Research Paper ■

Evaluation of the Expressiveness of an ICNP-based Nursing Data Dictionary in a Computerized Nursing Record System

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Abstract This study evaluated the domain completeness and expressiveness issues of the International Classification for Nursing Practice-based (ICNP) nursing data dictionary (NDD) through its application in an enterprise electronic medical record (EMR) system as a standard vocabulary at a single tertiary hospital in Korea. Data from 2,262 inpatients obtained over a period of 9 weeks (May to July 2003) were extracted from the EMR system for analysis. Among the 530,218 data-input events, 401,190 (75.7%) were entered from the NDD, 20,550 (3.9%) used only free text, and 108,478 (20.4%) used a combination of coded data and free text. A content analysis of the free-text events showed that 80.3% of the expressions could be found in the NDD, whereas 10.9% were context-specific expressions such as direct quotations of patient complaints and responses, and references to the care plan or orders of physicians. A total of 7.8% of the expressions was used for a supplementary purpose such as adding a conjunction or end verb to make an expression appear as natural language. Only 1.0% of the expressions were identified as not being covered by the NDD. This evaluation study demonstrates that the ICNP-based NDD has sufficient power to cover most of the expressions used in a clinical nursing setting.

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Introduction

The issues and challenges related to the development of nursing vocabularies have become more evident from reviews of nursing vocabularies' ability to capture and represent concepts, and their utility, syntax, and domain completeness.[1–13] Button et al.[14] reported different levels of granularity, a lack of atomic-level terms, an absence of combinatorial rules, and a lack of assessment terms, inadequate domain completeness, and suboptimal expressiveness as remaining challenges in the implementation of nursing vocabularies on computer-based systems. It is generally accepted that vocabulary initiatives have been uncoordinated, and that there has been little convergence toward a unified nursing language system that can be integrated within the wider health-care language arena.

In the mean time, the ICN (International Council of Nursing) initiated a project to develop a concept-oriented vocabulary designed primarily to serve as a common language for describing nursing practice with a structured and defined vocabulary. In 1999 the ICN released the beta version of the ICNP (International Classification for Nursing Practice).[15–17] The American Nurses Association (ANA), through its Committee on Databases Supporting Clinical Nursing Practice, has supported this international work by facilitating collaboration between the ICNP team and the developers of the following ANA-recognized nursing classifications: North American Nursing Diagnosis Association (NANDA) Taxonomy I, Nursing Interventions Classification (NIC), Omaha System, Home Health Care Classification, and Nursing Outcomes Classifications (NOC).[18] However, there have been criticisms of the ability of the ICNP to cover domain completeness, and of its expressiveness, granularity, and ease of use.[10,13] Cho and Park[19] reported that a ICNP beta version locally extended for maternity nursing in a real clinical environment exhibited good expressiveness and ease of use. Moreover, Liaskos and Mantas[20] reported positive user responses when the ICNP was applied to care planning.

However, there remains a need to evaluate and validate whether the ICNP fulfills its initially intended functions and is sufficiently flexible and extensible to summarize high-level data while including lower-level details where appropriate. For example, Florin et al.[21] suggested the need for empirical studies evaluating the ICNP that covered the full complexity of nursing information.

In an electronic medical record (EMR) environment, the ICNP must be both usable and useful as a standard terminology. To be usable, a terminology must be appropriate for the cognitive skills and training of users and the infrastructure resources, and match the organizational context where it is used. To be useful, a terminology must be in a form and contain all of the features relevant to the tasks in hand. The terminology should also be sufficiently broad and detailed, and allow local extensions without compromising the integ-

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Table 1 ■ Analysis Results of the Pilot Study

Nursing Department (Number of Patients)	Raw Phrases	Frequency (percentage)		
		Unique Phrases	Represented by the ICNP	Not Represented by the ICNP
Medical (225)	2,695 (36.7)	1,924 (48.9)		
Surgical (310)	1,318 (18.0)	681 (17.3)		
Pediatrics (229)	1,013 (13.8)	951 (24.3)	1,720 (43.8)	2,211 (56.2)
Obstetrics and gynecology (101)	2,310 (31.5)	375 (9.5)		
Total (865)	7,336 (100.0)	3,931 (100.0)		

rity of the terminology or diminishing its value for performing specific tasks.

To address the usability and usefulness of the ICNP, we focused on evaluating the expressiveness of the ICNP-based nursing data dictionary (NDD) in an enterprise EMR system. The aims of this study were twofold: (i) to quantify the extent to which the NDD is used in data-input events of nurses' notes; and (ii) to determine the reasons for not using the NDD.

Background

Three years ago we were involved in a project to develop an enterprise EMR system for the Bundang Seoul National University Hospital, a tertiary teaching hospital in Korea. The director of the nursing department of this hospital envisioned an EMR system as including a nursing database with the ability to support data reusability in clinical practice, research, education, and management. To support this vision, it was essential that all data entered were coded and retrievable using a standardized vocabulary.

