

Nursing intervention lexicon and taxonomy study: Language and classification methods

Research on nursing informatics to establish a Nursing Intervention Lexicon and Taxonomy is described. The rationale for using classification and language-based methods in establishing and validating a lexicon and taxonomy for use with automated systems is provided. The importance of designing automated systems with language-based analyses capabilities is emphasized.

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THERE IS NOTHING more basic to thought and language than our sense of similarity; our sorting of things into kinds."^{1(p116)} Indeed in examining and classifying phenomena, the nature of language as an expression of thought becomes a critical consideration.

The concepts of language and classification are central to nursing informatics research and represent complementary methods for establishing the meaning of nursing data. This article presents the aspects of language and classification that have implications for a nursing informatics research project to establish a lexicon and taxonomy of nursing interventions. The conceptual basis for the study has been described previously²; this article therefore focuses on describing how classification and language methods are relevant for use in the study. Classification

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methods are important because they provide organizing schemes for retrieving and using nursing data and information from automated systems. For example, automated patient acuity classification systems provide structured, quantifiable, and replicable ways to examine and measure patients' need for nursing care. Language methods are also important since nursing's data originate as terms used to describe care that are stored in automated information systems. For example, nursing data may be stored in either natural language form (as narrative nurses' notes) or in some standardized form (as selections made from a system's available care plans). Used together for nursing informatics research purposes, classification and language methods provide both the means and associated criteria for examining nurses' intervention statements for descriptive and explanatory purposes.

The purpose of the Nursing Intervention Lexicon and Taxonomy Study is to develop a lexicon (ie, a vocabulary) and a taxonomy (ie, an orderly classification) of nursing intervention statements. Research-based efforts to examine nursing's practice language and apply classification strategies from an informatics perspective are essential if nursing is to effectively use automated systems for practice and scientific purposes. Development of the lexicon and taxonomy is not intended as an attempt to standardize nursing language, but rather as a means to understand nursing terms, to examine relationships among the terms and to demonstrate valid and scientific methods for establishing and validating vocabularies and classifications for use with automated systems.

The integration of language and classification methods for studying nursing interventions represents a distinct departure from

ongoing consensus-based nursing taxonomic efforts using biologically oriented classification methods with mutually exclusive, hierarchical structures. Using language methods (ie, linguistic analyses of practicing nurses' actual intervention terms) adds a critical empirical dimension to understanding nursing phenomena by examining practice terms close to their source of origin. The focus on classification methods accommodates continual and rapid changes in practical and scientific knowledge. And while study efforts will result in a lexicon and taxonomy, there is full recognition of the short half-life of any such lexicon and taxonomy as a static and enduring outcome. Rather, the value of the study will be in discovering the methods used for establishing and then continually updating the lexicon and taxonomy for practice, administrative, and scientific purposes.

DEFINITIONS

Relevant nursing informatics examples and definitions of the concepts of concern help in description of the study methods. Definitions and examples of relationships among data, language, classification, and taxonomy, and among data, information, and knowledge are therefore necessary. Data represent discrete entities; information represents data that are interpreted, and knowledge represents information that is structured so that interrelationships are identified and formalized.³ Language represents the symbols used to assign meaning to data and to label categories of information in a classification. Taxonomies, ie, formalized structures constructed from classifications, depict interrelationships among information

from classification schemes and can be used to represent knowledge. The particular knowledge represented is related to the purposes served by the classifications comprising the taxonomy.

Transformation of raw data to information and then to knowledge within the substantive structure of a discipline is accomplished within a context that considers the nature of practitioners' practice values and beliefs about the discipline. The data used by practitioners for enacting their role within a discipline are variable. Currently these data are not always fully represented in automated systems environments. Practitioners' nursing intervention statements are an example. Intervention statements are a form of empirical data in language form that can be collected, analyzed, and used to construct nursing classifications. These classifications should allow efficient storage and effective retrieval of data from information systems. However, these information-rich structures (ie, classifications) should also be examined to yield knowledge with strong links to practice. The described transformations from data to information to knowledge represented in classifications and taxonomies can then be analyzed with scientifically valid methods. The language and classification methods proposed in this nursing intervention lexicon and taxonomy study provide an initial step in the discovery of the appropriate methods.

