Research and Applications

An examination of the coverage of the SNOMED CT coded nursing problem list subset

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ABSTRACT

Objective: The purpose of this article is to describe the current nursing problem list subset of Systematized Nomenclature of Medicine Clinical Terms (NPLS) coverage of the American Nurses Association (ANA) recognized standardized nursing terminologies (SNTs) and to identify potential ways to expand and enhance the utility of this list.

Materials and Methods: The study is a cross-sectional exploratory design. We mapped the content of the North American Nursing Diagnosis Association International (NANDA-I) (2018–2020), International Classification for Nursing Practice (ICNP) (2017 AB), Clinical Care Classification (CCC) (2018 AA), and Omaha System (2007AC) terminologies with each other and into NPLS (August 2017 edition) using Unified Medical Language System (UMLS) (release 2018AA) as the intermediary.

Results: We identified a total of 1470 unique nursing diagnosis concepts across SNTs in UMLS, including 175 in CCC, 840 in ICNP, 418 in Omaha System, and 631 in NPLS. The NPLS covers approximately 43% of the 1470 concepts—coverage for SNT content is 90% for CCC, 47% for ICNP, 59% for NANDA-I, and 32% for the Omaha System.

Discussion/Recommendations: The NPLS version 2017 coverage of SNT nursing diagnoses included in the UMLS is incomplete and equivocal. Recommendations: (1) ensure all SNT concepts in the UMLS are represented by SNOMED CT terms, (2) devise a formal strategy of partial matching to further enhance interoperability, (3) add a classification structure to the NPLS to enhance the ease of use and utility of the list, and (4) minimize redundancy within NPLS.

Key words: nursing problem list subset of Systematized Nomenclature of Medicine Clinical Terms, nursing terminology, content, usability, interoperability

INTRODUCTION

Electronic health records (EHRs) have made it possible to produce and extract large quantities of data and make them available for research in clinical data repositories. Nursing data, however, are not typically included in these repositories due in part to a lack of understanding of its importance and poor interoperability. We define interoperability as the ability to share and compare data gathered in different systems. The adoption of terminology standards is essential to enabling the standardization of the content and process of data collection so that resulting data are interoperable. Since 2011, a nursing problem list subset (NPLS) coded with the Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) has been...
available (and regularly updated) on the Unified Medical Language System (UMLS) website: https://www.nlm.nih.gov/research/umls/Snomed/nursing_problemlist_subset.html; Last accessed June 24, 2019. A main purpose has been to facilitate the collection of interoperable nursing problem data across institutions. In 2014, Kim et al. examined the coverage between SNOMED CT and International Classification for Nursing Practice (ICNP), one of the American Nurses Association’s (ANA) recognized standardized nursing terminologies (SNTs). Building on Kim et al. (2014), this article explores current coverage of nursing problems in the NPLS list and proposes potential ways to expand and enhance the utility of the list.

BACKGROUND AND SIGNIFICANCE

Over the past few decades through a formal process, the ANA has recognized 10 standardized terminologies and 2 minimum datasets for use in gathering consistent nursing data in EHRs (see Table 1). A main purpose of the recognized terminologies and datasets has been to enable the capture of interoperable nursing data for sharing and comparing nursing information across systems. There are 8 interface terminologies and 2 reference terminologies.

Interfacing terminologies are typically the terms displayed on the EHR screen that nurses see and select to describe care during documentation. Seven of the interface terminologies specifically focus on nursing practice and we refer to these as SNTs. Four (Clinical Care Classification [CCC], ICNP, Omaha System, and Perioperative Nursing Data Set [PNDS]) of the 7 SNTs contain terms for nursing diagnoses, interventions, and outcomes. The remaining 3 SNTs, North American Nursing Diagnosis Association International (NANDA-I) (diagnoses), Nursing Interventions Classification (NIC) (interventions), and Nursing Outcomes Classification System (NOC) (outcomes), include terms for only one type of nursing data element. It is possible to generate nursing data interoperable across institutions using the same SNT with (1) consistent implementation into EHRs and (2) consistent data collection and storage. To date, however, it has been difficult to generate interoperable nursing data due to the difference in SNTs used and wide variation in implementations across systems.