Selection of a Standard Vocabulary for Nursing Records

To develop a data standard for electronic nursing records in an enterprise EMR system, we attempted to define the computer-compatible database content in terms of its input, processing, and retrieval. An ad hoc committee formed by the nursing department of the Bundang Seoul National University Hospital decided to include the data content of the following five major paper-based nursing records in the EMR system: admission notes, discharge notes, activity/procedure notes, nurses' notes, and vital-sign sheets. This committee compared seven vocabularies [six major nursing vocabularies (NANDA Taxonomy II, NIC, NOC, Omaha System, Home Health Care Classification, and ICNP) plus SNOMED] with the following criteria that reflect the expectations of the nursing department for an EMR system:

1. To be easy and fast for end users to use.
2. To cover the entire nursing process, in terms of diagnosis, intervention, and outcome, as well as to be compatible with the content of five types of nursing records.
3. To support the expressions used across 21 nursing units, including the emergency room, intensive care unit, and dialysis room.
4. To be extendible and scalable to meet future specific requirements.
5. To support the use of data entered in one context in another context at an aggregated level.

Based on the comparison of the seven nursing vocabulary systems, the ad hoc committee reached a consensus that the ICNP beta version was the best candidate due to its rich expressiveness and extendibility as a concept-oriented terminology.

Development of the Nursing Data Dictionary

To build the nursing data dictionary (NDD) from the ICNP beta version, the ad hoc committee conducted a pilot study that had two goals: (i) to identify the concepts that were not cross-mapped with the ICNP beta version, which resulted in the creation of an extended ICNP; and (ii) to determine what types of expressions are used in real practice, and use this information to populate phrases in the extended ICNP. These populated phrases constituted the standard NDD with a built-in coding system.

The data for this pilot study were obtained by retrospectively sampling the paper charts of 865 patients discharged from medical (nephrology, endocrinology, metabolism, infectious disease, and pulmonary), surgical (general, thorax, orthopedics, and plastic surgery), pediatrics, and obstetrics and gynecology departments between August and October 2002. The data were collected by five 4th-year students at the College of Nursing who had received training about how to code the data. The data set was first created from data obtained from medical and surgical units, and then extended using data from the other nursing units.[22,23] The number of patient charts reviewed was determined by the data saturation point at which new data could not be extracted from the records. A total of 7,336 phrases were collected and reviewed for their uniqueness according to semantic similarity by domain experts consisting of the head nurses of nursing units. The 3,931 unique phrases identified from the semantic review were cross-mapped with the ICNP beta version by nurse informaticists (including the authors). Discrepancies in the cross-mapping results were resolved by consensus while referring to the definitions of the ICNP concepts. This resulted in 1,720 (43.8%) phrases that were completely mapped using a combination of ICNP concepts, and 2,211 (56.2%) phrases that were either only partially mapped or unmapped. Table 1 details the outcome of the cross-mapping analysis.

A detailed analysis of the partially unmapped data revealed that most of these data exhibited a high granularity in semantics. For a partially mapped example, the phrases '*recommend absolute bed rest*' and '*tenderness observed at the biopsy site*' contain concepts not included in the ICNP. For example, the concepts of *absolute bed rest*, *tenderness*, and *biopsy site* do not exist under the target or focus axis of the ICNP; however, the ICNP already has broader concepts that are relevant to these concepts: under the *patient activity* of the target axis, the *pain* of the focus axis, and the *wound* of the

Table 2 ■ Local Extension of Concepts to the ICNP Beta Version

Nursing Phenomena		Nursing Actions	
Axis	Number of Local Concepts Added (Percentage)	Axis	Number of Local Concepts Added (Percentage)
1A. Focus	208 (81.3)	2A. Action type	4 (1.5)
1B. Judgment	7 (2.7)	2B. Target	213 (81.3)
1C. Frequency	1 (0.4)	2C. Means	23 (8.8)
1D. Duration	12 (4.7)	2D. Time	5 (1.9)
1E. Topology	—	2E. Topology	—
1F. Body site	28 (10.9)	2F. Body site/location	17 (6.5)
1G. Likelihood	—	2G. Route	—
1H. Distribution	—	2H. Beneficiary	—
Subtotal	256 (100.0)	Subtotal	262 (100.0)

body-site axis, respectively. Unmapped examples included the expressions *'HOF (height of fundus) is not palpable'* and '*remind NPO'*, for which the concepts 'HOF', 'not palpable', 'remind', and 'NPO' were not included in the ICNP concepts.

