Review ■

Nursing Classification Systems: Necessary but not Sufficient for Representing "What Nurses Do" for Inclusion in Computer-based Patient Record Systems

SUZANNE BAKKEN HENRY, RN, DNSC, FAAN, CHARLES N. MEAD, MD, MS

Abstract Our premise is that from the perspective of maximum flexibility of data usage by computer-based record (CPR) systems, existing nursing classification systems are necessary, but not sufficient, for representing important aspects of "what nurses do." In particular, we have focused our attention on those classification systems that represent nurses' clinical activities through the abstraction of activities into categories of nursing interventions. In this theoretical paper, we argue that taxonomic, combinatorial vocabularies capable of coding atomic-level nursing activities are required to effectively capture *in a reproducible and reversible manner* the clinical decisions and actions of nurses, and that, without such vocabularies and associated grammars, potentially important clinical process data is lost during the encoding process. Existing nursing intervention classification systems do not fulfill these criteria. As background to our argument, we first present an overview of the content, methods, and evaluation criteria used in previous studies whose focus has been to evaluate the effectiveness of existing coding and classification systems. Next, using the Ingenerf typology of taxonomic vocabularies, we categorize the formal type and structure of three existing nursing intervention classification systems—Nursing Interventions Classification, Omaha System, and Home Health Care Classification. Third, we use records from home care patients to show examples of lossy data transformation, the loss of potentially significant atomic data, resulting from encoding using each of the three systems. Last, we provide an example of the application of a formal representation methodology (conceptual graphs) which we believe could be used as a model to build the required combinatorial, taxonomic vocabulary for representing nursing interventions.

■ **J Am Med Inform Assoc.** 1997;4:222–232.

The American Nurses Association (ANA) social policy statement defines nursing as the "diagnosis and treatment of human responses to actual or potential health problems."[1] The most universally accepted conceptual model of nursing[2]—the nursing process—delineates a five-stage process of "nursing activity states," including: *assessment* of the patients and their environment, *definition* (*diagnosis*) of specific patient problems requiring treatment, development of a *plan* of care, *intervention* (execution of the plan of care), and *evaluation* of the effectiveness of the plan. The latest version of the ANA Standards of Practice has added

Affiliations of the authors: Department of Community Health Systems, School of Nursing, University of California, San Francisco, CA (SBH, CNM); CareCentric Solutions, Inc., Duluth, GA (CNM).

Supported by NR3874, Representing Nursing Concepts for Computer-Based Systems, S. B. Henry, Principal Investigator. The data were provided by NR02215, Quality of Nursing Care of People with AIDS, W. L. Holzemer, Principal Investigator.

An earlier version of this article was presented at the 1996 AMIA Fall Symposium.

Correspondence and reprints: Suzanne Bakken Henry, RN, DNSc, FAAN, Box 0608, University of California, San Francisco, San Francisco, CA 94143-0608.
E-mail: nursing%sue_henry@ccmail.ucsf.edu

Received for publication: 12/23/96; accepted for publication: 1/24/97.

a sixth activity state, identification of patient outcome.[3] Other efforts to define nursing practice have been directed at developing a Nursing Minimum Data Set (NMDS) as part of the larger effort of creating a Unified Nursing Language System (UNLS).[4] Currently, the NMDS requires elements describing nursing diagnosis, nursing interventions, outcomes of patient care, and intensity of nursing care. To date, the NMDS has served as the overarching framework for the existing coding and classification work in nursing.

Significant efforts have been mounted in an effort to create a Unified Medical Language System (UMLS) that will serve as an architecture to cross-link standardized coding and classification systems,[5] as well as to the evaluation of the ability of standardized coding and classification systems to capture "real" clinical data.[6–10] Given the historically physician-centric nature of the United States' health care delivery system, much of this work has involved medical diagnoses, medical procedures and physician notes. However, pioneering research has also been conducted in nursing, and has led to the development of nursing-specific coding and classification systems for use in the context of the CPR, including the Nursing Intervention Classification System,[11] the International Classification of Nursing Practice,[2] and the Nursing Outcomes Classification.[12] However, important issues remain unresolved and are, in some instances, the topic of heated debate.[13–15]

Although presented at varying levels of abstraction, common among published perspectives of what nurses do is the notion of activities or behaviors related to an actual or potential health problem. It is nursing interventions and the activities and behaviors comprising the interventions that are the specific focus of this paper.

In this theoretical paper, we argue that combinatorial, taxonomic vocabularies capable of coding atomic-level nursing activities are required in order to effectively capture the details of the clinical nursing process. In particular, we have focused our attention on the portion of the nursing process traditionally referred to as "nursing intervention," i.e., the execution of the plan of care. We believe that combinatorial, taxonomic vocabularies of the type described in this paper are a necessity if the nursing community is to arrive at a comprehensive understanding of the details of the nursing process in a manner which will facilitate the development of a multi-purpose UNLS and facilitate an examination of the impact that nursing has on patient outcomes. Combinatorial, taxonomic vocabularies for nursing are needed to augment and refine, not replace, the existing classification systems.

As background to our argument, we first present an overview of the content, methods and evaluation criteria used in previous studies whose focus has been to evaluate the effectiveness of existing classification systems in representing various aspects of the nursing process. Next, using the Ingenerf typology of taxonomic vocabularies, we categorize the formal type and structure of three existing nursing intervention classification systems—NIC, Omaha System, and Home Health Care Classification (HHCC). Third, we use records from home care patients to show examples of lossy data transformation, the loss of potentially significant atomic data, resulting from encoding using each of the three systems. Last, we provide an example of the application of a formal representation methodology (conceptual graphs) which we believe could be used as a framework to build the required combinatorial, taxonomic vocabulary for representing nursing interventions.

