 6.15.

Figure 6.17 An example of an HL7 ADT transaction message. This message includes the MSH header segment, the EVN trigger definition segment, the PID patient-identification segment, the PV1 patient-visit segment, the OBR general-order segment, and several OBX results segments.

Figure 6.18 An example of ANSI X12 Interchange Document (Standard 835). This message is derived from a batch process, business-document orientation to a data-interchange model. The example does not include the control header or the functional-group header. The first line identifies the segment as a transaction-set header (ST). The last line is the transaction-set trailer (SE).The leading alphanumeric characters are tags that identify data content. For example, DTM is a date/time reference; N3 is address information; and BPR is the beginning segment for payment order/remittance advice.

Figure 6.1

Figure 6.2

1. The Secretary must adopt standards for transactions, and data elements for such transactions, to enable health information to be exchanged electronically that are appropriate for financial and administrative transactions consistent with the goals of improving the operation of the health care system and reducing costs, including:
    a. Health Claims or equivalent encounter information
    b. Health Claims Attachments
    c. Enrollment and Disenrollment in a Health Plan
    d. Eligibility For a Health Plan
    e. Health Care Payment and Remittance Advice
    f. Health Plan Premium Payments
    g. First Report of Injury
    h. Health Claim Status
    i. Referral Certification and Authorization
    j. Coordination of Benefits
2. The Secretary shall adopt standards providing for a unique health identifier for each individual, employer, health plan, and health care provider for use in the health care system.
3. The Secretary shall adopt standards for code sets for appropriate data elements for financial and administrative transactions.
4. The Secretary shall adopt security standards that …specify procedures for the electronic transmission and authentication of signatures.

Figure 6.3

- **Object**: Any part of the perceivable or conceivable world.
- **Name**: Designation of an object by a linguistic expression.
- **Concept**: A unit of thought constituted through abstraction on the basis of properties common to a set of objects.
- **Term**: Designation of a defined concept in a special language by a linguistic expression.
- **Terminology**: Set of terms representing the system of concepts of a particular subject field.
- **Nomenclature**: System of terms that is elaborated according to preestablished naming rules.
- **Dictionary**: Structured collection of lexical units, with linguistic information about each of them.
- **Vocabulary**: Dictionary containing the terminology of a subject field.

Figure 6.4

481 Pneumococcal Pneumonia

482 Other Bacterial Pneumonia
- 482.0 Pneumonia due to Klebsiella Pneumoniae
- 482.1 Pneumonia due to Pseudomonas
- 482.2 Pneumonia due to Haemophilus Influenzae
- 482.3 Pneumonia due to Streptococcus
- 482.4 Pneumonia due to Staphylococcus
- 482.8 Pneumonia due to Other Specified Bacteria
- 482.9 Bacterial pneumonia unspecified

484 Pneumonia in Infectious Disease Classified Elsewhere
- 484.3 Pneumonia in Whooping Cough
- 484.4 Pneumonia in Tularemia
- 484.5 Pneumonia in Anthrax

Figure 6.5

003 Other Salmonella Infections
- 003.0 Salmonella Gastroenteritis
- 003.1 Salmonella Septicemia
- 003.2 Localized Salmonella Infections
  - 003.20 Localized Salmonella Infection, Unspecified
  - 003.21 Salmonella Meningitis
  - 003.22 Salmonella Pneumonia
  - 003.23 Salmonella Arthritis
  - 003.24 Salmonella Osteomyelitis
  - 003.29 Other Localized Salmonella Infection
- 003.8 Other specified salmonella infections
- 003.9 Salmonella infection, unspecified

Figure 6.6

Respiratory disease w/ major chest operating room procedure, no major complication or comorbidity	75
Respiratory disease w/ major chest operating room procedure, minor complication or comorbidity	76
Respiratory disease w/ other respiratory system operating procedure, no complication or comorbidity	77
Respiratory infection w/ minor complication, age greater than 17	79
Respiratory infection w/ no minor complication, age greater than 17	80
Simple Pneumonia w/ minor complication, age greater than 17	89
Simple Pneumonia w/ no minor complication, age greater than 17	90
Respiratory disease w/ ventilator support	475
Respiratory disease w/ major chest operating room procedure and major complication or comorbidity	538
Respiratory disease, other respiratory system operating procedure and major complication	539
Respiratory infection w/ major complication or comorbidity	540
Respiratory infection w/ secondary diagnosis of bronchopulmonary dysplasia	631
Respiratory infection w/ secondary diagnosis of cystic fibrosis	740
Respiratory infection w/ minor complication, age not greater than 17	770
Respiratory infection w/ no minor complication, age not greater than 17	771
Simple Pneumonia w/ minor complication, age not greater than 17	772
Simple Pneumonia w/ no minor complication, age not greater than 17	773
Respiratory infection w/ primary diagnosis of tuberculosis	798

