Validation of Concept Mapping Between PNDS and SNOMED CT

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The importance of using standardized nursing terminologies has been emphasized by several key organizations. The American Nurses Association (ANA) has developed criteria based on the International Standards Organization to recognize nursing terminologies that are reliable, valid, and useful for practice.[1] The Joint Commission requires the use of standardized terminologies in electronic health records (EHRs)[2] as does the federal government in its certification process of information systems.[3] The certification process for information systems exists as a result of an executive order of President George W. Bush in 2004 that all Americans will have an interoperable EHR (ie, one that is transferable between all health care settings) by 2014.[4]

Incorporation of one or more standardized terminologies into EHRs allows for consistent documentation of patient care, interoperability, and exchange of data between clinical information systems. It also provides a means to investigate individual patients and population trends to develop best practice guidelines for patient care and supports nursing research for individual health care organizations and comparisons across local, state, national, and international organizations.[5] The word *terminology* as it is used throughout this article is synonymous with standardized language, vocabulary, classification, or nomenclature.

In 2000, AORN developed the Perioperative Nursing Data Set (PNDS) for use in perioperative clinical documentation.[6] The PNDS was mapped to the Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) in July 2003 by SNOMED CT staff members to support the electronic exchange of data. Although the PNDS has been integrated within the SNOMED CT, this mapping had not been formally validated.

Purpose of the Study

The purpose of this study was to validate the mapping of concepts between the PNDS and the SNOMED CT to ensure that concepts represented in one system have equivalent meanings in the other system. The specific aims of the study were to

- validate semantic comparability between the two terminology systems,
- evaluate the placement of PNDS concepts in the SNOMED CT hierarchy, and
- identify whether the assignment of PNDS concepts in the SNOMED CT hierarchy is similar for all mapped PNDS concepts.

Terminology used throughout this article is defined in Table 1 with accompanying examples.

ABSTRACT

THE PERIOPERATIVE NURSING DATA SET (PNDS) is a structured vocabulary developed by AORN to help document perioperative nursing practices.

THE PNDS HAS BEEN MAPPED to the Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) reference terminology model to support the electronic exchange of nursing data.

THIS STUDY VALIDATES the concept mapping between the PNDS and SNOMED CT, supporting an equivalent meaning of concepts between the two terminology systems. *AORN J* 87 (June 2008) 1217-1229. © AORN, Inc, 2008.

TABLE 1
Database Terminology, Definitions, and Examples

Clinical concept: An idea or expression with one distinct meaning. Examples in this article are nursing diagnoses (eg, wound healing) or interventions (eg, wound treatment education).

Granularity: The amount of detail in the definition of a concept, ranging from general to specific. For instance, "pain" is a general concept, whereas "chest pain" is more specific and, therefore, has a finer level of granularity.

Hierarchical structure: A way of organizing concepts from the generally defined to the more specific. Hierarchical structures can be compared to a tree, with general terms represented by the trunk and more specific details (ie, finer levels of granularity) represented by the branches.

Parent-child relationship: Within a data hierarchy, general concepts are considered "parent" concepts, and more-specific concepts are considered "child" concepts. For example, "education" is a more general or parent concept, whereas "procedural education" is more specific and, therefore, is considered a child concept.

SIGNIFICANCE OF THIS STUDY

The PNDS was developed by AORN to guide the documentation of nursing practice through the use of consistent terminology across varied health care settings.[6] The PNDS was mapped to the SNOMED CT to support the exchange of nursing data electronically with other specialties and across information systems to provide continuity, which may result in better and safer patient care. The use of standardized terminologies such as the PNDS allows for an aggregation of patient data to describe best practices and allows research to be performed using routine clinical documentation. When the PNDS is linked with other terminologies, researchers can track trends in patient populations over time and across health care specialties and settings. This functionality prevents redundant data capture while assisting with billing, statistical analysis, and health reporting.[5,7]

Linking the PNDS with other terminologies also supports the potential for new ways of developing nursing knowledge. For instance, knowledge discovery in databases, (eg, data mining) is a cutting-edge research method that uses semi-automated, artificial intelligence to explore large databases (eg, EHRs) to reveal relationships in data. This ability to explore EHRs may help researchers better understand the complexity of factors that influence patient outcomes. It is important, therefore, to ensure that concepts mapped between terminologies have comparable meaning both for practice and knowledge development.