Premises

This paper is based on two premises:

- The actions that nurses actually perform when caring for a patient—the actions now encoded as nursing interventions in existing classification systems—should form an important input into CPR systems.
- The structure and function of existing classification systems for encoding nursing interventions are not sufficient to completely capture this important aspect of "what nurses do" in a manner that facilitates both maximum data reuse and insight into the underlying nursing process.

To date, three systems have been recognized by the ANA Steering Committee on Databases to Support Clinical Practice as the intervention components of a UNLS[4]: (1) Nursing Interventions Classification (NIC)[11]; (2) Omaha System;[16] and (3) Georgetown Home Health Care Classification (HHCC).[17] The definitions of nursing intervention in these three systems reflect the specific purpose and perspective of each system, and, as a result, present differing levels of information granularity. Within NIC, a nursing intervention is defined as "any treatment, based upon clinical judgment and knowledge, that a nurse performs to enhance patient/client outcomes."[11] These interventions may be physician- or nurse-initiated treatments, and include both direct and indirect treatments. The more granular "nursing activities" are defined as concrete components of interventions, "the specific behaviors or actions that nurses do to imple-

ment an intervention and which assist patients/clients to move toward a desired outcome.'' The Intervention Scheme of the Omaha System has been defined from a more functional perspective as ''an open, flexible system of cues and clues . . . that could accommodate primary nursing functions that are either autonomous or collaborative.''[16] In the HHCC, a nursing intervention is defined as ''a single nursing action—treatment, procedure, or activity—designed to achieve an outcome to a diagnosis—medical or nursing—for which the nurse is accountable.''[18] In both Omaha and HHCC, close examination and comparison of specific intervention terms reveals inconsistent levels of information abstraction.

The limitations of the existing classification systems are due to several factors, including:

- Absence of a formalized atomic vocabulary of nursing intervention terms;
- Absence of combinatorial rules by which atomic terms can be combined into more complex concepts;
- Presence of terms that represent a fairly coarse—and hence somewhat ambiguous and inconsistent—level of data abstraction that often blurs many of the clinical details essential to accurately capturing nursing practice in a ''data-reuse-friendly'' form;
- Absence of formal encoding rules that would guarantee (or at least facilitate) inter-rater reliability; i.e., assuming a common raw data set, multiple encoders separated in time and space will generate the same encoded data set;
- Inability to reconstruct raw data from encoded data.

In spite of these limitations, existing classification systems have been shown to be quite useful in encoding much of ''what nurses do'' albeit at a somewhat abstract level. However, the resulting coded data are heavily dependent on the perspective of the encoder and, in the absence of the original raw data for repeated use as a reference, represent a 'one time only' data transformation, i.e. a person subsequently reviewing the encoded data is not able to reconstruct the nurse's original contextual thinking and actions with enough specificity to accurately derive the pre-encoded data, thereby limiting the data's reuse potential.

Problems of this sort are certainly not unique to the encoding of nursing interventions. Historically, systems have been developed with the goal of ''clustering'' common aspects of patient data, often for financial, managerial, or epidemiologic purposes, rather than for the purpose of expressively capturing specifics about the patient's care or condition. Thus, the developers of CPR systems are challenged by the somewhat conflicting goals of

- Capturing and electronically representing in a clinically expressive manner a broad array of data related to a specific patient's encounter with the healthcare system.
- Encoding this data utilizing standardized coding and classification systems—systems which are often designed with the above-mentioned perspectives in mind—so that the data can be linked to a variety of knowledge-based resources such as decision support systems, therapeutic protocols, clinical practice guidelines, and bibliographic databases.

The ideal coding system built around these principles would have the ability to

- Capture information at a more finely granulated and concept-specific level than present systems;
- Provide a means for constructing new, complex concepts from atomic concepts, thereby providing the coding system with a degree of expressiveness not presently available;
- Encode/abstract data using reversible abstraction rules, thereby facilitating multiple uses (multiple abstractions) of underlying data, as well as facilitating lossless data transformations.

Review of the Literature

Evaluation Criteria

While a ''gold standard'' coding system for representing the data generated during clinical practice has yet to be built, a number of authors with varying perspectives have proposed numerous evaluation criteria for such a system.[2,4,7–9,19–21] Several authors have focused on criteria related to the clinical expressiveness of the coding system, as well as the acceptability of the encoded representation to clinicians.[7–9,20] A summary of the various evaluation criteria reported in the literature is presented in Table 1. For the purposes of summarization, we have grouped all the published criteria into five categories: (1) domain completeness; (2) conceptual clarity and coherence; (3) data structures and relationships among terms; (4) clinical concept capture; and (5) utility.

