Focus on Implementation of Nursing Vocabularies in Systems

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Review ■

A Review of Major Nursing Vocabularies and the Extent to Which They Have the Characteristics Required for Implementation in Computer-based Systems

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A b s t r a c t   Building on the work of previous authors, the Computer-based Patient Record Institute (CPRI) Work Group on Codes and Structures has described features of a classification scheme for implementation within a computer-based patient record. The authors of the current study reviewed the evaluation literature related to six major nursing vocabularies (the North American Nursing Diagnosis Association Taxonomy 1, the Nursing Interventions Classification, the Nursing Outcomes Classification, the Home Health Care Classification, the Omaha System, and the International Classification for Nursing Practice) to determine the extent to which the vocabularies include the CPRI features. None of the vocabularies met all criteria. The Omaha System, Home Health Care Classification, and International Classification for Nursing Practice each included five features. Criteria not fully met by any systems were clear and non-redundant representation of concepts, administrative cross-references, syntax and grammar, synonyms, uncertainty, context-free identifiers, and language independence.

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The benefits of computer-based systems and standardized vocabularies have been described in detail by others.[1–4] The purpose of this paper is to review the evaluation literature related to six major nursing vocabularies to assess the extent to which they possess the characteristics needed for implementation in computer-based systems. The features of the framework of the Computer-based Patient Record Institute (CPRI) Work Group on Codes and Structures are used as the standard for comparison.[5] Although several authors have differentiated between levels of taxonomic vocabularies, the generic term "nursing vocabulary" is

Table 1 ■

Comparison of ANA-recognized Classification Systems and the International Classification for Nursing Practice

Classification System	Nursing Diagnoses	Nursing Interventions	Nursing Outcomes
North American Nursing Diagnosis Association	128 nursing diagnoses classified into 9 patterns	NA	NA
Nursing Interventions Classification	NA	433 nursing interventions classified into 6 domains and 27 classes	NA
Nursing Outcomes Classification	NA	NA	193 outcomes classified into 6 domains and 24 classes
Omaha System	40 problems classified into 4 domains with 2 sets of modifiers	62 targets with 4 categories of interventions	Five-point Likert scale for 3 outcomes related to specific diagnoses
Home Health Care Classification	145 diagnoses classified into 20 care components	160 nursing interventions classified into 20 care components with 4 types of qualifiers (assess, care, teach, manage)	3 qualifiers for the nursing diagnoses to predict the outcome (improved, stabilized, deteriorated)
International Classification for Nursing Practice	Nursing phenomena (n = 292) classified into the broad categories of Human Being and Environment	1,302 atomic-level concepts organized into 6 axes (actions, objects, approaches, means, body sites, time/place)	

NOTE: ANA indicates American Nurses Association; NA, not applicable.

used in this article to refer to all types of standardized coding and classification systems designed to represent nursing data.[6,7]

Standardized Nursing Vocabularies

Standardized nursing vocabularies have been developed to describe the nursing process, document nursing care, and facilitate the aggregation of data for comparisons at the local, regional, national, and international levels. In the United States, the American Nurses Association (ANA) established the Steering Committee on Databases to Support Clinical Nursing Practice to monitor and support the development and evolution of the use of multiple vocabularies and classification schemes within the framework of the Nursing Minimum Data Set.[8,9] Subsequently, the ANA developed criteria and a process for official ANA recognition. To date, there are five recognized nursing classifications: the North American Nursing Diagnosis Association (NANDA) Taxonomy 1,[10] the Omaha System,[11] the Home Health Care Classification (HHCC),[12] the Nursing Interventions Classification (NIC),[13] and the Nursing Outcomes Classification (NOC).[14]

There are also significant ongoing efforts not yet recognized by the ANA, such as the Patient Care Data Set,[15] the Nursing Intervention Lexicon and Taxonomy,[16,17] and the American Organization of Operating Room Nurses data set.[18]

At the international level, an alpha version of the International Classification for Nursing Practice (ICNP) has been published.[19] In its current version, the ICNP comprises pre-coordinated terms for nursing phenomena and a multi-axial, combinatorial approach based on atomic-level terms for nursing interventions.