A reference terminology, on the other hand, is a single set of non-redundant concepts to which multiple interface terminologies (eg, SNTs) can be mapped and similar context across terminologies identified. A well-constructed reference terminology makes it possible to share and compare data gathered with different interface terminologies that are mapped to it. The SNOMED CT is one of the reference terminologies recognized by ANA. It is considered the most comprehensive terminology available for recording clinical information in EHRs. SNOMED CT has 340 593 active concepts and is used in over 50 countries. SNOMED CT consists of concepts, descriptions, and relationships. A concept represents a unique clinical meaning; a description represents every concept by fully specified name (FSN: a concept’s meaning) and synonym; a relationship represents an association between 2 concepts.

In a 2015 position statement, the ANA reaffirmed support for using SNOMED CT to code nursing problems, interventions, and observations. The statement further specifies its use for coding nursing data “when exchanging a Consolidated Continuity of Care Document with another setting” typically captured in EHRs. The ANA’s position aligns with the Office of the National Coordinator’s (ONC) endorsement of SNOMED CT as the universal clinical terminology required for EHR certification by ONC for capturing clinical problems, interventions, and observations. The ONC EHR certification is, in turn, a requirement of the Centers for Medicaid and Medicare Systems (CMS) for reimbursement. While CMS does not typically reimburse nurses directly, using SNOMED CT to code applicable data elements offers an avenue to generate data that can justify financial support for nurses and nursing practice initiatives. Ensuring full representation of nursing concepts in SNOMED CT thus is an important goal for the profession.

Mapping SNTs to SNOMED CT

The mapping of SNTs (interface terminologies) to SNOMED CT (reference terminology) thus has the potential to facilitate the generation of interoperable nursing data in several ways. First, SNOMED CT can provide a way to compare data gathered using different interface SNTs. Second, subsets of SNOMED CT terms applicable to nursing can be extracted to support the development of nursing documentation systems that generate interoperable nursing data (NPLS is an example). Third, when the developers of SNTs maintain up-to-date mappings of their terms to SNOMED CT, it is possible to identify and fill gaps in nursing content within SNOMED CT.

There are 2 general ways of mapping SNTs to SNOMED CT that researchers have utilized: (1) mappings using UMLS as an intermediary and (2) direct mapping of SNTs to SNOMED CT. The UMLS is operated by the National Library of Medicine and through a combination of electronic and manual methods, connects (maps) each biomedical concept to like terms in over 150 different health and biomedical vocabularies and standards. The UMLS mappings identify the relationship between concepts including synonyms, siblings, parents, and children. Early versions of UMLS provided low coverage of nursing diagnosis concepts. More recently, additional ANA-recognized SNT terms have been added and updated in the UMLS. Cross-mapping of terms from different SNTs can thus be accomplished using UMLS as an intermediary. The second method is direct mapping that utilizes experts to identify terms in different terminologies that are equivalents. An example is the recent direct mapping of the ICNP to SNOMED CT that was carried out by

### Table 1. Standardized terminologies and datasets recognized by the American Nurses Association

| Category | Terminology |
|----------|-------------|
| Interface terminologies (standardized nursing terminologies) | Clinical Care Classification International Classification for Nursing Practice |
| | North American Nursing Diagnosis Association International Nursing Interventions Classification System |
| | Nursing Outcomes Classification System |
| | Omaha System |
| | Perioperative Nursing Data Set |
| | ABC Codes |
| Reference terminologies (nursing and other content) | Logical Observation Identifiers Names and Codes |
| | Systematized Nomenclature of Medicine Clinical Terms |
| NMDS | NMDS |
| | Nursing Management Minimum Data Set |

**Abbreviation:** NMDS: Nursing Minimum Data Set.
ICNP experts under a collaboration agreement between the International Council of Nurses and the International Health Terminology Standards Organization.15