With respect to coding systems for nursing, Clark and Lang described criteria from the perspective of the de-

Table 1 ■

Evaluation Criteria for Standardized Coding and Classification System to Support Clinical Practice

Criteria	Cimino, 1989	Chute, 1992	Campbell, 1992	Clark, 1992	McCormick, 1994	Ozbolt, 1996
Domain completeness						
Inclusive of terms to describe the domain	x			x		
Broad enough to serve multiple purposes				x		
Conceptual clarity and coherence						
Consistent with clearly defined framework				x		
Clear, understandable definitions					x	
Only one way to express each concept (non-redundancy)	x					
Terms refer to only one concept (unambiguous)	x					
Data structures/relationships among terms						
Explicit relationships among terms	x					
Multiple classification	x					
Clinical concept representation						
Clinial expressiveness		x	x			
Inclusion of modifiers (e.g., time, severity)		x	x			
Utility						
Useful in clinical practice	x	x	x	x	x	x
Process for continual refinement			x	x	x	x

velopment of the International Classification of Nursing Practice (ICNP).[2] McCloskey and Bulechek generated criteria specifically for the evaluation of the taxonomic structure of the Nursing Interventions Classification system that they developed; i.e., homogeneity of all interventions in a single Intervention Class.[11] The ANA Steering Committee on Databases to Support Clinical Practice is tasked with identifying coding systems which they believe support the development of the UNLS. For recognition by the Committee, a system must meet criteria for clinical usefulness, reliability and validity, and have processes for revision and extension.[4]

Evaluation Strategies in Nursing Studies in the United States

A variety of strategies have been utilized to evaluate the standardized coding and classification systems for use by nursing in the United States. The studies are listed individually in Table 2.[6,22–28] Excluded from the studies in this review are those done by system developers themselves for the purposes of creating, validating, and refining the systems, and studies aimed at validating a single entity within a system; e.g., validating the defining characteristics for a particular nursing diagnosis. In the following section, we discuss several studies from the historical perspective of the type of evaluation strategies utilized.

In the early 1990s, Griffith and Robinson conducted two provider surveys focused on the degree to which Physician's Current Procedural Terminology (CPT) coded services were provided by nurses in a variety of nursing specialties.[22,23] These studies provided evidence that nurses do perform a limited number of interventions that can be represented using the CPT codes. However, the determination of whether or not the CPT codes can represent the scope of nursing was not an intent of the study. While Griffith and Robinson identified the potential overlapping functions of physicians and nurses in some areas (as identified by CPT-coded procedures), the study by Zielstorff et al. highlighted the differences among coding systems in the UMLS, and the existing ANA-recognized nursing classification systems, which were at the time not included in the UMLS.[28] Subsequently, the nursing classification systems that have been recognized by the ANA Steering Committee on Databases to Support Clinical Practice have been added to the UMLS.

Most recent evaluation studies have tested existing classification systems with clinical data to examine the extent to which the systems capture clinical concepts and are domain complete.[6,24,25,27] The systems examined were Systematized Nomenclature of Human and Veterinary Medicine (SNOMED) (includes North American Nursing Diagnosis Association Taxonomy 1), UMLS, NIC, CPT, and HHCC. Recognizing that the

Table 2 ■

Evaluation Studies Related to Standardized Coding and Classification Systems for Nursing

First Author	System(s)	Focus	Methods
Griffith[22,23]	CPT	Concept capture, utility	Provider survey
Henry[6]	SNOMED (includes NANDA)	Concept capture, domain completeness	Semi-automated lexical matching of verbatim terms from chart with SNOMED
Henry[24]	NIC, CPT	Concept capture, domain completeness	Abstraction of nursing activity terms to NIC and CPT codes
Holzemer[25]	HHCC	Concept capture, domain completeness	Abstraction of patient problems and nursing activity terms to HHCC
Lange[26]	SNOMED, UMLS	Concept capture	Semi-automated lexical matching of atomic terms from intershift report notes
Parlocha[27]	HHCC	Concept capture, domain completeness	Abstraction of patient problem and nursing activity terms from patient charts to HHCC
Zielstorff[28]	UMLS	Domain completeness	Lexical matching of nursing terms to UMLS terms

standardized systems developed for nursing to date were aimed at classification or aggregation of atomic-level data into categories, four studies focused on the domain completeness of existing nursing classification systems. Henry et al. compared the ability of NIC and CPT codes for categorizing nursing activity terms from three acute care hospitals and reported the superiority of NIC to CPT in representing the domain of nursing activities.[24] Holzemer and associates used a related data set to examine the utility of the HHCC for categorizing patient problems and nursing interventions[25] and provided evidence that the HHCC was useful for classification purposes beyond the home health care setting for which it was designed. In her work on the development of a standardized set of patient care terms, Ozbolt noted that the Nursing Care Components of the HHCC were useful as an organizing framework, but that a standardized set of more atomic-level terms was needed.[14] Parlocha tested the utility of the HHCC to abstract chart data related to psychiatric home care with the intent of developing a critical path for Major Depressive Disorder.[27] While the HHCC problem scheme worked well for this data set, subcategories for psychiatric nursing interventions were added to adequately capture that area of nursing activities.

Proposing that clinical information systems should support the informal as well as the formal language of the nurse, Lange compared SNOMED and UMLS on concept matches for atomic-level intershift report data.[26] She found that 61 UMLS semantic types and 24 different source vocabularies were represented in the nursing data. Exact matches were found for 56% of the terms in UMLS and 49% in SNOMED.

