Representation of Everyday Clinical Nursing Language in UMLS and SNOMED

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Everyday clinical nursing language is informal and idiosyncratic. Whether the everyday language of nurses can be represented by standardized vocabulary systems, such as the UMLS and SNOMED, was the focus of the study. Computer systems that allow clinicians to pick terms that are familiar are likely to be better accepted and thus more effective than systems that impose formal terminologies on users. Nursing phrases were extracted from handwritten shift notes, reduced to atomic-level terms, and matched to UMLS and SNOMED. Exact matches were obtained for 56% of terms in UMLS and 49% in SNOMED. Fifty-nine semantic types and 24 different source vocabularies were represented by the terms. Nursing vocabularies were represented by only 5% of source vocabulary citations.

INTRODUCTION

Everyday nursing language is used in verbal communications with other nurses and in written notes for personal use. It consists of words and phrases used in notes written for personal use and in informal oral communication between clinicians. Everyday clinical language is characterized by abbreviations, jargon, idioms, and acronyms. Formal vocabularies have been proposed to represent nursing concepts in computer systems[1], but nurses typically use formal terminology only in the official patient record. A clinical information system should allow users to communicate in their usual language, without the additional mental processing effort of translating everyday words to formal terminology. An important requirement for clinical information systems, therefore, is the ability to represent clinical observations and actions in real-world terms.

For several years, nursing leaders and researchers have expressed concern about whether nursing concepts and language are represented in standardized national vocabularies systems, such as the Unified Medical Language System (UMLS)[2] and the Standardized Nomenclature of Medicine International (SNOMED III)[3]. Increasingly, developers of computerized health care information systems rely on standardized vocabularies as the basis for data models. The American Nurses Association (ANA) Steering Committee on Databases to Support Clinical Practice was created to determine the extent to which existing databases contained terminology pertinent to nursing practice[1]. Taxonomies approved by the ANA Database Committee to represent the data of clinical nursing include North American Nursing Diagnosis Association Taxonomy I (NANDA)[4], the Omaha Community Health System[5], the Home Health Care Classification System[6], and the Nursing Interventions Classification[7], all of which have been incorporated into recent versions of the UMLS Metathesaurus.

The UMLS is a long-term project of the National Library of Medicine (NLM) that seeks to address the problems of information retrieval from multiple, machine-readable biomedical information sources, including clinical records[2]. Two components of the UMLS (6th edition) were used in this study. The Metathesaurus contains listed biomedical concepts, their various names, and relations among them. The Semantic Network contains categories (semantic types) to which all Metathesaurus concepts have been linked. The Metathesaurus contains vocabulary or taxonomy sources of biomedical concepts, and links each Metathesaurus concept to its original source. The UMLS has been evaluated for its ability to represent clinical data[8,9,10], physician-generated patient problem lists[11], medical care processes in hypertension[12], nurse-generated patient discharge plans[13], and national nursing taxonomies[14].

SNOMED International contains nomenclatures for coding terms in human and veterinary medicine along 11 axes. The function axis, for example, contains terms and codes for patient symptoms. Nursing diagnoses and certain nursing procedures are contained in SNOMED III. SNOMED III has been evaluated for its representation of nurses' descriptions of patient problems[15], statement of veterinary patient problems[16], patients' descriptions of problems[17], and for its ability to classify patient records[10].

Three projects have tested the utility of UMLS and SNOMED to represent information requirements for clinical nursing. Henry and colleagues[15] used oral and written data sources to identify terms used by nurses to describe problems of persons living with AIDS.

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Signs and symptoms were used most frequently in oral data sources, while in written data sources, NANDA diagnoses were used most frequently. A subset of terms from written sources was used to test the ability of SNOMED III to represent nursing data. Sixty-nine percent of the terms in the subset were matched using one or more terms from SNOMED.

Zielstorff and colleagues[14] tested the first version of UMLS for inclusion of NANDA and Omaha System terms. When the nursing terms were left intact, exact matches were found for only 12% of the terms. When modifiers were stripped from the core concepts, exact matches were found for 30% of NANDA terms, 39% of Omaha System problems, and 33% of Omaha system interventions. This work provided support for the inclusion of nursing taxonomies in subsequent versions of UMLS.

The extent to which UMLS, SNOMED, and NANDA could capture the concepts used by nurses in typical nursing care plans was studied[13]. Using browsers for UMLS and SNOMED and manual search procedures for NANDA, the researchers attempted to match 372 parsed concepts taken from discharge nursing-care plans of adult, newborn, and pediatric patients. Overall, 79% of terms were matched in UMLS, 55% in SNOMED, and 18% in NANDA. UMLS was superior to SNOMED in its representation of etiologies, psychological concepts, and diagnoses, and NANDA was best at representing nursing diagnoses.

METHODS

The purpose of the study was to determine whether nurses' everyday clinical language could be represented by medical and nursing vocabularies contained in UMLS and SNOMED. Representation of nurses' everyday language in these systems is important because usability of computer systems depends on their fit with usual work patterns. Validation of proposed language standards for nursing so far has been based on formal, written documents, such as standards of care, or on nursing care plans and flow sheets, which often specify in advance the language to be used by nurses. Whether the proposed language standards also will represent non-document-based, informal, and unconstrained clinical nursing language has not been determined, and was the focus of this study.

