Journal of Biomedical Informatics 49 (2014) 213–220

Contents lists available at ScienceDirect

Journal of Biomedical Informatics

journal homepage: www.elsevier.com/locate/yjbin

Inter-terminology mapping of nursing problems

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ARTICLE INFO

Article history:
Received 25 November 2013
Accepted 1 March 2014
Available online 13 March 2014

Keywords:
Terminology
Mapping
International Classification for Nursing Practice
Systematized Nomenclature of Medicine–Clinical Terms

ABSTRACT

Purpose: The purpose of this study was to determine the degree of overlap between the International Classification for Nursing Practice (ICNP®) and the Systematized Nomenclature of Medicine–Clinical Terms (SNOMED–CT), with a specific focus on nursing problems, as a first step towards harmonization of content between the two terminologies.
Methods: Work within this study was divided across two ICNP subsets. The first subset ($n = 238$) was made up of ICNP diagnosis/outcome concepts that had been included in previous experimental mapping activities with Clinical Care Classification (CCC) and NANDA-International (NANDA-I). These ICNP concepts and their equivalent concepts within CCC and NANDA-I were used within the Unified Medical Language System (UMLS) framework to derive automatically candidate mappings to SNOMED–CT for validation by two reviewers. The second subset ($n = 565$) included all other ICNP diagnosis/outcome concepts plus those concepts from the first subset where the candidate mappings were rejected. Mappings from the second subset to SNOMED–CT were manually identified independently by the same two reviewers. Differences between the reviewers were resolved through discussion. The observed agreement between the two reviewers was calculated along with the inter-rater reliability using Cohen's Kappa (κ).
Results: For the first semi-automated mapping, according to the two reviewers the great majority of ICNP concepts (91.6%) correctly mapped to SNOMED–CT in UMLS. There was a good level of agreement between the reviewers in this part of the exercise ($\kappa = 0.7$). For the second manual mapping, nearly two-thirds of ICNP concepts (61.4%) could not be mapped to any SNOMED–CT concept. There was only a moderate level of agreement between the reviewers ($\kappa = 0.45$). While most of the mappings were one-to-one mappings, there were ambiguities in both terminologies which led to difficulties. The absence of mappings was due to a large extent to differences in content coverage, although lexical variations and semantic differences also played a part.
Conclusions: This study demonstrated a degree of overlap between ICNP and SNOMED–CT; it also identified significant differences in content coverage. The results from the semi-automated mapping were encouraging, particularly for 'older' ICNP content. The results from the manual mapping were less favorable suggesting a need for further enhancement of both terminologies, content development within SNOMED–CT and further research on mechanisms for harmonization.

1. Introduction

The usefulness of electronic health records relies on a consistent description of health care. The use of standardized patient care data in decision support and quality evaluation can minimize undesirable consequences of health care; standardization can also maximize opportunities for identifying new knowledge from massive and increasing volumes of clinical data. Standardized health terminologies are seen as essential in supporting meaningful use and interoperability between different electronic healthcare systems [1,2].

A variety of nursing terminologies have been developed to provide a source of standardized data for electronic health records. One such terminology, the International Classification for Nursing Practice (ICNP®), has been developed by the International Council of Nurses (ICN) to support nursing practice in any setting worldwide [3]. Recognizing that multiple terminologies might be required to support the various needs of terminology users, ICN has been involved in a number of initiatives to harmonize content within the World Health Organization (WHO) Family of International Classifications (FIC) and with the International Health Terminology Standards Development Organisation (IHTSDO).

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http://dx.doi.org/10.1016/j.jbi.2014.03.001
1532-0464/

ICNP as a related classification harmonizes content within FIC, for example with the International Classification of Functioning (ICF) [4] and more recently with the emerging International Classification of Health Interventions (ICHI). Outside FIC, a harmonization agreement between ICN and IHTSDO seeks to ensure consistency in nursing content between ICNP and the Systematized Nomenclature of Medicine–Clinical Terms (SNOMED–CT) [5].

As a first step towards instantiating the ICN-IHTSDO agreement, we designed a study to determine the degree of overlap between ICNP and SNOMED–CT. While the focus of this study was on so-called nursing problems, within ICNP, diagnoses, goals, and outcomes are modeled in the same way. These are referred to as diagnosis/outcome statements covering both positive and negative statements about health status for individuals, families or communities. In this paper we report on the results of the study, presenting overlapping content as cross-mappings between ICNP and SNOMED–CT. We discuss similarities and differences between the two terminologies, building on other studies to provide a rationale for and route towards mutual enhancement and to serve as a foundation for greater harmonization of content.