CLASSIFICATION

One's belief about the discipline and one's practice view directly influence what data are attended to in a practice arena and what kinds of data are aggregated to form a classi-

fication system. The Aristotelian view of disciplines provides a useful context for examining existing nursing classification systems. From the Aristotelian sense, a discipline and its classifications can be considered as either theoretic, practical, or productive. The theoretic implies a focus on the phenomena that make up the knowledge of the nursing discipline. The practical implies a focus on nursing practice aspects; the productive implies a focus on outcomes and resource management within the discipline.

Reported nursing classifications represent each of these Aristotelian perspectives. The theoretic perspective is represented by classifications of nursing phenomena and nursing knowledge.⁴⁻¹⁵ The practical perspective is represented by reports of automated system classifications for clinical practice purposes.¹⁶⁻²¹ The productive perspective is represented by automated classification systems used for patient acuity,²²⁻²⁴ nurse staffing,²⁵⁻²⁸ resource utilization,²⁹⁻³⁴ quality assurance,³⁵⁻⁴⁰ outcomes,⁴¹⁻⁴³ and productivity.⁴⁴⁻⁵¹ Each perspective is described below; automated systems exemplars for each perspective are also provided.

Theoretic perspective

Few nursing classifications representing the theoretic perspective have actually been used with automated systems. Classification of nursing diagnoses is one example of a taxonomy that has been proposed for automated systems use. Its actual use and validation in an automated system, however, have not been reported. The diagnosis taxonomy was constructed by superimposing a theoretic perspective on available nursing diagnoses.⁵² The developers of the taxonomy

report using a biologically based approach to classification that presumes mutually exclusive and hierarchically organized categories of phenomena. Concurrently, they derived conceptual labels for the nursing diagnosis categories from the unitary man model. Unfortunately, when nursing diagnoses are currently used in automated systems they are not presented in taxonomic form but are generally provided in alphabetized lists for system users. A second theoretically-derived classification of nursing diagnoses has been proposed using Orem's self-care model.⁵³ No evidence of either classification's use, validation, or testing in automated system environments has yet been located.

Currently, productive and practical Aristotelian perspectives dominate nursing classifications in automated system environments.

Currently, productive and practical Aristotelian perspectives dominate nursing classifications in automated system environments. The raw data of nursing are being used for building classification systems based on the pragmatic need to document nursing care, to quantify nurses' care contributions, and to manage the resources of nursing care. Thus, the organizing criterion for today's nursing classifications for automated systems is based on philosophic views of the discipline that are primarily practical and productive; the former referring to nursing actions and clinical practice and the latter denoting outcomes related to monitoring resource consumption and administering nursing resources. Although boundaries between these philosophic views are some-

what artificial, classifications concerned with planning, performing, and documenting nursing care would be considered in the practical domain.

Practical perspective

Two automated system examples of the practical perspective include the National Institutes of Health (NIH) Clinical Center's framework for assessing and documenting patient needs⁵⁴ and the Omaha Visiting Nurse Association's classification system for patient problems.⁴² Romano et al's⁵⁴ assessment framework provides an explanatory model that guides nurses in collecting patient assessment data using an automated system. The Omaha patient problem classification serves as the overarching organizing framework for community health nursing care delivery and its documentation.

Productive perspective

The productive view has been construed as administrative classification systems that measure outcomes or productivity. Joel's report of diagnosis related groups (DRGs) and relative intensity measures of nursing (RIMs) provides an exemplar of productivity-based classifications used in automated systems for resource allocation purposes.⁵⁵ The definition of RIMs required attention to nursing needs assessment categories, nursing activities classification, nursing skill levels, and nursing diagnoses categories.