Most of the evaluation studies that focused on the coding of nursing interventions have, to date, dealt with "classifying" (matching or nearly matching) actual clinical terms with terms or categories in one of the three ANA-recognized coding systems mentioned previously. Only two of the studies cited in Table 2 utilized a combinatorial vocabulary (i.e., one in which atomic terms may be combined to represent more complex concepts rather than a simple term-matching classification system) as their focus.[6,26] Henry et al. found that SNOMED terms other than those supplied by the North American Nursing Diagnosis Association (NANDA) were exact matches for nursing descriptions of patient problems, and that in some cases, multiple SNOMED terms were necessary to represent a specific patient problem. This conclusion supports the premise that combinatorial, taxonomic vocabularies such as SNOMED may have a central role in representing nursing concepts in a CPR. This conclusion is of particular interest given the fact that although

several of the Evaluation Criteria cited in Table 1 relate to properties of vocabulary structure such as rigorous taxonomy and combinatorial expressiveness, there is a relative absence of focus for this aspect of coding systems as they relate to nursing as opposed to medicine.[9,29–31]

Analysis of Nursing Intervention Classification Systems

Typology of Taxonomic Vocabularies

Ingenerf explicated four types of taxonomic vocabularies for health care based on the underlying structure and related knowledge representation formalism.[32] *Thesauri* are lexical vocabularies such as the UMLS Metathesaurus. *Classification systems* include vocabularies such as the International Classification of Diseases, which have as their primary purpose the partitioning of objects. They can be represented as hierarchies or decision trees and have as their main emphasis disjunctive and exhaustive classification. *Nomenclatures* are combinatorial, taxonomic vocabularies structures organized around polyhierarchies or axes (e.g., SNOMED International). Terms may be combined into more complex terms using an informal semantic grammar, but explicit rules for canonical representation of terms are lacking. *Formal terminologies* are based on concepts (a unit of thought), rather than on terms (a unit of language) and include explicit rules for sensible composition of primitive concepts into complex concepts. The concepts are represented using knowledge formalisms, such as conceptual graphs,[33] or, in the instance of the Galen Representation and Integration Language (GRAIL) Kernel, description logic combined with semantic networks.[31] In the following paragraphs, the intervention schema of NIC, Omaha, and HHCC are categorized according to the typology.

Nursing Interventions Classification

NIC has recently emerged as the leading candidate for a *de facto* standard for encoding nursing interventions in institutional settings. The 1996 version of NIC lists 433 nursing interventions partitioned into 6 Level 1 domains and 27 Level 2 classes.[11] For each intervention, the system provides a definition and a set of several (usually 10 or more) "nursing activities," which characterize the actual intervention but are not considered rigorously definitional of the intervention. One of the main limitations of NIC is the inexact relationship between nursing activities and nursing interventions. Specifically, a nursing intervention may be defined by one of, some of, all of, or activities other than those listed as associated with it in NIC. Because of this, NIC formally characterizes the activities—which certainly do describe elements of nursing process at a more granular level than the parent nursing interventions—as "related activities" for each of the nursing interventions.

As its name and design purpose implies, NIC is an example of a *classification system* in the Ingenerf typology. In common with other classification systems is the primary purpose of clustering. In the case of NIC, the type of concepts undergoing clustering into intervention categories are discrete nursing behaviors or activities. Further abstractions cluster the interventions into classes and classes into domains.

Omaha System

The Omaha System consists of a Problem Classification Scheme (40 problems or diagnoses, 2 sets of modifiers, and clusters of signs/symptoms), an Intervention Scheme, and a Problem Rating Scale for Outcomes.[34] It has been widely implemented in the community health setting both nationally and internationally since its development in the 1970s.

The intervention scheme of the Omaha System can be construed as biaxial in that it includes an axis of "target" of intervention as well as a modifier (although actually characterized as a category) of type of nursing action: (1) health teaching, guidance, and counseling; (2) treatments and procedures; (3) case management; and (4) surveillance. In practice settings, the codified levels are accompanied by nonstructured client-specific information.

The category of Other as one of 62 targets of intervention is a hallmark of what Ingenerf has called exhaustive, disjunctive vocabularies (i.e., *classification systems*). The two axes (targets and types of actions) cannot be combined to the full extent necessary to allow designation as a semantic grammar. Such a grammar would be required in order for Omaha to be considered a combinatorial, taxonomic vocabulary (*nomenclature*) by Ingenerf.

Georgetown Home Health Care Classification

As with Omaha, the HHCC is designed so that both nursing diagnoses and nursing interventions may be classified and encoded. At the highest level of abstraction, each of the 145 nursing diagnoses and 160 nursing interventions are categorized into 1 of 20 home health care components. Nursing interventions are further partitioned by mode of nursing action. In theory, each of the 160 nursing interventions can be delivered in any of 4 modes: assess, teach, provide direct care, and

manage the delivery of care, thus allowing nursing actions to be placed in 1 of 640 possible categories.

Similar to the Omaha System, the HHCC falls primarily into the category of *classification system* within the Ingenerf typology. Like Omaha, it possesses an attribute of a combinatorial, taxonomic vocabulary in that its interventions can be thought of as biaxial; one axis reflects the substantive focus of the intervention while the second axis is a modifier of type of nursing action (e.g., assess, teach, direct care, or manage). However, it too lacks a compositional grammar that would allow it to be classified as a *nomenclature.*

In summary, none of the three ANA-recognized nursing intervention classification systems meets the Ingenerf criteria for either a *nomenclature* or a *formal terminology.* One might respond to this fact by asking: Does nursing need a *nomenclature* or a *formal terminology* system to capture the important aspects of nursing process? We believe that the answer is yes and that the type of system needed is a *formal terminology.* In addition to the benefits of increased expressiveness gained through use of a combinatorial grammar that allows atomic terms to be combined to form complex concepts, *formal terminologies* and their associated knowledge representations can prevent the loss of atomic data common in classification systems that focus on abstracting atomic data into predefined bins. Information theory calls this type of one-way abstraction a ''lossy data transformation'' because, once the raw data is encoded, certain aspects of its detail are lost. We believe that in addition to limiting the reuse of the raw data (unless the raw data are saved in addition to the its encoded counterpart), this type of data loss can obscure data vital to clear understanding of nursing process. In the following section, we illustrate lossy data transformations in each of the three nursing intervention classification systems using data from a home care data set (NR02215).