1.1. ICNP

ICNP is a workstream within the ICN eHealth Programme which aims to transform nursing through the visionary application of information and communication technology [6]. The purpose of the ICNP as an international nursing terminology is to provide standard content for nurses worldwide to document their practice consistently [3]. ICNP has evolved significantly since its inception, transitioning through a multi-axial representation [3] to its current more formal form, in response to its increasing size and complexity, more sophisticated requirements of users, and the need to ensure quality [7].

ICNP takes as its foundation a formal Web Ontology Language (OWL) model [7]. Under this model, pre-coordinated nursing diagnosis, outcome and intervention statements (introduced in response to users' requests to facilitate implementation and reduce potential ambiguity) are composed of more primitive ICNP concepts [7]. The use of a modeling style guide and automated reasoning on the ontology assures consistency and conformance with the international standard for nursing terminologies, ISO 18104: Reference Terminology Model for Nursing [8].

ICNP is structurally stable and released every two years. The main change between releases is additional content. This stability is a result of greater consistency in modeling and the implementation of a quality improvement program [9]. The 2013 release includes 3894 concepts, 41% of which are pre-coordinated, including 783 diagnosis/outcome statements and 809 nursing interventions (this is an increase from 17% in Version 1). In order to support implementation of the increasing number of pre-coordinated concepts, a number of clinically relevant subsets of the terminology, called ICNP Catalogues, have been developed for specific conditions, specialties or practice areas [10]. A similar harmonization agreement is in place between ICN and SabaCare for ICNP and the Clinical Care Classification (CCC) [11].

1.2. SNOMED–CT

With its origins in the Systemized Nomenclature of Pathology (SNOP), SNOMED–CT has evolved to become an important international standardized terminology to support broader health care [12]. Accordingly, harmonization efforts have been made between IHTSDO and WHO for the International Classification of Diseases (ICD) Version 10 and SNOMED–CT [13], and between IHTSDO and the Regenstrief Institute for Logical Observation Identifiers Names and Codes (LOINC) and SNOMED–CT [14].

SNOMED–CT is released every 6 months as a set of tables comprising, among other elements, concept names and codes, descriptions, and relationships [15]. In common with ICNP, SNOMED–CT is also underpinned by description logic and organized in a tree structure with 19 top-level concepts [16]. The top-level concepts represent a range of domains such as body structures, clinical findings (e.g., diseases, disorders, drug actions), events, observable entities, procedures (e.g., treatment/therapy, surgical procedure, laboratory procedure), situations with explicit context, and substances [15]. Lower-level concepts are organized hierarchically. SNOMED–CT concepts may also have multiple 'parent' concepts. For example, the concept *ability to manage medication* (285033005) has two parent concepts: *drug therapy observable* (363819003) and *instrumental activity of daily living* (414514009) – both within the Observable Entity hierarchy.

In the early stages of development of SNOMED–CT, attempts were made through the U.S. College of American Pathologists (CAP) [17] at harmonization with a number of nursing terminologies that had been recognized by the American Nurses Association (ANA) [18]. These included the CCC, NANDA-International (NANDA-I), the Nursing Interventions Classification (NIC), the Nursing Outcomes Classification (NOC), the Omaha System, and the Perioperative Nursing Data Set (PNDS) [19–22]. As appropriate nursing content was not always available within SNOMED–CT at the time of the harmonization activity, new nursing content was added so that mappings could be made from the source terminologies. It is noted that harmonization with ICNP was not attempted at that time because of its multi-axial representational form.

However, previous work has explored the feasibility of harmonizing ICNP primitive concepts and SNOMED CT. For example, when mapping ICNP Version 1 primitive concepts (which are used to create a pre-coordinated diagnosis, intervention and outcome concepts) to SNOMED–CT, Park et al. (2011) found that 80% (i.e., 1331 of 1658) of primitive concepts were mapped to SNOMED CT (1-31-2007 release) [23], indicating the possibility of post-coordinating the primitive ICNP concepts for cross-mapping. Although any EHR system can take advantage of compositional capabilities of healthcare terminologies for data sharing and exchange, it could potentially create inconsistency in mappings across EHR systems. In light of this, the harmonization agreement between ICN and IHTSDO currently focuses on maximizing consistency in mappings of ICNP pre-coordinated concepts and exploring solutions for post-coordinating primitive concepts for unmatched pre-coordinated concepts.