LITERATURE REVIEW

The lack of consistency in describing patient needs and care has been criticized since the nursing profession began. In fact, there are some who believe that inconsistent use of standardized vocabularies has stifled the advancement of the nursing profession.[8] Lack of a standardized language leads to numerous interpretations of data and increases the potential for error.

Terminologies provide the content or words to document care within the structure of the nursing process. The nursing process determines which concepts are important to nursing for standardization. Diagnoses or problems are key concepts that ultimately guide the selection of nursing interventions and outcomes.[9] Studies have demonstrated the ability of standardized languages to support documentation and evaluation of the nursing process.[10-13]

No single terminology, classification, language, or nomenclature system has been developed that adequately encapsulates the breadth and depth of nursing care across all specialties and settings. In fact, 12 standardized languages or terminologies for nursing have been recognized by the ANA.[1] To achieve this recognition, these terminology systems must be maintained and the terminology must be updated on an ongoing basis to reflect the changing nature of nursing practice. Nurse practice committees and administrators determine the most appropriate terminology for their specialty practice; however, this means that as patients transition from one clinical

specialty or setting to another, many different standardized terminologies may be used to electronically communicate patient needs and care through the health care continuum.

With the governmental mandate for every American to have an interoperable EHR by 2014,[4] there is increasing pressure for nurses to identify patient conditions and name diagnoses, interventions, and outcomes as well as determine ways to link terms within multidisciplinary EHRs. The American Health Information Management Association has appealed for widespread adoption and implementation of the SNOMED CT as the standard for mapping terminologies to create a national health information network. Implementing one standard for mapping and exchange of clinical terminologies will allow interoperability of health care data between EHRs.[5]

Nurses choose terminology systems that best suit their clinical setting; however, this may result in a patient's electronic health record that uses several different terminology systems.

The US Department of Health and Human Services licensed the SNOMED CT in 2003 for the purpose of permitting all federal and private creators of computerized record systems to integrate the SNOMED CT within their EHRs. The National Committee on Vital and Health Statistics then proposed that the SNOMED CT be one of the federally approved terminologies. This proposal subsequently was accepted as the Federal Consolidated Health Informatics Standard.[14]

Recognition of the SNOMED CT by the federal government does not preclude the use of other nursing terminologies for clinical use. The PNDS provides useful terms to document nursing practice in the perioperative care setting, and mapping the PNDS to the SNOMED CT supports interoperability and extraction of data.

Multiple terminologies have been mapped to the SNOMED CT, and validation of these mappings has been initiated. Terminologies integrated within SNOMED CT include Clinical Care Classification; NANDA International (ie, formerly the North American Nursing Diagnosis Association); Nursing Interventions Classification (NIC); Nursing Outcomes Classification (NOC); the Omaha System; and the PNDS.[15]

Initial research on external validation of the mapping was conducted between the NIC/NOC systems and the SNOMED CT.[15-17] Investigators used both the concept definitions and the structure of the terminologies to determine whether the mapping between the systems preserved the meaning of the concepts. The SNOMED CT language editors provided the investigators with data tables that listed the SNOMED CT concept identification, a fully specified name, and the associated NIC/NOC labels and codes. The investigators used the codes for NIC and NOC concepts to determine the associated names, and they searched the SNOMED CT codes to determine whether the related SNOMED CT concepts and names were comparable. The investigators also searched the codes for NIC and NOC concepts using the Clinical Information Consultancy LookUp Engine version 5 (CLUE5) browser to determine if the placement within the hierarchy was the best fit (ie, it preserved the meaning of the concept and was the simplest mapping).

