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APPLIED INFORMATION MANAGEMENT

A Study of Selected UMLS Vocabularies and their use within the Electronic Health Record

CAPSTONE REPORT

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Abstract

for

**A Study of Selected UMLS Vocabularies and
their use within the Electronic Health Record**

This study examines eight UMLS controlled vocabularies and reviews them to determine how they may be used to support communication within the EHR. This study is important because no controlled vocabulary fully meets the needs of healthcare (Abdelhak, et al, 2001). Content analysis reveals that items generally included in the EHR are observations, laboratory tests, diagnostic imaging reports, treatments, therapies, drugs, patient information, legal permissions, and allergies. A descriptive profile of each vocabulary is included.

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CHAPTER 1 – PURPOSE OF STUDY

Brief Purpose

The purpose of this study is to select a sub-set of professional clinical controlled vocabularies from those contained in the Unified Medical Language System (UMLS) and to identify literature that has been published in relation to each selected vocabulary. The goal is to locate literature that examines each selected controlled vocabulary as a way to better understand the focus and how the vocabulary might be used to support clearer communication within the electronic health record.

A controlled vocabulary refers to "a restricted set of phrases, generally enumerated in a list and perhaps arranged into a hierarchy" (Giannangelo, 2006). This study focuses on identification of the larger topics of the controlled vocabularies themselves and not the terms contained within those controlled vocabularies. The assumption underlying this study is that the communication potential of the electronic health record will be improved from identification (and eventual use) of a more clearly defined and standardized set of terminologies.

Controlled vocabularies are referenced in many different ways. The concept of 'coded data' refers to the controlled vocabularies or classification systems used in healthcare (Abdelhak, et al, 2001). When used in relation to controlled vocabularies, coded data provides consistency in how diagnoses, procedures, laboratory tests, drugs and other forms of clinical information are expressed (Abdelhak, et al, 2001). Abdelhak (2001), in describing controlled vocabularies,

states, "none completely addresses the clarity and precision required to capture and represent all clinical facts contained in patient records" (p. 698).

Coding systems, also known as controlled vocabularies, are commonly used for such varied health information communication needs as payment of medical claims, billing, epidemiology, and outcomes research (Abdelhak, et al, 2001). There is currently much effort being given by medical informatics and health information management researchers to improve the existing controlled vocabularies through study, research and demonstration projects. The intent in each of these efforts is to identify ways to either improve or expand existing vocabularies or in some cases to develop a replacement vocabulary that is more complete, in order to provide consistent health care data throughout organizations (Abdelhak, et al, 2001).

This study is designed as a literature review (Leedy and Ormrod, 2005). Focus is on collection and examination of a set of controlled vocabularies presented in the Unified Medical Language System (UMLS) and related research about a subset of these controlled vocabularies. The UMLS currently contains 145 controlled vocabularies. A preliminary analysis of the UMLS vocabularies is conducted for the purpose of selecting a sub-set of controlled vocabularies for further consideration in this study.

Once a set of potential UMLS source vocabularies is selected, content analysis (Palmquist, et al, 2007) is conducted as a way to determine the larger topic foci of each of the selected controlled vocabularies. Results are presented as an annotated list of topics contained in each selected controlled vocabulary. It is the hope of this researcher that health information

management professionals and information system developers will be able to apply these to their work to improve the consistency of health care reporting data, as communicated within the electronic health record.

This study is targeted towards credentialed health information management professionals who are involved in implementing electronic health records. These professionals are employed in a variety of healthcare settings managing paper-based medical records and electronic health records (AHIMA Facts, 2007).   The majority of the medical record is currently free text (i.e., without any pre-defined structure), which results in much manual effort and abstracting of data in order to be able to provide reports based on the data (Abdelhak, et al, 2001). The use of controlled vocabularies to help abstract this data will eliminate manual work.

In order to support the communication needs of this professional community, the final outcome of this study is designed as a description of the purpose and use of each of the selected controlled vocabularies. The annotated list, developed as a way to present the data analysis results, is expanded into descriptions that suggest how some of these controlled vocabularies might be used to improve the consistency of health care reporting data in the electronic health record. The expectation is that these descriptions will help improve accessibility to data located within the electronic health record (Abdelhak, et al, 2001). Because much of the data within the record presently is unstructured text, it is difficult to access for reporting purposes. (Abdelhak, et al, 2001). The assumption underlying this study is that the ability to report using the data located within the electronic health record can be improved through careful study and application of the

information provided in the descriptions of the purpose and use of each selected controlled

vocabulary.

Full Purpose

Previous studies have concluded that no existing controlled vocabulary completely

captures the full scope of clinical care (Chute, Cohn, Campbell, Oliver, and Campbell, 1996).

Each one is intended for it's own purpose to record a portion of clinical care (Chute, et al, 1996).

The importance of these vocabularies is increasing rapidly with large-scale systems development

and international concerns (Chute, 2000). These controlled vocabularies are important to

provide content consistency for electronic health records related to diagnoses, procedures,

laboratory tests, drugs and so on (Abdelhak, et al, 2001). They are needed to allow healthcare

systems to be interoperable, exchanging data and providing the ability for healthcare providers to

treat patients wherever they may be located (Foley and Garrett, 2006).

Controlled vocabularies have been slow to be adopted by developers of health

information systems and users of clinical data (Giannangelo, 2006). Details about their

definitions and purposes are obscure and difficult to locate even in the age of the Internet

(Giannangelo, 2006). Information systems developers often create their own controlled

terminologies, rather than learning to use the ones that exist (Giannangelo, 2006). Because of

this, the National Library of Medicine created the UMLS to begin to offer accessibility and

education about over 100 available controlled vocabularies (Fenton, 2005).

This study is designed as a literature review (Leedy and Ormrod, 2005). According to

Leedy and Ormrod (2005), a literature review includes evaluating and organizing the literature

and does not simply report it. Focus is on examination of a set of controlled vocabularies

presented in the Unified Medical Language System (UMLS) and related research about a subset

of these controlled vocabularies. The National Library of Medicine (NLM) developed the

UMLS. It is intended to assist in the development of computer systems that understand

biomedicine and health language. The UMLS controlled vocabularies can be used to work with

a variety of types of information that include patient records, scientific literature, clinical

guidelines, and public health data (NLM, 2006). As part of the final outcome, this study

identifies which controlled vocabularies can be used with these and other types of information in

the electronic health record.

The purpose of this study is to analyze a set of controlled vocabularies, selected from the

UMLS, that may be of benefit as a way to improve healthcare quality and accessibility to

healthcare data (Abdelhak, et al, 2001) when used within the electronic health record. Many

terms and information categories that have very different meanings can be identified within

electronic health records. Terms and categories are used interchangeably because of the lack of

education and clarity in controlled vocabulary field (Giannangelo, 2006).   The goal of this study

is to identify the larger topics areas of a selected set of controlled vocabularies, as a way to

understand how these vocabularies can be used to support clearer communication within the

electronic health record.

Controlled vocabularies contain lists of terms or concepts with either a description or

definition of that term or concept. Clear definitions of the vocabularies are difficult to find

(Giannangelo, 2006). The data analysis process in this study is designed to identify on the

overarching purpose and definition of each of the eight selected controlled vocabularies, rather

than the specific terms contained within them. The UMLS Metathesaurus vocabularies that are

being studied contain a variety of vocabularies that have a variety of uses. Some are large

vocabularies used for statistical reporting and reimbursement (Fenton, 2006). Others are focused

more narrowly and are used for psychiatry, nursing, or other specific purposes (Fenton, 2006).

The first step in this study is to select a sub-set of controlled vocabularies contained in the

UMLS. There are 145 controlled vocabularies listed in the UMLS (NLM, 2007). After

duplicates related to older versions and foreign language versions are eliminated, there are 74

controlled vocabularies remaining. To initiate the analysis, a search of literature is conducted to

identify which of these 74 UMLS source vocabularies have been further examined in more than

twenty peer-reviewed articles. Only those source vocabularies that have been studied and

reported in the literature to this degree or more are selected for further use in this study. Any

vocabularies in that group that are typically used for the following purposes are eliminated from

the study group:

- organizing and retrieving literature (i.e. Medline)

- organizing and retrieving vocabularies (i.e. UMLS Metathesaurus)

- considered to be a data standard (i.e. HL7)

- an artificial intelligence diagnosis program (i.e. Dxplain)

- identifying genes (i.e. Gene Ontology)

- institution specific (i.e. Medical Entities Dictionary)

- focused on adverse reactions (i.e. COSTART)

- presently used primarily for reimbursement purposes (CPT, ICD-9-CM)

In addition, the Read Codes were eliminated because SNOMED CT is a further development of those codes. And although the vocabularies that are focused on adverse reactions are beneficial to the electronic health record, this set of vocabularies is suitable for a separate study.

A summary of the process of elimination of the vocabularies is presented in Appendix B. The selected final sub-set of eight UMLS controlled vocabularies examined in this study is noted in bold text.

The report of data analysis begins with a list of the controlled vocabularies selected for use during the content analysis. Results are presented as an annotated list of topics contained in each selected controlled vocabulary. These results are then expanded in a final outcome of this study, designed to provide a description of how each selected controlled vocabulary can be utilized within the electronic health record. For example, SNOMED CT is used in England as a standard controlled vocabulary to electronically exchange patient summary information between facilities (Ward, 2006).

This study is directed at a subset of the credentialed members of the American Health Information Management Association (AHIMA). AHIMA has over 51,000 members who are employed in 40 different work settings with 125 different job titles (AHIMA Facts, 2007). Specifically, this paper is targeted towards the health information management professionals and information system designers involved in developing electronic health records. Systems development is the process of designing and programming an information system (Austin and Boxerman, 1998). There are a variety of steps in any information systems development life

cycle (Austin and Boxerman, 1998). These steps do not directly affect this study but the results

can be used to provide the structure and standardization needed to design effective systems

(Austin and Boxerman, 1998). Historically most of the AHIMA members have managed paper-

based medical records (AHIMA Facts, 2007). Now with the move towards electronic health

records, HIM professionals are working in many roles to help define the electronic health records

to meet legal requirements and maintain high levels of data integrity, confidentiality, and

security (AHIMA Facts, 2007). Even with the development of electronic health records, the

majority of the medical record is unstructured text and solutions are needed to make the data

more accessible (Abdelhak, et al, 2001). Understanding terminologies and incorporating them

into the electronic health record permits the development of information systems that are able to

monitor quality and the practice of evidence-based medicine consistently (Bowman, 2005).

Significance of the Study

The use of the electronic health record in healthcare facilities is increasing with 18% of healthcare facilities having an electronic health record fully installed in 2005, up to 25% in 2006 (Healthcare IT News, 2006). As a result, better methods need to be developed for healthcare facilities to permit reporting and accessibility to this information (Austin and Boxerman, 1998). As the electronic health records develop, standardization becomes important and requires the use of controlled vocabularies (Imel, 2002). Much of the paper-based medical record is textual data and incorporating vocabularies into the process of creating the electronic health record allows the data to be used for outcomes research, decision support and knowledge management (Fenton, 2006).

The recognition of a need for controlled vocabularies is growing (Cimino, 1998). It is important for HIM professionals to develop knowledge in this area and lead the standardization efforts because of their training and experience in the management of patient records (Imel, 2002). For example, one of the responsibilities that HIM professionals have is clinical code assignment for reimbursement and registry operations (Fenton, 2006). HIM coders review documentation in the paper-based medical record or electronic health record and assign codes to conditions, treatment, and procedures based on the guidelines for specific classification systems (Fenton, 2006). This is a skill set that can be transferable and valuable in formally classifying medical knowledge with other controlled vocabularies, but requires a consistent application of concepts and definitions in order to be effective. During the process of clinical code assignment, the goal is to improve access to data and information that is consistently defined and reported,

both for internal use and to permit access to a national health infrastructure as it is developed

(Appavu, 2006). The amount of clinical data available is increasing rapidly and better methods

are needed to handle this data (Fenton, 2004).

Limitations of the Study

This study is limited to an examination of controlled vocabularies in the medical field. Only controlled vocabularies listed in the UMLS are considered for inclusion in this study.

The limitation of working with vocabularies from the UMLS only is selected because the resource is a fairly recent development available to researchers and practitioners, and is designed to organize the available vocabularies (Fenton, 2004).

Only controlled vocabularies that have been further examined in more than twenty research studies are selected for use in this study. The reason for this criterion is to determine which controlled vocabularies have been studied and are thus likely to provide clearer applications than those that have not yet been studied further.

A 'controlled vocabulary' as it is used in the medical field is simply a large list of terms associated with a particular area of inquiry. However, the definition of each of those individual terms can be complex because of the medical processes, diseases, tests, or whatever that they embody. The definition of the term 'controlled vocabulary' as used in this paper is a standardized set of terms and phrases used to describe a subject area or information domain (Stewart, 2006).

The definition of the controlled vocabulary itself is different from the "list of terms" that comprise the vocabulary. This paper does not analyze the list of terms within the vocabularies or

their definitions. It focuses instead on identification of the overarching purpose of the controlled vocabulary and which portions of the electronic health record can benefit from its use. For example, the Logical Observation Identifiers, Names, and Codes (LOINC), is used to report laboratory results. The components of the various test results comprise the list of terms within the vocabulary.