Figure 6.7

DE-10000	Bacterial infectious disease, NOS	(L-10000)
DE-10100	Bacterial pneumonia, NOS	(T-28000)(M-40000)(L-10000)
DE-11205	Pneumonia in anthrax	(T-28000)(M-40000)
DE-13212	Pneumonia in pertussis	(T-28000)(M-40000)
DE-13430	Pneumonic plague, NOS	(T-28000)(L-1E401)(DE-01750)
DE-13431	Primary pneumonic plague	(T-28000)(L-1E401)(DE-01750)
DE-13432	Secondary pneumonic plague	(T-28000)(L-1E401)(DE-01750)
DE-13510	Pneumococcal pneumonia	(T-28000)(M-40000)(L-25116)
DE-13934	Salmonella pneumonia	(T-28000)(L-17100)
DE-14120	Staphylococcal pneumonia	(T-28000)(L-24800)
DE-14213	Pneumonia due to Streptococcus	(T-28000)(M-40000)(L-25100)
DE-14817	Tuberculous pneumonia	(T-28000)(M-40000)(L-21801)
DE-15104	Pneumonia in typhoid fever	(T-28000)(M-40000)
DE-15613	Haemophilus influenzae pneumonia	(T-28000)(L-1F701)
DE-15710	Legionella pneumonia, NOS	(L-20401)
DE-15716	Pittsburg pneumonia	(L-20402)
DE-15810	Mycoplasma pneumonia	(T-28000)(L-22018)
DE-19110	Bacterial infection due to Klebsiella pneumoniae	(L-16001)
DE-19111	Pneumonia due to Klebsiella pneumoniae	(T-28000)(M-40000)(L-16001)
DE-19134	Achromobacter pneumonia	
DE-19151	Pneumonia due to Pseudomonas	(T-28000)(M-40000)(L-23400)
DE-19162	Pneumonia due to Proteus mirabilis	(T-28000)(M-40000)(L-16802)
DE-19204	Pneumonia due to E. coli	(T-28000)(M-40000)(L-15602)
DE-21611	Ornithosis with pneumonia	(T-28000)(M-40000)(L-2A902)
DE-21704	Pneumonia in Q fever	(T-28000)(M-40000)
DE-3632A	AIDS with bacterial pneumonia	(T-28000)(L-34800)(L-10000)
DE-3632B	AIDS with pneumococcal pneumonia	(T-28000)(L-34800)(L-25100)
DE-36333	AIDS with pneumonia, NOS	(T-28000)(M-40000)(L-34800)
D2-50100	Bronchopneumonia, NOS	(T-26000)(M-40000)
D2-50104	Peribronchial pneumonia	(T-26090)(M-40000)
D2-50110	Hemorrhagic bronchopneumonia	(T-26000)(M-40790)
D2-50120	Terminal bronchopneumonia	(T-26000)(M-40000)
D2-50130	Pleurobronchopneumonia	(T-26000)(M-40000)
D2-50130	Pleuropneumonia	(T-26000)(M-40000)
D2-50140	Pneumonia, NOS	(T-28000)(M-40000)
D2-50142	Catarrhal pneumonia	(T-28000)(M-40000)
D2-50150	Unresolved pneumonia	(T-28000)(M-40000)
D2-50152	Unresolved lobar pneumonia	(T-28770)(M-40000)
D2-50154	Organized pneumonia	
D2-50160	Granulomatous pneumonia, NOS	(T-28000)(M-44000)
D2-50300	Aspiration pneumonia, NOS	(T-28000)(M-40000)(G-C001) (F-29200)
D2-61020	Gangrenous pneumonia	(T-28000)(M-40700)
D8-72532	Infective pneumonia acquired prenatally, NOS	

Figure 6.8

- Respiratory Disorder
  - Infection of the Lower Respiratory Tract and Mediastinum
    - Acute Lower Respiratory Tract Infection
      - Pneumonia
        - Bacterial Pneumonia
          - Actinomycotic Pneumonia
          - Haemophilus Influenzae Pneumonia
          - Legionella pneumonia
          - Pneumococcal Pneumonia
          - Pneumonic Plague
            - Primary Pneumonic Plague
            - Secondary Pneumonic Plague
            - Pneumonic plague, unspecified
          - Salmonella Pneumonia
            - Typhoid Pneumonia
          - Staphylococcal Pneumonia
          - Meningococcal Pneumonia
          - Pneumonia due to Klebsiella pneumoniae
          - Pseudomonal pneumonia
          - Escherichia coli pneumona
          - Proteus pneumonia
          - Tularemia pneumonia
          - Pertussis pneumonia
          - Anthrax pneumonia
          - Nocardial pneumonia
          - Toxoplasma pneumonia
          - Streptococcal pneumonia
            - Group B streptococcal pneumonia
          - Secondary bacterial pneumonia *
          - Other bacterial pneumonia *
            - Pneumonia due to other specified bacteria *
              - Pneumonia due to bacteria NOS *
            - Bacterial pneumonia NOS *
          - Pneumonia due to other aerobic gram-negative bacteria *
          - Pneumonia in bacterial disease classified elsewhere *