The NPLS
NPLS was developed to facilitate the use of SNOMED CT as a reference coding (terminology) for a universal nursing problem list16 and has been updated in April 2011, June 2012, November 2014, and August 2017. NPLS term set includes SNOMED CT FSNs of terms that are represented in at least one of the following ANA-recognized SNTs: NANDA-I, CCC, Omaha System, and ICNP.16 The NIC and NOC SNTs were not included in the queries because they do not contain problem terms. The PNDS is also excluded because, as the developers of the NPLS noted, “nursing diagnostic concepts in PNDS are identical to NANDA.”2(pp. 685–686) The regularly updated NPLS therefore offers a potential means to collect nursing problems in an interoperable format coded with SNOMED CT. The methods for inclusion of the SNT diagnoses in the NPLS are described on the UMLS website. In this study, we examine the current coverage of SNT nursing diagnoses in the NPLS.

MATERIALS AND METHODS

Study methods
The study is a cross-sectional exploratory design. Using the UMLS (release 2018AA) as the intermediary, we first extracted the UMLS concept, indexed by a Concept Unique Identifier (CUI) in the UMLS Metathesaurus, represented within the SNT source terminologies, (NANDA-I [2018–2020], ICNP [2017 AB], CCC [2018 AA], Omaha System [2007AC]),17 and within the NPLS. The coverage of a source SNT in NPLS is then the percentage of unique concepts represented in this SNT that can be also found in NPLS. Similarly, we examined the overlap of concepts covered by any 2 source SNTs. To perform these steps, an expert in informatics downloaded the UMLS Metathesaurus data (MRCONSO.RRF) and imported them into data analysis platform R18 for processing. Each nursing diagnosis from different terminologies occupies 1 row in the data table, where the UMLS concept it represents and the corresponding CUI can be found. A program was written to link terms from different terminologies that represent the same UMLS concept. This process is very similar to the one used in Kim et al19 to map a subset of ICNP terms to SNOMED-CT.

RESULTS

Mapping
We identified the unique UMLS concepts (and related CUIs) for 244 NANDA-I diagnoses, 852 ICNP diagnoses, 176 CCC diagnoses, 418 Omaha System terms related to diagnoses (42 problems and 377 names of a sign of symptom of a problem), and 673 NPLS terms. Matching diagnoses from different terminologies linked to the same UMLS CUIs resulted in a table of mappings between terminologies. Table 2 includes example entries of the mapping table, in which each unique UMLS concept (CUI) occupied 1 row, followed by diagnosis (name and code) mapped to this concept in each SNT.

We found that in some SNTs, a single CUI map to more than 1 term within the SNT. For example, 2 ICNP terms, Fear about Death (10037834) and Death Anxiety (10041017) are linked to the same UMLS concept (CUI). Another example is in NPLS, where 3 terms, Pruritic Disorders (disorder), Itching (finding), and Itching of Skin (finding), all map to the same UMLS CUI. These cases exist in varying but limited degrees in ICNP, Omaha System, CCC, and NPLS (see Supplementary Appendix). Forty-four of these are instances in which a UMLS CUI is linked to 2 diagnoses in a single SNT. In addition, 6 UMLS CUIs each map to 3 SNOMED CT terms.

Coverage of NPLS for nursing terminologies
Accounting for the multiple names for the same UMLS concepts across SNTs, we identified a total 1470 unique nursing diagnosis-related concepts (CUIs) in UMLS; 175 represented in CCC, 840 in ICNP, 244 in NANDA-I, 418 in Omaha System, and 631 in NPLS. We found 3 (0.2%) concepts (CUIs) present in all 5 terminologies; 71 (4.8%) present in 4; 126 (8.6%) present in 3; 361 (24.6%) present in 2; and 909 (62.0%) represented in only one terminology. In Table 3, we show the overlap in CUIs covered across the different SNTs and NPLS.