Cross-mapping with the ICNP identified 518 new concepts, and these terms were added to the existing ICNP structure. When we placed a new concept in the structure of the ICNP, we referenced the concept definition contained in a medical or nursing dictionary. For example, we added "discomfort (the state of being tense and feeling pain, or an uncomfortable feeling in some part of the body)" under "sensation (subjective feeling of bodily state or condition resulting from stimulation of a sensory receptor site, transmission of the nerve impulses along afferent nerve fibers to the brain, or experiencing a mental state that may or may not result in response to an external stimulus)" and "NPO (nil per os–nothing by mouth)" under "diet (food and drink regularly provided or consumed, the kind and amount of food prescribed for a person for a special reason, or a regimen of eating and drinking sparingly so as to reduce one's weight)" according to the concept definition provided by the ICNP, and assigned new codes accordingly. For instance, in the nursing phenomena classification, the concepts of 'ataxia' and 'Glasgow coma scale' were added to the Focus axis, 'delayed' and 'balanced' were added to the Judgment axis, 'progressive' was added to the Frequency axis, 'short term' and 'quarter' were added to the Duration axis, and 'fontanel' and 'palm' were added to the Body-site axis. For the nursing actions classification, 'sizing' and 'scoring' were added to the Action axis, 'blood tinged sputum' and 'physical exercise' were added to the Target axis, 'starch' and 'arm sling' were added to the Means axis, 'post anesthesia' and 'post treatment' were added to the Time axis, and 'shoulder' and 'inguinal' were added to the Body-site axis. Table 2 details the extended concepts according to axes of the ICNP. As a result of this, the original ICNP beta version (released in 1999) was extended from 2,634 to 3,152 concepts. This extended ICNP increased the cross-mapping rate to 96% from 43.8%.

The extended ICNP was used to develop the ICNP-based NDD. Several phrases had the same combinations of concepts. For example, both *'complained of general weakness'* and *'complained of loss of strength'* have the same concept combination of *muscle weakness* and *yes*. This strategy was used to overcome synonym problems and provide the users with preference in expression. The above efforts resulted in 8,589 phrases being included in the NDD, which were organized into a tree structure so as to make the NDD easy to manage and maintain. This tree structure also helps the users to navigate the NDD to locate a phrase they want.

Methods and Materials

Bundang Seoul National University Hospital is a tertiary teaching institution with 900 beds, 30 nursing units, and 600 registered nurses. The enterprise EMR system was first implemented in May 2003 after several rounds of beta testing. The clinical information system of this hospital consisted of a physician order entry system, a laboratory information system, a picture archiving and communication system (PACS), and an EMR system including an electronic nursing record system. The EMR system was used at nursing units for both inpatients and outpatients. The nursing record system was designed to apply the extended ICNP as a standard terminology and the NDD as a controlled interface vocabulary. A vocabulary server was developed for populating and managing the NDD.

The user application supports three types of data input: coded data input using the NDD, non-coded data input using free text, and a combination of coded data and free text. For example, the content of the nursing-care record for a patient who has received a liver biopsy procedure could be *'. . . no biopsy site pain and abdominal pain. But observed mild oozing and redness. Positioning on right side and maintaining the right lateral position for preventing hemorrhage. . . .'* From the perspective of the user, this information can be represented using five items in the standardized NDD: *no biopsy site pain, no abdominal pain, observed oozing, observed redness,* and *position on right side*.

All of the registered nurses who participated in this study received training on how to use the system in their daily tasks. The data for this research were extracted from a centralized EMR database that included the clinical data of 2,262 inpatients who had been admitted during 9 weeks between May and July 2003. The data used in the analysis were limited to the 580,000 data-input records entered from the interface of nurses' notes. In the first review of data quality, 49,782 redundant records that had been stored repeatedly during transfers between nursing units were deleted, and hence 530,218 records were used in the analysis.

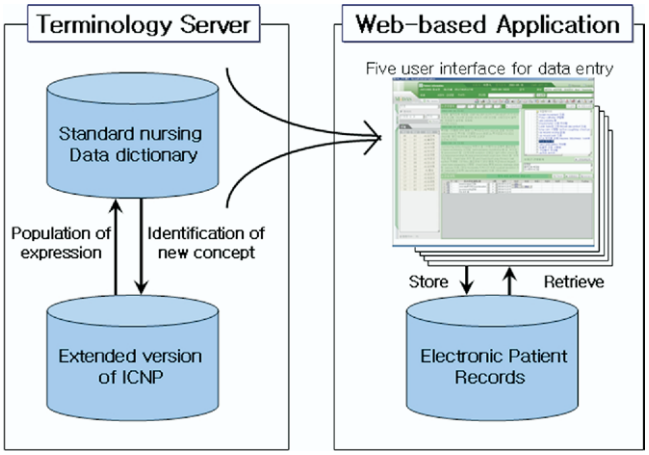

Figure 1. Elements of the EMR system.