Figure 6.9

4-3-3-2-1-7-1 Pneumonia
4-3-3-2-1-7-1-3 Causes of Pneumonia
4-3-3-2-1-7-1-3-1 Bacterial Pneumonia
4-3-3-2-1-7-1-3-1-1 Presumed Bacterial Pneumonia
4-3-3-2-1-7-1-3-1-2 Streptococcus Pneumonia
4-3-3-2-1-7-1-3-1-3 Staphylococcus Aureus Pneumonia
4-3-3-2-1-7-1-3-1-3-1 Staphylococcal Pneumonia
4-3-3-2-1-7-1-3-1-4 Streptococcus Pyogenes Pneumonia
4-3-3-2-1-7-1-3-1-5 Neisseria Meningitidis Pneumonia
4-3-3-2-1-7-1-3-1-6 Branhamella Catarrhalis Pneumonia
4-3-3-2-1-7-1-3-1-7 Hemophilus Influenzae Pneumonia
4-3-3-2-1-7-1-3-1-8 Klebsiella Pneumonia
4-3-3-2-1-7-1-3-1-9 Escherichia Coli Pneumonia
4-3-3-2-1-7-1-3-1-10 Serratia Species Pneumonia
4-3-3-2-1-7-1-3-1-11 Enterobacteria Species Pneumonia
4-3-3-2-1-7-1-3-1-12 Proteus Species Pneumonia
4-3-3-2-1-7-1-3-1-13 Pseudomonas Aeruginosa Pneumonia
4-3-3-2-1-7-1-3-1-14 Pseudomonas Capacia Pneumonia
4-3-3-2-1-7-1-3-1-15 Pseudomonas Multiphilia Pneumonia
4-3-3-2-1-7-1-3-1-16 Pseudomonas Pseudoalcaligenes Pneumonia
4-3-3-2-1-7-1-3-1-17 Actinobacter Species Pneumonia
4-3-3-2-1-7-1-3-1-18 Legionella Species Pneumonia
4-3-3-2-1-7-1-3-1-19 Anaerobic Microbial Pneumonia
4-3-3-2-1-7-1-3-1-19-1 Fusobacterium Species Pneumonia
4-3-3-2-1-7-1-3-1-19-2 Bacteroides Species Pneumonia
4-3-3-2-1-7-1-3-1-19-3 Peptostreptococcus Species Pneumonia
4-3-3-2-1-7-1-3-1-19-4 Microaerophilic Streptococcus Pneumonia
4-3-3-2-1-7-1-3-1-20 Actinomyces Pneumonia
4-3-3-2-1-7-1-3-1-21 Nocardia Species Pneumonia
4-3-3-2-1-7-1-3-1-22 Mycoplasma Pneumonia
4-3-3-2-1-7-1-3-1-23 Coxiella Burnetti Pneumonia
4-3-3-2-1-7-1-3-1-24 Chlamydia Psittaci Pneumonia
4-3-3-2-1-7-1-3-1-25 Chlamydia Trachopmatis Pneumonia
4-3-3-2-1-7-1-3-1-26 Pseudomonas Pseudomallei Pneumonia
4-3-3-2-1-7-1-3-1-27 Paturella Pneumonia
4-3-3-2-1-7-1-3-1-28 Francisella Pneumonia
4-3-3-2-1-7-1-3-1-29 Yersinia Pestis Pneumonia
4-3-3-2-1-7-1-3-1-30 Bacillis Anthracis Pneumonia
4-3-3-2-1-7-1-3-1-31 Brucella Species Pneumonia
4-3-3-2-1-7-1-3-1-32 Chlamydial Pneumonia
4-3-3-2-1-7-1-3-1-33 Mycobacterial Pneumonia
4-3-22-1 Bacterial Disease
4-3-22-1-1 Bacteriogenic Pneumonia
4-3-22-1-1-2 Pneumococcus Pneumonia
4-3-22-1-1-3 Staphylococcal Pneumonia

4-3-22-1-1-3-1 Primary Staphylococcal Pneumonia
4-3-22-1-1-3-2 Secondary Staphylococcal Pneumonia
4-3-22-1-1-4 Streptococcal Pneumonia