The expert consensus of two postdoctoral informatics nurses was used to determine when mapped concepts were not assigned to the best location or were assigned to a different level of granularity. When this occurred, the term then was considered to be misassigned. The investigators found that five of 75 NIC/NOC concepts (6.6%) were misassigned. They concluded that the methodology for validating mapping of terminologies between systems was useful to determine whether the knowledge represented in both systems was preserved in

the mapping. An external validation had not been conducted of the mapping between the PNDS and the SNOMED CT, however, to ensure that the meanings of the mapped terms were comparable.

History of the PNDS

Building on the data elements of the Nursing Minimum Data Set,[18] the PNDS was developed by AORN to document nursing processes in perioperative settings. The project began in 1988 to address the inadequacy of existing standardized languages to describe the perioperative nursing process.[19] The PNDS contains 74 nursing diagnoses, 133 nursing interventions, and 28 nurse-sensitive patient outcomes. The nursing diagnoses are a subset of NANDA diagnoses.[6] The interventions and outcomes were developed from a review of the literature, consultation with multiple expert panels, and validation surveys given to AORN members.[19]

The PNDS is organized into a conceptual framework, depicting how the data elements support perioperative nursing practices, as shown in Figure 1. This framework is patient centered, with concentric circles representing the domains and data elements of perioperative nursing practice. Nursing diagnoses and outcomes are categorized into four domains:

- safety,
- physiologic response to surgery,
- patient and family behavioral response to surgery, and
- the health system.

Interventions cross all four domains. Concepts are identified both by definition and by their placement within the conceptual framework.

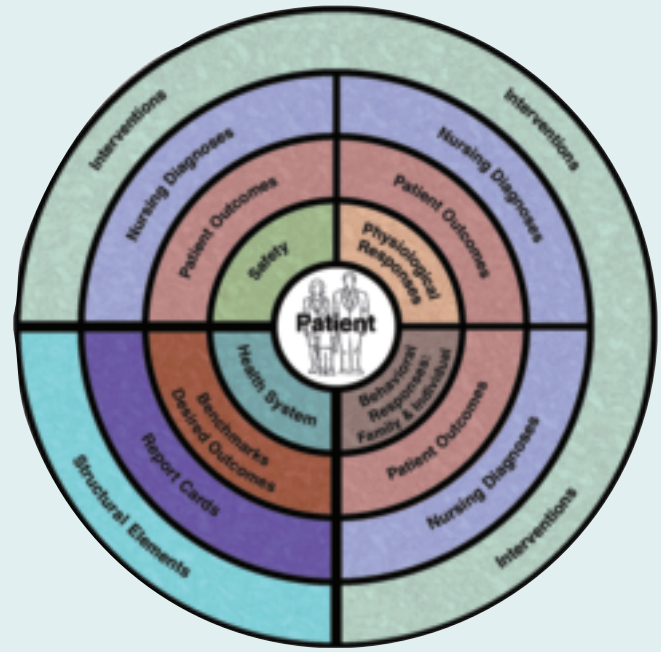
History of the SNOMED CT

Composed of 308,000 clinical concepts, the SNOMED CT is a multidisciplinary terminology system that has been recognized by the ANA. This terminology system is based on clinical concepts, and each concept is based on a specific definition. The defining relationships among the concepts create the SNOMED CT hierarchical structure. The January 2007 release of SNOMED CT contains more than 777,000 descriptions to express clinical concepts, including both the display name and related synonyms. There also are more than 924,000 defining relationships supporting the meaning of the concepts within the SNOMED CT hierarchies. These defining relationships enhance data retrieval and can be used to support nursing research. This system has been described as

> *a comprehensive, precise, clinical reference terminology that contains concepts linked to clinical knowledge to enable accurate recording of data without ambiguity.*[5(p30)]

There are 19 upper-level hierarchies, and each of these contain additional subhierarchies. This parent-child relationship is known as an "Is-A"

Figure 1
Perioperative Patient Focused Model



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relationship, where one class *is a* subclass of another class. In the SNOMED CT, an Is-A relationship exists when a parent concept has a broader meaning than its child concept. For example, the procedure "verification of allergy status" is a child of and therefore has an Is-A relationship with the procedure "verification routine." Similar to a tree, the SNOMED CT continues to branch into finer levels of granularity where the lowest level concepts in the hierarchy contain the most granular meanings.