1.3. Issues around terminology mappings

While SNOMED–CT contains nursing content, it is not possible to retrieve this content directly as a nursing-relevant subset. The Unified Medical Language System (UMLS), a product of the U.S. National Library Medicine (NLM) on the other hand, provides a framework that allows its constituent terminologies to be viewed either as an individual entity or as an integrated whole [24,25]. Within UMLS semantically equivalent concepts are assigned to the same concept unique identifier (CUI) regardless of their source [24,25]. This ideally makes it possible to link equivalent concepts drawn from multiple terminologies using CUIs, while retaining the ability to identify their source. Our previous related research indicated that UMLS is a reliable source to extract cross-mappings between some nursing terminologies within the unified framework although there were a number of gaps in mappings with ICNP [26]. Indeed, a current nursing problem list was based on cross-mappings of nursing terminologies that were available in UMLS (followed by expert review) [27]. The development of the problem list, however, demonstrated that additional work, described within this paper, would be needed to be able to identify and retrieve

appropriate candidate mappings between ICNP and SNOMED–CT within UMLS [26,27].

Similarly there have been some success and failure with automated or semi-automated approaches to cross-mappings. For example, using string-based and semantic-based searches, a machine-aided mapping of ICD-9CM to SNOMED–CT through UMLS resulted in a 91% coverage, a 43% recall and a 27% precision [28]. However, it would appear that automated approaches alone are not adequate for all domains. For example, in one study that sought to automatically map a local medication terminology to SNOMED–CT using UMLS, more than one third of source concepts could not be mapped due to the complexity of the three systems [29].

In addition, several authors have reported challenges in cross-mapping between SNOMED–CT and other standardized terminologies [30,31]. One study that sought to map between LOINC and SNOMED–CT in UMLS resulted in a high proportion of unmatched LOINC concepts due to unspecified concept definitions, a lack of pre-coordinated concepts and a different granularity within SNOMED–CT [30]. In a second study, quality issues (i.e. inconsistencies, redundancies, and deficiencies) in SNOMED–CT were found to be barriers in mapping legacy data to SNOMED–CT [31]. These issues also have been addressed in a recent survey of SNOMED–CT users, requiring the ongoing enhancement of SNOMED–CT, for example in order to support meaningful use [32].

2. Methods

As an essential step towards harmonization of ICNP and SNOMED–CT content, this study was designed to examine the degree of equivalence, through a mapping activity, between ICNP nursing diagnosis and outcome statements and SNOMED–CT concepts. In this study, both ICNP nursing diagnoses and outcomes are considered to represent a patient health status, problem, asset, or condition at a point in time, as mentioned previously [3]. The most recent release of each terminology was utilized in this study; ICNP 2013 Release as the source terminology and SNOMED–CT 2013 January Release (2013-1-31) as the target terminology. The goal of the mapping work was to seek those SNOMED–CT concepts with semantic equivalence to ICNP concepts. Work within this study was divided across two ICNP subsets; different approaches to mapping were used for each subset – semi-automated for subset I and manual for subset II.

2.1. Cross-mapping for subset I

Candidate cross-mappings for the first subset were identified by linking multiple tables from both the ICNP and UMLS (2011AB release) databases. The first subset included 238 ICNP concepts that had been included in previous experimental mapping studies with CCC and NANDA-I [33,34]. Both equivalent CCC and NANDA-I concepts identified from these two earlier studies are called *intermediate concepts* hereafter in this paper on account of their role in the process of deriving candidates, as illustrated in Fig. 1. We then identified CUIs of intermediate concepts from MRCONSO via relationships within UMLS for the ICNP concepts. Note that MRCONSO is a UMLS table containing all concepts submitted to NLM for integration into the unified framework [24]. Assuming that semantically equivalent concepts would be assigned to the same CUI, we then identified SNOMED–CT concepts with the same CUI to act as candidates.

Two authors independently examined the accuracy of candidate mappings. The percentage agreement between the two authors was calculated along with inter-rater reliability using Cohen's Kappa (κ). Kappa has a range from 0 to 1.00, with larger values indicating better inter-coder reliability [35]. In general, a Kappa >.70 is considered satisfactory. Any disagreement was discussed until consensus was reached. It should be noted that we did not use candidate mappings between ICNP and SNOMED–CT that were already available in UMLS as our previous study (which examined semantic equivalence and locality of ICNP concepts in UMLS [26]) suggested that this might not be fruitful due to the suboptimal integration of ICNP into UMLS.

2.2. Cross-mapping for subset II

The second subset comprised: (a) ICNP concepts that had not been included in the previous experimental mapping studies, and (b) concepts from the first subset that were, in the eyes of the reviewers, not accurately mapped to SNOMED–CT via a UMLS CUI. The same two authors independently manually searched for semantically equivalent SNOMED–CT concepts using a number of resources: the CliniClue® browser [36], the source ICNP OWL file and the ICNP web browser [37]. Each author identified a candidate SNOMED–CT concept corresponding to a given ICNP concept or noted that there was no equivalent concept in SNOMED–CT. After consolidating the cross-mappings manually generated by the two reviewers, we measured the percentage of agreement and Cohen's Kappa (κ) between the two reviewers. Any disagreement was once again resolved through discussion.