Figure 6.10

Blood glucose	GLUCOSE:MCNC:PT:BLD:QN:
Plasma glucose	GLUCOSE:MCNC:PT:PLAS:QN:
Serum glucose	GLUCOSE:MCNC:PT:SER:QN:
Urine glucose concentration	GLUCOSE:MCNC:PT:UR:QN:
Urine glucose by dip stick	GLUCOSE:MCNC:PT:UR:SQ:TEST STRIP
Glucose tolerance test at 2 hours	GLUCOSE^2H POST 100 G GLUCOSE PO: MCNC:PT:PLAS:QN:
Ionized whole blood calcium	CALCIUM.FREE:SCNC:PT:BLD:QN:
Serum or plasma ionized calcium	CALCIUM.FREE:SCNC:PT:SER/PLAS:QN:
24 hour calcium excretion	CALCIUM.TOTAL:MRAT:24H:UR:QN:
Whole blood total calcium	CALCIUM.TOTAL:SCNC:PT:BLD:QN:
Serum or plasma total calcium	CALCIUM.TOTAL:SCNC:PT:SER/PLAS:QN:
Automated hematocrit	HEMATOCRIT:NFR:PT:BLD:QN: AUTOMATED COUNT
Manual spun hematocrit	HEMATOCRIT:NFR:PT:BLD:QN:SPUN
Urine erythrocyte casts	ERYTHROCYTE CASTS:ACNC:PT:URNS:SQ: MICROSCOPY.LIGHT
Erythrocyte MCHC	ERYTHROCYTE MEAN CORPUSCULAR HEMOGLOBIN CONCENTRATION:MCNC:PT: RBC:QN:AUTOMATED COUNT
Erythrocyte MCH	ERYTHROCYTE MEAN CORPUSCULAR HEMOGLOBIN:MCNC:PT:RBC:QN: AUTOMATED COUNT
Erythrocyte MCV	ERYTHROCYTE MEAN CORPUSCULAR VOLUME: ENTVOL:PT:RBC:QN:AUTOMATED COUNT
Automated Blood RBC	ERYTHROCYTES:NCNC:PT:BLD:QN: AUTOMATED COUNT
Manual blood RBC	ERYTHROCYTES:NCNC:PT:BLD:QN: MANUAL COUNT
ESR by Westergren method	ERYTHROCYTE SEDIMENTATION RATE:VEL:PT: BLD:QN:WESTERGREN
ESR by Wintrobe method	ERYTHROCYTE SEDIMENTATION RATE:VEL:PT: BLD:QN:WINTROBE

Figure 6.11

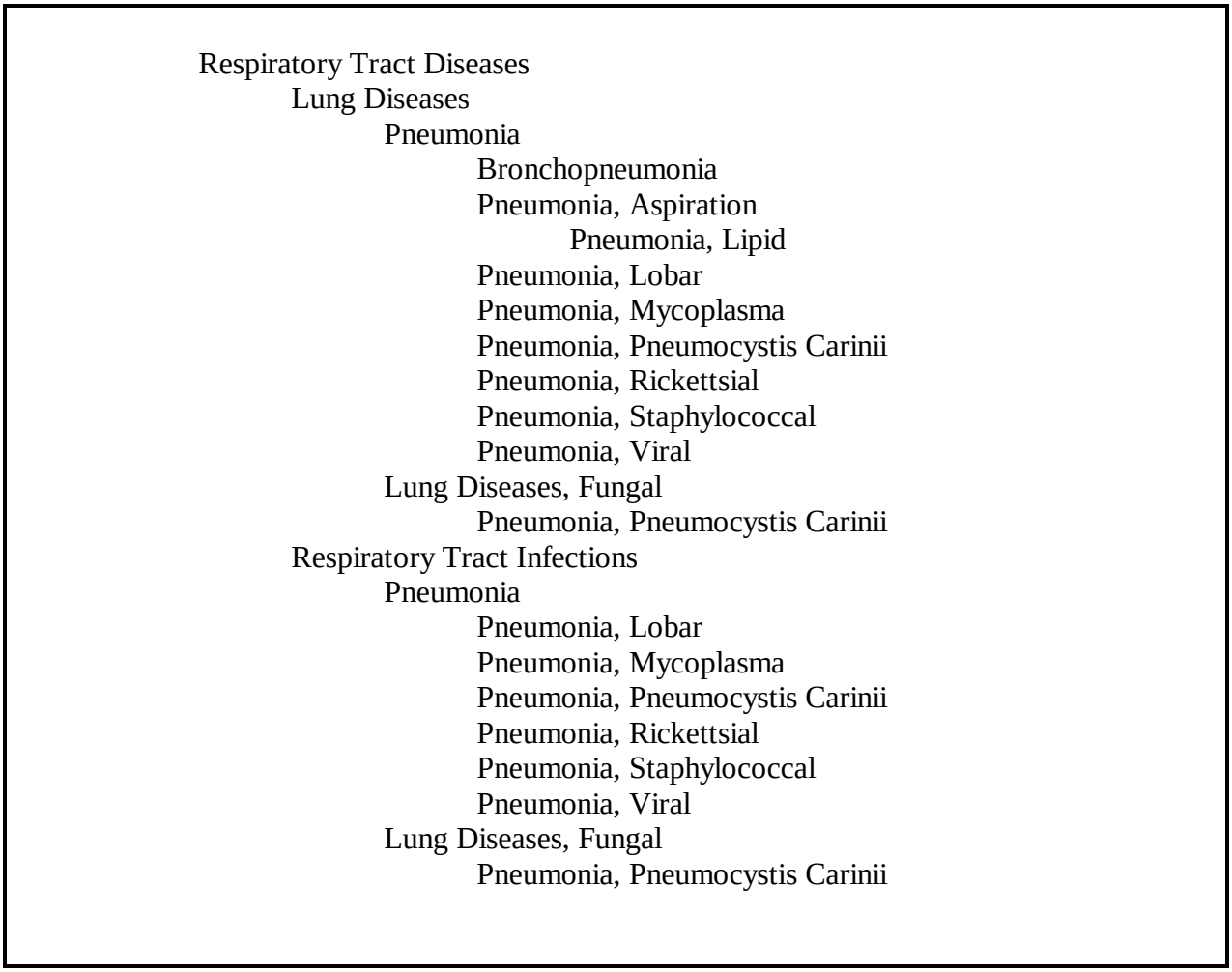
Respiratory Tract Diseases
Lung Diseases
Pneumonia
Bronchopneumonia
Pneumonia, Aspiration
Pneumonia, Lipid
Pneumonia, Lobar
Pneumonia, Mycoplasma
Pneumonia, Pneumocystis Carinii
Pneumonia, Rickettsial
Pneumonia, Staphylococcal
Pneumonia, Viral
Lung Diseases, Fungal
Pneumonia, Pneumocystis Carinii
Respiratory Tract Infections
Pneumonia
Pneumonia, Lobar
Pneumonia, Mycoplasma
Pneumonia, Pneumocystis Carinii
Pneumonia, Rickettsial
Pneumonia, Staphylococcal
Pneumonia, Viral
Lung Diseases, Fungal
Pneumonia, Pneumocystis Carinii