As shown in Table 2, as one progresses down the hierarchy of concepts, each level of intervention becomes more and more specific in its meaning. The intervention of "wound healing education" is defined within the SNOMED CT as Is-A type of "wound treatment education" with a synonym of "wound care education." The hierarchical organization of the concepts in the SNOMED CT helps provide a greater understanding of the meanings of the concepts based on the way they are related within the hierarchical structure.

Design, Sample, and Protocol

A descriptive study was conducted to validate the mapping of PNDS terms with SNOMED CT concepts using a methodology comparable to that used by Lu et al.[16] The procedure included comparing the mapping of all the PNDS concepts within the SNOMED CT. The cross mapping was conducted by staff members at SNOMED CT and AORN. A spreadsheet of the mapping was provided by SNOMED CT clinical editors, and this was used by the research team. The cross mapping table included the PNDS code; the PNDS display name; the SNOMED CT concept identification; and the SNOMED CT fully specified name, defined as an unambiguous, human-readable name.

Specific methods were used to validate the semantic comparability between the two terminology systems, evaluate the placement of PNDS concepts in the SNOMED CT hierarchy, and identify whether the assignment of the PNDS concepts in the SNOMED CT hierarchy is similar for all PNDS concepts. The semantic comparability was determined by examining the PNDS concept display name in the spreadsheet against the SNOMED CT fully specified name. When the PNDS expression was different from the SNOMED CT fully specified name, the investigators referred to Merriam-Webster's Online Dictionary[20] to make definition comparisons. This step was necessary because the SNOMED CT does not include concept definitions. If the definition could not be found in Webster's or when the definition was insufficient, the researchers consulted Stedman's Online Medical Dictionary[21] to further clarify the terms.

The CLUE5 browser was used to look up the hierarchical placement of each PNDS concept in the SNOMED CT to validate the placement of the PNDS concept within the appropriate SNOMED CT hierarchy. The investigators concurred that the PNDS concepts should be categorized in the SNOMED CT as follows:

- PNDS Diagnoses mapped to SNOMED CT Clinical Findings,
- PNDS Interventions mapped to SNOMED CT Procedures, and

Table 2
Systematized Nomenclature of Medicine Clinical Terms Hierarchical Arrangement of Concepts for "Wound Healing" or "Wound Care" Education

Procedures/interventions
Procedure by site
Administrative/management procedure
Regimes and therapies
Procedure by intent
Procedure by method
Education
- Procedure education
  - Care regimes education
    - Wound treatment education
      - Wound healing or wound care education

- PNDS Outcomes mapped to SNOMED CT Clinical Findings.

The CLUE5 browser was used to identify whether the assignment of the PNDS concepts occurred at the same hierarchal levels within the SNOMED CT. Following the mapping, a consensus process was incorporated between the developers of both the PNDS and SNOMED CT and one reviewer who was familiar with the methodology to validate the findings.

Results

We compared PNDS and SNOMED CT concepts for semantic equivalence, and only one PNDS term was identified as potentially not equivalent. The PNDS concept of "administers prescribed prophylactic treatment" was mapped to the SNOMED CT concept of "preventive procedure." "Administers prescribed prophylactic treatment" is defined in the PNDS as "safely administers prescribed treatment to prevent disease."[22(p178)] We combined the words *preventive* and *procedure* using the Merriam-Webster's Online Dictionary to determine that a *preventive procedure* is defined as "a series of steps followed in a regular definite order used to prevent disease."[20] Stedman's Online Medical Dictionary defined *procedure* as the "act or conduct of diagnosis, treatment, or operation," and *preventive* was synonymous with *prophylactic*.[21] We consulted with the PNDS and SNOMED CT developers and concluded that these concepts were equivalent in meaning. All PNDS concepts, therefore, were determined to be semantically comparable to the mapped SNOMED CT concepts.

We also evaluated whether the PNDS concepts were appropriately placed in the SNOMED CT hierarchy, and we concluded that all PNDS terms were mapped to the correct hierarchy in the SNOMED CT. All PNDS Diagnoses and Outcomes were mapped to SNOMED CT Clinical Findings, and all PNDS Interventions were mapped to SNOMED CT Procedures.