For example, 78 (32%) NANDA diagnosis labels had counterparts in CCC, while 115 (47%) had counterparts in ICNP. Focusing on the reference terminology NPLS, we observed that NPLS provides 90% (158/175) coverage for CCC, 47% (395/840) for ICNP, 59% (144/244) for NANDA-I, and 32% (134/418) for Omaha System. Interestingly, we found minimal overlap (<5%) between Omaha System and the other SNTs.

Comparison with expert mapping
In 2011, Kim et al19 compared UMLS semantic mapping (UMLS Release 2009AB) with expert cross mapping of nursing diagnoses and found UMLS semantic mapping to have low accuracy (33%). To assess the quality of mapping provided by the current release version of UMLS, we compared the expert created ICNP to SNOMED CT nursing diagnoses (problems) equivalence table3 with the mapping produced by our automated process that utilized UMLS. We found that our automated process was able to reproduce 88% of the mappings created by the expert. This accuracy number is similar to the 91.6% reported by Kim et al19 produced when the automated mapping through UMLS was assessed by experts manually.

DISCUSSION

This study provides evidence of progress toward the comprehensive representation of nursing diagnoses in SNOMED CT. We also identified challenges that must be addressed to improve the quality and utility of the NPLS as a tool for generating interoperable nursing problem data. The challenges include (1) incomplete representation of SNT nursing problems in the NPLS; (2) substantial discrepancy in concepts covered by different SNTs; (3) organization of the NPLS that does not support ease of implementation and utility; and (4) minimizing redundancy within NPLS.

Incomplete representation
Through this study, we learned that the full range of problems as captured in interface SNTs is not comprehensively represented in NPLS at this time. For example, 100% of NANDA-I terms have UMLS CUIs but 41% do not have SNOMED CT codes so only 59% are represented in the NPLS. As a result, when using the NPLS as the reference terminology to examine data gathered with different SNTs across systems, it will not be possible to establish interoperability of those diagnoses with CUIs without a corresponding SNOMED CT code. To serve as a viable reference terminology subset for nursing diagnoses, it is important therefore that all known nursing diagnoses concepts be represented in the NPLS.20 This in turn requires that the nursing terminology developers (or another
designated entity) take responsibility for ensuring that all CUIs for
the terms in each of the SNTs have equivalent SNOMED CT codes.

Partial matching
As noted above, across SNTs we found that 62% of the SNT CUIs
(n = 909) were represented in just 1 SNT. The overlaps between
interface SNTs were often below 50%. We expected the overlap of
terms across SNTs to be higher given the similarity of purposes of
the SNTs. Since the nursing interface terminologies in the UMLS
(CCC, NANDA-I, ICNP, and Omaha System) were all designed to
represent the whole of nursing practice, the content covering nursing
diagnoses is expected to be quite similar. Thus, the low level of exact
matches may not be due primarily to differences in content only but
is also likely a function of representing the same or similar content
differently. A major implication is that even if the NPLS is expanded
to include all unique SNT diagnoses CUIs, datasets of nursing prob-
lems coded at the interface with different SNTs would map to sub-
stantially dissimilar NPLS terms even when patients present with
similar nursing problems. For example, fewer than 50% of
NANDA-I terms had equivalent counterparts in CCC and vice
versa. Therefore, comparisons made between 2 data files (1 coded
with NANDA-I and the other with CCC) will be limited to only
those concepts that have exact term matches in the NPLS excluding
similar content in both represented by different term combinations
in each. Consequently, true interoperability would still be out of