2.3. Combining subsets I and II

The final step in the method was to combine the mappings from Subset I and Subset II. The resulting equivalency table of ICNP and SNOMED–CT is further described below, along with overall mapping results.

3. Results

3.1. Mapping result of subset I

For the great majority of candidate mappings derived through intermediate concepts, one-to-one relationships existed between selected ICNP concepts and candidate SNOMED–CT concepts in UMLS. That is, when retrieving candidate SNOMED–CT concepts from UMLS using intermediate concepts, 222 ICNP concepts (93.3%) were potentially mapped via a CUI to one SNOMED–CT concept. In 16 cases, one ICNP concept mapped to more than one SNOMED–CT concept. In other words, in these cases, the concepts were considered to be semantically equivalent in UMLS but not in SNOMED–CT. One reason for this might be that different mapping algorithms and auditing process are adopted to maintain UMLS [38], which may result in the assignment of the same CUIs to concepts that might not be identical semantically in a given terminology system.

According to the two reviewers, when using the intermediate concepts to determine candidate mappings to SNOMED–CT, the majority of ICNP concepts (n = 218, 91.6%) were already correctly mapped to SNOMED–CT in UMLS. The observed agreement between the two reviewers was 85% and a Kappa value of 0.7 indicates a good level of agreement between the two reviewers [35]. Table 1 shows example ICNP concepts and results of cross-mapping to SNOMED–CT. The 20 remaining ICNP concepts were included in the second subset for the manual search.

3.2. Mapping result of subset II

Using the manual approach described previously, the two coders attempted independently to identify mappings to SNOMED–CT for a total of 565 concepts. Surprisingly nearly two-thirds of these (n = 347, 61.4%) could not be mapped to any SNOMED–CT concept

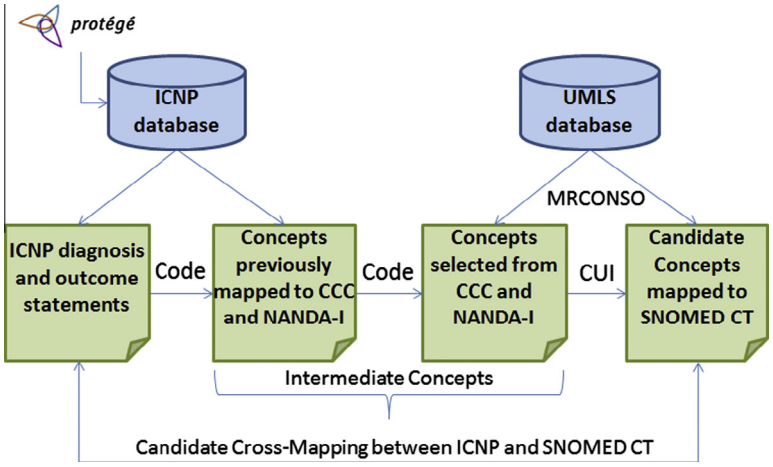

Fig. 1. Creation of a candidate cross-mapping for subset I using UMLS (2011AB release).

Table 1
Example cross-mapping through CUIs in UMLS (2011AB release).

ICNP nursing problem concepts	SNOMED–CT clinical findings	Mapping results
10000477 Anxiety	48694002 Anxiety (finding)	Correct match
10000567 Constipation	14760008 Constipation (disorder)	Correct match
10000567 Constipation	35298007 Slow transit constipation (disorder)	Incorrect match
10000918 Impaired health maintenance	24441001 Health maintenance alteration (finding)	Correct match
10000918 Impaired health maintenance	414487007 Ineffective health maintenance (finding)	Incorrect match
10000960 Impaired dressing and grooming	87788003 Self-dressing/grooming deficit (finding)	Correct match
10000956 Impaired ability to bath	57982001 Self-bathing/hygiene deficit (finding)	Incorrect match
10021941 Lack of knowledge of medication regime	129866007 Deficient knowledge of medication regimen (finding)	Correct match
10023202 Risk for complication with contraception use	409044009 Contraception risk (finding)	Correct match
10015356 Risk for suicide	225444004 At risk for suicide (finding)	Correct match

(co-incidentally exactly the same number of concepts could be mapped from subset II as from subset I i.e. $n = 218$). For this second exercise, the overall observed agreement between the two coders was lower at 72.4% and the Kappa value was 0.45 (i.e., moderate agreement). Regardless of the approach used, consensus (100%) was achieved through discussion. Fig. 2 depicts a summary of mapping results by ICNP subset.