Data were drawn from nurses' written shift notes, a tool used almost universally by nurses for personal data and information management during a work shift. Shift notes are written by the nurse for personal use, thus they are a good source for data that represent how nurses think about patient care. Examination of shift notes can inform system developers about nurses' use of data and information in relation to the provision of patient care.

Shift notes were obtained from 14 Registered Nurses (RNs) who worked as staff nurses on four medical-surgical nursing units (cardiovascular, orthopedic, oncology, and general surgery) of an academic health sciences center hospital. Study procedures were reviewed and approved by the appropriate Institutional Review Board and subjects gave written informed consent. Subjects averaged 41 years of age, had been RNs an average of 10 years, and had worked on present units an average of 7 years.

On the days when data were collected, patient acuity averaged 3.4 on a 5-point scale in which 5 represented greatest acuity. A total of 43 patients was assigned to the 14 subjects during the data collection period. Patients' length of present hospitalization ranged from an average of 4 days on the cardiovascular unit to 19 days on the bone-marrow transplant unit.

Each RN's shift notes contained information about patients assigned to that RN for that particular shift. Notes were created by the RNs during and immediately after change-of-shift report. Information written in the notes was obtained from shift report, paper-based medical and nursing charts, medication schedules, a computer-based laboratory results-reporting system, and hand-written nursing care plans. Shift notes were photocopied within one hour after morning report for use in the study.

Terms were manually extracted from the photocopied notes by identifying phrases (combinations of words, numbers, or graphic symbols) that represented clinical meaning, then entering the phrases verbatim into a spreadsheet program. Contextual information was retained by recording note headings and by grouping terms into empirically-derived substantive categories. Examples of phrases and substantive category are shown in Table 1.

To analyze the representation of nursing language in UMLS and SNOMED, phrases were reduced to "atomic-level" term[18]. Atomic-level terms are those which cannot be further reduced without loosing clinical meaning. Atomic terms provide flexibility and parsimony in clinical dictionaries, because they

can be combined to create multiple molecular terms. The set of atomic terms was reviewed and exact duplicates were eliminated. Synonyms were retained in the term set. For example, the terms "HL"and "hep lock" are synonyms of the term "heparin lock". Similarly, the terms "CL", "cl liq" and "clear liq" are synonyms for the term "clear liquid." The final set of unique atomic terms was then analyzed for representation in the standard vocabularies.

Table 1. Examples of nursing terms and substantive categories.

Term	Substantive Category
MVA bladder rupture	Medical diagnosis
NPO	Diet
D5 1/2 NS c 20@125	IV status
O2 2L	Oxygen therapy
CXR	X-ray order
rectal fistula	Medical diagnosis
diarrhea	Signs, symptoms

A browser and keyword search algorithm developed at the University of Utah[19] were used to search the UMLS and SNOMED vocabulary systems for matches and to store results of the matching process. The procedure for finding matches was as follows. First, each vocabulary system was searched for the nursing term exactly as it was found in the term set. For example, the nursing term "WNL" was entered as the search term. The algorithm returned all terms with words beginning with the letters WNL. This list was scanned manually to identify possible matches. If no match was found, the nursing term was expanded to its non-abbreviated form, in this case to "within normal limits," and the search was repeated. If no match was found again, then a clinically equivalent synonym, for example "normal", might be used as the search term. This process was repeated until all known expressions of the nursing term were tried, or until a match was found in each source vocabulary.

All searches and matches were accomplished by the author. The search process was tedious and difficult. In the example above, the search for "WNL" yielded a lengthy list of vocabulary terms. Scrolling through the list required several minutes. Repeated searches for the same term were often necessary. These methods probably introduced error into the matching process. To test the reliability of the matching process used, a 10% subset of the nursing terms has been matched by a 3-member expert panel. Results will be reported in a later paper.

Matches between nursing terms and source vocabulary terms were scored using the following system[10,19]:

M4: Exact concept match. The source vocabulary term is judged to have the exact meaning of the nursing term. For example, the UMLS term "chair, commode" was an exact match for the nursing term "BSC." The SNOMED term "clear fluid diet" was an exact match for the nursing term "clear liq".

M3: One-to-many match. Several terms from the source vocabulary are needed to represent the meaning of the nursing term. For example, the UMLS and SNOMED terms "dye" and "intravenous" were needed to match the nursing term "IV dye."

M2: Main concept is matched, but modifiers are missing. The source vocabulary term is the parent concept of the nursing term; modifiers are missing in the source vocabulary term. For example, the UMLS term "analgesics" was an M2 match of the nursing term "no pain med."

M1: Partial match of the main concept. The source vocabulary term is a child concept of the nursing term and is more specific than the nursing term. For example, the source vocabulary term "Pedal edema, unilateral" is more specific than the nursing term "pedal edema."

U: Unmatched term. No match is found for the nursing term in the source vocabulary.