The study is designed as a literature review (Leedy and Ormrod, 2005). This limitation is applied because the data is textual in nature.

The data analysis strategy selected is content analysis (Leedy and Ormrod, 2005) because the process provides a way to identify the presence of selected words and concepts in texts. Conceptual analysis as defined by Palmquist et.al. (Palmquist, Busch, De Maret, Flynn, Kellum, Le, Meyers, Saunders, and White, 2005) is the specific strategy used.

The time frame for literature collection is limited to 2003 through 2007, except when needed for definitions. This is the time period where serious study of the controlled vocabularies in the medical field began and the bulk of the literature is more recent. The Department of Health and Human Services announced the first set of designated standards on March 21, 2003, marking the beginning of national standards that presently are complied with on a voluntary basis (ONC, 2006).

Problem Area

Healthcare produces a great deal of data and the efficiency with which this data is managed has significant impact on the quality of healthcare (Austin and Boxerman, 1998). Standards have been established more readily in other industries, such as banking and the airlines, because the data can be more easily queried and retrieved (Appavu, 2006). In healthcare, the data is multidisciplinary and spans multiple locations and facilities for one episode of care, creating more complexity than these industries must handle (Appavu, 2006). Controlled vocabularies are needed to properly represent the concepts that are a part of the symptoms, diagnoses, procedures and health status in the electronic health record (Johns, 2002). The time span of 1990 to 2010 will be recognized as the period of active deployment of electronic health records (Abdelhak, et al, 2001). Standards are the key to interoperability of the systems and data (AHIMA, 2006).

Medical informatics, health information professionals, and the federal government are actively studying available standards.   Health care reforms, cost containment, and the changes in healthcare delivery require that standards development occur (Abdelhak, et al, 2001).

When the collection and recording of data is not standardized, healthcare organizations cannot be confident that reporting of quality indicators used for compliance and other reporting mechanisms are comparing the same data either within the organization or with data from other organizations (AHIMA, 2006). A few institutions that include the Regenstreif Institute and Columbia University, have implemented electronic health records that include controlled

vocabularies for healthcare, and with the increase in electronic health records, more health information management professionals and information systems developers need to develop knowledge of how to use them (Levy, 2004).

The UMLS project from the National Library of Medicine is the broadest attempt to bring the various controlled vocabularies together (Johns, 2002). The U.S. Department of Health and Human Services is also coordinating the official approval of vocabularies (ONC, 2006). This study identifies the areas where further study and research needs to be completed, therefore extending current knowledge.

An important first step that is beginning to take place is the harmonization of electronic standards for healthcare in the United States (Halamka, 2006). Many standards are redundant with so many versions and variations that they become non-standard (Halamka, 2006). Multiple vocabularies are required to capture all the elements of clinical content in an electronic health record (Bowman, 2005). At this time, no single controlled vocabulary captures the entire content of healthcare terminology (Levy, 2004). An example is the National Drug Codes that are used for pharmacy inventory control. These are too complex and detailed to use for physician order entry (Levy, 2004).

This researcher is a member of an AHIMA practice council that is working on defining standards and career development opportunities related to clinical terminologies and classification systems, which are both under the umbrella term of controlled vocabularies, to assist health information management professionals in this area.

There remains a lot of work to be done before the history and physical (H&P) content in a record is consistent between two institutions (Rollins, 2003). Continuing development of standards and controlled vocabularies is critical as systems and electronic health records advance (Abdelhak, et al, 2001).

CHAPTER 2 - REVIEW OF REFERENCES

This chapter provides a review of the major references used for this study. The references are presented in alphabetical order. Each entry describes how the reference relates to the study and the background of the authors or editors that indicate this is reliable content.

Abdelhak, M., Grostick, S., Hanken, M., Jacobs, E. (eds.) (2001). *Health Information: Management of a Strategic Resource."* Philadelphia: W. B. Saunders Company.

This resource is a textbook frequently used in health information technology and health information administration programs. It contains chapters on electronic health records, the information system life cycle, coding and reimbursement systems and other topics that provide important background information for this study. It is also a source of definitions for the following terms:

- Abstracting
- Clinical Decision Support
- Electronic Health Record
- Epidemiology
- Literature Review
- Medical Informatics
- Outcomes
- Registry

Mervat Abdelhak, Ph.D., RHIA, is the Department Chair and Associate Professor in Health Information Management at the University of Pittsburgh. Mervat served as the President of the AHIMA during 2006. Sara Grostick, MA, RHIA, is the Director of Health Information Management Program and Associate Professor at the University of Alabama at Birmingham. Mary Alice Hanken, Ph.D., RHIA is an independent consultant and senior lecturer in the Health Information Administration Program at the University of Washington. Ellen Jacobs, M.Ed., RHIA is the Director, Health Information Management Program and Associate Professor at the College of Saint Mary in Omaha, Nebraska.

Appavu, S. (2006, February). Standards Harmony: Why Is It So Hard for Healthcare? *Journal of AHIMA, 77,* 54.

This article describes why it has been more difficult for healthcare to harmonize standards than it was for other industries such as banking and travel. It discusses the various standards organizations and the work in progress towards harmonizing standards in healthcare. This information is used as background information in this study, presented in the Significance of the Study and the Problem Area.

The author of the article, Soloman I. Appavu, CHPS, CPHIMS, FHIMSS is director of systems planning at a hospital in Illinois. He has served on various boards of ANSI, ISO, and the US Technology Advisory Group. He has achieved fellow status in the Healthcare Information Management and Systems Society (HIMSS).

Austin, C., Boxerman, S., (1998). *Information Systems for Health Services Administration, Fifth Edition.* Chicago: Health Administration Press.

This book is intended as a textbook for graduate or advanced undergraduate courses on health information systems. It is used to obtain background information and definitions related to information systems in healthcare that may incorporate controlled terminologies – specifically, relating to systems development, and the information systems life cycle in the Full Purpose. It provides background information in the Significance of the Study and the Problem Area related to the management of data in healthcare.

The authors, Charles J. Austin, Ph.D. and Stuart B. Boxerman, D. Sc., are professors in the field. Charles Austin, Ph.D. is a professor at the Medical University of Suth Carolina. Stuart Boxerman is Deputy Director of the Health Administration program at Washington University School of Medicine in St. Louis, Missouri.

Bowman, S. (2005, Spring). Coordination of SNOMED-CT and ICD-10: Getting the Most out of Electronic Health Record Systems. *Perspectives in Health Information Management.*

This is an important reference for the topic of controlled vocabularies and their use in electronic health records. The discussion also pertains to expanding the use of electronic health records into a national health information infrastructure for the electronic sharing of patient information as a patient moves from one facility to another.

This reference is used in the study as part of the full purpose and problem area definition. The specific areas that it supports are the importance of working with multiple vocabularies since individual vocabularies generally are developed for a specific purpose and have limited scope. The terminologies are important for monitoring quality of care and moving evidence-based medicine forward. This reference is used as one item in the data set for coding, as part of the analysis of data for SNOMED-CT.

The author, Sue Bowman, RHIA, CCS, is a professional practice manager at the American Health Information Management Association (AHIMA), a professional association, and as a result frequently publishes in the association Journal and in the Perspectives for Health Information Management. She authors books, audio seminars and distance learning programs published by AHIMA.

Chute, C., Cohn, S., Campbell, K., Oliver, D., Campbell, J. (1996). The Content Coverage of Clinical Classifications. *Journal of the American Medical Informatics Association, 3,* 224-233.

This research paper extracted clinical text from four medical centers and parsed them into distinct concepts. These concepts are grouped into six categories and coded with seven controlled vocabularies that include ICD-9-CM, ICD-10, CPT, SNOMED III, Read V2, UMLS 1.3, and NANDA. The information is scored related to the quality of the match for each

vocabulary. The study concludes that SNOMED-CT scored the highest, but no vocabulary fully captured all concepts.

The article is referenced in this study for information related to the need for a variety of controlled vocabularies to fully capture the medical concepts required in the electronic health record.

The authors of this article are physicians actively involved in research related to clinical concepts in health-care related controlled vocabularies. Three of the authors, Christopher G. Chute, MD, DrPH, Keith E. Campbell, MD, and James R. Campbell, MD, are common names in published research in this field. The authors are affiliated with Mayo Foundation, Kaiser Permanente, Stanford University School of Medicine, and the Department of Internal Medicine at the University of Nebraska.

de Keizer, N., Abu-Hanna, A., Zwetsloot-Schonk, J. (2000). Understanding Terminological
     Systems I: Terminology and Typology. *Methods of Information in Medicine, 39,* 16-21.

The authors developed a referential framework into which they placed definitions to develop a typology of terminological systems. They applied this framework to five existing controlled vocabularies (or terminological systems), which included ICD-9-CM and ICD-10, NHS clinical terms (READ codes), SNOMED, UMLS, and GALEN. The purpose of their study is to assist in the movement from using medical data coding retrospectively for epidemiological

and administrative purposes, to applying the coding of data in daily medical practice with the development of electronic systems.

The article is utilized in this study because of the definitions provided for the various terms used in describing controlled vocabularies that include thesaurus, classification, nomenclature, coding system and coding scheme.

An academic research institution in The Netherlands published this article. Researchers in The Netherlands and Germany do much of the research related to clinical terminologies. The major international standards associations frequently meet in those countries along with the United States and Australia. Two authors, N. F. de Keizer and A. Abu-Hanna, are affiliated with the Department of Medical Informatics at the Academic Medical Center in Amsterdam. The third author, J. H. M. Zwetsloot-Schonk is affiliated with the Julius Center for Patient Oriented Research, Utrecht University Medical School, Utrecht, The Netherlands.

Fenton, S. (2004, October). Clinical Vocabularies: Essential to the Future of Health Information Management. *2004 IFHRO Conference and AHIMA Convention Proceedings.*

This article discusses the history of controlled vocabularies in healthcare from their beginnings in the 1500's. It provides an overview of concepts and data formalization, the characteristics needed in vocabularies, current and future standards and the opportunities available for their use in health information management.

This article is referenced related to the significance and limitations and for the overview of information provided and the discussion about the UMLS and how it can be used in health information management and the electronic health record.

Sue Fenton, MBA, RHIA (Ph.D. candidate) is the Director of Research for the Foundation for Research and Education (FORE) that is part of the American Health Information Management Association (AHIMA). She was previously a part-time professional practice manager at AHIMA. Sue developed distance learning courses on clinical vocabularies for AHIMA, began a research community of practice and a research track for the national convention. She is presently developing a program to train health information management professionals on how to complete operational research in order to improve the professional body of knowledge.

Fenton, S. (2006). Clinical Classifications and Terminologies. In K. M. LaTour & S. Eichenwald (Eds.), *Health Information Management: Concepts, Principles, and Practice, 2nd Edition*, Chicago: AHIMA.

This is a chapter from a book used in health information administration programs that are used to qualify students for the national RHIA credentialing exam. It is used for background information in the Full Purpose and Significance of the Study.

The chapter is written by Sue Fenton, MBA, RHIA, who is the director of research at AHIMA.

Giannangelo, K. (Ed.). (2006). *Healthcare Code Sets, Clinical Terminologies, and*

Classification Systems. Chicago: American Health Information Management

Association.

This book was recently published by AHIMA to fill a void that exists for those needing

introductory information on controlled vocabularies in healthcare. Much of the published

literature and research assumes a base level of knowledge in this topic. Introductory material is

limited to a chapter in various textbooks. The important role of this book is emphasized in the

foreword, which is written by James J. Cimino, M.D., Professor of Biomedical Informatics and

Medicine at Columbia College. He is a prominent researcher in the field of controlled

vocabularies in healthcare. This book is utilized for background information and definitions,

related to both general information on controlled vocabularies and introductory information on

specific vocabularies.

The book is edited by Kathy Giannangelo, RHIA, CCS, who is professional practice

manager at AHIMA. She develops programs and educational offerings related to clinical

terminology and classification systems. She is AHIMA's representative on issues relating to

vocabulary standard development.

Johns, M. (ed.) (2002). *Health Information Management Technology: An Applied Approach.*

      Chicago: AHIMA.

This book was recently published by AHIMA for use in health information technology

programs. Those programs approved by AHIMA qualify individuals graduating to sit for the

national RHIT credentialing examination. This credential is often required for health

information management positions in hospitals. The book contains chapters on clinical

vocabularies and information systems that are used for background information in this study.

The author, Merida L. Johns, Ph.D., RHIA, is the director of the master's program in

information systems management at Loyola University in Chicago. She has been the founding

director for several programs in health information technology, health information

administration, and health informatics.

Leedy, P., Ormrod, J. (2005). *Practical Research: Planning and Design, 8th Edition,* New

      Jersey: Pearson Education, Inc.

This text covers the full range of research methodologies. The portion providing

instruction for a review of literature is referenced for this study.

Paul Leedy is from the American University and Jeanne Ellis Ormrod is from the

University of Northern Colorado and the University of New Hampshire.

van Bemmel, J., Musen, M. (eds.) (1997). *Handbook of Medical Informatics.* Heidelberg,

    Germany: Springer-Verlag.

This is a very complete and detailed textbook for Medical Informatics that is used in the

OHSU medical informatics program. It is used in this study for background information and

definitions of controlled vocabulary and medical informatics terminology.

The editors, who also authored many of the chapters of the book, are J. H. van Bemmel

from Erasmus University, Rotterdam, The Netherlands, and M.A. Musen, Standford University.