3.3. Overall mapping results

When the two subsets were combined, 436 of 783 ICNP nursing diagnostic and outcome statements (55.7%) mapped to SNOMED–CT concepts residing in the Clinical Findings and Situations hierarchies. A significant minority ($n = 347$, 44.3%) were not mapped. The overall observed agreement between the two reviewers was 77% (=602/783); the overall Kappa value was 0.54, indicating moderate agreement between the two coders.

Most (>95%) of the 436 mapped concepts had one-to-one mappings to SNOMED–CT. A small number of concepts, however, presented challenges in cross-mapping due to ambiguities in both terminologies (Tables 2–4). Seven concepts were mapped to either broader or narrower concepts in SNOMED–CT (Table 2); a single ICNP concept was mapped to two SNOMED–CT concepts in three cases (Table 3); and two ICNP concepts were mapped to the same

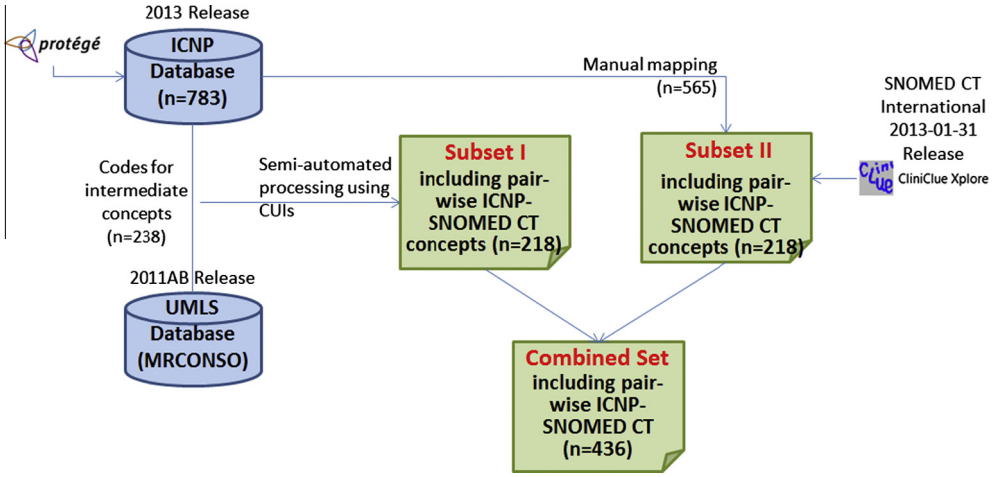

Fig. 2. A summary of cross-mappings of ICNP to SNOMED–CT.

SNOMED–CT concept in 10 cases (Table 4). Accordingly, a total of 436 ICNP concepts were mapped to 424 SNOMED–CT concepts. Fig. 3 illustrates examples of one-to-one, one-to-many and many-to-one mapping relationships.

The great majority of ICNP-mapped SNOMED–CT concepts (97.2%) were from the SNOMED–CT Clinical Finding hierarchy where the patient is a subject of a given finding occurring at a specified time (which is a default context in SNOMED–CT) [16]. However, 12 concepts were located in the Situation with Explicit Context hierarchy where context dependent concepts represent not-yet-occurred conditions, historical conditions or family's condition other than the patient [16]. Concepts associated with 'absence of a certain condition' such as *no vomiting* (162062008) and *diarrhea not present* (162104009) and 'degree of response to treatment' such as *poor response to treatment* (405786003) were also found in this hierarchy. Table 5 presents examples of 'absence' concepts placed under the two different domains in SNOMED–CT.

4. Discussion

As a first step to harmonizing ICNP with SNOMED–CT, this study examined the degree to which ICNP nursing diagnoses and outcomes had equivalent or corresponding SNOMED–CT concepts. It demonstrated that when using the most recent releases, more than half of ICNP diagnostic and outcome statements (2013 release) have mappings to SNOMED–CT (2013-01-31 release).

We applied two mapping methods in this study, which resulted in different outcomes. The use of ICNP concepts and intermediate concepts (i.e., CCC and NANDA-I) used in previous experimental mapping studies resulted in a useful set of candidate cross-mappings between ICNP and SNOMED–CT through UMLS. This is perhaps unsurprising as both CCC and NANDA-I have been integrated into both SNOMED–CT and UMLS. In contrast, most of ICNP diagnosis and outcome concepts that had not been included in previous experimental mapping studies were not as likely to be found in SNOMED–CT, possibly indicating unique additional nursing domain content within ICNP. When more closely reviewing our mapping results, there existed similarities and differences between ICNP and SNOMED–CT. The following is a discussion of where similarities and discrepancies reside in the two terminologies, along with areas of future research and development. It is noted that as the direction of mapping was from ICNP to SNOMED–CT, the majority of mapping issues exposed in this study point towards SNOMED–CT rather than ICNP. If the direction of mapping had been the other way round, it is likely that the majority of issues exposed would have pointed towards ICNP rather than SNOMED–CT.