After evaluating whether the assignment of PNDS concepts in the SNOMED CT hierarchy was similar for all PNDS concepts, we determined that all but one of the PNDS diagnosis concepts were mapped to the same level of abstraction in the SNOMED CT hierarchy, and all but 10 PNDS intervention concepts were mapped to the same level of abstraction in the SNOMED CT hierarchy. Moreover, all of the PNDS outcome concepts were mapped to the same level of abstraction in the SNOMED CT hierarchy.

Investigators determined that all Perioperative Nursing Data Set concepts were semantically comparable to the mapped Systematized Nomenclature of Medicine Clinical Terms concepts.

In the PNDS, all interventions exist at the same level of granularity; however, when they are mapped to the SNOMED CT, there are 11 higher-level (ie, parent) PNDS concepts that have a total of 23 lower-level (ie, child) PNDS concepts. The number of PNDS child concepts range from one to six child concepts per SNOMED CT parent concept (Table 3).

Discussion

In this study, we conducted a validation of the mapping between the PNDS and SNOMED CT terminology systems. We found that the concepts had comparable meanings between the two systems and that the placement of the PNDS concepts in SNOMED CT was valid. All PNDS diagnoses and outcomes were mapped to concepts in the findings hierarchy of SNOMED CT, and PNDS interventions were mapped to the procedure hierarchy.

We found differences between the two terminologies regarding some of the hierarchical relationships of PNDS concepts mapped to the SNOMED CT. The PNDS structure does not contain a hierarchical structure within diagnoses, interventions, and outcomes. This implies that all concepts are at the same level of granularity within each one of these categories. When

TABLE 3
Comparison of PNDS Concepts by Hierarchical Level in the SNOMED CT Terminology System

PNDS name (code)	SNOMED CT name (code)	PNDS child record(s) (code)
Diagnosis		
Risk for fluid volume imbalance (X20)	At risk for imbalanced fluid volume (129693008)	Risk for fluid volume deficit (X18)
Interventions		
Administers prescribed prophylactic treatments (I10)	Preventive procedure (169443000)	Verifies allergies (I123) Implements latex allergy precautions as needed (I139) Implements aseptic technique (I70) Protects from cross-contamination (I98)
Maintains patient confidentiality (I151)	Maintaining confidentiality of patient information (372920002)	Shares patient information only with those directly involved in care (I116)
Uses a clinical pathway (I119)	Following clinical pathway protocol (370858005)	Implements pain guidelines (I71)
Implements hemostasis techniques (I133)	Implementation of hemostasis techniques (372034000)	Applies chemical hemostatic agents (RN first assistant) (I140)
Assess psychosocial issues specific to the patient's nutritional status (I18)	Assessment of psychosocial issues specific to patient nutritional status (370780002)	Evaluates response to instruction about prescribed medications (I48)
Determines knowledge level (I135)	Determination of knowledge level (37078809)	Assesses knowledge regarding wound care and phases of wound healing (I149)
Evaluates for signs and symptoms of physical injury to skin and tissue (I152)	Evaluation for signs and symptoms of physical injury to skin and tissue (370796004)	Evaluates for signs and symptoms of skin and tissue injury as a result of transfer or transport (I42)

mapped to the SNOMED CT, however, 23 of the PNDS concepts were mapped to lower-level (ie, child) concepts of 11 higher-level (ie, parent) PNDS concepts. AORN should consider whether a parent concept such as "identifies psychosocial status" is clinically useful or whether a more-specific concept such as "assesses psychosocial issues specific to the patient's medication management" would provide clearer direction for care. If both levels of concepts prove useful, AORN may want to consider revising the structure of the PNDS in the future.