Table 2. Example of mapping table generated for the study

| CUI   | ICNP             | NANDA-I             | CCC             | Omaha              | NPLS                       |
|-------|------------------|---------------------|-----------------|--------------------|---------------------------|
| C0000737 | Abdominal pain [10043953] |                      |                |                    |                           |
| C0001118 | Acid base imbalance [10033539] |                      |                |                    |                           |
| C0001807 | Aggressive behavior [10047087] |                      |                |                    |                           |
| C0001973 | Alcohol dependence [10041347] |                      |                |                    |                           |
| C0002092 |                         |                      |                |                    | Alcohol dependence (disorder) [66590003] |
| C0002871 |                         |                      |                |                    | Anemia [30.06]             |
| C0002957 | Anger [10045578] |                      |                |                    | Angina (disorder)/ischemic chest pain (finding) [194828000/225566008] |
| C0002962 |                         |                      |                |                    |                           |
| C0003123 | Anxiety [10000477] | Anxiety [146]       | Anxiety [P40.0] | Anorexia [30.05]   |                           |
| C00033578 | Apnea [10035020] |                      |                |                    |                           |
| C0003635 | Apraxia [10047041] |                      |                |                    |                           |
| C0003962 |                         |                      |                |                    |                           |
| C0005775 | Burn wound [10029737] |                      |                |                    |                           |
| C0007166 | Decreased cardiac output [29] |                      |                |                    |                           |
| C0009240 | Cognition [23] |                      |                |                    |                           |

Note: Diagnosis names and codes used in source SNT are listed.
Abbreviations: CCC: Clinical Care Classification; CUI: Concept Unique Identifier; ICNP: International Classification for Nursing Practice; NANDA-I: North American Nursing Diagnosis Association International; NPLS: nursing problem list subset of SNOMED CT; SNT: standardized nursing terminology.

Table 3. Coverage of NPLS for nursing terminologies and overlapping among terminologies

| Standardized nursing terminology | n | CCC (%) | ICNP (%) | NANDA-I (%) | NPLS (%) | Omaha (%) |
|--------------------------------|---|---------|----------|-------------|----------|-----------|
| CCC                            | 175 | 100     | 77       | 45          | 90       | 5         |
| ICNP                           | 840 | 16      | 100      | 14          | 47       | 2         |
| NANDA-I                        | 244 | 32      | 47       | 100         | 59       | 3         |
| NPLS                           | 631 | 25      | 63       | 23          | 100      | 21        |
| Omaha                          | 418 | 2       | 5        | 2           | 32       | 100       |

Abbreviations: CCC: Clinical Care Classification; ICNP: International Classification for Nursing Practice; NANDA-I: North American Nursing Diagnosis Association International; NPLS: Nursing problem list subset of SNOMED CT; SNOMED CT: Systematized Nomenclature of Medicine Clinical Terms.
reach without going beyond the exact matching. To enhance interoperability, additional methods are therefore needed to formalize the similarities (ie, partial matching) that exist between and among SNTs problems not captured through the exact matched terms.

Expanding the mapping to include close synonyms would be a first step. For example, NANDA-I diagnosis, decreased cardiac output, mapped to the NPLS term of the same name, did not have an exact match in any other interface SNTs. The closest counterpart seemed to be impaired cardiac output in ICNP and cardiac output alteration in CCC. Using only exact matches in the NPLS thus fails to capture the similarity of the NANDA-I term to the CCC and ICNP concepts mapped to the same SNOMED CT code. Whether these terms can be mapped with each other and the implication on data processing and analysis must be carefully assessed case by case. Another reason attributed to low overlap between interface SNTs is different levels of granularity for the same nursing problem present in different SNTs. For example, impaired physical mobility is a diagnosis in NANDA-I, ICNP, and CCC (under slightly different names), but the first 2 SNTs also had its finer granularity variations addressing bed/wheelchair/transfer mobility. While we agree with including different levels of granularity (children of broader concepts), it is not clear how to manage children of similar concepts when the similarities are not explicated. For example, the children of NANDA-I, decreased cardiac output would likely be similar to the children of the ICNP diagnosis impaired cardiac output but through current mappings would appear as distinctly different concepts. We suggest attention be given to adequately capturing similarities across broader concepts before finalizing the approach to including different levels of granularity. This is another important consideration for minimizing redundancy in the NPLS. Additional context contained in other EHR data and advanced data processing techniques could be utilized when a research question requires finer granularity information. Finally, since some organization use only one of the ANA-recognized nursing diagnoses terminologies, an interim suggestion is to create a list of SNOMED CT codes/preferred terms mapped to the diagnoses for each of the terminologies in the UMLS (eg, separate lists for CCC, ICNP, NANDA-I, and Omaha System). Making these lists available on the UMLS website can facilitate ease in connecting one’s local term sets to SNOMED CT.