4.1. Variations in lexical expressions for semantically equivalent concepts

When intermediate concepts were used, many nursing problem and outcome statements were lexically identical or very similar (Table 4). Lexical differences for equivalent concepts followed consistent patterns. For instance, ICNP uses the word "impaired" to represent a negative meaning of a given concept; the words "alteration" and "deficit" are used frequently in SNOMED–CT for the same concept. Also, in ICNP all "risk" related concepts start with the words "risk for" whereas the same concepts within SNOMED–CT often begin with "at risk for" or end with "risk". The consistent patterns for these relatively minor differences in lexical expressions is informing ongoing work around automated cross-mapping between the two terminologies, the results of which are reported elsewhere.

In comparison, in the manual search, lexical differences between concepts made it difficult to search the CliniClue browser (which without enhancement is designed to support lexical rather than semantic searching) for semantically equivalent concepts. This would have required users to be able to recall all possible synonyms for a particular SNOMED–CT concept. For example, the identification of the SNOMED–CT concept *polypharmacy* (129846003) as a mapping for the ICNP concept *complex medication regime* (10022983) follows no consistent pattern. Other examples include the mapping of ICNP *homebound* (10029887) to SNOMED–CT *housebound* (160689007) and ICNP *adequate hydration* (10025115) to SNOMED–CT *positive fluid balance* (251857007). Issues such as these contributed to a lower level of agreement between the two coders.

4.2. Semantic differences associated with the hierarchical structure

In some cases, concepts in the two terminologies could not be mapped because of their placement in the SNOMED–CT hierarchy. For example, the ICNP concept *acid base imbalance* (10033539) might appear to map to *disorder of acid–base balance* (26436007) in SNOMED–CT. However, *disorder of acid–base balance* (26436007) is a child of *metabolic disease* (75934005); and as *acid base imbalance* in ICNP is considered to be a sign that is recognized during the course of disease, and not a disease itself. Accordingly, this map was rejected. As a further example, the ICNP concept *elder abuse* (10029825) might appear to map to *elder abuse* (95921002) in SNOMED–CT. However, the SNOMED–CT concept is considered an Event rather than a Clinical Finding and this map was also rejected.

Since ICNP nursing diagnoses and outcomes statements represent a clinical judgment on the healthcare needs and assets of individuals, families and communities, our search for mapping was mainly limited to SNOMED–CT Clinical Findings and Situation concepts. This limitation was determined according to previous discussions with SNOMED–CT experts. SNOMED–CT concepts located outside that hierarchy were not considered for cross-mapping. For example, in common with *elder abuse* from the SNOMED–CT Events hierarchy, there were several ICNP concepts that were lexically identical to SNOMED–CT concepts but appeared in the Observable Entity hierarchy. These potential

Table 2
Inexact matches between ICNP and SNOMED–CT.

ICNP nursing problem concepts	SNOMED–CT clinical findings	Note
10023452 Ability to perform health maintenance	365232000 Finding related to ability to manage personal health care (finding)	BC [a]
10029479 Lack of awareness of symptoms	406124004 Lack of awareness (finding)	BC
10033663 Effective acid base balance	365721001 Finding of acid–base balance (finding)	BC
10029446 Self awareness	365934006 Finding related to awareness of self (finding)	BC
10028207 Effective dressing and grooming	284973007 Able to dress (finding)	NC [b]
10028207 Effective dressing and grooming	284856006 Able to perform grooming activity (finding)	NC
10027371 Lack of knowledge of community service	425209002 Unfamiliar with process for obtaining community services (finding)	NC
10022441 Unrealistic expectation	110477003 Unrealistic expectation from treatment (finding)	NC

[a] BC – semantically broader concept in SNOMED–CT.
[b] NC – semantically narrower concept in SNOMED–CT.

Table 3
One-to-many relations between ICNP and SNOMED–CT.

ICNP nursing problem concepts	SNOMED–CT clinical findings	Note
10028207 Effective dressing and grooming	284973007 Able to dress (finding) 284856006 Able to perform grooming activity (finding)	Lack of clarity in ICNP
10027290 Impaired weight	22495007 Abnormal weight (finding) 301336003 Body weight problem (finding)	Lack of clarity in SNOMED–CT
10029716 Negative behavior	25786006 Abnormal behavior (finding) 277843001 Problem behavior (finding)	Lack of clarity in SNOMED–CT

Table 4
Many-to-one relations between ICNP and SNOMED–CT.