Publishers in both The Netherlands and Germany, where much of the research on controlled

vocabularies is done, publish the book.

CHAPTER 3 - METHOD

Literature Collection

A preliminary search is conducted within the concept of controlled vocabularies utilizing various alternative terms to identify general literature that addresses the topic of the use of controlled vocabularies in healthcare. Google scholar is found to be the best source of literature. Literature collection is completed by conducting searches in various databases for literature on controlled vocabularies. Based on initial search findings, a set of key words is established to identify sources relevant to the study. Search terms were selected based on this researchers education in the field of health information management as a credentialed professional. The following terms are included in the search:

- nomenclature

- ontology

- classification system

- controlled vocabulary

- reference terminology

- taxonomy

- data standard

- messaging terminology

- metathesaurus

- lexicon

During initial searches, there were many results received that were not relevant to the study. Therefore additional criteria is added to restrict the results with the following key words:

- medical

- healthcare

- clinical

The digital library of the Association of Computing Machinery is searched without the healthcare limitation since this researcher is aware that it is a good source of literature on the topic of controlled vocabularies and searching without the limitation did not provide excessive numbers of unrelated literature.

Indexes to peer-reviewed journals known to this researcher as being good sources of information for controlled vocabularies related to healthcare were searched for literature to locate general information about controlled vocabularies in healthcare. This included:

- Journal of the American Medical Informatics Association

- Journal of the American Health Information Management Association

- Journal of the Healthcare Information Management and Systems Society

- Perspectives in Health Information Management

This researcher is able to access these sources as a part of professional association memberships.

Literature is collected that is published between 2003 and 2007 because of two key events in the field during this time period: (1) SNOMED is selected as the first standard controlled vocabulary by the Department of Health and Human Services (ONC, 2006), and (2) regular discussion of the development of the UMLS, in the health information management professional journals.

Data Analysis

Data analysis is completed by the eight-step strategy described by Palmquist et al. (2005). The data analysis process includes three phases. In phase 1, literature is searched to determine which UMLS vocabularies are currently being utilized in the peer-reviewed and professional literature. Selection of a sub-set of controlled vocabularies from the UMLS for review involves two steps. The first step eliminates duplicates that are older versions of a vocabulary or a foreign language translation of the controlled vocabulary. The second step involves a search of selected medical informatics and health information management journals in order to determine which controlled vocabularies have been further examined in more than twenty peer-reviewed journal articles. Any vocabularies in that group that are typically used for organizing and retrieving literature (i.e. Medline), organizing and retrieving vocabularies (i.e. UMLS Metathesaurus), or considered to be data standards or diagnosis program (i.e. HL7 and DXplain) are eliminated from the study group.   The goal in this step is to determine which controlled vocabularies have been researched. Only those eight controlled vocabularies that are examined in more than twenty journal articles are included in the study in order to limit the vocabularies studied to a

manageable number.   As a result of this step, a bibliography is developed for each selected vocabulary.

In phase 2, each of the 20 pieces of literature identified in relation to each vocabulary in the selected sub-set of eight controlled vocabularies is subjected to conceptual analysis as defined by Palmquist el al, (2007) according to the following plan.

Step One: Level of Analysis.   Each of the 20 identified bibliographic literature items are read for each of the eight selected vocabularies to identify information that pertains to the way the vocabulary is used. Analysis proceeds at the concept level.

Step Two: Concepts to Code. Each piece of literature is coded for topics that the vocabulary addresses that relate to the electronic health record. An initial set of topics is framed to guide the coding process for each set of 20 articles, developed in relation to the focus of each of the eight selected controlled vocabularies. Therefore, the number of concepts to code for varies from vocabulary to vocabulary. For example, the initial set of coding concepts for the controlled vocabulary Omaha System, includes nursing problems, nursing interventions and Likert-scale (Westra, Solomon, and Ashley, 2006). Each of these concepts is listed as a key component of the vocabulary. Additional topics are added to this list as they emerge through the reading.

Step Three: Coding for Existence or Frequency. The topics are reviewed for existence of the mention of the relationships between the vocabulary and the electronic health record.

Step Four: Distinguishing Among Concepts. The concepts are only dealt with if they address a relationship between the focus of the vocabulary in question and some aspect of the electronic health record.

Step Five: Developing Rules for Coding. Each piece of related literature is coded in relationship to how the larger focus of the vocabulary in question is defined in phase one of the data analysis – most often by the formal title of the vocabulary. Only information identified in the related literature that fits within the large generalized description is accepted.

Step Six: Handling of Irrelevant Information. Any information that does not pertain to one of the eight vocabularies (in relation to the electronic health record) is considered irrelevant and is ignored.

Step Seven: Coding the Texts. Each topic identified in the related literature for each vocabulary is notated in a spreadsheet. The columns of the spreadsheet match the bibliographic listing for each vocabulary with 20 columns, one to represent each piece of literature reviewed.

Data Presentation

Step Eight: Analyzing Results. For each of the eight selected vocabularies, the topics are listed that are addressed in each of the 20 pieces of literature that relate the vocabulary to electronic health record content.

The data analysis is presented in three parts. Part one lists the twenty pieces of literature that are selected for evaluation in this study. Part two presents a table for each of the eight selected vocabularies, listing each of the topics identified related to an electronic health record. Part three presents a brief annotated profile of each of the eight selected controlled vocabularies, describing the key points that relate the vocabulary to the electronic health record that are identified in the coding process.

The final outcome of this study is presented in the Conclusion chapter of this paper, formatted as a set of narrative descriptions of the purpose and use of each of the eight selected controlled vocabularies. Narratives describe each of the concepts identified in the coding process and relate them to the components of the electronic health record. This narrative set is intended to provide health information management professionals with a reference when selecting controlled vocabularies to use in the electronic health record for reporting purposes or for clinical decision support. It can also be used to identify vocabulary topics for future research.

CHAPTER 4 - ANALYSIS OF DATA

Eight vocabularies are selected as a sub-set from the UMLS Source Vocabularies. Selected vocabularies are:

- International Classification of Primary Care (ICPC)

- Logical Observation Identifier Names and Codes (LOINC)

- NANDA Nursing Diagnoses

- Nursing Interventions Classification (NIC)

- Nursing Outcomes Classification (NOC)

- The Omaha System: Applications for Community Health Nursing

- RxNorm

- Systemized Nomenclature of Medicine Clinical Terms (SNOMED CT)

More than twenty journal articles are available for these controlled vocabularies and they contain topics that are valuable for the electronic health record. These articles are listed in a bibliography for each vocabulary. They are then reviewed and EHR topics are listed that are discussed in the literature. Finally an annotated profile is prepared for each vocabulary describing how it is used in the literature.

Part One: Bibliographies for Eight Selected Controlled Vocabularies

       This section contains a list of twenty pieces of literature available for each of the eight

selected controlled vocabularies. These are identified by a search of Google Scholar and

reviewing literature from the Journal of the American Medical Informatics Association, the

Journal of the American Health Information Management Association, and the Journal of Health

Information Systems Management.

Bibliography for Vocabulary #1: International Classification of Primary Care (ICPC)

1. Akkerman, A., van der Wouden, J., Kuyvenhoven, M., Dieleman, J., Verheij, T. (2004). Antibiotic prescribing for respiratory tract infections in Dutch primary care in relation to patient age and clinical entities.

2. Bentzen, N. (2004). Family Medicine Research: Implications for Wonca.

3. Binsbergen, J. Drenthen, A. (2003). Patient information letters on nutrition: development and implementation.

4. Bowman, S. (2004, November/December). ICD-10: All in the Family.

5. Fischer, T., Fischer, S., Kochen, M., Hummers-Pradier, E. (2005). Influence of patient symptoms and physical findings on general practitioners' treatment of respiratory tract infections: a direct observation study.

6. Harrison, C., Britt, H. (2004). The rates and management of psychological problems in Australian general practice.

7. Hoeymans, N., Garssen, A., Westert, G., Verhaak, P. (2004). Measuring mental health of the Dutch population: a comparison of the GHQ-12 and the MHI-5.

8. Nease, D., Green, L. (2003). Clinfo Tracker: A Generalizable Prompting Tool for Primary Care.

9. Otters, H., Schellevis, F., Damen, J., van der Wouden, J., van Suijkelom-Smit, L., Koes, B. (2005, August). Epidemiology of unintentional injuries in childhood: a population-based survey in general practice.

10. Phillips, W. (2003). The Expert … Is the Patient in Front of Us.

11. Stange, K. (2004). Provocative Questions.

12. Starfield, B., Shi, Leiyu, Macinko, J. (2005). Contribution of Primary Care to Health Systems and Health.

13. Treweek, S. (2004). A New Quality Improvement Study Every Day? Using Qtools to Build Quality Improvement Projects Around Primary Care Electronic Medical Record Systems.

14. van den Akker, M., Schuurman, A., Metsemakers, J., Buntinx, F. (2004). Is depression related to subsequent diabetes mellitus?

15. van den Heuvel-Janssen, H., Borghouts, Muris, J., Koes, B., Bouter, L., Knottnerus, J. (2006, March). Chronic non-specific abdominal complaints in general practice: a prospective study on management, patient health status and course of complaints.

16. van Weel, C. (2003). Longitudinal Research and Data Collection in Primary Care.

17. van Weel, C., Rosser, W. (2004). Improving Health Care Globally.

18. Verbeke, M., Schrans, D., Deroose, S., De Maeseneer, J. (2006). The International Classification of Primary Care (ICPC-2): an essential tool in the EPR of the GP.

19. Yzermans, C., Donker, G., Kerssens, J., Dirkzwager, A., Soeteman, R., ten Veen, P. (2005). Health problems of victims before and after disaster: a longitundinal study in general practice.

20. Zantinge, E., Verhaak, P., Kerssens, J., Bensing, J. (2005, August). The workload of GPs: consultations of patients with psychological and somatic problems compared.

Bibliography for Vocabulary #2: Logical Observation Identifier Names & Codes (LOINC)

1. AHIMA e-HIM Workgroup on EHR Data Content. (2006, February). Data Standard Time: Data Content Standardization and the HIM Role.

2. Cheung, N., Fung, V., Kong, J. (2004). The Hong Kong Hospital Authority's Information Architecture.

3. Choi, J., Jenkins, M., Cimino, J., White, T., Bakken, S. (2005). Toward Semantic Interoperability in Home Health Care: Formally Representing OASIS Items for Integration into a Concept-oriented Terminology.

4. Coonan, K. (2004). Medical Information Standards Applicable to Emergency Department Information Systems.

5. Dolin, R., Mattison, J., Cohn, S., Campbell, K., Wiesenthal, A., Hochhalter, B., LaBerge, D., Barsoum, R., Shalaby, J., Abilla, A., Clements, R., Correia, C., Esteva, D., Fedack, J., Goldberg, B., Gopalarao, S., Hafeza, E., Hendler, P., Hernandez, E., Kamangar, R., Khan, R., Kurtovich, G., Lazzareschi, G., Lee, M., Lee, T., Levy, D., Lukoff, J., Lundberg, C., Madden, M., Ngo, T., Nguyen, B., Patel, N., Resneck, J., Ross, D., Schwarz, K., Selhorst, C., Snyder, A., Umarji, M., Vilner, M., Zer-Chen, R., Zingo, C. (2004). Kaiser Permanente's Convergent Medical Terminology.

6. Eichelberg, M., Aden, T., Riesmeier, J., Dogac, A., Laleci, G. (2005, December). A Survey and Analysis of Electronic Healthcare Record Standards.

7. Foley, M., Hall, C., Perron, K., D'Andrea, R. (2007, February). Translation, Please.

8. Khan, A., Griffith, S., Moore, C., Russell, D., Rosario, A., Bertolli, J. (2006). Standardizing Laboratory Data by Mapping to LOINC.

9. Khan, A., Russell, D., Moore, C., Rosario, A., Griffith, S. Bertolli, J. (2003). The Map to LOINC Project.

10. Kho, A., Zafar, A., Tierney, W. (2007). Information Technology in PBRNs: The Indiana University Medical Group Research Network Experience.

11. McDonald, C., Huff, S., Suico, J., Hill, G., Leavelle, D., Aller, R., Forrey, A., Mercer, K., DeMoore, G., Hook, J., William, W., Case, J., Maloney, P. (2003). LOINC, a Universal Standard for Identifying Laboratory Observations: A 5-Year Update.

12. M'ikanatha, N., Southwell, B., Lautenbach, E. (2003). Automated Laboratory Reporting of Infectious Diseases in a Climate of Bioterrorism.

13. Parker, C., Rocha, R., Campbell, J., Tu, Samson, Huff, S. (2004). Detailed Clinical Models for Sharable, Executable Guidelines.

14. Pincus, Z., Musen, M. (2003). Contextualizing Heterogeneous Data for Integration and Inference.

15. Shapiro, J., Bakken, S., Hyun, S., Melton, G., Schlegel, C., Johnson, S. (2005). Document Ontology: Supporting Narrative Documents in Electronic Health Records.

16. Staes, C., Huff, S., Evans, R., Narus, S., Tilley, C., Sorensen, J. (2005). Development of an Information Model for Storing Organ Donor Data Within an Electronic Medical Record.