Figure 6.12

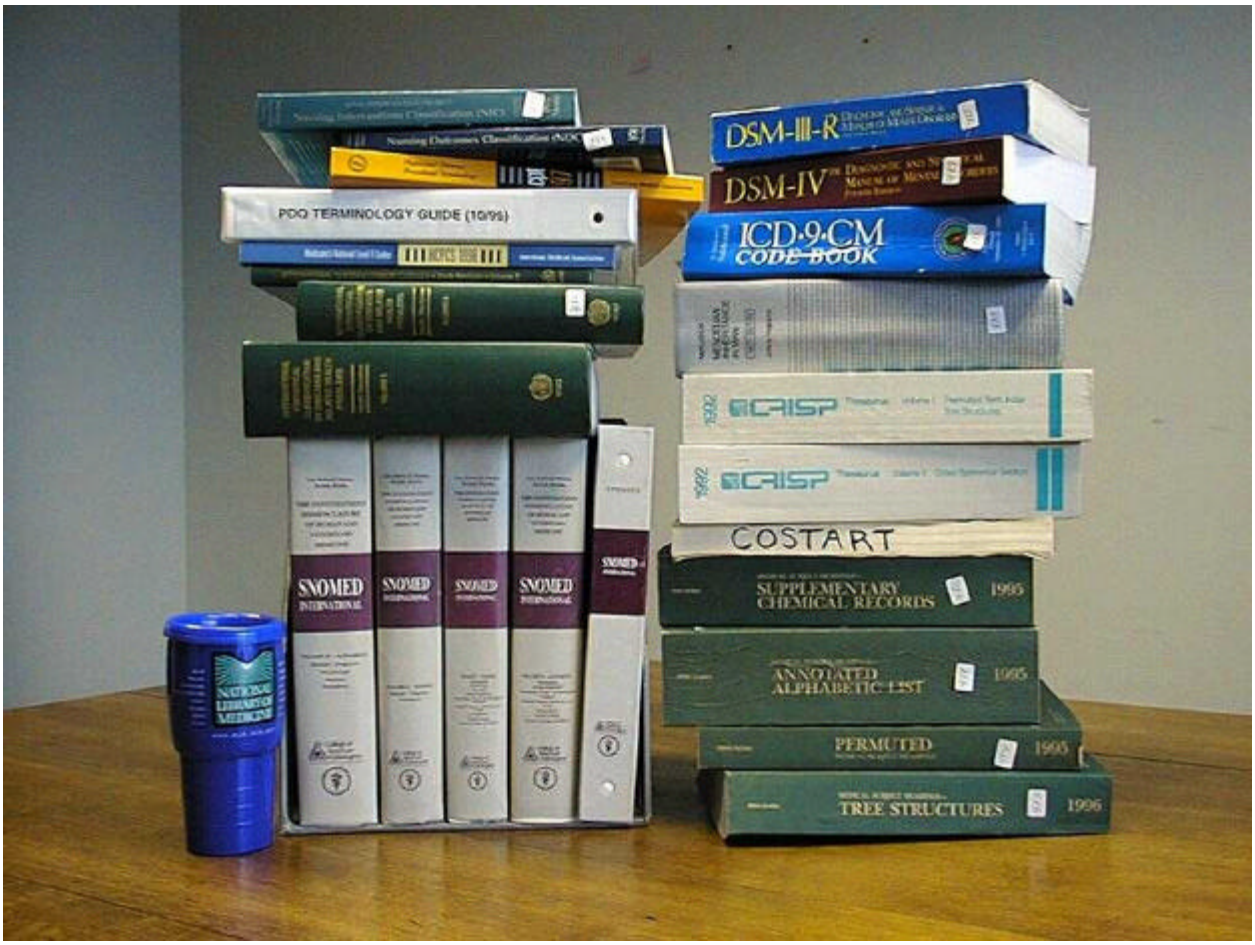
DSM-III-R
DSM-IV
ICD-9-CM
CODE BOOK
PDQ TERMINOLOGY GUIDE (10/95)
CRISP
CRISP
COSTART
SNOMED
SNOMED
SNOMED
SNOMED
SUPPLEMENTARY CHEMICAL RECORDS 1995
ANNOTATED ALPHABETIC LIST 1995
PERMUTED 1995
TREE STRUCTURES 1996