The evaluation literature related to the five ANA-recognized systems and the ICNP is specifically exam-

Table 2 ■

Features of Classification Systems that Support Implementation within a Computer-based Patient Record

- Complete and comprehensive with sufficient granularity (depth and level of detail) to depict the clinical process
- Clarity (clear and non-redundant representation of concepts)
- Mapping (administrative cross-references)
- Atomic and compositional character
- Syntax and grammar for defining logical and clinically relevant constructions of compositional terms
- Synonyms
- Attributes (modifiers or qualifiers)
- Uncertainty (graduated record of certainty for findings and assessments)
- Hierarchies and inheritance (multiple parents or children as clinically appropriate)
- Context-free identifiers
- Unique identifiers
- Definitions (concise explanations of meaning)
- Language independence

ined in this article. See Table 1 for a description of each nursing vocabulary.

Framework for Analysis

Building on the work of previous authors,[20–22] the CPRI Work Group on Codes and Structures suggested features of a classification scheme for implementation within a computer-based patient record (Table 2).[5] These features are aimed at enhancing information retrieval, facilitating multiple uses of data, providing unambiguous concept definitions, and managing the size of a vocabulary.

Implicit in these features are the characteristics of a formal terminology as defined by Ingenerf in his typology of taxonomic vocabularies (Table 3), i.e., concepts represented using knowledge formalisms that provide explicit rules for sensible composition of primitive concepts into complex concepts.[7] Other authors have also described the significance of the terminology model and the importance of separating this detailed model focused on concept definition and terminology management from the information model used to support the design of clinical applications.[23,24] Congruent with these approaches, Spackman et al.[25] have labeled associated concepts and relationships organized according to a specific terminology model as the reference terminology—e.g., SNOMED RT—and the terminology used in the actual application interface as the interface terminology.

Analysis and Identification of Knowledge Gaps

The CPRI features are used as criteria against which the state of knowledge development related to nursing vocabularies is measured. Research studies are summarized in Table 4. The inclusion of CPRI features in the six major nursing vocabularies is shown in Table 5 and described in the following paragraphs.

Complete and comprehensive coverage of the clinical spectrum with sufficient granularity (depth and level of detail) to depict the clinical process. As noted earlier in this article, rigorously designed nursing vocabularies exist for diagnoses, interventions, and outcomes. A series of validation studies have demonstrated the utility of the ANA-recognized systems for the abstraction or categorization of nursing data.[26–29] Additional studies have demonstrated the utility of vocabulary systems not specifically designed for nursing for the representation of nursing data in intershift reports and the terms nurses use to document patient problems in the patient record.[26,30] Conversely, a comparative study of the NIC and Current Procedural Terminology[31] codes

Table 3 ■

Types of Taxonomic Vocabularies

- *Thesauri*: Vocabularies based on words, e.g., Medical Subject Headings (MeSH) terms.
- *Classification systems*: Vocabularies with the purpose of exhaustive and disjunctive partitioning of objects, e.g., International Classification of Diseases, Nursing Interventions Classification.
- *Nomenclatures*: Combinatorial vocabularies with structures organized around polyhierarchies or axes, e.g., SNOMED International, International Classification for Nursing Practice intervention scheme. Explicit rules for canonic representation are lacking.
- *Formal terminologies*: Vocabularies based on concepts (a unit of thought) rather than terms (a unit of language) that include explicit rules for sensible composition of primitive concepts into complex concepts, e.g., GALEN, SNOMED RT, Kaiser Permanente Convergent Medical Terminology.

demonstrated the superiority of the NIC for the categorization of nursing activities and supported Zielstorff's earlier findings on the need for nursing-specific vocabularies.[27,32]

With regard to depth and level of detail, a number of investigations have provided evidence that the granularity of ANA-recognized vocabulary systems is not sufficient to support multiple data uses within computer-based systems.[26,29,33,34] This is not surprising, given their primary purpose of classification. In contrast, the nursing intervention scheme of the alpha version of the ICNP comprises atomic-level terms.[19]

Clear and non-redundant concept representation with concise definitions. The ANA-recognized vocabulary systems have definitions for their components: problems, interventions, and outcomes.[10–14] The vocabularies also include defining characteristics for NANDA diagnoses, representative activities for NIC interventions, and indicators for NOC outcomes. The ICNP includes definitions for nursing phenomena and nursing interventions.[19] However, no formal definitions of concepts in terms of a terminology model comprising concepts and relationships represented using a description logic formalism (e.g., conceptual graphs) are included in any of the six systems. In addition, none of the systems includes a mechanism to ensure nonredundant concept representation.