The data were analyzed to determine the extent to which the NDD was used in data input and to identify problems with the NDD. In the analysis, each record was regarded as an individual data-input event. On the basis of 530,218 data-input records, we coded each event using the small number of categories used in the study of Cimino et al.[24] When the user selected a pre-coordinated standard NDD without adding additional free text, this was coded as a 'full use of the NDD'; if the user did not select anything from the NDD and used only free text, this was coded as a 'no use of the NDD'; and all the other outcomes, including modification of the NDD, were coded as 'partial use of the NDD'. Results for which the NDD was either not used or used only partially were further categorized into insufficient coverage (where the NDD did not contain the desired phrase), usability problems (where the user failed to find the phrase in the NDD), specific context (where the care context of the desired expression was too specific to be pre-coordinated with the NDD), and supplementary (words that did not have a special meaning but were used to make the expressions appear as natural language). All coding was performed in three steps. The first step involved classifying each record as 'full use of the NDD', 'no use of the NDD', or 'partial use of the NDD' by checking the value of the NDD code field and free-text field in the database. This systematic process was performed by researchers using SQL query statements. The next step involved classifying the no use of the NDD records into four categories. The five research assistants who had previously collected the data from charts classified each record by comparing it with the NDD. Based on this preliminary classification, at the third step two nurses who had expertise in clinical care together assigned the final coding, with discrepancies between them resolved through discussion.

Results

Figure 1 shows the components of and relationships between the ICNP vocabulary and the nursing-documentation part of the EMR system, which consists of a terminology server, patients' data storage, and a Web-based user application. The terminology server manages the ICNP vocabulary and a standardized NDD that is the collection of pre-coordinated phrases populated from the ICNP with qualifiers that permit the user to describe items at a more-detailed level where desired, such as by specifying amounts and colors. The server delivers the NDD to the user application, which allows users to use the coded data when they create a new entry. Figure 2 shows a sample screenshot of the nurses' notes showing the NDD, the data-input window, and the review window for validating the input data. The left column displays the list of patients registered in one nursing unit. The lower portion of the screen shows a summary of the data input, the left part of which shows the nursing phenomena and the right part shows the nursing actions. In the upper portion of the screen, the left part shows the completed nursing records along with the data-input-event time and the right part displays the standard NDD with a tree structure.

The first level of the NDD tree reflects the nursing framework, and contains the following items: ADT (admission, discharge, and transfer), vital signs/measurements, pulmonary system, cardiology, genitourinary system, gastrointestinal system, skin, neurology, musculoskeletal system, medication, emergency, perisurgical, psychosocial, education, and other events. The design of the lower levels of the tree differed between the different nursing units, which enabled each unit to select its own preferred NDD subset and organize it within their tree structure so as to maximize the convenience of tree navigation. Also, the user interface provides additional capabilities such as keyword searching and the NDD list currently in use. This approach not only improves the ease of use, but also allows the NDD to be managed in a consistent manner.

The nursing units involved in the EMR operation were categorized into the following eight nursing departments for analysis: medical, surgical, maternity, psychiatry, pediatrics, rehabilitation, anesthesia, and dental. In an acute-care setting such as the study hospital, the characterization of nursing care provided to patients differs with the medical diagnosis. Table 3 lists the numbers of patients and data-input events. Seventy-two of the 2,262 patients belonged to two nursing departments due to collaborative care between two medical specialties. These patients were therefore counted twice in the number of patients, but the associated data-input events were independent in terms of time and nursing department. The medical department consisted of the following 10 subdivisions: pulmonary, cardiology, gastroenterology, hematology, oncology, endocrinology, allergy, nephrology, rheumatology, and gerontology. More than 50% of the patients belonged to a medical department. Four subdivisions were used for the surgical department: general surgery, neurosurgery, orthopedics, and plastic and reconstructive surgery. The anesthesia and dental departments comprised only eight and six patients, respectively. There were a total of 530,218 data-input events, with the NDD used in 510,695 of them. Each department used a mean of 2,080 unique NDD phrases (approximately one-fourth of the total number of phrases in the NDD), and the average number of uses per phrase (ANUP) was 35.2.

The medical department accounted for over half of the total data-input events, patients, and NDD phrases, and was followed by the rehabilitation, surgical, pediatrics, maternity, and psychiatry departments. The medical department also used the highest number (4,016) of unique NDD phrases and showed the highest ANUP (68.2). The psychiatry, anes-