Examples of Lossy Data Transformations

Graves introduced the conceptual model of a three-tiered hierarchy of data—information—knowledge as a framework for conceptualizing nursing informatics.[35] In this model, both information and knowledge represent successive abstractions and transformations of atomic data. As mentioned above, a primary feature of any data transformation is its characterization as lossless (the abstraction does not destroy the underlying data) or lossy (the abstraction results in data loss). Data loss can be prevented if the transformation is well-defined to be reversible. Finely granular terminologies with associated knowledge representations are one approach to do the latter.

While some researchers have argued that there is no advantage to preserving or standardizing the more atomic-level nursing actions data,[11,16] the state of the science related to understanding clinical processes and, in particular, evaluating the effectiveness of nursing interventions is not sufficiently developed enough to know the cost/benefit of representing data at various levels of abstraction.[14,21] The following examples are provided simply to illustrate the potential for lossy data transformations in NIC, Omaha, and HHCC and *not* meant to serve as a judgment as to the significance of such a loss. Whether or not these types of lossy transformations are of significance is a testable hypothesis.

Nursing Interventions Classification

Nursing Interventions Classification (NIC) includes nursing activities characteristic of each intervention; however, they are not standardized or codified thereby potentially limiting reversible data transformations. The following activities could all reasonably be categorized as *Pain Management* in NIC:

- Instruct Home Health Aid in comfort measures;
- Assess/evaluate effectiveness of Tylenol #3 for neuropathic pain;
- Telephone call to physician to discuss pain control;
- Instruct in nonpharmaceutical comfort measures.

Alternatively, they could be categorized as *Delegation*, *Medication Administration*, *Telephone Consultation*, and *Teaching*: *Individual*, thus possibly limiting the recall of a query designed to retrieve nursing actions related to pain management. These types of queries are important for operational activities such as critical path development, quality management, process improvement, and assessing compliance with national guidelines as well as for research purposes. The codified atomic-level data may also be the level of abstraction at which linkages to decision support systems are triggered.

Omaha System

In the development of the Omaha System, Martin and Scheet noted that the third level of their intervention scheme (client-specific information) was as important as the category and target levels in relation to professional practice, documentation, communication, quality assurance, and legal issues, but that the diversity and amount of detail was too great to organize into an intervention scheme or an information system.[16] However, the more recent focus on process improve-

ment and efficiency that has accompanied managed care has led many organizations to reconsider the importance of capturing data at the point of care so that it can be transformed into useful information for operational decision making.[36]

The targets of intervention within Omaha reflect diversity in level of abstraction. For instance, *Medication set-up* in the category of Treatments and Procedures appears to be a more atomic-level nursing activity than *Signs/symptoms*: *physical.* The home care data set of NR02215 includes a multitude of physical signs and symptoms including diarrhea, numbness and tingling of extremities, dyspnea, orthopnea, fatigue, fever, night sweats. For purposes of examining the processes of symptom management, it would be important to know which particular sign or symptom the nursing actions were aimed toward. Additionally, there is the potential for actions related to physical signs and symptoms to fall into more than one intervention category, for example, nursing actions such as ''Instruct in signs and symptoms of urinary tract infection and catheter care'' might alternatively be categorized as *Signs/symptoms*: *physical* or *Bladder care.* However, if the actions were codified and linked with both parent terms, then the retrieval of the specific action data could be accessed through either transformation path.

Georgetown Home Health Care Classification

Consistent with its definition of nursing intervention as a single action, as noted in the introductory paragraphs of this article, HHCC is inherently more granular than NIC; however, the interventions are not uniformly abstracted at the level of a single nursing action. For example, assessing skin turgor, checking orthostatic vital signs, instructing the patient in the signs and symptoms of dehydration, and weighing the patient can all be categorized as *Hydration status —actions taken to manage the state of fluid balance*, and differentiated by type of nursing action (assess, teach, care, manage). In this schema, both checking orthostatic vital signs and weighing the patient would be categorized as direct care; however, these two actions may vary in the level of personnel required to carry-out the action or perhaps have a differential impact on outcomes related to *Hydration status*, thus suggesting that it may be useful to encode these more granular terms prior to data transformation into *Hydration status*: *care* (F15.1.2).

Formal Representation of Nursing Intervention/Nursing Activity Concepts

Formal representation of nursing intervention/nursing activity concepts requires a set of standardized atomic-level terms, organized into a hierarchical and (most likely) multi-axial taxonomy. The vocabulary needs to be augmented by a formal semantic grammar (set of combinatorial rules) that defines the rules for the combination of atomic terms into complex concepts. Finally, the entire system should be expressible in a non-ambiguous manner using recognized knowledge formalisms.

Standardized Sets of Atomic-level Terms

Several studies have documented that systems such as SNOMED and the Read Codes are excellent sources of atomic-level terms for patient findings, and the Logical Observation Identifier Names and Codes (LOINC) database is an acknowledged source of names, codes, and synonyms for 6,300 laboratory test observations.[37] However, there is not yet a comprehensive standardized and codified list of nursing activity terms.