ICNP nursing problem concepts	SNOMED–CT clinical findings	Note
10039952 Helplessness [a] 10001578 Powerlessness [a]	33300005 Feeling powerless (finding)	Lack of clarity in ICNP
10000682 Excess food intake 10025535 Impaired high nutritional intake	45346005 Alteration in nutrition: more than body requirements (finding)	Lack of clarity in SNOMED–CT
10001359 Impaired urinary system process 10021790 Impaired urination	47252008 Alteration in patterns of urinary elimination (finding)	Lack of clarity in both
10015114 Risk for excess food intake 10025471 Risk for nutritional excess	48501009 Alteration in nutrition: potential for more than body requirements (finding)	Lack of clarity in SNOMED–CT
10023078 Impaired family process 10000788 Interrupted family process [b]	64313000 Alteration in family processes (finding) [b]	Lack of clarity in SNOMED–CT
10015146 Risk for injury [a] 10015360 Risk for trauma [a]	81763001 At risk for injury (finding)	Lack of clarity in ICNP
10000607 Deficient food intake 10025519 Impaired low nutritional intake	88202002 Alteration in nutrition: less than body requirements (finding)	Lack of clarity in SNOMED–CT
10037586 Risk for being underweight 10023013 Risk for impaired nutritional intake	129845004 At risk for imbalanced nutrition, less than body requirements (finding)	Lack of clarity in ICNP
10022983 complex medication regime 10030042 Polypharmacy	129846003 Polypharmacy (finding)	Lack of clarity in ICNP
10025209 Disuse response 10023097 Disuse syndrome	129892000 Disuse syndrome (finding)	Lack of clarity in ICNP
10021828 Ability to adjust 10022378 Effective coping	225909006 Able to cope (finding)	Lack of clarity in ICNP
10025115 Adequate hydration 10033721 Effective fluid balance	251857007 Positive fluid balance (finding)	Lack of clarity in ICNP
10028211 Effective ability to dress 10028207 Effective dressing and grooming	284973007 Able to dress (finding)	Lack of clarity in ICNP

[a] Both are marked as synonyms in SNOMED–CT.
[b] 'Alteration' and 'interrupted' are considered synonyms in SNOMED–CT.

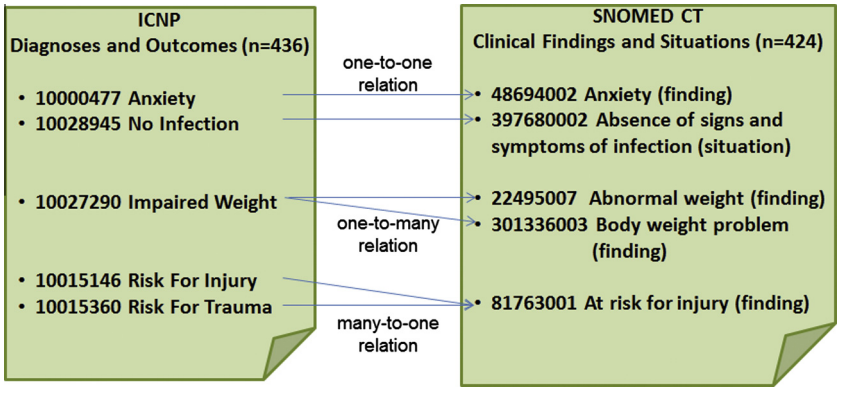

Fig. 3. Example relationships between ICNP and SNOMED–CT.

matches caused some disagreement between the reviewers but ultimately all were rejected. For example, the mapping between the ICNP concept *knowledge of medication* (10025968) and *knowledge: medication* (405112004) from the SNOMED–CT Observable Entity hierarchy was rejected. Similarly for *symptom control* (10025820) and *symptoms control* (405085007) and *acceptance of health status* (10023499) and *acceptance behavior: health status* (405054003).

4.3. Lack of pre-coordinated concepts in SNOMED–CT

In order to maximize consistency in mappings, we limited mappings to pre-coordinated concepts only. In other words, post-coordination of SNOMED–CT concepts was not permitted. This led to the rejection of several potential maps. For example, the potential mapping between the ICNP concept *decreased spiritual distress* (10027149) and a post-coordination of *spiritual distress*

Table 5
Example cross-mapping of ICNP 'Absence' concepts to SNOMED–CT.

ICNP nursing problem concepts	SNOMED–CT concepts	Top level in SNOMED–CT
10028945 No infection	397680002 Absence of signs and symptoms of infection	Situation
10028966 No injury	397719002 Absence of signs and symptoms of physical injury	Situation
10028984 No nausea	162056003 No nausea	Situation
10029008 No pain	81765008 No pain	Situation
10029181 No vomiting	162062008 No vomiting	Situation
10029147 No tobacco abuse	8392000 Non-smoker	Finding
10034704 No fall	298345007 Does not fall	Finding

(26110006) with the qualifier *decreased* (1250004) in SNOMED–CT was rejected. Similarly, for the ICNP concept *improved electrolyte imbalance* (10033518) and a post-coordination of *electrolyte imbalance* (105593004) with the qualifier *improved* (385425000).