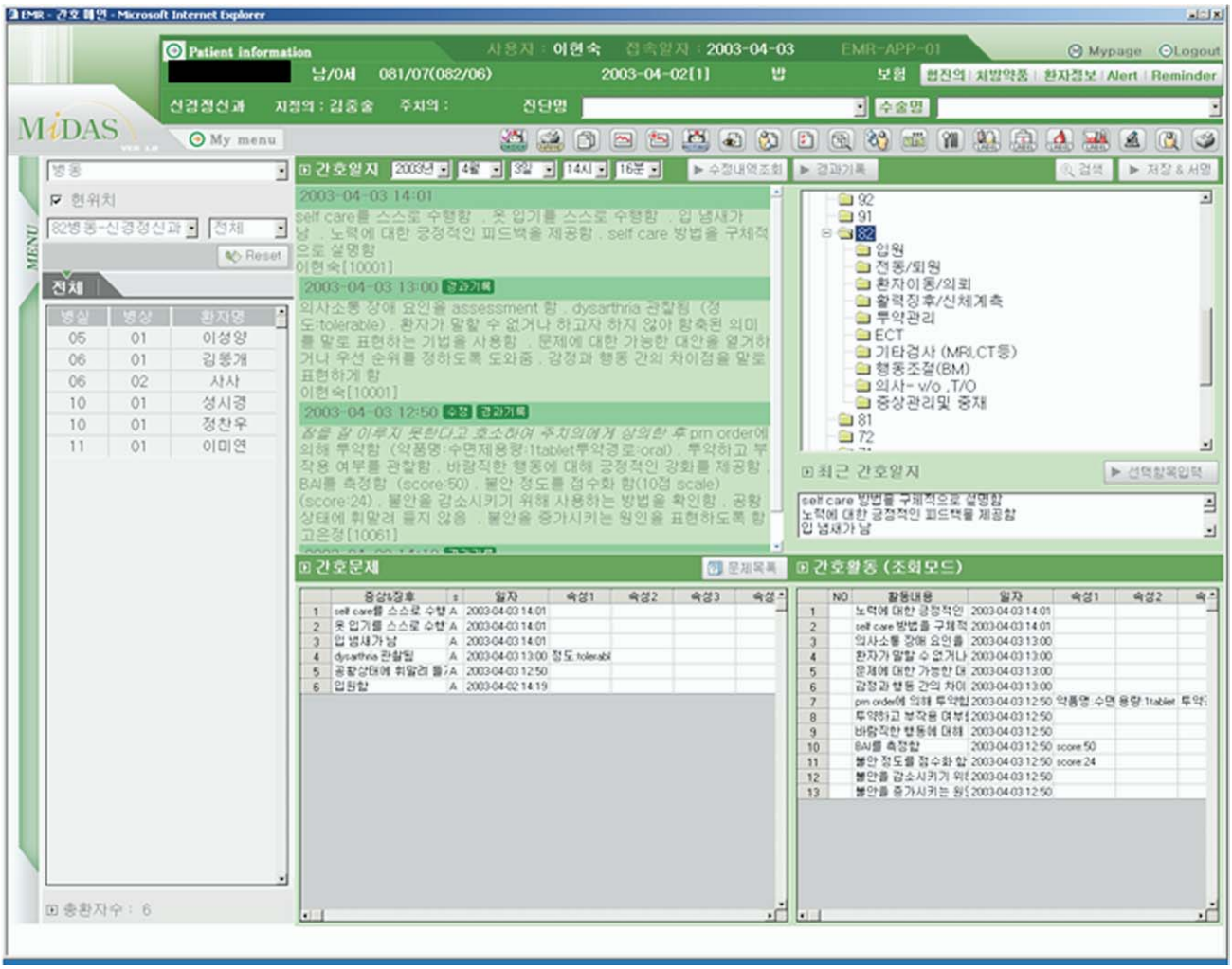

Figure 2. Example of a Web-based user application for nurses' notes.

thesia, and dental departments showed higher variances since the average redundancies of the NDD were below 7.0, while the ANUP for the pediatrics and rehabilitation departments were 36.0 and 34.8, respectively.

Figure 3 shows the changes in the data-input behaviors of users over the 9-week study period. The NDD was used in almost 70% of the total data-input events during each week, whereas the use of free text increased slightly and the ratio of combined use of the NDD and free text decreased continuously to the 6th week. However, thereafter the frequencies of use of the NDD and free text remained constant at around 5% and 20%, respectively.

Table 4 lists the results of the analysis of data-input events. Of the 530,218 data-input events, 401,190 (75.7%), 20,550 (3.9%), and 108,478 (20.4%) were classified as full use, no use, and partial use of the NDD, respectively. Across the departments, the frequencies of the full and no use of the NDD ranged from 28.8% to 86.8% (average for all data-input

Table 3 ■ Numbers of Patients and Data-input Events by Nursing Department

Nursing Department	Number (Percentage)				
	Patients	Total Data Input	NDD Phrases Used	Unique NDD Phrases	ANUP
Medical	1,243 (53.3)	284,173 (53.6)	273,741 (53.6)	4,016	68.2
Surgical	269 (11.5)	57,815 (10.9)	57,186 (11.2)	2,545	22.5
Maternity	147 (6.3)	38,319 (7.2)	37,740 (7.4)	1,604	23.5
Psychiatry	51 (2.2)	11,000 (2.1)	5,057 (1.0)	733	6.9
Pediatrics	240 (10.3)	45,380 (8.6)	44,885 (8.8)	1,246	36.0
Rehabilitation	370 (15.9)	91,639 (17.3)	90,257 (17.7)	2,593	34.8
Anesthesia	8 (0.3)	1,577 (0.3)	1,517 (0.3)	331	4.6
Dental	6 (0.3)	315 (0.1)	312 (0.1)	144	2.2
Total/average	2,334 (100.0)	530,218 (100.0)	510,695 (100.0)	2,080	35.2

Note: 72 patients were treated in two departments during the study period. ANUP stands for the average number of uses per phrase.