The ability to query data against a relational database to support robust data extraction is a distinguishing feature of the SNOMED CT. The differences in how the concepts are organized in the PNDS and SNOMED CT, however, may produce different results when conducting a query of information stored in a data warehouse. For instance, if the PNDS data were queried for the intervention "evaluates response to instructions (I50)," all records in the database would be selected for this intervention. If, however, this query were run using the equivalent SNOMED CT concept of "evaluation of response to instructions (370806004)" an

TABLE 3
Comparison of PNDS Concepts by Hierarchical Level in the SNOMED CT Terminology System (continued)

PNDS name (code)	SNOMED CT name (code)	PNDS child record(s) (code)
Interventions		
		Evaluates for signs of radiation injury to skin and tissue (I43)
Identifies psychosocial status (I68)	Psychosocial assessment (371585000)	Assesses psychosocial issues specific to the patient's medication management (I17) Assesses psychosocial issues specific to the patient's nutritional status (I18) Elicits perceptions of surgery (I32) Evaluates psychosocial response to plan of care (I47) Identifies and reports philosophical, cultural, and spiritual beliefs and values (I57) Identifies cultural and value components related to pain (I61)
Evaluates response to instructions (I50)	Evaluation of response to instructions (370806004)	Evaluates response to instruction about prescribed medications (I48) Evaluates response to instruction about wound care and phases of wound healing (I49) Evaluates response to nutritional instruction (I52) Evaluates response to pain management instruction (I53)
Manages specimen handling and disposition (I84)	Specimen collecting (17636008)	Manages culture specimen collection (I83)

investigator could query this single concept alone, or he or she could include this concept as well as all related (ie, child) concepts. In the latter case, all records would be extracted not only for the concept of "evaluation of response to instructions (370806004)," but also for the PNDS child intervention concepts of "evaluates response to instruction about prescribed medications (I48)," "evaluates response to instruction about wound care and phases of wound healing (I49)," "evaluates response to nutritional instruction (I52)," and "evaluates response to pain management instruction (I53)."

LIMITATIONS

The mapping was completed through a reiterative process in which one of the investigators mapped PNDS concepts to the SNOMED CT and a second investigator validated each mapping. This study would have been strengthened if both investigators had completed the mapping independently and interrater reliability had been measured. The other three investigators had expertise in the terminology systems and methodologies, however, and they provided expert validation of the accuracy of these findings.

Recommendations for Clinical Practice

Mapping the PNDS to the SNOMED CT may provide several benefits to nurses in clinical practice. First, the PNDS has unique interventions and outcomes that are specific to the perioperative setting. The PNDS not only provides concepts to document perioperative nursing care, but it also provides guidelines for the relationship of diagnoses, interventions, and outcomes for consistent care planning and documentation.[22] Mapping the PNDS to the SNOMED CT allows the inclusion of standardized terminologies used by other specialties or settings, which may be included in patients' EHRs. This supports interoperability across many organizations.

Documentation also is enhanced by including the PNDS with other standardized languages. Standardized languages represent the common diagnoses, interventions, and outcomes used in the nursing process.[9] When documentation of the standardized languages is implemented throughout the nursing process, data extraction to identify best practices yields better results. When standardized languages are mapped with other terminology systems, then best practices can be translated further into all settings that support the terminologies.[8]

Recommendations for Education

Mapping between terminology systems also will help nurse educators prepare nursing students for the future. The PNDS is useful for educating undergraduates as well as nurse anesthetists for effective documentation of perioperative nursing practice. It is not necessary for nurse educators to select only one terminology system; rather, the findings of this study support the notion that specialized terminologies such as the PNDS can be used for one type of nursing practice, then exchanged by mapping to the SNOMED CT for use in other settings or practices.

The use of the PNDS and SNOMED CT technology systems helps support nurse educators as they emphasize the importance of documentation. No single terminology system is available to do this; but after mapping between systems has been validated, data can be exchanged between various terminology systems used in diverse practices and settings.

Mapping also can support nurse educators as they develop educational programs and orient new staff members.[8] In particular, the PNDS is useful because it provides guidelines or templates to link nursing diagnoses, interventions, and outcomes for consistent documentation within and across perioperative settings.

When standardized terminology systems are mapped to one another, best practices can be translated into all health care settings that support the terminologies.