17. Sun, J., Sun, Y. (2006). A System for Automated Lexical Mapping.

18. Van Hoof, V., Wormek, A., Schleutermann, S., Schumacher, T., Lothaire, O., Trendelenburg, C. (2004). Medical Expert Systems Developed in j.MD, a Java Based Expert System Shell Application in Clinical Laboratories.

19. Windle, J., Van-Milligan, G., Duffy, S., McClay, J., Campbell, J. (2003). Web-based Physician Order Entry.

20. Wurtz, R., Cameron, B. (2005). Electronic Laboratory Reporting for the Infectious Diseases Physician and Clinical Microbiologist.

Bibliography for Vocabulary #3: NANDA Nursing Diagnoses

1. Allred, S., Smith, K., Flowers, L. (2004, Fall). Electronic Implementation of National Nursing Standards – NANDA, NOC and NIC as an Effective Teaching Tool.

2. Axelsson, L., Bjorvell, C., Mattiasson, A., Randers, I. (2006). Swedish Registered Nurses' Incentives to Use Nursing Diagnoses in Clinical Practice.

3. Bakken, S., Hyun, S., Friedman, C., Johnson, S. (2005). ISO reference terminology models for nursing.

4. Creason, N. (2004). Clinical Validation of Nursing Diagnoses.

5. Evers, G. (2003). Developing Nursing Science in Europe.

6. Florin, J., Ehrenberg, A., Ehnfors, M. (2005). Quality of Nursing Diagnoses: Evaluation of an Educational Intervention.

7. Foley, M., Hall, C., Perron, K., D'Andrea, R. (2007, February). Translation, Please.

8. Gibbons, S., Lauder, W., Ludwick, R. (2006). Self-Neglect: A Proposed New NANDA Diagnosis.

9. Harris, M., Kim, H., Rhudy, L., Savora, G., Chute, C. (2003). Testing the Generalizability of the ISO Model for Nursing Diagnoses.

10. Junttila, K., Salantera, S., Hupli, M. (2005). Perioperative Nurses' Attitudes Toward the Use of Nursing Diagnoses in Documentation.

11. Kautz, D., Kuiper, R., Pesut, D., Williams, R. (2006). Using NANDA, NIC, NOC (NNN) Language for Clinical Reasoning with the Outcome-Present State-Test (OPT) Model.

12. Keenan, G. (2006). Research Update: Revitalizing the Care Planning Process with NANDA, NIC and NOC Using the Hands Method.

13. Kelley, J., Weber, J., Sprengel, A. (2005). Taxonomy of Nursing Practice: Adding an Administrative Domain.

14. Kopala, B., Burkhart, L. (2005). Ethical Dilemma and Moral Distress: Proposed New NANDA Diagnoses.

15. Krogh, G., Dale, C., Naden, D. (2005). A Framework for Integrating NANDA, NIC, and NOC Terminology in Electronic Patient Records.

16. Lavin, M., Avant, K., Craft-Rosenberg, M., Herdman, T., Gebbie, K. (2004). Contexts for the Study of the Economic Influence of Nursing Diagnoses on Patient Outcomes.

17. Lavin, M., Krieger, M., Meyer, G., Spasser, M., Reese, C., Carlson, J. (2005). Development and Evaluation of Evidence-Based Nursing (EBN) Filters and Related Databases.

18. Muller-Staub, M., Lavin, M., Needham, I., van Achterberg, T. (2006). Nursing Diagnoses, Interventions and Outcomes – Application and Impact on Nursing Practice.

19. Park, M., Delaney, C., Maas, M., Reed, D. (2004). Using a Nursing Minimum Data Set with Older Patients with Dementia in an Acute Care Setting.

20. Warren, J., Casey, A., Konicek, D., Lundberg, C., Correia, C., Zingo, C. (2003). Where Is the Nursing in SNOMED CT?

Bibliography for Vocabulary #4: Nursing Interventions Classification (NIC)

1. Allred, S., Smith, K., Flowers, L. (2004, Fall). Electronic Implementation of National Nursing Standards − NANDA, NOC and NIC as an Effective Teaching Tool.

2. Behrenbeck, J., Timm, J., Griebenow, L., Demmer, K. (2004). Nursing-Sensitive Outcome Reliability Testing in a Tertiary Care Setting.

3. Cavendish, R., Konecny, L., Mitzeliotis, C., Russo, D., Luise, B., Lanza, M., Medefindt, J., Bajo, M. (2003). Spiritual Care Activities of Nurses Using Nursing Interventions Classification (NIC) Labels.

4. Dochterman, J., Titler, M., Wang, J., Reed, D., Pettit, D., Mathew-Wilson, M., Budreau, G., Bulechek, G., Kraus, V., Kanak, M. (2005). Describing Use of Nursing Interventions for Three Groups of Patients.

5. Dolin, R., Mattison, J., Cohn, S., Campbell, K., Wiesenthal, A., Hochhalter, B., LaBerge, D., Barsoum, R., Shalaby, J., Abilla, A., Clements, R., Correia, C., Esteva, D., Fedack, J., Goldberg, B., Gopalarao, S., Hafeza, E., Hendler, P., Hernandez, E., Kamangar, R., Khan, R., Kurtovich, G., Lazzareschi, G., Lee, M., Lee, T., Levy, D., Lukoff, J., Lundberg, C., Madden, M., Ngo, T., Nguyen, B., Patel, N., Resneck, J., Ross, D., Schwarz, K., Selhorst, C., Snyder, A., Umarji, M., Vilner, M., Zer-Chen, R., Zingo, C. (2004). Kaiser Permanente's Convergent Medical Terminology.

6. Foley, M., Hall, C., Perron, K., D'Andrea, R. (2007, February). Translation, Please.

7. Haugsdal, C., Scherb, C. (2003). Using the Nursing Interventions Classification to Describe the Work of the Nurse Practitioner.

8. Junttila, K., Salantera, S., Hupli, M. (2005). Perioperative Nurses' Attitudes Toward the Use of Nursing Diagnoses in Documentation.

9. Karkkainen, O., Eriksson, K. (2003). Evaluation of Patient Records as part of developing a Nursing Classification System.

10. Karkkainen, O., Eriksson, K. (2004). Structuring the documentation of Nursing care on the basis of a theoretical process model.

11. Kautz, D., Kuiper, R., Pesut, D., Williams, R. (2006). Using NANDA, NIC, NOC (NNN) Language for Clinical Reasoning with the Outcome-Present State-Test (OPT) Model.

12. Keenan, G. (2006). Research Update: Revitalizing the Care Planning Process with NANDA, NIC and NOC Using the Hands Method.

13. Krogh, G., Dale, C., Naden, D. (2005). A Framework for Integrating NANDA, NIC, and NOC Terminology in Electronic Patient Records.

14. Lavin, M., Avant, K., Craft-Rosenberg, M., Herdman, T., Gebbie, K. (2004). Contexts for the Study of the Economic Influence of Nursing Diagnoses on Patient Outcomes.

15. Lin, Y., Dai, Y., Hwang, S. (2003). The Effect of Reminiscence on the Elderly Population: A Systematic Review.

16. Moorhead, S., Johnson, M. (2004). Diagnostic-Specific Outcomes and Nursing Effectiveness Research.

17. Muller-Staub, M., Lavin, M., Needham, I., van Achterberg, T. (2006). Nursing Diagnoses, Interventions and Outcomes – Application and Impact on Nursing Practice.

18. Park, M., Delaney, C., Maas, M., Reed, D. (2004). Using a Nursing Minimum Data Set with Older Patients with Dementia in an Acute Care Setting.

19. Schein, C., Gagnon, A., Chan, L., Morin, I., Grondines, J. (2005). The Association

Between Specific Nurse Case Management Interventions and Elder Health.

20. Warren, J., Casey, A., Konicek, D., Lundberg, C., Correia, C., Zingo, C. (2003). Where

Is the Nursing in SNOMED CT?

Bibliography for Vocabulary #5: Nursing Outcomes Classification (NOC)

1. Allred, S., Smith, K., Flowers, L. (2004, Fall). Electronic Implementation of National Nursing Standards – NANDA, NOC and NIC as an Effective Teaching Tool.

2. Bakken, S., Hyun, S., Friedman, C., Johnson, S. (2005). ISO reference terminology models for nursing.

3. Behrenbeck, J., Timm, J., Griebenow, L., Demmer, K. (2004). Nursing-Sensitive Outcome Reliability Testing in a Tertiary Care Setting.

4. Butler, M., Treacy, M., Scott, A., Hyde, A., Neela, P., Irving, K., Byrne, A., Drennan, J. (2006). Towards a nursing minimum data set for Ireland.

5. Cho, I., Park, H. (2006). Evaluation of the Expressiveness of an ICNP-based Nursing Data Dictionary in a Computerized Nursing Record System.

6. Gudmundsdottir, E., Delaney, C., Thoroddsen, A., Karlsson, T. (2004). Translation and validation of the Nursing Outcomes Classification labels and definitions for acute care nursing in Iceland.

7. Head, B., Aquilino, M., Johnson, M., Reed, D., Maas, M., Moorhead, S. (2004). Content Validity and Nursing Sensitivity of Community-Level Outcomes From the Nursing Outcomes Classification (NOC).

8. Karkkainen, O., Eriksson, K. (2003). Evaluation of Patient Records as part of developing a Nursing Classification System.

9. Karkkainen, O., Eriksson, K. (2004). Structuring the documentation of Nursing care on the basis of a theoretical process model.

10. Kautz, D., Kuiper, R., Pesut, D., Williams, R. (2006). Using NANDA, NIC, NOC (NNN) Language for Clinical Reasoning with the Outcome-Present State-Test (OPT) Model.

11. Keenan, G. (2006). Research Update: Revitalizing the Care Planning Process with NANDA, NIC and NOC Using the Hands Method.

12. Krogh, G., Dale, C., Naden, D. (2005). A Framework for Integrating NANDA, NIC, and NOC Terminology in Electronic Patient Records.

13. Lavin, M., Avant, K., Craft-Rosenberg, M., Herdman, T., Gebbie, K. (2004). Contexts for the Study of the Economic Influence of Nursing Diagnoses on Patient Outcomes.

14. Moorhead, S., Johnson, M. (2004). Diagnostic-Specific Outcomes and Nursing Effectiveness Research.

15. Mrayyan, M. (2005). The influence of Standardized Language on Nurses' Autonomy.

16. Muller-Staub, M., Lavin, M., Needham, I., van Achterberg, T. (2006). Nursing Diagnoses, Interventions and Outcomes – Application and Impact on Nursing Practice.

17. Park, M., Delaney, C., Maas, M., Reed, D. (2004). Using a Nursing Minimum Data Set with Older Patients with Dementia in an Acute Care Setting.

18. Schein, C., Gagnon, A., Chan, L., Morin, I., Grondines, J. (2005). The Association Between Specific Nurse Case Management Interventions and Elder Health.

19. Volrathongchai, K., Delaney, C., Phuphaibul, R. (2003). Nursing Minimum Data Set development and implementation in Thailand.

20. Warren, J., Casey, A., Konicek, D., Lundberg, C., Correia, C., Zingo, C. (2003). Where Is the Nursing in SNOMED CT?

**Bibliography for Vocabulary #6: The Omaha System –
Applications for Community Health Nursing**

1. Arts, D., Keizer, N., de Jonge, E., Cornet, R. (2004). Comparison of methods for evaluation of a medical terminological system.

2. Bakken, S., Hyun, S., Friedman, C., Johnson, S. (2005). ISO reference terminology models for nursing.

3. Brooten, D., Youngblut, J., Deatrick, J., Naylor, M., York, R. (2003). Patient Problems, Advanced Practice Nurse (APN) Interventions, Time and Contacts Among Five Patient Groups.

4. Butler, M., Treacy, M., Scott, A., Hyde, A., Neela, P., Irving, K., Byrne, A., Drennan, J. (2006). Towards a nursing minimum data set for Ireland.

5. Cho, I., Park, H. (2006). Evaluation of the Expressiveness of an ICNP-based Nursing Data Dictionary in a Computerized Nursing Record System.

6. Dick, K., Frazier, S. (2006). An exploration of nurse practitioner care to homebound frail elders.

7. Goossen, W. (2006). Cross-Mapping Between Three Terminologies With the International Standard Nursing Reference Terminology Module.

8. Kaiser, K., Rudolph, E. (2003). Achieving Clarity in Evaluation of Community/Public Health Nurse Generalist Competencies through Development of a Clinical Performance Evaluation Tool.

9. Hamilton, B., Manias, E. (2006). A critical analysis of psychiatric nurses oral and written language in the acute inpatient setting.

10. Harris, M., Kim, H., Rhudy, L., Savora, G., Chute, C. (2003). Testing the Generalizability of the ISO Model for Nursing Diagnoses.

11. Hwang, J., Cimino, J., Bakken, S. (2003). Integrating Nursing Diagnostic Concepts into the Medical Entries Dictionary Using the ISO Reference Terminology Model for Nursing Diagnosis.

12. Lavin, M., Avant, K., Craft-Rosenberg, M., Herdman, T., Gebbie, K. (2004). Contexts for the Study of the Economic Influence of Nursing Diagnoses on Patient Outcomes.