Figure 6.13

C0004626: Pneumonia, Bacterial
C0023241: Legionnaires' Disease
C0032286: Pneumonia due to other specified bacteria
C0032308: Pneumonia, Staphylococcal
C0152489: Salmonella pneumonia
C0155858: Other bacterial pneumonia
C0155859: Pneumonia due to Klebsiella pneumoniae
C0155860: Pneumonia due to Pseudomonas
C0155862: Pneumonia due to Streptococcus
C0155865: Pneumonia in pertussis
C0155866: Pneumonia in anthrax
C0238380: PNEUMONIA, KLEBSIELLA AND OTHER GRAM NEGATIVE BACILLI
C0238381: PNEUMONIA, TULAREMIC
C0242056: PNEUMONIA, CLASSIC PNEUMOCOCCAL LOBAR
C0242057: PNEUMONIA, FRIEDLAENDER BACILLUS
C0275977: Pneumonia in typhoid fever
C0276026: Haemophilus influenzae pneumonia
C0276039: Pittsburgh pneumonia
C0276071: Achromobacter pneumonia
C0276080: Pneumonia due to Proteus mirabilis
C0276089: Pneumonia due to E. Coli
C0276523: AIDS with bacterial pneumonia
C0276524: AIDS with pneumococcal pneumonia
C0339946: Pneumonia with tularemia
C0339947: Pneumonia with anthrax
C0339952: Secondary bacterial pneumonia
C0339953: Pneumonia due to escherichia coli
C0339954: Pneumonia due to proteus
C0339956: Typhoid pneumonia
C0339957: Meningococcal pneumonia
C0343320: Congenital pneumonia due to staphylococcus
C0343321: Congenital pneumonia due to group A hemolytic streptococcus
C0343322: Congenital pneumonia due to group B hemolytic streptococcus
C0343323: Congenital pneumonia due to Escherichia coli
C0343324: Congenital pneumonia due to pseudomonas
C0348678: Pneumonia due to other aerobic gram-negative bacteria
C0348680: Pneumonia in bacterial diseases classified elsewhere
C0348801: Pneumonia due to streptococcus, group B
C0349495: Congenital bacterial pneumonia
C0349692: Lobar (pneumococcal) pneumonia
C0375322: Pneumococcal pneumonia {Streptococcus pneumoniae pneumonia}
C0375323: Pneumonia due to Streptococcus, unspecified
C0375324: Pneumonia due to Streptococcus Group A
C0375326: Pneumonia due to other Streptococcus
C0375327: Pneumonia due to anaerobes

C0375328: Pneumonia due to escherichia coli {E. Coli}
C0375329: Pneumonia due to other gram-negative bacteria
C0375330: Bacterial pneumonia, unspecified