Recommendations for Future Research

Validation of the mapping of concepts across terminology systems is critical to ensure that the meanings of terms in one system are consistent with the related terms in another system. One issue raised by this study is how to define appropriate criteria to validate the mapping. The PNDS and SNOMED CT terminologies have very different structures and organization of concepts. The PNDS concepts are organized within four domains, and this design emphasizes the relationship of nursing diagnoses and interventions to patient outcomes. These relationships are not preserved when the PNDS is mapped to the SNOMED CT, because both the purpose and organizational structure of the SNOMED CT are completely different. Although the validation criteria created by Lu et al[15] were helpful to determine whether meaning is preserved, additional research methods should be developed to validate mapping of terms between systems. In particular, further investigation is needed to

examine whether differences in the level of granularity between organizing structures influence the meaning of concepts represented by both systems.

Mapping of the PNDS with other terminologies supports standardized collection of data for informatics research as well as clinical excellence. Informatics research related to data collection using terminologies and the integration of these terminologies into clinical information systems are two key areas that need further study. This conclusion is consistent with the recommendations of McCormick et al[23] concerning the future of nursing informatics.

Standardized data collected as part of routine charting can be aggregated to investigate best practices by using such methods as data mining or knowledge discovery in databases. When concepts from different terminologies have comparable meaning, patient care in diverse settings can be tracked. For example, it may be possible to track the care of a patient from the perioperative setting to other settings such as the ambulatory surgical unit or even on to home care. More research is needed to demonstrate this capability and to explain outcomes of care across settings.

Cross mapping terminology systems will help support trends in data analysis at the individual patient and population levels across all health care settings. The analysis of quality care and research across terminologies and information systems is theoretically possible, but it has yet to be demonstrated. Quality of care should be monitored more closely to ensure that the highest quality of care is provided to patients. Mapping terminologies can be useful to help identify best practices, which then can be implemented in both clinical practice and nurse education settings. – AORN –

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Editor's note: *The Perioperative Nursing Data Set (PNDS) is a trademark of AORN, Inc, Denver, CO. Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) is a registered trademark of the International Health Terminology Standards Development Organisation, Copenhagen, Denmark. Clinical Information Consultancy Lookup Engine version 5 (CLUE5), is a registered trademark of the Clinical Information Consultancy, Ltd, Reading, United Kingdom.*

REFERENCES

1. ANA recognized terminologies and data element sets. American Nurses Association. http://nursingworld.org/npii/terminologies.htm. Accessed March 3, 2008.
2. Joint Commission on Accreditation of Healthcare Organizations. *Comprehensive Accreditation Manual for Hospitals: The Official Handbook.* Oakbrook Terrace, IL: Joint Commission on Accreditation of Healthcare Organizations; 2004.
3. Health Information Technology: HIT certification: background. US Department of Health & Human Services. http://www.hhs.gov/healthit/certification/background. Accessed March 3, 2008.
4. Bush GW. Executive order: incentives for the use of health information technology and establishing the position of the National Health Information Technology Coordinator. http://www.whitehouse.gov/news/releases/2004/04/20040427-4.html. Accessed March 3, 2008.
5. Implementation of SNOMED-CT needed to facilitate interoperable exchange of health information. Adopted July 21, 2005. American Health Information Management Association. http://www.ahima.org/dc/positions/PS_SNOMED.asp. Accessed March 3, 2008.
6. Kleinbeck SVM. Development of the Perioperative Nursing Data Set. *AORN J.* 1999;70(1):15-28.
7. Park M, Delaney C, Maas M, Reed D. Using a Nursing Minimum Data Set with older patients with dementia in an acute care setting. *J Adv Nurs.* 2004;47(3):329-339.
8. Doyle M. Promoting standardized nursing language using an electronic medical record system. *AORN J.* 2006;83(6):1336-1348.
9. Lunney M, Delaney C, Duffy M, Moorhead S, Welton J. Advocating for standardized nursing languages in electronic health records. *J Nurs Adm.* 2005;35(1):1-3.
10. Martin KS. *The Omaha System: A Key to Practice, Documentation, and Information Management.* 2nd ed. St Louis, MO: Elsevier Saunders; 2005.
11. Rivera JC, Parris KM. Use of nursing diagnoses and interventions in public health nursing practice. *Nurs Diagn.* 2002;13(1):15-23.
12. Smith K, Smith V, Krugman M, Oman K. Evaluating the impact of computerized clinical documentation. *Comput Inform Nurs.* 2005;23(3):132-138.
13. Titler M, Dochterman J, Xie XJ, et al. Nursing interventions and other factors associated with discharge disposition in older patients after hip fractures.