In addition, in this study, only 12 of the 38 ICNP 'absence' concepts mapped to SNOMED–CT (via either the Situation or Clinical Findings hierarchies). This could have been improved through post-coordination of SNOMED–CT concepts (e.g., using *no*, *none*, *not seen* from Qualifier Value). Our finding is different from that of a previous study where SNOMED–CT covered 89% of negation concepts identified from patient history and physical examination records through an automated procedure [39].

4.4. Differences in content coverage

While more than half of the ICNP diagnosis and outcome concepts examined in this study could be matched with SNOMED–CT concepts, the large number of unmatched concepts points towards a potential need for additional content within SNOMED–CT. These findings are consistent with the results of a recent survey of SNOMED–CT users who identified the need for enhancement in content coverage [32].

The number of nursing diagnoses and outcomes in ICNP has increased fourfold since the release of Version 1 in 2005. Interestingly, in this study ninety-seven percent of unmatched concepts (=337/347) were added after the release of Version 1. As mentioned previously, in order to facilitate the implementation of ICNP, a number of ICNP Catalogues have been developed over recent years. These catalogues have contributed to the increase in size of ICNP. The majority (61% = 210/347) of the unmatched concepts within this study appear in ICNP Catalogues. In order to ensure clinical relevance many clinical experts have contributed to the development of ICNP Catalogues. While there is a great deal of overlap between SNOMED–CT and older content within ICNP, newer content (i.e. those concepts submitted and added to ICNP over the past 8 years) is not mirrored in SNOMED–CT despite its clinical relevance.

Also concerning content coverage, unlike other terminologies, ICNP includes both negative and positive diagnosis and outcome concepts (i.e., 291 of 783 concepts would be considered positive). As EHR systems advance, and with an increased emphasis on health rather than illness, users of ICNP have requested both positive and negative content to represent and support their documentation of practice more completely. Subsequently, ICNP has added more positive content. In this study 65% of positive diagnostic concepts (=189/291) were not mapped to any SNOMED–CT concept; only 32% of negative diagnostic concepts were not mapped. This indicates that positive diagnostic concepts may not be represented as well in SNOMED–CT as negative diagnostic concepts. For instance, the negative ICNP concept *lack of knowledge of dietary regime* (10021939) was mapped to *deficient knowledge of dietary regime* (129863004) in SNOMED–CT, but the concept presenting the positive concept *knowledge of dietary regime* (10023772) had no equivalence in SNOMED–CT.

4.5. Future research and development

There was lack of clarity in certain concepts drawn from the two terminologies as presented in Tables 3 and 4. The existence of one-to-many and many-to-one relations indicates that there are areas of quality improvement for both terminologies. However, many-to-one relations also revealed the existence of different perspectives on clinical concepts by discipline. For example, while *risk for injury* and *risk for trauma* are regarded as synonyms in SNOMED–CT and UMLS, nursing terminology developers consider them to be semantically dissimilar concepts [26].

Lack of clarity in both terminologies resulted in a high level of disagreement between the two reviewers, as each one was compelled to choose only one best candidate concept from SNOMED–CT. For example, the two reviewers initially identified two different SNOMED–CT concepts when mapping an ICNP concept *effective ability to bath* (self) (10028224) – *able to bath self* (284803009) and *able to perform bathing activity* (284798000). A further mapping might be to *able to wash self (finding)* (284786005). The semantic difference between these and other concepts, even where they are hierarchically related, is not clear. Accordingly, a broader community-based review process (involving terminology experts and practicing nurses) is underway in collaboration with the IHTSDO Nursing Special Interest Group to ensure the quality of cross-mapping between the two terminologies.

5. Conclusion

This study examined the degree of overlap between ICNP and SNOMED–CT through the identification of mappings between nursing diagnosis and outcome statements. This provided a first tangible step towards harmonization of nursing content within the two terminologies. The similarities and differences identified between the terminologies suggest the need for further research and development. However, it may not be appropriate merely to include missing content *en masse*. Instead, it might be worthwhile to explore a strategy for leveraging the strengths of each terminology, perhaps with each terminology complementing the domain content of the other via a unified terminology platform such as UMLS (i.e., harmonization rather than unification). As well as informing the enhancement of ICNP and SNOMED–CT, this study also informs the development of methods for future maintenance of mappings between ever-evolving terminologies.

Acknowledgment

The authors acknowledge support from the International Council of Nurses in conducting this study.

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