Currently, a number of research teams are addressing this problem from different perspectives. Ozbolt and associates have developed and continue to refine for the acute care environment a finely granular set of standardized problem and activity terms.[14,21,38] Grobe and associates are utilizing complex natural language processing techniques to examine both content and structure of nursing documentation as an expansion of the work on the Nursing Lexicon and Taxonomy.[39,40] The Iowa Intervention Project has developed a large list of nursing activity terms to accompany the NIC taxonomy structure, but the activity terms have not been standardized or codified. In Europe, the TELENURSING concerted action in conjunction with the efforts of the International Classification of Nursing Practice has developed a list of verbs related to nursing interventions; e.g., teaching, supporting, analyzing.[41,42] The Galen approach is also being applied to nursing terminology.[48]

A recent report on the architecture for the ICNP delineates six axes for nursing interventions: action types, object types, types of approaches, means, anatomic sites, and time/place.[43] In contrast to Omaha and HHCC, the types of nursing actions are classified into five major categories (observing, managing, performing, caring, and informing) comprising subdivisions of more specific actions. While a combinatorial approach to the generation of complex concepts from primitive concepts is suggested, no compositional grammar is specified for the combination of concepts, nor is an underlying knowledge formalism (other than a non-cyclic inheritance hierarchy) described.

Table 3 ■

Example of Application of Conceptual Graph Schema to Nursing Activity Concepts

a. Simplified conceptual graph *schema* for a nursing activity concept

[activity]-
(has initiator) →
[{MD, skilled profesional, paraprofessional, patient, caregiver, self}]
(has provider) →
[{MD, skilled professional, paraprofessional, patient, caregiver, self}]
(has recipient) →
[{patient, family, formal caregiver, informal caregiver, skilled professional, paraprofessional}]
(has delivery mode) →
[{assess, teach, provide, manage}]
(has response) →
[{verbalizes understanding, provides return demonstration, initiates service}]

b. Instantiation of the *schema* with terms from a nursing note
Obtained medical history. Taught insulin injection. Return demonstration by patient. Dressed wound per MD order. Placed call to Meals on Wheels for initiation of services.

[medical history]-
(has provider) → [home care nurse]
(has recipient) → [patient]
(has delivery mode) → [assess]*
[insulin injection]-
(has provider) → [home care nurse]
(has recipient) → [patient]
(has delivery mode) → [teach]
(has response) → [provides return demonstration]**
[wound dressing]-
(has initiator) → [MD]
(has provider) → [home care nurse]
(has recipient) → [patient]
(has delivery mode) → [provide]
[service request]-
(has provider) → [home care nurse]
(has recipient) → [Meals on Wheels]
(has delivery mode) → [manage]
(has response) → [initiated services]

*It is assumed that an underlying model to support synonomy exists that would allow correct linkage of the term ''obtained'' with the delivery mode ''assess.''
**It is anticipated that concepts linked to the ''has response'' relation will most often themselves be expressed via a ''response conceptual graph'' schema similar—but not necessarily identical—to the activity schema presented above.

Application of Conceptual Graph Notation to Nursing Activity Data

As mentioned previously, a *formal* terminology requires a well-defined, non-ambiguous set of terms in combination with a formalized mechanism for defining the syntax for combinations of atomic-level data into desired complex concepts. Description logic, more specifically, the conceptual graph notation described by Sowa,[44] has been applied to patient findings such as symptoms, bone scan results, and x-rays in the medical domain.[9,33] Little is known about similarities or differences in structure between nursing and medical knowledge or whether the same strategies for representing knowledge are appropriate or feasible. No published report of the use of conceptual graphs for representation of nursing intervention or activity terms could be found in the literature. The examples in this section are provided to illustrate the potential application of knowledge formalisms to nursing activity terms, not to suggest that conceptual graphs are the only approach to formal representation of atomic-level activity data.

A conceptual graph is a finite, connected, and bipartite graph consisting of two types of nodes: concepts nodes and relationship nodes. Types of relationship nodes used to link concept nodes have been described in the medical informatics literature—for example, ''located in,'' ''radiating to,'' ''with laterality,'' ''during,'' ''significant,'' ''with severity,'' and ''with value.'' The benefits of conceptual graphs have been summarized by several authors and include the ability to (1) represent complex relationships among entities; (2) provide context for applications such as structured data entry through the expression of selection constraints; (3) map to database structures; and (4) provide a declarative representation through mapping to first-order predicate calculus.[9,33,45]

The example in Table 3 illustrates with simplified con-

ceptual graph notation a *schema* showing the concept of nursing activity and the relations commonly associated with it. Unlike a *type definition*, the relationships in the *schema* are not necessary and sufficient conditions for that type.[44] We suggest that nursing activity concepts have at *least* five types of relationship nodes: (1) has initiator; (2) has provider; (3) has recipient; (4) has delivery mode (type of action); and (5) has response. The concept nodes are noted by brackets [ ] and the conceptual relations nodes are noted by parentheses ( ). An illustrative set of possible concepts in the *schema* is enclosed in braces { }. An instantiation using a nursing note phrase from a home care data set follows the *schema.* Although not delineated in the examples, additional conceptual graph notations exist to express collective versus disjunctive sets of concepts, to denote the number of elements in a set, and to define a specific instance of a concept (e.g., a specific patient).

Tools such as K-Rep, currently being used by a number of organizations to apply description logic to the development of scaleable and expressive medical terminologies,[46] and the GRAIL Kernel,[31] are essential to the efficient representation of atomic-level data in a formalized knowledge schema.