Nurs Res. 2006;55(4):231-242.
14. Giannangelo K, Berkowitz L. SNOMED CT helps drive EHR success. *J AHIMA*. 2005;76:66-67. http://library.ahima.org/xpedio/groups/public/documents/ahima/bok1_026463.hcsp?dDocName=bok1_026463. Accessed March 3, 2008.
15. Lu DF, Eichmann D, Konicek D, Park HT, Ucharattana P, Delaney C. Standardized nursing language in the systematized nomenclature of medicine clinical terms: A cross-mapping validation method. *Comput Inform Nurs.* 2006;24(5):288-296.
16. Lu DF, Park HT, Ucharattana P, Konicek D, Delaney C. Nursing outcomes classification in the Systematized Nomenclature of Medicine Clinical Terms: a cross-mapping validation. *Comput Inform Nurs.* 2007;25(3):159-170.
17. Park HT, Lu DF, Konicek D, Delaney C. Nursing interventions classification in Systematized Nomenclature of Medicine Clinical Terms: a cross-mapping validation. *Comput Inform Nurs.* 2007; 25(4):198-210.
18. Werley HH, Devine EC, Zorn CR, Ryan P, Westra BL. The Nursing Minimum Data Set: abstraction tool for standardized, comparable, essential data. *Am J Public Health.* 1991;81(4):421-426.
19. Beyea SC. Perioperative data elements: interventions and outcomes. *AORN J.* 2000;71(2):344-352.
20. Merriam-Webster Online. http://www.merriam-webster.com/dictionary. Accessed March 5, 2008.
21. Stedman's Online Medical Dictionary. http://www.stedmans.com. Accessed March 5, 2008.
22. Petersen C, ed. *Perioperative Nursing Data Set: The Perioperative Nursing Vocabulary.* Rev 2nd ed. Denver, CO: AORN, Inc; 2007.
23. McCormick KA, Delaney CJ, Brennan PF, et al. Guideposts to the future—an agenda for nursing informatics. *J Am Med Inform Assoc.* 2007;14(1):19-24.

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Secondhand Smoke Affects Toddlers' Cardiovascular Health

Secondhand smoke may not only affect young children's respiratory systems, it may affect their cardiovascular systems as well, according to a March 13, 2008, news release from the American Heart Association. Research indicates that secondhand smoke induces markers for heart disease in a child as early as the toddler years.

Researchers studied 128 children ages two to five years and adolescents ages nine to 14 years. Hair sample analysis of nicotine levels revealed that children in the younger age group absorbed six times more nicotine than those in the adolescent age group.

Intracellular adhesion molecules (ICAM) are specific inflammatory markers of endothelial cell stress, which contributes to artery clogging and atherosclerosis and raises the risk of heart disease. Endothelial progenitor cells (EPC) replenish the epithelium and serve as a biological marker for vascular function. Blood analysis results revealed an inverted relationship between the number of smokers in the home and EPC levels in children of toddler age. The more a toddler was exposed to tobacco smoke, the fewer EPC cells were found circulating in the bloodstream. Based on the increase in soluble ICAM in the exposed children, researchers speculate that cigarette combustion causes the endothelial damage.

Overall findings indicate that cardiovascular effects of tobacco exposure in children are very similar to the effects found in adults. Until further studies can be done to determine long-term effects, researchers advise that parents and others do not smoke in homes with children.

Toddlers affected most by secondhand smoke exposure at home [news release]. Colorado Springs, CO. American Heart Association; March 13, 2008. http://americanheart.mediaroom.com/index.php?s=43&item=365. Accessed March 13, 2008.