13. Marek, K., Popejoy, L., Petroski, G., Rantz, M. (2006). Nursing Care Coordination in Community-Based Long-Term Care.

14. Moorhead, S., Johnson, M. (2004). Diagnostic-Specific Outcomes and Nursing Effectiveness Research.

15. Neff, D., Kinion, E., Cardina, C. (2007). Nurse Managed Center.

16. Sansoni, J., Giustini, M. (2006). More than terminology: using ICNP to enhance nursing's visibility in Italy.

17. Volrathongchai, K., Delaney, C., Phuphaibul, R. (2003). Nursing Minimum Data Set development and implementation in Thailand.

18. Warren, J., Casey, A., Konicek, D., Lundberg, C., Correia, C., Zingo, C. (2003). Where Is the Nursing in SNOMED CT?

19. Westra, B., Solomon, D., Ashley, D. (2006, Summer). Use of the Omaha System Data to Validate Medicare Required Outcomes in Home Care.

20. Wong, F., Chung, L. (2006). Establishing a definition for a nurse-led clinic.

Bibliography for Vocabulary #7: RxNorm

1. Chen, Y., Perl, Y., Geller, J., Cimino, J. (2007). Analysis of a Study of the Users, Uses, and Future Agenda of the UMLS.

2. Chute, C., Carter, J., Tuttle, M., Haber, M., Brown, S. (2003). Integrating Pharmacokinetics Knowledge into a Drug Ontology as an extension to support Pharmacogenomics.

3. Coonan, K. (2004). Medical Information Standards Applicable to Emergency Department Information Systems.

4. Dolin, R., Mattison, J., Cohn, S., Campbell, K., Wiesenthal, A., Hochhalter, B., LaBerge, D., Barsoum, R., Shalaby, J., Abilla, A., Clements, R., Correia, C., Esteva, D., Fedack, J., Goldberg, B., Gopalarao, S., Hafeza, E., Hendler, P., Hernandez, E., Kamangar, R., Khan, R., Kurtovich, G., Lazzareschi, G., Lee, M., Lee, T., Levy, D., Lukoff, J., Lundberg, C., Madden, M., Ngo, T., Nguyen, B., Patel, N., Resneck, J., Ross, D., Schwarz, K., Selhorst, C., Snyder, A., Umarji, M., Vilner, M., Zer-Chen, R., Zingo, C. (2004). Kaiser Permanente's Convergent Medical Terminology.

5. Ferranti, J., Musser, R., Kauamoto, K., Hammond, W. (2006). The Clinical Document Architecture and the Continuity of Care Record.

6. Foley, M., Hall, C., Perron, K., D'Andrea, R. (2007, February). Translation, Please.

7. Fung, K., Hole, W., Nelson, S., Srinivasan, S., Powell, T., Roth, L. (2005). Integrating SNOMED CT into the UMLS.

8. Greenes, R., Sordo, M., Zaccagnini, D., Meyer, M., Kuperman, G. (2004). Design of a

    Standards-Based External Rules Engine for Decision Support in a Variety of Application

    Contexts.

9. Gunter, T., Terry, N. (2005, Jan-Mar). The Emergence of National Electronic Health

    Record Architectures in the United States and Australia.

10. Hara, K., Matsumoto, Y. (2005). Information Extraction and Sentence Classification

    applied to Clinical Trial MEDLINE Abstracts.

11. Martin, P., Haefeli, W., Martin-Facklan, M. (2004). A Drug Database Model as a Central

    Element for Computer-Supported Dose Adjustment within a CPOE System.

12. Miller, R., Gardner, R., Johnson, K., Hripcsak, G. (2005). Clinical Decision Support and

    Electronic Prescribing Systems.

13. Niland, J., Rouse, L., Stahl, D. (2006). An Informatics Blueprint for Healthcare Quality

    Information Systems.

14. Pakhomov, S., Buntrock, J., Duffy, P. (2005). High Throughput Modularized NLP

    System for Clinical Text.

15. Richesson, R., Andrews, J., Krischer, J. (2006). Use of SNOMED CT to Represent

    Clinical Research Data.

16. Rindflesch, T., Pakhomov, S., Fiszman, M., Kilicoglu, H., Sanchez, V. (2005). Medical

    Facts to Support Inferencing in Natural Language Processing.

17. Rosenbloom, S., Miller, R., Johnson, K., Elkin P. Brown, S. (2006). Interface

    Terminologies: Facilitating Direct Entry of Clinical Data into Electronic Health Record

    Systems.

18. Schade, C., Sullivan, F., de Lusignan, S., Madeley, J. (2006). e-Prescribing, Efficiency, Quality: Lessons from the Computerization of UK Family Practice.

19. Solbrig, H., Chute, C. (2004). Terminology Access Methods Leveraging LDAP Resources.

20. Stead, W., Kelly, B., Kolodner, R. (2004). Achievable Steps Toward Building a National Health Information Infrastructure in the U.S.

Bibliography for Vocabulary #8: Systematized Nomenclature of Medicine (SNOMED)

Clinical Terms (CT)

1. AHIMA e-HIM Workgroup on EHR Data Content. (2006, February). Data Standard Time: Data Content Standardization and the HIM Role.

2. Bakken, S., Hyun, S., Friedman, C., Johnson, S. (2005). ISO reference terminology models for nursing.

3. Bakken, S., Hyun, S., Friedman, C., Johnson, S. (2004). A Comparison of Semantic Categories of the ISO Reference Terminology Models for Nursing and the MedLEE Natural Language Processing, System.

4. Bowie, J. (2004, August). Four Options for Implementing SNOMED.

5. Bowman, S. (2005, Spring). Coordination of SNOMED-CT and ICD-10: Getting the Most out of Electronic Health Record Systems.

6. Bowman, S. (2005, July/August). Coordinating SNOMED-CT and ICD-10.

7. Eichelberg, M., Aden, T., Riesmeier, J., Dogac, A., Laleci, G. (2005, December). A Survey and Analysis of Electronic Healthcare Record Standards.

8. Elkin, P., Brown, S., Bauer, B., Husser, C., Carruth, W., Bergstrom, L., Wahner-Roedler, D. (2004). A controlled trial of automated classification of negation from clinical notes.

9. Foley, M., Hall, C., Perron, K., D'Andrea, R. (2007, February). Translation, Please.

10. Fung, K., Hole, W., Nelson, S., Srinivasan, S., Powell, T., Roth, L. (2005). Integrating SNOMED CT into the UMLS: An Exploration of Different Views of Synonymy and Quality of Editing.

11. Giannangelo, K., Berkowitz, L. (2005, April). SNOMED CT Helps Drive EHR Success.

12. Green, J., Wilcke, J., Abbott, J., Rees, L. (2006). Development and Evaluation of Methods for Structured Recording of Heart Murmur Findings Using SNOMED-CT Post-Coordination.

13. Huang, Y., Lowe, H., Hersh, W. (2003). A Pilot Study of Contextual UMLS Indexing to Improve the Precision of Concept-based Representation in XML-structured Clinical Radiology Reports.

14. Lieberman, M., Ricciardi, T., Masarie, F., Spackman, K. (2003). The Use of SNOMED CT Simplifies Querying of a Clinical Data Warehouse.

15. Parker, C., Rocha, R., Campbell, J., Tu, Samson, Huff, S. (2004). Detailed Clinical Models for Sharable, Executable Guidelines.

16. Richesson, R., Andrew, J., Krischer, J. (2006). Use of SNOMED CT to Represent Clinical Research Data: A Semantic Characterization of Data Items on Case Report Forms in Vasculitis Research.

17. Rosenbloom, T., Miller, R., Johnson, K., Elkin, P., Brown, S. (2006). Interface Terminologies: Facilitating Direct Entry of Clinical Data into Electronic Health Record Systems.

18. Wasserman, H., Wang, J. (2003). An Applied Evaluation of SNOMED CT as a Clinical Vocabulary for the Computerized Diagnosis and Problem List.

19. Zhou, X., Han, H., Chankai, I., Prestrud, A., Brooks, A. (2006). Approaches to Text Mining for Clinical Medical Records.

20. Zweigenbaum, P., Grabar, N. (2003). Corpus-Based Associations Provide Additional Morphological Variants to Medical Terminologies.

Part Two: Vocabulary Topics Related To The Electronic Health Record

This part of the data presentation lists EHR topics mentioned in each of the pieces of literature. The numbering at the top of each chart matches the numbering in the bibliography listing in part one. The topic is checked each time it is mentioned. A total column is included to determine which items are mentioned most frequently in the selected literature.

Table 1: Results of Coding Vocabulary #1: International Classification of Primary Care (ICPC)

EHR Topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
n/a						x															1
Clinical entity	x																				1
Signs and Symptoms	x						x					x	x					x	x		6
Diagnosis	x	x	x		x		x		x			x	x	x	x	x	x	x	x	x	14
Reason for encounter		x		x			x														3
Assessment				x																	1
Process of care (decision, action, plans)				x						x											2
Primary Care Documentation											x										1
Diagnostic procedures																x					1
Therapeutic procedures																x					1
Problem List								x				x					x				3

Table 2: Results of Coding Vocabulary #2: Logical Observation Identifier Names and Codes (LOINC)

EHR Topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
n/a			x		x	x									x				x		5
Lab Test	x							x	x	x			x			x	x	x		x	9
Lab Observations	x			x				x		x	x						x			x	7
Lab Results	x	x					x			x		x		x		x	x	x		x	10
Other Tests							x														1
Other Clinical Observations											x					x					2

Table 3: Results of Coding Vocabulary #3: NANDA Nursing Diagnoses

EHR Topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
n/a																				x	1
Nursing diagnosis	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		19
Problem	x	x				x															3
Etiology	x	x				x															3
Signs and Symptoms	x	x				x															3

Table 4: Results of Coding Vocabulary #4: Nursing Interventions Classification (NIC)

EHR Topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
n/a					x					x										x	3
Nursing Interviewing	x					x															2
Nursing Activities	x		x																		2
Nursing Interventions		x	x	x			x	x	x		x	x	x	x	x	x	x	x	x		15

Table 5: Results of Coding Vocabulary #5: Nursing Outcomes Classification (NOC)

EHR Topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
n/a				x	x				x						x					x	5
Nursing Care Result	x											x									2
Outcomes		x	x			X	x	x		x	x		x	x		x	x	x	x		13
Likert-Scale													x								1

Table 6: Results of Coding Vocabulary #6: The Omaha System: Applications for Community Health Nursing

EHR Topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
n/a	x				x		x											x			4
Problem List												x							x		2
Nursing Interventions			x	x		x		x	x		x		x		x	x	x		x	x	12
Likert-Scale																			x		1
Patient Problem		x	x	x							x		x	x							6
Diagnosis								x	x		x					x	x			x	6
Outcomes				x		x		x	x		x	x				x	x				8
Signs and Symptoms																		x			1
Term Phrases										x											1
Assessment						x														x	2

Table 7: Results of Coding Vocabulary #7: RxNorm

EHR Topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
n/a				x	x				x							x		x	x		6
Medications/ Drugs		x				x	x	x	x		x	x	x	x	x		x			x	12
Drug Products	x		x																		2
Drug Doses									x												1
Drug Ingredients							x				x										2
Drug actions																	x				1

Table 8: Results of Coding Vocabulary #8: Systematized Nomenclature of Medicine (SNOMED) Clinical Terms (CT)

EHR Topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
n/a																					
Vital Signs					x											x					2
Signs and Symptoms					x																1
Medications					x				x	x				x							4
Interventions					x				x												2
Tests					x																1
Problem Lists					x				x							x					3
Clinical Alerts					x																1
Medical Device Data					x																1
CPOE					x																1
Clinical Outcomes Measurement					x																1
Clinical Findings										x		x					x				3
Clinical Concepts	x		x			x	x	x			x			x	x	x	x	x		x	12
Nursing Concepts		x																			1
Nursing Diagnosis		x	x																		2
Nursing Interventions		x	x																		2
Diagnosis									x					x		x	x			x	5
History of Present Illness									x												1
Past Medical History									x							x					2
Physical Exam									x			x				x					3
Lab Tests									x												1
Other Tests									x												1
Procedures									x	x			x			x					4
Radiology Reports													x								1
Adverse																x					1

EHR Topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Events																					
EKG Results																x					1
Family History																x					1
Behavioral Risk Factors																x					1
H&P Components																			x		1

Raw data results reveal that across these vocabularies, the following ten topics that receive mention five or more time in this sub-set: clinical concepts; diagnosis; nursing intervention; medications/drugs; signs and symptoms; lab tests; lab observations; lab results; nursing diagnosis; and patient problems.

Part Three: Annotated Profiles by Vocabulary

Part three of the data analysis report presents a brief annotated profile of each of the eight selected controlled vocabularies, describing the key points that relate the vocabulary to the electronic health record that are identified in the coding process.

Vocabulary #1: International Classification of Primary Care (ICPC)

The ICPC codes by clinical entity (such as ear, upper respiratory tract, sinus, throat) with associated symptoms and diagnoses (Akkerman, et al, 2004). The World Organization of Family Doctors developed this classification originally for paper-based records and then moving to electronic records (Bowman, 2004). ICPC is used extensively in Europe and Australia (Bowman, 2004). In Belgium it will soon be required for accreditation of general practitioner EHRs. In the Netherlands, all official data on morbidity in family practice and electronic prescribing systems use ICPC (Bowman, 2004).

When ICPC was created, it was the first time that providers could use a single classification system for the reasons for encounter, diagnoses or problems, and process of care (Verbeke, et al, 2006).