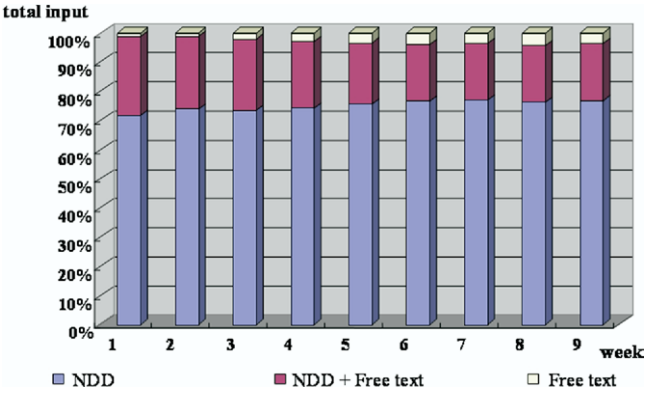

Figure 3. Trends in the data-input behaviors of users over time.

events, 75.7%) and from 1.1% to 54.0% (average for all data-input events, 3.9%), respectively. The frequencies of full use and non-use of the NDD were over 70% and under 4.0% in all departments except for the psychiatry department, respectively. Over half of the data-input events in the psychiatry department were performed using only free text.

The frequency of the partial use of the NDD varied much less across the departments, from 12.1% to 23.2% (average for all data-input events, 20.4%). A partial use of the NDD means that the user was not satisfied with the expression and hence modified it, even though they initially chose an NDD phrase. Common cases of this class were adding information using free text. This type of information could be used to improve the NDD or to identify misunderstandings in the use of the NDD by users.

We reviewed the cases of non-use of the NDD to determine the underlying reasons. Table 5 indicates that in 16,495 (80.3%) of the 20,550 data-input events, the NDD actually did contain the desired phrases but the user did not find them. All departments except the psychiatry department showed frequent usability problems, mostly related to synonym or user-interface problems. In many cases the nurses used synonyms and abbreviations instead of full terms, such as 'AC' for amniocentesis (this is also used for abdominal circumference); 'O_2' for oxygen; 'HT', 'HTS', or 'HTN' for hypertension; and 'NS tube', 'NS-tube', 'L-tube', or 'SB-tube' (Sengstaken-Blakemore) for nasogastric tube. Furthermore, due to the bilingual environment of our study requiring the combined use of Korean and English, in some cases more than one Korean term was used for an English term. For example, *gakdam* and *garae* corresponded to *sputum*, and *daecher* and *daeung* were interpreted as *coping* in English. User-interface problems were associated with nurses not taking sufficient time to find expressions. Another usability problem was that expressions entered as free text were too general or not sufficiently objective, such as *alert mentality*, *suction done*, and *cooling now*. The exact meanings were inferred from the medical diagnosis and from the immediately preceding or subsequent data entered.

A total of 2,246 (10.9%) of the 20,550 cases were attributed to the context-specific category. Most such cases were direct quotations of patients, caregivers, and attending physicians, and description of their behaviors, such as *'wants to see Dr. Jung'*, *'fever is consistent but patient says it is tolerable'*, *'his mother does not want to interrupt his sleep'*, and *'Dr. Kim visited and observed.'* Such cases constituted 1,863 (31.3%) of 5,943 data-input events of the psychiatry department. Two types of other cases were identified in this category. The first was addressing a physician's verbal order or care plan, such as *'If the patient is getting irritable during testing, then let's give a single ampule valium IM injection,' 'Let's start transfusion as soon as the blood pack is delivered from the blood bank,' 'give NRD after gas out,'* and *'L-tube insertion expected.'* The other type was recording laboratory or diagnostic test results, such as *'Hct 42%'*, *'Serum albumin 3.0 g/dl,'* and *'no pleural effusion reported in X-ray test.'*

Some users entered adverbs (e.g., 'slowly', 'already', and 'yet') and conjunctions (e.g., 'and,' 'but,' and 'however') in the free-text field. These terms convey no information by themselves but are used to ensure that complete sentences consisting of several phrases from the NDD appear as natural language. For example, when a user wanted to record a clinical event as *'After injection of mixed fentanyl solution by physician, BP 100/75 mmHg measured.' 'Change the position to lateral and keep the IV 5% D5W fluid with 30 gtt,'* he or she could choose the following four phrases from the NDD: *administer medication* [drug name dosage route administer]; *measure BP* [SBP DBP]; *change position* [from to purpose]; and *increase IV fluid infusion* [type of fluid infusion rate route], and complete the entry by selecting the qualifiers (i.e., the parts in brackets). Conjunctive phrases such as *after that* and *slowly* were then added between phrases. Even though in most natural languages processing systems dealing with non-structured free-text, the word "after" is considered to be important for determining time sequences, it is not necessary to use the word "after" in the nursing notes in this study because the nurses' notes are already structured