Conclusions

In this article, we have provided arguments to support our premise that standardized classification systems are necessary, but not sufficient, for representing the nursing intervention/nursing activities aspects of nursing for CPR systems. We have shown that none of the ANA-recognized nursing intervention systems meet the criteria of a *formal terminology* but should instead be viewed as *classification systems.* We have provided examples of lossy data transformations secondary to use of *classification systems*; such transformations are avoidable if data is encoded using a *formal terminology.* Lastly, we have illustrated the application of one type of knowledge formalism, conceptual graphs, as a formal model for representing nursing activities and interventions.

The large-scale efforts of the National Library of Medicine and the Agency for Health Care Policy and Research related to identifying the meta-set of terms needed for multiple uses and supporting the linkage among terms through the structure of the UMLS has the potential to significantly accelerate the developments in coding and classification systems.[47] However, there are several areas of critical need that must be addressed. First, additional work is needed to build upon and refine a standardized set of atomic-level terms relevant to nursing, including those for assessments, problems, activities, and interventions. Second, the rapidly evolving nature of computer-based systems implementation in health care has highlighted the need for *nomenclatures* and *formal terminologies* in addition to *classification systems* to support the practice of nursing. Research is needed to explicate and test models of knowledge representation appropriate for finely granular nursing terms and to formally represent the existing nursing classification systems. Third, studies must be done to assess the cost/benefit of standardizing and codifying atomic-level data, including studies that link actions with patient outcomes data. These types of studies are essential to gather the evidence that will actually support or disprove the premise of this article.

References ■

1. American Nurses Association. Nursing: A social policy statement. Kansas City, MO. American Nurses Association, 1980.
2. Clark J, Lang NM. Nursing's next advance: an international classification for nursing practice. International Nursing Review. 1992;39:109–12.
3. American Nurses Association. Standards of Clinical Nursing Practice. Kansas City, MO: American Nurses Association, 1991.
4. McCormick K, Lang N, Zielstorff R, Milholland DK, Saba V, Jacox A. Toward standard classification schemes for nursing language: recommendations of the American Nurses Association Steering Committee on Databases to Support Nursing Practice. JAMIA. 1994;1:421–7.
5. Humphreys B, Lindberg DAB. Bulding the unified medical language system. In: Kingsland, III L (ed.); Symposium on Computer Applications in Medical Care: Washington, DC IEEE Computer Society Press, 1989:475–80.
6. Henry SB, Holzemer WL, Reilly CA, Campbell KE. Terms used by nurses to describe patient problems: Can SNOMED III represent nursing concepts in the patient record? JAMIA. 1994;1:61–74.
7. Chute CG, Atken GE, Ihrke DM. An empirical evaluation of concept capture by clinical classifications. In: Lun KC, Degoulet P, Piemme TE, Riehoff O (eds.); MedInfo92. Geneva, Switzerland: North-Holland, 1992:1469–74.
8. Chute CG, Cohn SP, Campbell KE, Oliver DE, Campbell JR. The content coverage of clinical classifications. JAMIA. 1996;3:224–33.
9. Campbell KE, Musen M. Representation of clinical data using SNOMED III and conceptual graphs. In: Frisse ME (ed.): Symposium on Computer Applications in Medical Care. New York: McGraw-Hill, Inc., 1992:354–7.
10. Campbell JR, Kallhenberg GA, Sherrick RC. The clinical utility of META: an analysis for hypertension. In: Frisse ME (ed.): Proceedings of the Sixteenth Annual Symposium on Computer Applications in Medical Care. New York: McGraw-Hill, 1993:397–401.
11. McCloskey JC, Bulechek GM. Nursing Interventions Classification, 2nd ed. St. Louis: Mosby, 1996.
12. Maas M, Johnson M, Moorhead S. Classifying nursing-sensitive patient outcomes. Image: Journal of Nursing Scholarship. 1996;28:295–301.