In total, nursing classification systems used in automated systems have been developed first by describing the objects of interest and then by formulating hypotheses

about their structures and relationships. With the exception of the Nursing Minimum Data Set,⁵⁶ however, little attention has been focused on testing these classification systems across settings using information systems technology. Such cross-setting comparisons are essential for validation and reliability purposes as well as for determining definitional quality and equivalence of the data in the different classifications. Definitional quality in classifications for automated systems results from clear specification of data format, elements, and attributes; once established and validated, these specifications can contribute to establishing a standard data format and uniform language parameters.

Taxonomies of phenomena can best be constructed by combining several classifications composed of similar phenomena. As is evident from the nursing classifications reported, few cross classification comparisons or syntheses of phenomena have been reported. In fact, nursing productivity classifications are probably the most ready and available for comparison for taxonomic purposes. The theoretic and practical classifications need much more redundancy before taxonomic work on these existing automated systems classifications can be accomplished. Thus the intervention study was designed to construct a lexicon of nursing intervention terms and then derive a taxonomy using language-based methods of analyses.

The rationale for the study was based on recognition that taxonomic investigation of nursing's clinical data from practice-oriented classifications is hampered by lack of clear definition of nursing's data elements, absence of uniform and standard nursing terminology, and lack of identified methods

for establishing equivalency among nursing's terminology. It is believed that the means for establishing equivalence among nursing's terms and concepts for automated systems use can be derived primarily from a combination of classification and language analyses methods.

The aggregation of nursing data for a classification results in identification of some essential concepts. Language is the primary method used for describing the attributes of the terms and concepts, and for labeling the categories of a classification. Similarity of meaning becomes the major criterion for category membership and for comparison of categories of terms. In such a language-based classification, category inclusion criteria can no longer be based on the biological paradigm of mutual exclusion. In fact, just the opposite is true. The challenge becomes one of representing terms and concepts in their "most appropriate and explanatory location" with multiple pointers and references to all other locations of the term or concept. In this way, the multiple subtle variations and innuendos of meanings can be represented in a language-based classification system. Finally, the terms' locations can be substantiated and validated using reasoned and replicable processes of inquiry.

LANGUAGE

The language-based approach to classification is important because computers are being used increasingly to amass large datasets. Informatics scientists have recognized the potential that exists in using these datasets for descriptive and explanatory purposes. However, the processes required for interpreting information and discovering

knowledge from these datasets, especially when they contain textual information, are not yet evident. In addition, the lack of comparable and well-defined data elements for automated systems, such as those proposed and being tested by Werley and Lang under the rubric of a Nursing Minimum Data Set, have impaired nursing's ability to investigate clinical phenomena using data from varied settings.⁵⁷ In fact, most existing data sets and nursing classification systems used with automated information systems have been a natural outgrowth of the desire to use numerical clinical data such as acuity, staff mix, and resource consumption figures for reimbursement or management purposes within institutional settings, rather than for knowledge discovery purposes. This study of nursing intervention language represents a departure from using these numerical clinical data and provides an opportunity to examine nursing terms using automated systems analysis methods.

A language focus is needed for informatics research on this study of nursing interventions for two reasons. First, nursing language represents the symbols nurses use to convey the meaning for these nursing care data. Second, clinical practice language presents perplexing computational problems in today's automated health information system environments. Computer translation programs for understanding practitioners' natural language terms are primitive and undeveloped. Translation programs continue to be used experimentally in automated systems with only selected aspects of clinical language, rather than for vigorous and robust day-to-day uses.⁵⁸ In general, today's automated record systems are designed with fairly rigid and structured user interfaces that have hierarchic menus, checklists, and

numbered selections. If free text entry for clinical records (a tradition for nurses notes and nursing care plans) is allowed, the data cannot be retrieved at a later time because of the lack of robust natural language and controlled vocabulary methods. As a result, years of nursing's valuable textual data can reside in stored form in "data cemeteries," unavailable for use without expensive and tedious retrieval procedures.

The study of nursing interventions must therefore be considered from at least three perspectives: the natural language perspective, the controlled vocabulary and standard terminology perspective, and the representational structure perspective. Each perspective adds important information for understanding the complexity and challenges associated with defining nursing's data and establishing and validating nursing terms and classifications for automated systems. Each is described next in clarifying the language methods for the Nursing Intervention Lexicon and Taxonomy Study.