Table 4 ■ Analysis of Data-input Events by Department

Nursing Department	Number (Percentage of Each Department)			
	Total	Full Use of the NDD	No Use of the NDD	Partial Use of the NDD
Medical	284,173 (100.0)	209,209 (73.6)	11,453 (4.0)	63,511 (22.3)
Surgical	57,815 (100.0)	46,772 (80.9)	630 (1.1)	10,413 (18.0)
Maternity	38,319 (100.0)	32,070 (83.7)	580 (1.5)	5,669 (14.8)
Psychiatry	11,000 (100.0)	3,283 (28.8)	5,943 (54.0)	1,774 (16.1)
Pediatrics	45,380 (100.0)	39,382 (86.8)	496 (1.1)	5,502 (12.1)
Rehabilitation	91,639 (100.0)	69,026 (75.3)	1,383 (1.5)	21,230 (23.2)
Anesthesia	1,577 (100.0)	1,182 (75.0)	61 (3.9)	334 (21.2)
Dental	315 (100.0)	266 (84.4)	4 (1.3)	45 (14.3)
Total	530,218 (100.0)	401,190 (75.7)	20,550 (3.9)	108,478 (20.4)

Table 5 ■ Further Analysis of Non-use Cases by Department

Nursing Department	Number (Percentage of Each Department)				
	Total	Usability Problem	Context Specific	Supplementary	Insufficient Coverage
Medical	11,453 (100.0)	10,345 (90.3)	309 (2.7)	680 (5.9)	121 (1.1)
Surgical	630 (100.0)	580 (92.1)	20 (3.2)	28 (4.4)	2 (0.3)
Maternity	580 (100.0)	526 (90.7)	20 (3.4)	29 (5.0)	4 (0.7)
Psychiatry	5,943 (100.0)	3,241 (54.5)	1,863 (31.3)	771 (13.0)	69 (1.2)
Pediatrics	496 (100.0)	453 (91.3)	14 (2.8)	25 (5.0)	3 (0.6)
Rehabilitation	1,383 (100.0)	1,296 (93.7)	18 (1.3)	60 (4.3)	8 (0.6)
Anesthesia	61 (100.0)	50 (82.0)	2 (3.3)	7 (11.5)	2 (3.3)
Dental	4 (100.0)	4 (100.0)	—	—	—
Total	20,550 (100.0)	16,495 (80.3)	2,246 (10.9)	1,600 (7.8)	208 (1.0)

according to the nursing process of assessments, diagnoses, interventions, and outcomes implying time sequences in order. The word "slowly" was considered to be redundant with the "fluid rate" qualifier. In this way some cases comprised a qualifier's value for the NDD phrases previously chosen with new free-text input, such as the value of BP (e.g., *100/75 mmHg*) or the specific position (e.g., *lateral*). These cases are typical examples of the supplementary category.

The NDD did not contain pre-coordinated phrases for 208 (1%) of the 20,550 data-input events. Most such cases involved specific information about devices or materials related to diagnostic tests, such as the diameter or size of an arterial catheter used in angiography. Such cases were classified as insufficient coverage. These were expected since the priority when populating the NDD from the extended ICNP was to cover the most common expressions.

Discussion

The implementation of a computer-based nursing record system poses new challenges to the traditional methods of nursing documentation. The cornerstone of such a system providing best care is its ability to capture clinical data during the care process, and to store, aggregate, and analyze the data so as to produce reports that not only describe the care but also improve the understanding of quality, effectiveness, and costs, which can contribute to improving clinical processes. Data standardization is the key to performing these operations.[5] The ICNP is one of the recent nursing vocabularies developed by the ICN after existing nursing terminologies were recognized as being too abstract to efficiently express patient problems, nursing activities, and nursing practice.[25]

This study performed a detailed investigation of how a standardized vocabulary (i.e., the NDD) developed from the ICNP could be used for the nurses' notes in an EMR system. The evaluation approach used in this study focused on the coverage and granularity of the NDD, by assessing the extent to which expressions used by users were represented by the NDD or by free text, and why each of these were used in a particular situation.

The analysis clearly demonstrated an overall positive response of users, given that the NDD was used in 96.3% of the data-input events. Moreover, 75.5% of the data-input events that used the NDD were classified as cases with full use of the NDD. This implies that the NDD potentially provided sufficient expressiveness to cover the narrative nurses' notes. The medical units used the highest number of unique NDD phrases (i.e., 46.8% of the total NDD), and its prominent ANUP indicated that the same expressions were used repetitively in the data input of the same patient and between different patients. This reflects the similarity of nursing services in the medical department, even though the patients had different medical diagnoses. Surgical, maternity, and rehabilitation departments also showed a high ANUP, which was attributed to them sharing common routine procedures, such as perioperative care and physical therapy. In contrast, the diverse signs and symptoms exhibited by psychiatric patients resulted in a low ANUP for the psychiatry department. The ANUP reflects the extent to which the nursing expressions used in each department could be formalized. The high ANUP of the pediatrics department in the present study appears to result from another factor–the low diversity of medical diagnoses during the study period. Of the 240 pediatrics patients, 68% had infectious diseases, 17% had conditions originating in the perinatal period, 10% had congenital heart disease, and 5% had Kawasaki disease, albinism, urticaria, metabolic acidosis, and other diseases. These study limitations were probably caused by data being collected for only 9 weeks after implementing the EMR system.