Many identified health problems that may be tracked in problem lists never develop into an actual diagnosis (van Weel, et al, 2004).

The following include a count of the uses noted in the literature for the ICPC, with the non-specific listings excluded.

- Diagnosis – 14

- Signs and Symptoms – 6

- Reason for Encounter – 3

- Problem List – 3 (Diagnoses or Signs and Symptoms may be included in this list)

- Process of care (decision, action, plans) – 2

- Assessment – 1

- Primary Care Documentation – 1 (may be another name for process of care)

- Diagnostic procedures – 1

- Therapeutic procedures – 1

Vocabulary #2: Logical Observation Identifier Names and Codes (LOINC)

LOINC is a terminology system for lab tests and observations that was developed by the Regenstrief Institute and the LOINC Committee. The system allows the results to appear in a way that is widely understood (AHIMA, 2006).

The observations included in LOINC are fields that are a part of a laboratory test, such as components, property measured, timing, type of sample, type of scale, and method used to produce the result (Khan, 2006).

This information is becoming very important to public health agencies for disease surveillance (Khan, 2006). Usefulness has been demonstrated in following organ donors and transplant patients (Staes, et al, 2005).

LOINC is generally thought of for laboratory tests and results, however there are LOINC codes for other clinical observations such as chest x-ray tests and results, EKG's and vital signs (McDonald, et al, 2003).

LOINC often works in conjunction with SNOMED where the LOINC number names the diagnostic test performed and the SNOMED concept describes the result in more detail than LOINC can (Wurtz, 2005).

The following include a count of the uses noted in the literature for LOINC with the non-specific listings excluded.

- Lab Results – 10
- Lab Tests – 9
- Lab Observations – 7
- Other Clinical Observations (non-lab) – 2
- Other Tests (non-lab) – 1

Vocabulary #3: NANDA Nursing Diagnoses

NANDA was developed in 1973 as a way to document nursing diagnoses that are not focused on the disease process but instead deal with the human response to health problems (Allred, et al, 2004).

Research measuring nursing care process is increasing since some countries, such as Switzerland, have passed laws stating that only scientifically proven healthcare processes will be reimbursed (Muller-Staub, et al, 2006).

A few of the references referred to problem, etiology and signs and symptoms as a process for formulating a nursing diagnosis.

A difficulty in locating literature for NANDA is that much of the research is in German literature maintained in unindexed databases that must be manually searched (Mueller-Staub, et al, 2006).

The following include a count of the uses noted in the literature for NANDA with the non-specific listings excluded.

- Nursing Diagnosis – 19
- Problem – 3 (Diagnoses or Signs and Symptoms may be included in this list)
- Etiology – 3
- Signs and Symptoms – 3

Vocabulary #4: Nursing Interventions Classification (NIC)

NIC defines the interventions performed by nurses in hospitals (Allred, et al, 2004). They are nursing interventions or treatments that are expected to improve patient outcomes (Muller-Staub, et al, 2006).

A difficulty in locating literature for NIC is that much of the research is in German literature maintained in unindexed databases that must be manually searched (Mueller-Staub, et al, 2006).

The following include a count of the uses noted in the literature for NIC with the non-specific listings excluded.

- Nursing Interventions – 15
- Nursing Activities – 2 (may be another name for interventions)
- Nursing Interviewing – 2

Vocabulary #5: Nursing Outcomes Classification (NOC)

NOC definitions are the results expected from the interventions offered to the patient (Allred, et al, 2004). Nursing outcomes are evaluated with successful response or unsuccessful repsonse (Muller-Staub, et al, 2006). NOC utilizes a five-point Lickert scale to evaluate outcome indicators (Lavin, 2004).

A difficulty in locating literature for NOC is that much of the research is in German literature maintained in unindexed databases that must be manually searched (Mueller-Staub, et al, 2006).

The following include a count of the uses noted in the literature for NOC with the non-specific listings excluded.

- Outcomes – 13
- Nursing Care Results – 2 (may be another name for outcomes)
- Likert-Scale – 1

Vocabulary #6: The Omaha System: Applications for Community Health Nursing

Nursing diagnosis systems and different from diagnoses made by physicians since they provide for clinical judgments about individual, family, or community responses to health problems or life events. This can include actual or potential problems (Hwang, et al, 2003).

The Omaha System is one of the first nursing terminologies and was developed by the Visiting Nurse Association in Omaha (Westra, et al, 2006). The main components of the Omaha System are the Problem Classification Scheme, the Intervention Scheme, and the Problem Rating Scale (Westra, et al, 2006).

The following include a count of the uses noted in the literature for the Omaha System with the non-specific listings excluded.

- Nursing Interventions – 12

- Outcomes – 8

- Patient problems – 6 (may include diagnoses or signs and symptoms)

- Diagnosis – 6

- Problem List – 2 (may be another name for patient problems)

- Assessment – 2

- Likert-Scale – 1

- Signs and Symptoms – 1

Vocabulary #7: RxNorm

RxNorm contains standardized names for clinical drugs to include active ingredients, strength and dose. It links active ingredients to brand name and combination drugs (Coonan, 2004).

The following include a count of the uses noted in the literature for RxNorm with the non-specific listings excluded.

- Medications/Drugs – 12

- Drug Products – 2

- Drug Ingredients – 2

- Drug Doses – 1

- Drug Actions – 1

Vocabulary #8: SNOMED Clinical Terms (CT)

SNOMED CT is a reference terminology for clinical concepts that was developed by the College of American Pathologists (AHIMA, 2006). Continuing development occurs by SNOMED International, which is a division of the College of American Pathologists (Bowie, 2004).

In a specific example of how SNOMED CT was used for clinical findings, a study looked at structured recording of heart murmur findings using SNOMED CT (Green, et al, 2006).

The majority of references stated that SNOMED CT included "clinical concepts", which is a broad description. The following include a count of the uses noted in the literature for the SNOMED CT with the non-specific listings excluded.

- Diagnosis – 5

- Medications – 4

- Procedures – 4

- Clinical Findings – 3

- Physical Exam – 3

- Vital Signs – 2

- Interventions – 2 (vital sign monitoring may be a part of this)

- Nursing diagnosis – 2

- Nursing interventions – 2 (also listed separately as interventions)

- Past Medical History – 2

- Signs and Symptoms – 1

- Tests – 1

- Clinical Alerts – 1

- Medical device data – 1 (may include vital signs and may be included under interventions)

- CPOE – 1

- Clinical Outcomes Measurement – 1

- History of Present Illness – 1

- Lab Tests – 1

- Other Tests – 1

- Radiology Reports – 1

- Adverse Events – 1

- EKG Results – 1

- Family History – 1

- Behavioral risk factors – 1

- H&P Components – 1

Summary of Electronic Health Record Terminology as Used in the Eight Selected

Controlled Vocabularies

Most controlled vocabularies have a specific focus. SNOMED CT covers the broadest range of EHR topics. The other seven studied in this paper have the following focus:

- ICPC – Physician Offices (Primary Care)

- LOINC – Laboratory Tests and Results

- NANDA – Nursing Diagnoses or Problems

- NIC – Nursing Interventions

- NOC – Nursing Outcomes

- Omaha System – Nursing Problems, Interventions and Outcomes for community health, such as home care.

- RxNorm – Drugs

With implementation of EHRs on the increase, standardized data content is becoming critical to the quality of data (AHIMA, 2006). Standardizing EHR content is difficult when various systems by different vendors are linked together to form the EHR (AHIMA, 2006). Each system has different names for the same data element or may have data elements with varying definitions (AHIMA, 2006).

As revealed in the analysis reported above, items generally included in the EHR are observations, laboratory tests, diagnostic imaging reports, treatments, therapies, drugs administered, patient identifying information, legal permissions and allergies (Eichelberg, 2005).

As part of this, electronic nursing documentation is often implemented, which includes assessment, problem identification and problem management (Allred, et al, 2004).

Without standardization, electronic information is difficult to use in decision-making (Allred, et al, 2004). The key components that must be standardized for improved documentation are diagnoses (or problems), interventions and outcomes (Allred, et al, 2004). The most popular standardized languages for diagnoses or problems are NANDA and Omaha. NIC can be used for interventions and NOC for outcomes.

Some of the literature refers to topics in the vocabularies in a generalized way, such as "clinical concepts" or "clinical entity" that are not identifiable with a specific topic in the electronic health record. Determining the best way to use a controlled vocabulary in the EHR would be easier to identify if a standardized list of the EHR components were developed against which each controlled vocabulary could be evaluated.

CHAPTER 5 - CONCLUSIONS

There is no single controlled vocabulary that fully meets the needs of healthcare data communication within the electronic health record (Chute, et al, 1996). SNOMED CT covers the broadest range of clinical concepts, demonstrated by the length of the list of EHR topics reported in the Analysis of Data chapter.

Much of the data within the electronic health record as currently manifested is unstructured text and as such, is difficult to access for reporting purposes (Abdehak, et al, 2001). Utilizing controlled vocabularies can help structure the text consistently and will help with data retrieval and reporting.

There is some difficulty in identifying EHR topics when reviewing the literature collected, related to each of the eight controlled vocabularies studied in this paper. The researchers cited often make assumptions regarding the application of each vocabulary. In most cases, this study is limited to listing how the vocabulary is used when researchers extract data from the health record to complete clinical care research.

Implications for Further Research

In order to clearly understand how each controlled vocabulary fits into the electronic health record, it will be useful to conduct a future study on the parts of the health record with

consistent descriptions, prior to a full study on the use of each of the controlled vocabularies that may be used. Such studies may need to define the differences in the health record within different care settings, such as ambulatory surgery, psychiatric, acute care, physician offices, and others.

Developing a better understanding and use of the controlled vocabularies in the health record is critical for the successful development of a national healthcare infrastructure, thus permitting the electronic exchange of health records between care settings while maintaining data integrity and confidentiality. Additionally, in future studies it is important to consider the extensibility of the controlled vocabularies as medical knowledge is increasing rapidly.

APPENDIX A
UMLS METATHESAURUS SOURCE VOCABULARIES
Original 74 Vocabularies Identified for Initial Review

UMLS Code	Description	Source
AIR93	AI/RHEUM	National Library of Medicine
ALT2006	Alternative Billing Concepts	Alternative Billing Concepts http://www.alternativelink.com
AOD2000	Alcohol and Other Drug Thesaurus	National Institute on Alcohol Abuse and Alcoholism
AOT2003	Authorized Osteopathic Thesaurus	American Association of Colleges of Osteopathic Medicine
BI98	Beth Israel OMR Clinical Problem List Vocabulary	Beth Israel Deaconess Medical Center http://clinquery.bidmc.harvard.edu
CCPSS99	Canonical Clinical Problem Statement System	Vanderbilt University Medical Center
CCS2005	Clinical Classifications Software	Agency for Healthcare Research and Quality (AHRQ) http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp
CDT2007-2008	Current Dental Terminology 2007-2008	American Dental Association
COSTAR_89-95	Computer-Stored Ambulatory Records	Massachusetts General Hospital
CPM2003	Medical Entities Dictionary	Columbia Presbyterian Medical Center
CPT2007	Current Procedural Terminology	American Medical Association http://www.ama-assn.org Note: Concept names are identified with code MTHCH2007.
CSP2006	Computer Retrieval of Information on Scientific Projects (CRISP)	National Institutes of Health
CST95	Coding Symbols for Thesaurus of Adverse Reaction Terms	U.S. Food and Drug Administration, Center for Drug Evaluation and Research http://www.ntis.gov/fcpc/cpn5580.htm

UMLS Code	Description	Source
	(COSTART)	
CTCAEV3	Common Terminology Criteria for Adverse Events	National Cancer Institute
DDB00	Diseases Database 2000	Medical Object Oriented Software Enterprises http://www.diseasesdatabase.com
DSM4_1994	Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)	American Psychiatric Association
DXP94	DXplain (An expert diagnosis program)	Massachusetts General Hospital
GO2006_01_20	Gene Ontology	The Gene Ontology Consortium http://www.geneontology.org/#cite_go
HCDT2007-2008	HCPCS Version of Current Dental Terminology 2007-2008	U.S. Centers for Medicare & Medicaid Services
HCPCS2007	Healthcare Common Procedure Coding System	U.S. Centers for Medicare & Medicaid Services Note: Concept names are identified with code MTHHH2007.
HCPT2007	Version of Physicians' Current Procedural Terminology (CPT) included in the Healthcare Common Procedure Coding System	U.S. Centers for Medicare & Medicaid Services
HHC2003	Home Health Care Classification of Nursing Diagnoses and Interventions	Georgetown University
HL7V3.0_2006_05	Health Level Seven Vocabulary (HL7)	Health Level Seven http://www.hl7.org