Natural language perspective

The natural language perspective is concerned with discovering methods for achieving machine understanding or automated interpreting of narrative text information. A variety of methods have been developed to enable restricted segments of frequently used text phrases to be understood and made unambiguous for automated systems use. Research on natural language methods has been painfully slow, however, with automated text translation and machine-based methods for understanding narrative text entries yielding very limited results. Research has demonstrated the many difficul-

ties inherent in developing automated systems and robust natural language procedures that accommodate unrestricted clinical terms in records and allow users' free text entry.

Mapping text as terms and concepts for storage in a database to allow subsequent sorting and retrieval offers the best research opportunities. It continues to be a major focus of natural language studies of medical records and other medical language databases.⁵⁹⁻⁶³ The use of a semantic network of terms continues to be a promising way of representing the structure of nursing intervention terms and is described more fully under the representational structure section of this article.

Controlled vocabulary and standardized terminology perspective

Controlled vocabulary and standardized terminology methods share a common characteristic. Both require some restriction of the range of terms used. A thesaurus for an electronic database is a good example of a controlled vocabulary; only certain thesaurus terms can be used as retrieval terms or as indexing terms in the system. If a system has the capability to partially understand a user's term and suggest alternatives, or if the system can make "behind the scene" alterations so the terms are equivalent and therefore usable for storage and retrieval, it is considered to be partially standardizing the users' entries.

In its narrowest sense, standardized terminology is quite similar to a controlled vocabulary in its restriction on the terms available for use. In its more general sense,

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however, a standardized terminology that operates at a meta level above the users' actual terms in a single system, and mediates terms across several systems, is usually less restrictive to users. A good example of the use of controlled vocabulary and standardized terms exists in MedLine's automated bibliographic retrieval system. A set of controlled vocabulary terms⁶⁴ drawn from the thesaurus are the terms available to a user for searching the literature database. The system also has procedures for standardizing terms that can be used to point to related terms or present broader or narrower terms as possible searching alternatives. Excessively restrictive controlled vocabularies and rigid standardizing of terms in automated systems often result in frustration and nonuse of such systems by professionals who typically express ideas using the fullest range of terminology.

Controlled vocabulary techniques used for indexing, sorting, and retrieving data have been most successful when relatively small conceptual domains are represented. The restrictive nature of the controlled vocabularies can be extremely difficult and frustrating for users unless the automated system interface assists in deriving, locating, and presenting alternative terms for users' verification. Research on controlled vocabulary methods and their use in automated medical

information systems is currently underway.⁶⁵⁻⁶⁸ These studies provide strong support for a language-based approach to examining the natural language of nursing interventions within the context of a classification paradigm for indexing, sorting, and retrieving data.

The notion of a standard terminology, ie, a lexicon of uniform terms that exists at a level separate from the clinical terminology user's language but which exists to serve as a means for establishing equivalency between terms from different classification sources, could be a valuable contribution to development of automated systems for nursing. Like the concept of the Unified Medical Language System (UMLS) being proposed by the scientists at the National Library of Medicine, such a system of uniform terms facilitates the mapping and linking of several established vocabularies, thus offering a standardized terminology system for automatic translation of terms. Extensive research efforts are being directed at building a UMLS Meta Thesaurus of biomedical concepts—a continually evolving repository of biomedical terminology.⁶⁹⁻⁷¹ In general, the UMLS efforts have been directed at examining sets of existing medical terms such as International Classification of Disease—9th Revision (ICD-9),⁷² Medical Subject Heading (MeSH),⁶⁴ Current Procedural Terminology—4th edition (CPT-4),⁷³ Current Medical Information and Terminology (CMIT),⁷⁴ and Systematized Nomenclature of Medicine (SNOMED),⁷⁵ using combinations of linguistic and philosophic methods for deriving the unifying or standardizing concepts and terms for medicine's representing clinical knowledge. The current intervention study is directed at constructing a large set of

nursing interventions from practicing nurses for the lexicon. Linguistic methods for arranging the terms into a classification structure constitutes the taxonomic phase of the study. The actual classification or representational structure will be language based.