Figure 6.14

Bacterial pneumonia	
Source:	CSP93/PT/2596-5280; DOR27/DT/U000523; ICD91/PT/482.9; ICD91/IT/482.9
Parent:	*Bacterial Infections*; *Pneumonia*; *Influenza with Pneumonia*
Child:	*Pneumonia, Mycoplasma*
Narrower:	*Pneumonia, Lobar*; *Pneumonia, Rickettsial*; *Pneumonia, Staphylococcal*; *Pneumonia due to Klebsiella Pneumoniae*;*Pneumonia due to Pseudomonas*; *Pneumonia due to Hemophilus influenzae (H. influenzae)*
Other:	*Klebsiella Pneumoniae, Streptococcus Pneumoniae*
Pneumonia, Lobar	
Source:	ICD91/IT/481; MSH94/PM/D011018; MSH94/MH/D011018; SNM2/RT/M-40000; ICD91/PT/481; SNM2/PT/D-0164; DXP92/PT/U000473; MSH94/EP/D011018; INS94/MH/D011018;INS94/SY/D011018
Synonym:	Pneumonia, diplococcal
Parent:	*Bacterial Infections*; *Influenza with Pneumonia*
Broader:	*Bacterial Pneumonia*; *Inflammation*
Other:	*Streptococcus Pneumoniae*
Semantic:	inverse-is-a: *Pneumonia* has-result: *Pneumococcal Infections Pneumonia, Staphylococcal*
Source:	ICD91/PT/482.4; ICD91/IT/482.4; MSH94/MH/D011023; MSH94/PM/D011023; MSH94/EP/D011023; SNM2/PT/D-017X; INS94/MH/D011023; INS94/SY/D011023
Parent:	*Bacterial Infections*; *Influenza with Pneumonia*
Broader:	*Bacterial Pneumonia*
Semantic:	inverse-is-a: *Pneumonia*; *Staphylococcal Infections Pneumonia, Streptococcal*
Source:	ICD91/IT/482.3
Other:	*Streptococcus Pneumoniae Pneumonia due to Streptococcus*
Source:	ICD91/PT/482.3
ATX:	Pneumonia AND Streptococcal Infections AND NOT Pneumonia, Lobar
Parent:	*Influenza with Pneumonia*
Pneumonia in Anthrax	
Source:	ICD91/PT/484.5; ICD91/IT/022.1; ICD91/IT/484.5
Parent:	*Influenza with Pneumonia*
Broader:	*Pneumonia in other infectious diseases classified elsewhere*
Other:	*Pneumonia, Anthrax*
Pneumonia, Anthrax	
Source:	ICD91/IT/022.1; ICD91/IT/484.5
Other:	*Pneumonia in Anthrax*

Figure 6.15

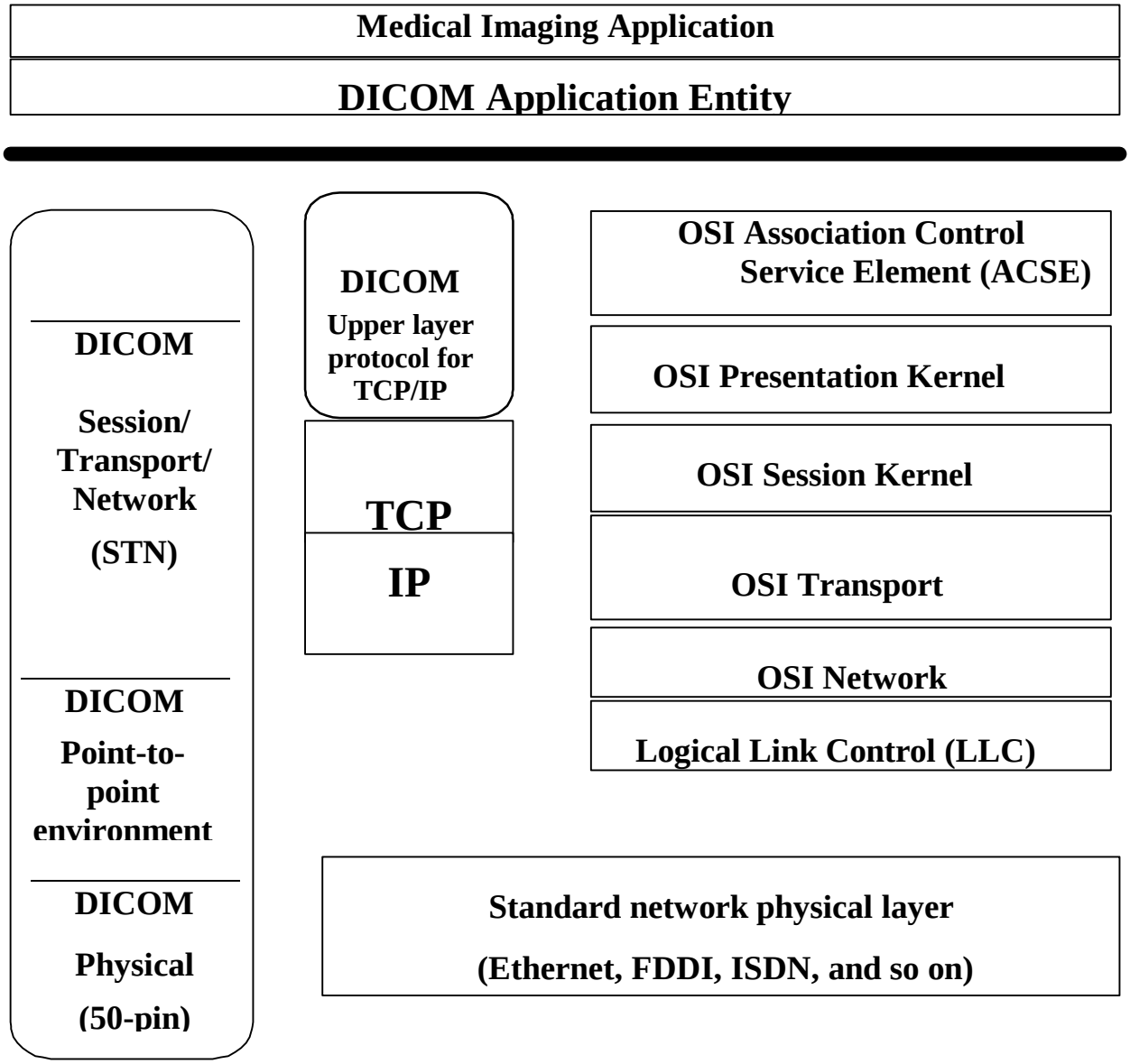
Medical Imaging Application
DICOM Application Entity
DICOM
Session/
Transport/
Network
(STN)
DICOM
Point-to-
point
environment
DICOM
Physical
(50-pin)
DICOM
Upper layer
protocol for
TCP/IP
TCP
IP
OSI Association Control
Service Element (ACSE)
OSI Presentation Kernel
OSI Session Kernel
OSI Transport
OSI Network
Logical Link Control (LLC)
Standard network physical layer
(Ethernet, FDDI, ISDN, and so on)