Atomic and compositional character with syntax and grammar for the composition of complex concepts. Some nursing vocabularies (e.g., the HHCC and Omaha System) have compositional characteristics, although, with the exception of the ICNP,[1,36] the systems themselves are not conceptualized as multi-axial by their developers. For representation of nursing activities, the ICNP includes the following axes: action types, object types,

Table 4 ▪

Chronologic Review of Studies Related to Vocabulary Systems for Nursing Data

	System(s)	Focus	Findings
Griffith, 1992,[47] 1993[48]	CPT	Concept capture, utility	Self-reports suggested that nurses perform a number of CPT-coded procedures.
Zielstorff et al., 1993[32]	UMLS, Omaha System, HHCC, NIC	Concept capture, domain completeness	UMLS lacked concept matches for the majority of terms in the nursing classification systems.
Henry et al., 1994[26]	SNOMED (includes NANDA Taxonomy)	Concept capture, domain completeness	NANDA Taxonomy alone lacked sufficient granularity to capture words used by nurses to describe patient problems; NANDA Taxonomy plus additional SNOMED terms matched 69% of the terms in the source vocabulary; many required multiple terms supporting the need for a compositional vocabulary.
Ozbolt et al., 1994[33]	HHCC	Concept capture, domain completeness	HHCC Care Components were a useful organizing framework for nursing problems and interventions in the hospital setting, but a more atomic set of terms was required to capture sufficient clinical detail.
Parlocha, 1995[29]	HHCC	Concept capture, domain completeness	HHCC provided appropriate matches for the majority of terms from the source data set; additional terms were required to capture the clinical detail in the area of psychiatric home care.
Lange, 1996[30]	SNOMED, UMLS	Concept capture	Exact matches were found in UMLS (56%) and SNOMED (49%) for intershift report terms; 61 UMLS semantic types and 24 difference source vocabularies were represented in the data.
Henry et al., 1997[27]	NIC, CPT	Concept capture, domain completeness	100% of the source terms could be abstracted to NIC interventions and 6% to CPT codes; some source terms could be abstracted to multiple categories supporting the need for hierarchic classifications that allow multiple parents.
Holzemer et al., 1997[28]	HHCC	Concept capture, domain completeness	HHCC demonstrated utility for categorization of nursing activity terms for a hospital sample.
Henry and Mead, 1997[34]	HHCC, Omaha System, NIC	Atomic and compositional character, syntax and grammar	Demonstrated lossy data transformations with each classification system; proposed a conceptual graph schema as a representation for a terminology model for nursing activity concepts.
Hardiker and Kirby, 1997[6]; Hardiker and Rector, 1998[40]	ICNP	Syntax and grammar	GRAIL medical foundation model extended to incorporate nursing concepts including ICNP.
Mead and Henry, 1997[39]		Syntax and grammar	Tested terminology model comprising selected semantic types from the ICNP intervention schema and the nursing activity model described by Henry and Mead[34]; most frequently occurring types were Action, Object, Provider, and Recipient, while Means, Anatomic Sites, and Time/Place occurred infrequently in the home care data set.
Redes, 1997[49]	NIC	Domain completeness	241 NIC interventions used by more than 50% of the school nurse sample; 50 interventions not used by sample.

NOTE: CPT indicates Current Procedural Terminology; UMLS, Unified Medical Language System; HHCC, Home Health Care Classification; NIC, Nursing Interventions Classification; SNOMED, Systematized Nomenclature of Human and Veterinary Medicine; NANDA, North American Nursing Diagnosis Association.

Table 5 ■

CPRI Framework Features Included in the Nursing Classification Systems

	NANDA Taxonomy	NIC	NOC	Omaha System	HHCC	ICNP
Complete and comprehensive coverage with sufficient granularity	No	No	No	No	No	Yes
Clear and non-redundant representation of concepts	No	No	No	No	No	No
Administrative cross-references	No	No	No	No	No	No
Atomic and compositional character	No	No	No	Yes	Yes	Yes
Syntax and grammar	No	No	No	No	No	No
Synonyms	No	No	No	No	No	No
Attributes	Yes	No	No	Yes	Yes	Yes
Uncertainty	No	No	No	No	No	No
Hierarchies and inheritance	Yes	Yes	Yes	Yes	Yes	Yes
Context-free identifiers	No	No	No	No	No	No
Unique identifiers	Yes	Yes	Yes	Yes	Yes	No
Definitions	Yes	Yes	Yes	Yes	Yes	Yes
Language independence	No	No	No	No	No	No

NOTE: CPRI indicates Computer-based Patient Record Institute; NANDA, North American Nursing Diagnosis Association; NIC, Nursing Interventions Classification; NOC, Nursing Outcomes Classification; HHCC, Home Health Care Classification; ICNP, International Classification for Nursing Practice.

types of approaches, means, anatomic sites, and time/place.[37]

Sources of atomic-level terms in addition to selected portions of the ANA-recognized vocabularies and the ICNP that have potential utility for nursing include the Patient Care Data Set,[15] SNOMED International,[38] and proprietary data sets.