Organization and ease of use of NPLS
The current NPLS is a running list of 673 nursing problems. For each problem, the list includes the preferred concept name, SNOMED CT code, UMLS CUI, and status of each concept (current or inactive). There is no information accompanying the list about the relationships among the problems. We have seen above that the concepts included in the NPLS are not independent and unique (eg, decreased cardiac output vs cardiac output alteration). Another example is NPLS terms related to pain, including pain, acute pain, chronic pain, ischemic chest pain, difficulty coping with pain, inadequate pain control, among others. Adding a classification structure, similar to those provided by each SNT, to explicate the shared qualities and interrelationships among the problems in the NPLS would not only enhance the reliability and validity of the data coded with the NPLS but also improve the usability (ie, ease of use) while simultaneously enhancing the level of interoperability achieved.\footnote{2,20}

Eliminating redundancy
A main purpose of the NPLS is to provide a subset of SNOMED CT codes representing a list of non-redundant nursing problems that when implemented consistently into electronic systems produces interoperable nursing data. The NPLS list currently includes unique problems based on the UMLS mapping of concepts across SNTs (ie, CCC, ICNP, NANDA-I, and Omaha System).\footnote{2} We found some redundancy where multiple terms were mapped to the exact UMLS CUIs. The mapping strategy used to identify the unique nursing problem concepts in the NPLS does not detect the redundancy occurring when there is partial overlap (similar but not exact) in the meanings of terms between and among concepts in the SNTs.

Careful attention to minimizing and managing redundancy is crucial to the integrity of a terminology intended for use in generating interoperable data.\footnote{20} Assignment of more than 1 code to identical or similar concepts in a terminology results in redundancy and ambiguity that reduces the integrity and utility of the data. An ideal terminology (controlled vocabulary) contains concepts that do not overlap in meaning and thus do not appear within the vocabulary under more than 1 code. Non-redundancy of concepts in a dataset supports the validity and reliability of the results obtained from analyses of these data.\footnote{20}

CONCLUSION
Creation of the NPLS is a major step toward establishing interoperability of nursing problem data that will enhance communication between nurses and other disciplines in clinical practice and facilitate valuable research. The NPLS is a vehicle that is providing the capability to share and compare nursing problem data coded with different SNTs in EHRs. In our study, we identified gaps that if addressed can dramatically improve the value and utility of the NPLS. One is the incomplete coverage of nursing problems in SNOMED CT NPLS. To reconcile this gap, it is important for developers of SNTs to ensure timely update of the terminologies in the UMLS and that SNOMED CT codes exist for all of their nursing diagnoses. Another challenge identified is the incomplete overlap in concept coverage among interface SNTs; we found <50% content overlap between most interface SNTs. In the absence of a rigorous partial matching strategy, the interoperability of NPLS coded data used in research will be compromised. Third, the absence of a structure to articulate the relationships among the 673 problems within the NPLS limits the ease of use and utility of the list. We recommend the addition of a classification structure, similar to those that exist for each of the SNTs, as a potential solution. Efforts must be made to ensure the non-redundancy of terms in the NPLS. Finally, we also recommend that specific methods for implementing the NPLS into EHR be developed to help users ensure that interoperable nursing data is ultimately generated. In the absence of clear information to inform appropriate use of the NPLS, implementation may result in a level of variation that severely limits the degree of interoperability achieved.

SUPPLEMENTARY MATERIAL
Supplementary material is available at Journal of the American Medical Informatics Association online.

CONTRIBUTORS
All authors contributed to the design of work, data analysis, interpretation, critical revision, and approval of the manuscript. YY retrieved data from UMLS and created the data table to be discussed.
All authors interpreted data and participated in writing the manuscript.

Conflict of interest statement. None declared.

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