13. Ozbolt J, Fruchtnicht JN, Hayden J. Reply to letter to the editor. JAMIA. 1994;16:471–2.
14. Ozbolt J, Fruchtnicht JN, Hayden JR. Toward data standards for clinical nursing information. JAMIA. 1994;1:175–85.
15. McCloskey JC, Bulechek GM. Letter to the editor. JAMIA. 1994;16:469–71.
16. Martin KS, Scheet NJ. The Omaha System: Applications for Community Health Nursing. Philadelphia: Saunders, 1992.
17. Saba VK. The classification of home health care nursing: diagnoses and interventions. Caring Magazine. 1992;11:50–56.
18. Saba VK. Home Health Care Classification of Nursing Diagnoses and Interventions. Washington, DC: Georgetown Univesity, 1994.
19. Cimino JJ, Hripsak G, Johnson SB, Clayton PD. Designing an introspective, multi-purpose, controlled medical vocabulary. In: Kingsland III LC (ed.): Symposium on Computer Applications in Medical Care. Washington, DC. IEEE Computer Society Press, 1989:513–8.
20. Campbell JR, Payne TH. A comparison of four schemes for codification of problem lists. In: Ozbolt J (ed.): Symposium for Computer Applications in Medical Care. Philadelphia: Hanley & Belfus, 1994:201–5.
21. Ozbolt JG. From minimum data to maximum impact: using clinical data to strengthen patient care. Advanced Practice Nursing Quarterly. 1996;1:62–9.
22. Griffith HM, Robinson KR. Survey of the degree to which critical care nurses are performing Current Procedural Terminology-coded services. Am J Crit Care. 1992;1:91–8.
23. Griffith HM, Robinson KR. Current Procedural Terminology (CPT) coded services provided by nurse specialists. Image: Journal of Nursing Scholarship. 1993;25:178–86.
24. Henry SB, Holzemer WL, Randell C, Hsieh S-F, Miller TJ. Comparison of Nursing Interventions Classification and Current Procedural Terminology codes for categorizing nursing activities. Image. In press.
25. Holzemer WL, Henry SB, Dawson C, Sousa K, Bain C, Hsieh S-F. An evaluation of the utility of the Home Health Care Classification for categorizing patient problems and nursing interventions from the hospital setting. NI97. Stockholm, Sweden, 1997.
26. Lange L. Representation of everyday clinical nursing language in UMLS and SNOMED. In: Cimino JJ (ed.): AMIA Fall Symposium. Washington, DC: Hanley & Belfus, 1996: 140–4.
27. Parlocha PK. Examination of a Critical Path for Psychiatric Home Care Patients with a Diagnosis of Major Depressive Disorder (PhD). San Francisco, CA: University of California, San Francisco, 1995.
28. Zielstorff RD, Cimino C, Barnett GO, Hassan L, Blewett DR. Representation of nursing terminology in the UMLS metathesaurus: a pilot study. In: Frisse ME (ed.): Symposium on Computer Applications in Medical Care. New York: McGraw-Hill, 1993:392–6.
29. Evans D, Chute C, Cimino JJ, et al. CANON: Toward a medical concept representation language. Bethesda, MD: American Medical Informatics Association: Proceedings of the American Medical Informatics Association Spring Congress, 1993.
30. Friedman C, Huff SM, Hersh WR, Pattison-Gordon E, Cimino JJ. The Canon Group's effort: working toward a merged model. JAMIA. 1995;2:4–18.
31. Rector AL, Glwinski AJ, Nowlan WA, Rossi-Mori A. Medical concept models and medical records: an approach based on GALEN and PEN & PAD. JAMIA. 1995;2:19–35.
32. Ingenerf J. Taxonomic vocabularies in medicine: the intention of usage determines different established structures. In: Greenes RA, Peterson HE, Protti DJ (eds.): MedInfo95. Vancouver, British Columbia: HealthCare Computing & Communications, Canada, Inc., 1995:136–9.
33. Bernauer J. Conceptual graphs as an operational model for descriptive findings. In: Frisse ME (ed.): Symposium for Computer Applications in Medical Care. New York: McGraw-Hill, 1992:114–8.
34. Martin KS, Scheet NJ. The Omaha System: A community health nursing data management model. In: Lun KC, Degoulet P, Piemme TE, Rienhoff O (eds.): MedInfo92. Geneva: North-Holland, 1992:1036–40.
35. Graves JR, Corcoran S. An overview of nursing informatics. Image: Journal of Nursing Scholarship. 1989;21:227–31.
36. Henry SB. Informatics: essential infrastructure for quality assessment and improvement in nursing. JAMIA. 1995;2: 169–82.
37. Forrey AW, McDonald CJ, DeMoor G, et al. Logical observation identifier names and codes (LOINC) database: a public use set of codes and names for electronic reporting of clinical laboratory results. Clinical Chemistry. 1996;42:81–90.
38. Ozbolt J, Graves J. Clinical nursing informatics: developing tools for knowledge workers. Nursing Clin North Am. 1993; 28:407–25.
39. Grobe SJ. Nursing Intervention Lexicon and Taxonomy: Methodological aspects. In: Hovenga EJS, Hannah KJ, McCormick KA, Ronald JS (eds.): Nursing Informatics 91: Proceedings of the Fourth International Conference on Nursing Use of Computers and Information Science; Berlin: Springer-Verlag, 1991:126–31.
40. Grobe SJ. The Nursing Intervention Lexicon and Taxonomy: implications for representing nursing care data in automated patient records. Holistic Nursing Practice. 1996;11: 48–63.
41. Mortensen RA, Nielsen GH. Concerted action TELENURSING. In: Henry SB, Holzemer WL, Tallberg M, Grobe SJ (eds.): Informatics: the infrastructure for quality assessment and improvement in nursing. Proceedings of the Fifth International Nursing Informatics Symposium Post-Conference. Austin, Texas: UC Nursing Press, 1994:36–45.
42. Mortensen RA, Nielsen GH. International Classification of Nursing Practice (version 0.2). Geneva, Switzerland: International Council of Nursing, 1996.
43. Nielsen GH, Mortensen RA. The architecture for an International Classification of Nursing Practice (ICNP). International Nursing Review. 1996;43:175–82.
44. Sowa J. Conceptual structures. Reading, MA: Addison-Wesley, 1984.
45. Moorman PW, van Ginneken AM, van der Lei J, van Bemmel JH. A model for structured data entry based on explicit descriptional knowledge. Methods of Information in Medicine. 1994;343:454–63.
46. Mays E, Weida R, Dionne R, et al. Scalable and expressive medical terminologies. In: Cimino JJ (ed.): AMIA Fall Symposium. Washington, DC: Hanley & Belfus, 1996:256–63.
47. Humphreys B. Vocabularies for computer-based patient records: identifying candidates for large scale testing. Minutes of an invitational meeting at the National Library of Medicine, December, 1994.
48. Hardiker N. Personal communication, November 8, 1996.