Representational structure perspective

Representational structures for terms should allow linkages to exist between terms that are more than just biologically derived hierarchical types. Terms must relate to other terms in a classification in a variety of ways and without an excessively narrow restrictive criterion of mutual exclusivity.^{69,76-81} Use of a semantic network is proposed as one way of describing the links between related terms and properties of the concepts that the terms reference. Current research in discovering useful representational structures for medical terms focuses on establishing, validating, and evaluating semantic networks like the UMLS MetaThesaurus.^{69,70,82} Semantic networks have direct relevance for this nursing study.

In summary, the focus on natural language methods is essential for this study and for nursing informatics research efforts on classification because there are important distinctions in automated system design and operations that can be influenced by one's perspective on language. For example, exclusion of natural language methods from an automated system can force overreliance on controlled vocabulary methods making user input quite restrictive and frustrating. Lack of attention to natural language methods for automated system can also prevent progress toward the automated coding of nursing data

for an abstracted record. It can also force the burden of controlled vocabulary or standardization on the individual user resulting in rigid input methods. Likewise, establishing classification systems for nursing phenomena without attention to the language perspective can drastically affect the system's retrieval capabilities and its explanatory and descriptive usefulness.

As classifications are initially devised, they require substantial agreement on the theoretic and operational definitions as well as on alternative terms used to label the categories of a classification. Establishing valid, reliable, and substantiated classifications thus requires several methodologic steps. First, clarity about the primary purpose of a classification is essential. Second, ways to measure agreement on theoretic definitions and the acceptable alternative terms must be established even though such definitions are difficult and severely impaired by the context-sensitive nature of natural language. Third, the operational definitions of the nursing phenomena must be derived from source clinical data.

The use of language methods and the strategies for establishing and validating classifications such as the Nursing Intervention Lexicon and Taxonomy can assist nursing in developing a fresh view of classification that is not dependent on the biological perspective, and can be useful for advancing nursing science through informatics research. The study of a body of natural language statements such as nursing interventions, using automated systems, permits classifications to be subjected to empirical tests of validity, reliability, and definitional quality. Such studies are the critical next step in preparing for adoption of automated systems for nursing and in establishing nursing

classifications for theoretic, practical, or productive purposes.

STUDY PROGRESS

Construction of the lexicon of nursing interventions has begun using the linguistic principles of synonymy. Nursing intervention statements, consisting of verb phrases and noun phrases, are being collected from experienced clinicians using a Hypercard instrument. Information about a chronically ill adult (derived from actual client home care records) is presented and subjects enter nursing intervention statements. Subjects are then asked to select synonyms for the verb phrases in their intervention statements from the instrument's database. The synonyms selected by subjects will eventually serve as useful alternative terms once criterion levels for verb similarity are achieved.

The database of synonyms was constructed using thesauri⁸³⁻⁸⁵ with independent review procedures. Substantiation of verb relatedness and relevance for inclusion in the database was accomplished by mapping verbs using the criterion of their sharing common noun phrases or objects. The sources of the original verb phrases for the database were a hospital information system's nursing interventions, a colleague's Delphi study of nursing interventions, and several published nursing case plan printed documents. The database of intervention verb phrases and synonyms is designed to develop incrementally with subject's use.

Once saturation of verb phrases and synonyms occurs, the task of developing the semantic network begins. The structural representation will result from examination

of the interventions and the synonyms indicated by the subjects. Continual updating of the verbal maps will also contribute to constructing the semantic network. The semantic representation will form the basis for the classification of interventions. Representing terms in their various contexts of meaning will provide a preliminary structure for validation and for tests of terminology equivalence and retrieval. Based on results of these tests, the representation will be ready for continuing validation using additional sets of nursing intervention statements.

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The goal of developing automated systems that are responsive to practitioner's needs and that do not place unnecessarily restrictive language parameters on the users of systems is realistic. Systems that allow effective retrieval from textual clinical records, while distant on the horizon, are also realistic. Only through language and classification-based methods of informatics research and continued studies do such dreams become reality.

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