Figure 6.16

H|~^\&|95243|HAMMO001|COMMUNITY AND FAMILY MEDICINE|BOX 2914^DUKE UNIVERSITY MEDICAL CENTER^DURHAM^NC|919-684-6721||SMITHKLINE CLINICAL LABS|TEST MESSAGE|D|2|199401170932<cr>

P|1|999-99-9999|||GUNCH^MODINE^SUE||19430704|F|<cr>

RT 1, BOX 97^ZIRCONIA^NC^27401||704-982-1234||DOCTOR^PRIMARY^A^^DR.<cr>

OBR|1|101||80018^CHEM 18|R||||N|||||MD&PRIMARY&A&DR.<cr>

OBR|2|102||85025^AUTO CBC|R||||N|||||MD&PRIMARY&A&DR.

Figure 6.17

MSH|^~&\|DHIS|OR|TMR|SICU|199212071425|password|ADT|16603529|P|2.1<cr>

EVN|A02|199212071425||<cr>

PID|||Z99999^5^M11||GUNCH^MODINE^SUE|RILEY|19430704 |F||C|RT. 1, BOX 97^ZIRCONIA^NC^27401 |HEND|(704)982-1234|(704)983-1822||S|C||245-33-9999<cr>

PV1|1|I|N22^2204|||OR^03|0940^DOCTOR^HOSPITAL^A|||SUR|||||A3<cr>

OBR|7|||93000^EKG REPORT|R|199401111000|199401111330|||RMT||||19940111 11330|?|P030||||||199401120930||||||88-126666|A111|VIRANYI^ANDREW<cr>

OBX|1|ST|93000.1^VENTRICULAR RATE(EKG)||91|/MIN|60-100<cr>

OBX|2|ST|93000.2^ATRIAL RATE(EKG)||150|/MIN|60-100<cr>

...

OBX|8|ST|93000&IMP^EKG DIAGNOSIS|1|^ATRIAL FIBRILATION<cr>

Figure 6.18

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SUPPLECODE*01*134999883*DA*867869899*940116<n/l>
TRN*1*45166*IDNUMBER<n/l>
DTM*009*940104<n/l>
N1*PR*HEALTHY INSURANCE COMPANY<n/l>
N3*1002 WEST MAIN STREET<n/l>
N4*DURHAM*NC*27001<n/l>
N1*PE*DUKE MEDICAL CENTER<n/l>
N3*2001 ERWIN ROAD<n/l>
N4*DURHAM*NC*27710<n/l>
CLP*078189203*1*6530*4895*CIN<n/l>
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NM1*15*IAM*A*PATIENT<n/l>
REF*1K*942238493<n/l>
DTM*232*940101<n/l>
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