M4, M3, and M2 are considered "good" matches because they indicate that the nursing term can be represented by terms currently present in the source vocabularies. M1 and U scores indicate that a suitable term is not present and suggest a need for improvement of the source vocabulary.

Using the browser-editor developed by Lu[19], the semantic type and original vocabulary source of each concept that was matched to a nursing term was obtained from the UMLS.

RESULTS

From the 14 shift notes, 627 clinically meaningful phrases were identified. These yielded 890 atomic-level terms. Elimination of duplicates resulted in a final set of 576 terms that were matched to UMLS and SNOMED. Table 2 shows the match scores for

each vocabulary system. More M4 (exact) matches were found in UMLS (56.4%) than SNOMED (49.1%), and UMLS had fewer unmatched terms (19.1%) than SNOMED (25.3%). Good (M4, M3, M2) matches were found in UMLS for almost 70% and in SNOMED for 60% of the nursing terms.

Table 2. Match scores for each source vocabulary.

Match Score	UMLS	%	SNO-MED	%
M4	325	56.4%	283	49.1%
M3	7	1.2%	10	1.7%
M2	66	11.5%	52	9.0%
M1	68	11.8%	85	14.8%
U	110	19.1%	146	25.3%

In Table 3, UMLS and SNOMED match scores are compared. Exact match (M4) scores occurred for SNOMED in 254 (78%) of UMLS exact matches, while 33 (10%) of UMLS M4 matches were unmatched in SNOMED. There were M4 matches for both SNOMED and UMLS for 254 out of 576 nursing terms (44%), while no matches were found in either vocabulary for 89 terms (15%). Matches were found in UMLS for 33 of 146 terms (23%) missed by SNOMED, while SNOMED was able to match 19 of 110 (17%) non-matches in UMLS.

Table 3. Crosstabulation of UMLS and SNOMED match scores

	SNOMED					
UMLS	M4	M3	M2	M1	U	Total
M4	254	2	2	34	33	325
M3	0	7	0	0	0	7
M2	4	1	46	5	10	66
M1	6	0	3	45	14	68
U	19	0	1	1	89	110
Total	283	10	52	85	146	576

Terms that were unmatched in UMLS and SNOMED (n=89) consisted of modifiers, terms describing time, Latin terms, acronyms and abbreviations, and findings (Table 4). Qualitative and quantitative concepts and modifiers, including time-related terms, accounted for the largest number of unmatched terms. Examples of this category are *liter, slight, last dose,* and *prn*. Unmatched acronyms and abbreviations included such terms as *BRP* (bathroom privileges) and *OC* (on call). In the findings and other category, unmatched terms included *afebrile, results, activity,* and *eggnog*.

Table 4. Categories of terms unmatched in UMLS and SNOMED

Category	Num-ber	Per-cent
Qualitative, quantitative, time, Latin terms	37	42%
Findings, other	22	25%
Abbreviations, acronyms, jargon	22	25%
Brand names for drugs, equipment	7	8%

Of the 133 semantic types in UMLS, 61 were represented by the nursing terms. The 576 terms yielded 623 semantic type citations, for a ratio of 1.1 semantic types per term. The top 3 semantic types represented in the nursing terms were Therapeutic or Preventive Procedure (n=93), Disease or Syndrome (n=59), and finding (n=54). The density of terms was greatest in the Event-Activity type, with 170 terms categorized by 10 semantic types (17:1).

For the 576 nursing terms, 849 citations to 24 different source vocabularies were identified. Some terms were cited in more than one source vocabulary. Vocabularies with more than 100 occurrences were: Medical Subject Headings (n=193), SNOMED II (n=107), and Snomed International (n=101). Nursing vocabularies were poorly represented in the term set, with 24 terms found in the Nursing Interventions Classification, 10 terms in Home Health Care Classification, 3 in the Omaha System, and only 1 term in NANDA.

DISCUSSION

It is important to determine whether the everyday language of nurses can be represented by standardized vocabulary systems, such as the UMLS and SNOMED. Systems that allow clinical users to pick familiar and idiosyncratic terms are likely to be better accepted and thus more effective than systems that impose formal terminologies on users. The study was limited by using a sample of nursing terms from a data source that required manual extraction and conversion to electronic form. Data handling and analytic procedures may have introduced errors.

Most everyday nursing terms in this set could be matched with "good" matches by UMLS and SNOMED. This suggests that both systems are comprehensive in coverage of clinical nursing language, which may be too diverse to be represented only by the current standard nursing vocabularies. Only 5% of the source citations for the nursing terms came from ANA-approved nursing vocabulary sets.

The match scores achieved for the nursing terms are comparable to UMLS scores for core hypertension concepts[12] and for laboratory terms[9], but demonstrate a much higher proportion of exact matches than was found in an early study in which only 12% of nursing terms were matched to UMLS[14]. The scores are comparable to those achieved by SNOMED in other studies[15]. No previous studies have reported UMLS semantic types or source vocabularies of concepts matched to clinical nursing terms. The ratio of 1.1 semantic types per nursing term suggests a relatively unambiguous term set[20]. The nursing terms tapped 24 of the 34 source vocabularies included in UMLS, including all 4 nursing source vocabularies.

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