The work on defining the syntax and grammar for combining nursing concepts into logical and clinically relevant constructions is in its infancy. As shown in Table 6, Hardiker and Kirby[6] reported the use of the GALEN Representation and Integration Language (GRAIL)[24] to extend the GALEN Medical Foundation Model for representation of nursing concepts, and Henry and Mead[34] proposed a basic terminology model for defining nursing activities using conceptual graphs. A recent test of a converged model for nursing

Table 6 ■

Examples of Terminology Models

Representation of ICNP concepts using the GALEN Medical Terminology Model and GRAIL[6]:

Phenomenon*which*
    hasRelevantDomain Nursing Domain
    *name*NursingPhenomenon

Ability*which*
    refersTo Mobilizing
    hasState Impaired
    *name*Mobility

Generic Nursing Activity Model represented using simplified conceptual graph notation[34]:

[activity]–
    (*has initiator*)
    [{MD, skilled professional, paraprofessional, patient, caregiver}]
    (*has provider*)
    [{MD, skilled professional, paraprofessional, patient, caregiver}]
    (*has recipient*)
    [{patient, family, informal caregiver, skilled professional, paraprofessional}]
    (*has delivery mode*)
    [{assess, teach, direct care, manage}]
    (*has response*)
    [{verbalizes understanding, provides return demonstration, initiates service}]

Table 7 ■

Attributes of Three Terminology Models with Potential Sources of Atomic Terms to Serve as Values for the Attributes

Campbell[41]	Henry and Mead[34]	Hardiker and Rector[40]	Potential Sources of Atomic Terms
has indication	—	—	SNOMED Disease and Function axes; Omaha System Problem Scheme; Home Health Care Classification Nursing Diagnoses; ICNP Object (e.g., Health Condition includes diseases; Nursing Phenomena) axis; Patient Care Data Set
has initiator	has initiator	—	SNOMED Occupations axis
has provider	has provider	hasPersonPerforming	SNOMED Occupations axis
has method	has delivery mode	Processwhich	ICNP Action Type axis; Home Health Care Classification Delivery Mode; Omaha System
has recipient	has recipient (individual, family, caregiver, community)	actsOn	ICNP Object (Individual and Nursing Phenomena [includes Family, Community, Significant Other]) axis
has participating agent	—	—	ICNP Object (Individual and Nursing Phenomena [includes Family, Community, Significant Other]) axis; SNOMED Occupations axis
employs equipment	—	actsOn OtherObjects	ICNP Object and Means (e.g., Device) axes; SNOMED Device Axis
has laterality	—	hasLocation; hasLaterality	ICNP Body Sites or Object axes; SNOMED General (e.g., right) and Topography axes (e.g., lung)
	has response	—	ICNP Object (e.g., Body responsiveness) axis

activities demonstrated that that target, recipient, and mode of action were universally present in 100 terms from a home care data set.[39]

To further illustrate the status of the selected nursing vocabularies related to this criterion, Table 7 compares the attributes of nursing interventions as proposed in three terminology models and lists potential sources of atomic terms to serve as values for the attributes.[6,34,40,41] Notice that the only attributes of the GRAIL representation included in the table are those specifically illustrated by Hardiker and Rector[40] in relationship to the ICNP and thus are not intended to be reflective of the expressiveness of GRAIL in its entirety.

Synonyms. None of the vocabularies reviewed explicitly supports synonyms.

Attributes. The intervention schemes of the HHCC, Omaha System, and ICNP include mechanisms to modify or qualify a core term. For example, in all three systems a core term for nursing intervention can be modified by the particular mode of delivery or type of action (e.g., teaching, managing, observing). The NANDA Taxonomy and HHCC both differentiate between "at Risk for" and actual problems.