The percentage of unique NDD phrases used ranged from 46.8% to 1.7% across the departments. These proportions were lower than we had expected, but may reflect the richness of the NDD. When the NDD was populated from the extended ICNP, some users doubted that the NDD contained sufficient phrases. Considering the results of our analysis of cases of no use of the NDD, the insufficient coverage (where further improvement is needed in the NDD) represented only 1.0% of the total number of cases of no use of the NDD. Over 80% of the cases of no use of the NDD were caused by usability problems due to the user interface. We had considered the user interface carefully when implementing the system, and employed tree navigation, keyword searching, and searching of the recently used NDD phrases to help the users find what they wanted. We believe that continuous monitoring of users' behaviors when using this type of system and feedback from them will provide useful information for improving the user interface.

Our use of bilingualism in the nursing documentation increased the number of phrases in the NDD, since some nurses prefer to use English words and others prefer to use Korean words in nursing records. Moreover, it is not uncommon for clinicians to use English and Korean words

together in an expression. This situation resulted in us including semantically identical phrases more than once in the NDD even when they had the same mapping with the extended ICNP.

The use of the NDD tended to increase slightly over the course of the study, which suggests adaptation by the users. This increase stabilized during the last 3 weeks, with the three data-input options being used at constant proportions. The fact that 75% of the data input was carried out successfully using the NDD implies that the ICNP-based NDD is effective for capturing and storing nursing data in coded format, which also makes it possible to aggregate and analyze nursing data using the linkage among ICNP concepts. The results of the free-text analysis of cases of no use of the NDD demonstrated the need to improve the user interface in terms of providing more synonyms and abbreviations. Moreover, the users should be restricted to using synonyms and abbreviations that are both generally accepted by the wider community and authorized at the institution level. However, to optimize the coverage and expressiveness of the NDD, it is important to balance the implementation of standards (at a central level) with the freedom to use various expressions. Allowing more-detailed and less-common expressions requires that the NDD be extended, but this also increases the navigation complexity experienced by users.

It is clear that capturing nursing-process data including assessments, diagnoses, interventions, and outcomes will improve care processes and clinical decision-making. However, our analysis of free-text nurses' notes showed that they cover a broad spectrum. Patient care is a multidisciplinary process, and the requirement for explicit communication and feedback in collaborations is obvious. Other disciplines with interdependent functions allow the production of documentation that requires those departments (such as the pharmacy or the blood bank) and nurses to complete, such as when nurses are involved in administering or assisting. The nurses' notes contain such information in both binary responses (e.g., given/not given, done/not done) and descriptions of the administration process. Contents in nurses' notes range from the most-general to the most-specific classes of nursing information. The notes cover many clinically specific contexts such as direct quotations from patients, physicians, and caregivers. Therefore, the use of free text appears to be inevitable for supporting specific situations and administrative procedures that cannot be efficiently predefined in an NDD. That is, even though the use of structured vocabulary capture will increase progressively over time, there may always remain a small residual component of the description of the patient's situation that cannot be represented in a predefined manner, due to the unusual and unique circumstances of some patient's condition.

Conclusion

None of the existing nursing terminologies have been previously applied and evaluated with the nurses' notes in an enterprise EMR system. This study evaluated nursing-domain completeness and expressiveness issues of the ICNP-based NDD. The fact that 75% of the data input was achieved using only the standard vocabulary (i.e., the NDD) pre-coordinated from a local extension of the ICNP is suggestive of its high potential for use in real settings.

It is important to determine how to apply the nursing vocabulary standard to fill practical needs. The nurse's note is the standard method used to capture nursing activities at the bedside as well as detailed nursing assessments of inpatients. Due to the traditional narrative format of nurses' notes, we chose the approach using the ICNP-based NDD. Our results demonstrated that the ICNP-based NDD could cover more than 75% of the nursing expressions in a real EMR system. Such an approach allows more aggregated-level data to be derived from the acquisition and analysis of low-level nursing data.

The trends toward multidisciplinary models of care and documentation, data reuse, and data comparisons across heterogeneous representations have accelerated the need for members of the nursing profession to collaborate with each other and with other health-care professionals. The ICNP represents an international collaboration and commitment to ensuring that comparable nursing data are available for multiple purposes. The findings of this study will contribute to the ongoing development process of the ICNP as well as to the effective implementation of electronic nursing documentation. Specifically, the ICNP-based NDD developed in this study represents a rich data set that encompasses the nursing practice performed in a tertiary teaching hospital. The NDD itself or subsets thereof can be applied in similar settings in Korea. This will contribute to the development of ICNP catalogues that the ICN is proposing as purpose-specific subsets of nursing diagnoses, interventions, and outcomes for a specific or specialty area or practice.[26]

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