UMLS Code	Description	Source
HLREL_1998	ICPC2E-ICD10 relationships from Dr. Henk Lamberts	University of Amsterdam
HUGO_2005_04	HUGO Gene Nomenclature	HUGO Gene Nomenclature Committee, Department of Biology, University College London
ICD10_1998	International Statistical Classification of Diseases and Related Health Problems (ICD-10)	World Health Organization
ICD9CM_2007	International Classification of Diseases, 9th Edition, Clinical Modification	U.S. Department of Health and Human Services, Centers for Medicare and Medicaid Services Note: Metathesaurus additional entry terms are listed under code MTHICD9_2007
ICPC2EENG_200203	International Classification of Primary Care (ICPC)	World Organization of National Colleges, Academies and Academic Associations of General Practitioners/Family Physicians Note: Concept names are listed under code MTHICPC2EAE_200203
JABL99	Online Congenital Multiple Anomaly/Mental Retardation Syndromes	National Library of Medicine
LCH90	Library of Congress Subject Headings	Library of Congress (this source has considerable non-biomedical content and is not included in its entirety. http://www.lcweb.loc.gov
LNC217	Logical Observation Identifier Names and Codes (LOINC)	The Regenstrief Institute
MBD06	MEDLINE Backfiles (1996-2000)	National Library of Medicine http://www.nlm.nih.gov
MCM92	Glossary of Methodologic Terms for Clinical	McMaster University, Canada

UMLS Code	Description	Source
	Epidemiologic Studies of Human Disorders	
MDDB_2006_09_20	Master Drug Data Base, 2006	Medi-Span http://www.medi-span.com/products/product_mddb.asp
MDR91	Medical Dictionary for Regulatory Activities Terminology (MedDRA)	Northrop Grumman
MED06	MEDLINE Current Files (2001-2006)	National Library of Medicine http://www.nlm.nih.gov
MEDLINEPLUS_20040814	MedlinePlus Health Topics	National Library of Medicine
MIM93	Online Mendelian Inheritance in Man (OMIM)	John Hopkins University, Center for Biotechnology Information
MMSL_2006_09_01	Medisource Lexicon	Multum Information Services http://www.multum.com
MMX_2006_09_11	Micromedex DRUGDEX	Micromedex http://www.micromedex.com
MSH2007_2006_11_27	Medical Subject Headings (MeSH)	National Library of Medicine
MTH	UMLS Metathesaurus	National Library of Medicine
MTHFDA_2006_10_11	Metathesaurus Forms of FDA National Drug Code Directory	National Library of Medicine
MTHMST2001	Metathesaurus Version of Minimal Standard Terminology Digestive Endoscopy	National Library of Medicine
MTHPDQ2005	Metathesaurus Forms of Physician Data Query	National Cancer Institute

UMLS Code	Description	Source
NAN2004	NANDA nursing diagnoses	NANDA International
NCBI2006_01_04	NCBI Taxonomy	U.S. Department of Health and Human Services, National Institutes of Health http://www.ncbi.nlm.gov/Taxonomy/
NCI2006_03D	NCI Thesaurus	National Cancer Institute, National Institutes of Health http://nci.nih.gov
NCI-CTCAEV3	NCI modified Common Terminology Criteria for Adverse Events	National Cancer Institute
NCISEER_1999	NCI Surveillance, Epidemiology, and End Results (SEER)	http://www-seer.ims.nci.nih.gov/Admin/ConvProgs/
NDDF_2006_09_15	National Drug Data File Plus Source Vocabulary	First DataBank
NDFRT_2004_01	National Drug File – Reference Terminology	U.S. Department of Veterans Affairs
NEU99	Neuronames Brain Hierarchy	University of Washington, Primate Information Center http://rprcsgi.rprc.washington.edu/neuronames/
NIC2005	Nursing Interventions Classification (NIC)	
NLM-MED	National Library of Medicine Medline Data	National Library of Medicine http://www.nlm.nih.gov
NOC97	Nursing Outcomes Classification (NOC)	Iowa Outcomes Project
OMS94	The Omaha System: Applications for Community Health Nursing	W.B. Saunders
PCDS97	Patient Data Care	Vanderbilt University School of Nursing

UMLS Code	Description	Source
	Set (PCDS)	
PDQ2005	PDQ	National Cancer Institute
PNDS2002	Perioperative Nursing Data Set	Association of Operating Room Nurses
PPAC98	Pharmacy Practice Activity Classification (PPAC)	American Pharmaceutical Association
PSY2004	Thesaurus of psychological index terms	American Psychological Association
QMR96	Quick Medical Reference (QMR)	First DataBank
RAM99	QMR clinically related terms from Randolf A. Miller	Vanderbilt University
RCD99	Clinical Terms Version 3 (CTV3) (Read Codes)	National Health Service National Coding and Classification Centre
RXNORM_06AD_061121F	RxNorm work done by NLM	National Library of Medicine
SNOMEDCT_2006_07_31	SNOMED Clinical Terms	College of American Pathologists http://www.snomed.org
SPN2003	Standard Product Nomenclature (SPN)	U.S. Food and Drug Administration
ULT93	Ultrasound Structured Attribute Reporting (UltraSTAR)	Brigham & Womens Hospital
UMD2007	Universal Medical Device Nomenclature System (UMDNS)	ECRI
USPMG_2004	United States Pharmacopeia (USP)	Medicare Prescription Drug Benefit Model Guidelines: Drug Categories and Classes in Part D http://www.usp.org/healthcareInfo/mmg/ finalGuidelines.html
UWDA173	University of Washington	University of Washington

UMLS Code	Description	Source
	Digital Anatomist (UWDA)	
VANDF_2005_03_23	Veterans Health Administration National Drug File	U.S. Department of Veterans Affairs http://www.vapbm.org/PBM/natform.htm
WHO97	WHO Adverse Drug Reaction Terminology (WHOART)	World Health Organization

Note: Older versions and foreign language translations of vocabularies were excluded from this table.

APPENDIX B
RESULTS OF THE SEARCH FOR RELATED LITERATURE
Vocabularies selected for further study are bolded

UMLS Code	Description	Literature Count
AIR93	AI/RHEUM	4
ALT2006	Alternative Billing Concepts	2
AOD2000	Alcohol and Other Drug Thesaurus	0
AOT2003	Authorized Osteopathic Thesaurus	0
BI98	Beth Israel OMR Clinical Problem List Vocabulary	1
CCPSS99	Canonical Clinical Problem Statement System	0
CCS2005	Clinical Classifications Software (formerly called CCHPR)	17
CDT2007-2008	Current Dental Terminology 2007-2008	20
COSTAR_89-95	Computer-Stored Ambulatory Records	2
CPM2003	Medical Entities Dictionary	Institution Specific
CPT2007	Current Procedural Terminology	Reimbursement and Statistical
CSP2006	Computer Retrieval of Information on Scientific Projects (CRISP)	0
CST95	Coding Symbols for Thesaurus of Adverse Reaction Terms (COSTART)	Adverse Reactions
CTCAEV3	Common Terminology Criteria for Adverse Events	Adverse Reactions
DDB00	Diseases Database 2000	1
DSM4_1994	Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)	Reimbursement and Statistical
DXP94	DXplain (An expert diagnosis program)	Diagnosis program
GO2006_01_20	Gene Ontology	Gene identification
HCDT2007-2008	HCPCS Version of Current Dental Terminology 2007-2008	0
HCPCS2007	Healthcare Common Procedure Coding System	4*
HCPT2007	Version of Physicians' Current Procedural Terminology (CPT) included in the Healthcare Common Procedure Coding System	0
HHC2003	Home Health Care Classification of Nursing Diagnoses and Interventions	Institution Specific
HL7V3.0_2006_05	Health Level Seven Vocabulary (HL7)	Data Standard
HLREL_1998	ICPC2E-ICD10 relationships from Dr. Henk Lamberts	2

UMLS Code	Description	Literature Count
HUGO_2005_04	HUGO Gene Nomenclature	Gene Identification
ICD10_1998	International Statistical Classification of Diseases and Related Health Problems (ICD-10)	Reimbursement and Statistical
ICD9CM_2007	International Classification of Diseases, 9th Edition, Clinical Modification	20+
ICPC2EENG_200203	**International Classification of Primary Care (ICPC)**	**20+**
JABL99	Online Congenital Multiple Anomaly/Mental Retardation Syndromes	0
LCH90	Library of Congress Subject Headings	Literature retrieval
LNC217	**Logical Observation Identifier Names and Codes (LOINC)**	**20+**
MBD06	MEDLINE Backfiles (1996-2000)	Literature retrieval
MCM92	Glossary of Methodologic Terms for Clinical Epidemiologic Studies of Human Disorders	1
MDDB_2006_09_20	Master Drug Data Base, 2006	7
MDR91	Medical Dictionary for Regulatory Activities Terminology (MedDRA)	Adverse Events and Clinical Trials
MED06	MEDLINE Current Files (2001-2006)	Literature retrieval
MEDLINEPLUS_20040814	MedlinePlus Health Topics	Literature retrieval
MIM93	Online Mendelian Inheritance in Man (OMIM)	Gene Identification
MMSL_2006_09_01	Medisource Lexicon	0
MMX_2006_09_11	Micromedex DRUGDEX	6
MSH2007_2006_11_27	Medical Subject Headings (MeSH)	Literature Retrieval
MTH	UMLS Metathesaurus	Vocabulary organization
MTHFDA_2006_10_11	Metathesaurus Forms of FDA National Drug Code Directory	1
MTHMST2001	Metathesaurus Version of Minimal Standard Terminology Digestive Endoscopy	1
MTHPDQ2005	Metathesaurus Forms of Physician Data Query	2
NAN2004	**NANDA nursing diagnoses**	**20+**
NCBI2006_01_04	NCBI Taxonomy	Literature Retrieval
NCI2006_03D	NCI Thesaurus	Tumor and Gene Identification
NCI-CTCAEV3	NCI modified Common Terminology Criteria for Adverse Events	20+
NCISEER_1999	NCI Surveillance, Epidemiology, and End Results (SEER)	Database
NDDF_2006_09_15	National Drug Data File Plus Source	0

UMLS Code	Description	Literature Count
	Vocabulary	
NDFRT_2004_01	National Drug File – Reference Terminology	10
NEU99	Neuronames Brain Hierarchy	13
NIC2005	**Nursing Interventions Classification (NIC)**	**20+**
NLM-MED	National Library of Medicine Medline Data	Literature Retrieval
NOC97	**Nursing Outcomes Classification (NOC)**	**20+**
OMS94	**The Omaha System: Applications for Community Health Nursing**	**20+**
PCDS97	Patient Data Care Set (PCDS)	0
PDQ2005	PDQ	0
PNDS2002	Perioperative Nursing Data Set	7
PPAC98	Pharmacy Practice Activity Classification (PPAC)	0
PSY2004	Thesaurus of psychological index terms	13
QMR96	Quick Medical Reference (QMR)	Diagnosis program
RAM99	QMR clinically related terms from Randolf A. Miller	0
RCD99	Clinical Terms Version 3 (CTV3) (Read Codes)	Associated with SNOMED
RXNORM_06AD_061121F	**RxNorm work done by NLM**	**20+**
SNOMEDCT_2006_07_31	**SNOMED Clinical Terms**	**20+**
SPN2003	Standard Product Nomenclature (SPN)	0
ULT93	Ultrasound Structured Attribute Reporting (UltraSTAR)	1
UMD2007	Universal Medical Device Nomenclature System (UMDNS)	2
USPMG_2004	United States Pharmacopeia (USP)	Data Standard
UWDA173	University of Washington Digital Anatomist (UWDA)	10
VANDF_2005_03_23	Veterans Health Administration National Drug File	7
WHO97	WHO Adverse Drug Reaction Terminology (WHOART)	9

*There were more results than count listed but they were not research-related.

APPENDIX C

Definitions

Abstracting. "Preparation of a brief summary characterizing the patient and disease. Diagnostic workup, extent of disease, treatment, and end results may also be documented on an abstract form" (Abdelhak, et al, 2001).

Classification System. "A system that is clinically descriptive and arranges or organizes like or related entities" (Giannangelo, 2006).

Clinical Decision Support. "Computer software applications that bring information from laboratories, electronic textbooks, bibliographic databases, and administrative applications to integrate the support data needed to reinforce the clinician's decision requirements" (Abdelhak, et al, 2001).

Clinical Terminology. "A set of standardized terms and their synonyms that record patient findings, circumstances, events, and interventions with sufficient detail to support clinical care, decision support, outcomes research, and quality improvement; and can be efficiently mapped to broader classifications for administrative, regulatory, oversight, and fiscal requirements" (Giannangelo, 2006).

Coded Data. Coded data includes "any set of codes used to encode data elements, such as tables of terms, medical concepts, medical diagnostic codes, or medical procedure codes; includes both the codes and their descriptions" (Giannangelo, 2006).

Coder. "Healthcare worker responsible for assigning numeric or alphanumeric characters to diagnostic or procedural statements for ease in computerization" (Johns, 2002).

Controlled Vocabulary. "A standardized set of terms and phrases used to describe a subject area or information domain" (Stewart, 2006).

Data Standards. "A document, established by consensus and approved by a recognized body, which provides rules, guidelines, or characteristics for activities" (van Bemmel and Musen, 1997).

Discovery. "Access to documents or witnesses by parties to a legal proceeding. A document or information is discoverable if it must be produced to the party who requests it" (Roach, Hoban, Broccolo, Roth, Blanchard, 2006).

Electronic Health Record. "Any information relating to the past, present, or future physical/mental health, or condition of an individual. It resides in electronic system(s) used to capture, transmit, receive, store, retrieve, link, and manipulate multimedia data for the primary purpose of providing health care and health related services" (Abdelhak, et al, 2001).

Epidemiology. "The study of disease and the determinants of disease in populations" (Abdelhak, et al, 2001).