Uncertainty (graduated record of certainty for findings and assessments). Four of the nursing vocabularies (the NANDA Taxonomy, HHCC, Omaha System, and ICNP) include some type of scheme for findings and assessments including nursing diagnoses. However, none of them includes a graduated certainty scale.

Hierarchies and inheritance (multiple parents or children as clinically appropriate). The NANDA Taxonomy, Omaha System, and HHCC have hierarchic structures with multiple children but not multiple parents. In addition to a hierarchic structure with multiple children, the NIC explicitly includes multiple parents (classes) for some interventions and, less explicitly, multiple parents (interventions) for activity terms. The architecture of the alpha version of the ICNP provides for multiple hierarchies in the intervention scheme but not in the nursing phenomenon.

Recent reports have described the use of tools including K-Rep[42] and GRAIL[24] for terminology management including automatic classification of newly composed concepts into multiple hierarchies. Campbell et al.[43] reported the implementation of Gálapagos, a configuration and conflict resolution environment built on top of K-Rep, and Zingo[44] described initial work on defining nursing concepts within the environment. Hardiker et al.[6,40] discussed the use of GRAIL to model and classify the ICNP concepts within GALEN.

Administrative cross-references. In the United States, as selected nursing vocabularies become part of the Unified Medical Language System (UMLS),[45] they are linked, where appropriate, with administrative codes as well as synonymous concepts in other standardized coding and classification systems contained in the UMLS. Not surprisingly, the administrative mappings are few, owing to the invisibility of nursing practice in administrative and epidemiologic reporting systems. However, ongoing efforts are aimed at mapping

nursing terms into the International Classification of Diseases–Clinical Modification for both diagnoses and procedures in addition to lobbying for the inclusion of the ANA-recognized systems into other administrative and epidemiologic systems. The ICNP terms are mapped to the NANDA Taxonomy, NIC, HHCC, and Omaha System as well as to selected nursing vocabularies from other countries such as Australia, El Salvador, and Sweden.

Context-free and unique identifiers. The ANA-recognized systems meet the requirement of having unique identifiers; however, as in other classification systems such as International Classification of Diseases, the identifiers are not context-free. The identifier scheme of the ICNP is not clear from the published literature.[19] The terms are given alphanumeric assignments in the written report, but a term may have more than one assignment. For example, Tracheal Tube has one alphanumeric assignment as a Physical Object and another as a type of Tube classified under Nursing Interventions Using Instruments in the Means axis. The assignments appear primarily to delineate IS-A relationships within a particular hierarchy rather than serving as unique identifiers.

Language independence. The HHCC, NANDA Taxonomy, NIC, and Omaha System have been translated into other languages, and the ICNP is intended to be used in the three official languages of the International Council of Nursing (British English, Spanish, and French). However, language independence requires formal concept representation and, as mentioned earlier, the work in nursing in this area is in an early stage of development. Moreover, because of the wide variation in nursing practice globally, not all concepts in the systems developed in the United States are applicable in other countries. In addition, the meaning of a translated concept may also be culturally bound. For further discussion of the role of culture in language, see the Viewpoint by Diana Forsythe in this issue.[46]

Conclusion

An assessment of the findings of the evaluation literature related to vocabulary systems for nursing data against the features suggested by the CPRI Work Group on Codes and Structures[5] revealed that none of the systems met all the criteria. The Omaha System, HHCC, and ICNP each met five criteria. Features not included in any systems include clear and non-redundant representation of concepts, administrative cross-references, syntax and grammar, synonyms, certainty scales, context-free identifiers, and language independence.

Our review suggests several areas for future research and development. First, additional atomic-level terms are needed to represent nursing data with sufficient granularity to capture the clinical process. Second, knowledge formalisms for the definition of nursing concepts must be developed or applied to nursing data and tested across populations and across the continuum of care. Third, linkages must be mapped between atomic-level terms and existing clinical and administrative classification systems. Last, additional strategies and tools are needed to assist developers and users to interact with vocabulary systems for multiple purposes including data modeling and clinical applications development.

Vocabulary is an urgent issue for nursing. Yet uncoordinated vocabulary initiatives prevail, primarily because of minimal funding. To meet the needs of nursing, convergence toward a unified nursing language system that is integrated within the larger health care language is critical. This convergence requires the knowledge and skills of persons expert in nursing vocabulary development as well as experts in nursing informatics. Furthermore, the integration of vocabularies into computer-based systems demands cooperation among vocabulary developers, system vendors, and the organizations engaged in the implementation.

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