Glossary. "When a concept in a terminology or thesaurus is accompanied by a definition" (de Keizer, et al, 2000).

History and Physical (H&P). "A comprehensive document generated by the physician or other examiner at the patient's first office visit. The H&P documents important data related to the patient's medical history, social history, and the complaint or illness that prompted the patient to seek medical attention. The primary purpose of the H&P is to compile information that the physician needs to determine a diagnosis and a treatment plan for the patient" (Masters and Gylys, 2003).

Literature Review. "A search of the published research to determine what research has already been performed in this area" (Abdelhak, et al, 2001).

Medical Informatics. "Field that concerns itself with the cognitive, information processing, and communication tools of medical practice, education, and research, including the information science and the technology to support these tasks" (Abdelhak, et al, 2001).

Medical Record. "An account of a patient's health and disease after he or she has sought medical help" (van Bemmel and Musen, 1997).

Nomenclature. "A system of terms composed according to pre-established composition rules or

the set of rules itself for composing new complex concepts" (de Keizer, 2000).

Nosology. "A classification of diseases" (de Keizer, et al, 2000)

Ontology. "A common vocabulary organized by meaning that allows for an understanding of

the structure of descriptive information, which helps to facilitate interoperability"

(Giannangelo, 2006).

Outcomes. "End result of treatment or intervention; compared to preestablished criteria defining

desired outcomes" (Abdelhak, et al, 2001).

Reference Terminology. "A set of concepts and relationships that provides a common

consultation point for comparison and aggregation of data about the entire healthcare

process, recorded by multiple individuals, systems, or institutions" (Giannangelo, 2006).

Registry. "Statewide and nationwide collections of data used to make information available to

improve quality of care and measure the effectiveness of a particular aspect of health care

delivery, i.e., trauma, cardiac" (Abdelhak, et al, 2001).

Taxonomy. "An arrangement of classes according to the Is_a relationship from the subordinate

class to the superordinate class" (de Keizer, et al, 2000).

Terminology. "A collection of words or phrases with their meanings" (Giannangelo, 2006).

Thesaurus. "A terminology, in which terms are ordered, e.g., alphabetically or systematically

and in which concepts can possibly be described by more than one (synonymous) term"

(de Keizer, et al, 2000).

Unified Medical Language System (UMLS). "A multipurpose resource that includes concepts

and terms from many different source vocabularies developed" (Giannangelo, 2006).

Vocabulary. "Even though there are slight differences in the definitions of terminology and

vocabulary, the terms are frequently used interchangeably" (Giannangelo, 2006).

BIBLIOGRAPHY

Abdelhak, M., Grostick, S., Hanken, M., Jacobs, E. (2001). *Health Information: Management of a Strategic Resource."* Philadelphia: W. B. Saunders Company.

AHIMA e-HIM Work Group on the Legal Health Record (2005, September). Update: Guidelines for Defining the Legal Health Record for Disclosure Purposes. *Journal of the American Health Information Management Association, 76,* 64A-G.

AHIMA e-HIM Workgroup on EHR Data Content. (2006, February). Data Standard Time: Data Content Standardization and the HIM Role. *Journal of the American Health Information Management Association, 77,* 26-32.

AHIMA Facts (2007). Retrieved April 4, 2007 from http://www.ahima.org/about/about.asp.

Akkerman, A., van der Wouden, J., Kuyvenhoven, M., Dieleman, J., Verheij, T. (2004). Antibiotic prescribing for respiratory tract infections in Dutch primary care in relation to patient age and clinical entities. *Journal of Antimicrobial Chemotherapy, 54,* 1116-1121.

Allred, S., Smith, K., Flowers, L. (2004, Fall). Electronic Implementation of National Nursing Standards – NANDA, NOC and NIC as an Effective Teaching Tool. *Journal of Heath Information Management, 18,* 56-60.

Appavu, S. (2006, February). Standards Harmony: Why Is It So Hard for Healthcare? *Journal of American Health Information Management Association, 77,* 54.

Austin, C., Boxerman, S., (1998). *Information Systems for Health Services Administration, Fifth Edition.* Chicago: Health Administration Press.

Bales, M., Kukafka, R., Burkhardt, A., Friedman, C. (2006). Qualitative assessment of the International Classification of Functioning, Disability, and Health with respect to the desiderata for controlled medical vocabularies. *International Journal of Medical Informatics, 75.* 384-395

Bowie, J. (2004, August). Four Options for Implementing SNOMED. *Journal of American Health Information Management Association, 75,* 30-33

Bowman, S. (2005, August). Coordinating SNOMED-CT and ICD-10: Getting the Most out of Electronic Health Record Systems. *Journal of American Health Information Management Association, 76,* 60-61.

Bowman, S. (2005, Spring). Coordination of SNOMED-CT and ICD-10: Getting the Most out of Electronic Health Record Systems. *Perspectives in Health Information Management.*

Bowman, S. (2004, November/December). ICD-10: All in the Family. *Journal of American Health Information Management Association, 75,* 62-63.

Chute, C. (2000). Clinical Classification and Terminology: Some History and Current

Observations. *Journal of the American Medical Informatics Association, 7,* 298-303.

Chute, C., Cohn, S., Campbell, K., Oliver, D., Campbell, J. (1996). The Content Coverage of

Clinical Classifications. *Journal of the American Medical Informatics Association, 3,*

224-233.

Cimino, J. (1998). Desiderata for Controlled Medical Vocabularies in the Twenty-First Century.

Methods of Information in Medicine, 37, 394-403.

Coonan, K. (2004). Medical Information Standards Applicable to Emergency Department

Information Systems. *Academic Emergency Medicine, 11,* 1198-1205.

Dameron, O., Roques, E., Rubin, D., Marquet, G., Bergun, A. (2005). Grading lung tumors

using OWL-DL based reasoning. *Proceedings of the 9th International Protégé*

Conference.

de Keizer, N., Abu-Hanna, A., Zwetsloot-Schonk, J. (2000). Understanding Terminological

Systems I: Terminology and Typology. *Methods of Information in Medicine, 39.* 16-21.

Eichelberg, M., Aden, T., Riesmeier, J., Dogac, A., Laleci, G. (2005, December). A Survey and

    Analysis of Electronic Healthcare Record Standards. *Association of Computing*

    Machinery Computing Surveys, 37, 277-315.

Fenton, S. (2004, October). Clinical Vocabularies: Essential to the Future of Health Information

    Management. *2004 IFHRO Conference and American Health Information Management*

    Association Convention Proceedings.

Fenton, S. (2005, May). An Introduction to the Unified Medical Language System. *Journal of*

    the American Health Information Management Association, 76, 60-62.

Fenton, S. (2006). Clinical Classifications and Terminologies. In K. M. LaTour & S.

    Eichenwald (Eds.), *Health Information Management: Concepts, Principles, and Practice,*

    2nd Edition, Chicago: AHIMA.

Foley, M., Garrett, G. (2006, July-August). The Code Ahead: Key Issues Shaping Clinical

    Terminology and Classification. *Journal of American Health Information Management*

    Association, 77, 24-30.

Giannangelo, K. (Ed.). (2006). *Healthcare Code Sets, Clinical Terminologies, and*

    Classification Systems. Chicago: American Health Information Management

    Association.

Golbreich, C., Zhang, S., Bodenreider, O. (2006). The Foundational Model of Anatomy in

OWL: Experience and Perspectives. *Journal of Web Semantics, 4,* 181-195.

Green, J., Wilcke, J., Abbott, J., Rees, L. (2006). Development and Evaluation of Methods for

Structured Recording of Heart Murmur Findings Using SNOMED-CT Post-

Coordination. *Journal of American Medical Informatics Association, 13,* 321-333.

Halamka, J. (2006, Fall). Harmonizing Healthcare Data Standards. *Journal of Healthcare*

Information Management, 20, 11-13.

Healthcare IT News (2006, March). EMR Utilization on the Rise.

Hwang, J., Cimino, J., Bakken, S. (2003). Integrating Nursing Diagnostic Concepts into the

Medical Entries Dictionary Using the ISO Reference Terminology Model for Nursing

Diagnosis. *JAMIA 10,* 382-388.

Imel, M. (2002). SNOMED Overview. *American Health Information Management Association*

Conference Proceedings.

Johns, M. (ed.) (2002). *Health Information Management Technology: An Applied Approach.*

Chicago: AHIMA.

Kaufman, J., Etron, I., Deen, G, Ford, D., Smith, E., Knoop, S., Nelken, H., Kol, T., Mesika, Y.,

 Witting, K., Julier, K., Bennett, C., Rapp, B., Carmeli, B., Cohen, S. (2005, Fall). From

 Regional Health Information Organizations to a National Healthcare Information

 Infrastructure. *Perspectives in Health Information Management.*

Khan, A., Griffith, S., Moore, C., Russell, D., Rosario, A., Bertolli, J. (2006). Standardizing

 Laboratory Data by Mapping to LOINC. *Journal of American Medical Informatics*

 Association, 13, 353-355.

Lavin, M., Avant, K., Craft-Rosenberg, M., Herdman, T., Gebbie, K. (2004). Contexts for the

 Study of the Economic Influence of Nursing Diagnoses on Patient Outcomes.

 International Journal of Nursing Terminologies and Classifications, 15, 39-47.

Leedy, P., Ormrod, J. (2005). *Practical Research: Planning and Design, 8th Edition,* New

 Jersey: Pearson Education, Inc.

Levy, B. (2004, Summer). Evolving to Clinical Terminology. *Journal of Healthcare*

 Information Management, 18, 37-43.

Masters, R., Gylys, B. (2003). *Introducing Medical Terminology Specialties: A Medical*

 Specialties Approach with Patient Records. Philadephia: F.A. Davis Company.

McDonald, C., Huff, S., Suico, J., Hill, G., Leavelle, D., Aller, R., Forrey, A., Mercer, K., DeMoore, G., Hook, J., William, W., Case, J., Maloney, P. (2003). LOINC, a Universal Standard for Identifying Laboratory Observations: A 5-Year Update. *Clinical Chemistry, 49,* 624-633.

Muller-Staub, M., Lavin, M., Needham, I., van Achterberg, T. (2006). Nursing Diagnoses, Interventions and Outcomes – Application and Impact on Nursing Practice. *Journal of Advanced Nursing, 56,* 514-537.

NLM (2006). About the UMLS® Resources, Retrieved 4/17/07 from
http://www.nlm.nih.gov/research/umls/about_umls.html

NLM (2007). Appendix A.1, Appendix to the License Agreement for Use of the UMLS Metathesaurus, UMLS Metathesaurus Source Vocabularies – 2007AA Edition. Retrieved 3/31/2007 from http://www.nlm.nih.gov/research/umls/metaa1.html.

Office of the National Coordinator for Health Information Technology (ONC), Presidential Initiatives (2006), Retrieved 4/25/2007 from
http://www.hhs.gov/healthit/chiinitiative.html

Palmquist, M., Busch, C., De Maret, P., Flynn, T., Kellum, R., Le, S., Meyers, B., Saunders, M., White, R. (2005). Content Analysis. Retrieved April 1, 2007 from Colorado State

University Department of English Web site:

http://writing.colostate.edu/guides/research/content/.

Roach, W., Hoban, R., Broccolo, B., Roth, A., Blanchard, T. (2006). *Medical Records and the*

Law. MA: Jones and Barlett Publishers.

Rollins, G. (2003, January. HIM on the Front Lines of Change: Marching Toward the National

Health Information Infrastructure. *Journal of American Health Information Management*

Association, 74, 22-26.

Staes, C., Huff, S., Evans, R., Narus, S., Tilley, C., Sorensen, J. (2005). Development of an

Information Model for Storing Organ Donor Data Within an Electronic Medical Record.

Journal of American Medical Informatics Association, 12, 357-363.

Stewart, D. (2006). A Brief Introduction to Controlled Vocabularies. *University of Oregon,*

AIM 610: Managing Information Assets, Unit 2, Lecture 2.

Tobias, J., Chilukuri, R., Komatsoulis, G., Mohanty, S., Sioutos, N., Warzel, D., Wright, L.,

Crowley, R. (2006). The CAP Cancer Protocols – A case study of caCORE based data

standards implementation to integrate with the Cancer Biomedical Informatics Grid.

BioMed Central Medical Informatics and Decision Making.

van Bemmel, J., Musen, M. (eds.s) (1997). *Handbook of Medical Informatics.* The Netherlands: Springer.

van Weel, C., Rosser, W. (2004). Improving Health Care Globally. *Annals of Family Medicine, 2,* S5-S16.

Verbeke, M., Schrans, D., Deroose, S., De Maeseneer, J. (2006). The International Classification of Primary Care (ICPC-2): an essential tool in the EPR of the GP. *Studies in Health Techology Informatics.*

Ward, A. (2006, July/August). Implementing SNOMED CT in England. *Journal of American Health Information Management Association, 77,* 42-43.

Westra, B., Solomon, D., Ashley, D. (2006, Summer). Use of the Omaha System Data to Validate Medicare Required Outcomes in Home Care. *Journal of Healthcare Information Management, 20,* 88-94.

Wurtz, R., Cameron, B. (2005). Electronic Laboratory Reporting for the Infectious Diseases Physician and Clinical Microbiologist. *Clinical Infectious Diseases, 40,* 1638-43.