MEDINFO 2010
C. Safran et al. (Eds.)
IOS Press, 2010

doi:10.3233/978-1-60750-588-4-1109

Mapping ICNP Version 1 Concepts to SNOMED CT

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Abstract

The purpose of this study is to evaluate the ability of SNOMED CT to represent concepts of the ICNP Version 1 – the 7-Axis model. We selected the 1568 concepts of the ICNP 7-Axis model. From January 2007 through June 2007, the first author mapped the ICNP Version 1 concepts to the SNOMED CT using CLUE browser 5.0. The second author from the SNOMED Terminology Solutions and the third author from the ICN validated mapping result. In total, SNOMED CT covered 1381 concepts of 1658 (83%) ICNP 7-Axis model concepts ranging from 65% coverage rate of the Actions Axis concepts to 94% coverage rate of the Judgment Axis concepts. SNOMED CT can represent most (83%) of the ICNP Version 1 concepts. Improvements in ICNP Version 1 in terms of concept naming and definition, and adding missing concepts to the SNOMED CT would lead to greater coverage of the ICNP Version 1 concepts.

Keywords:

Clinical terminology, ICNP, SNOMED, Coverage

Introduction

Standardization in the field of health information becomes important as computer-based information system and electronic health record are being introduced rapidly in health care facilities around the world. A variety of standard development activities are happening in the International Standard Development Organizations such as ISO, HL 7 and CEN. Standardized health care terminologies and classifications are the most important standard for data quality, data sharing and exchanging and decision support [1].

Unfortunately, most of application packages and institution-based systems have its own terminologies, resulting in overlooked synonymy and semantic collisions among concepts, which in turn producing non-interoperable data. Furthermore, most of countries have designated more than one health care terminology and classification standards for institution-based and interoperable medical records instead of recommending one single terminology and classification. For example, the United States, United Kingdom, Canada and Australia recognize more than one health care terminology and classification [2]. Thus, critical challenges are to link terminologies and classification used in the existing clinical information systems to standardized terminologies and classifications for data sharing and exchange. One solution for this problem is to map different terminologies to a broader health care terminology such as SNOMED CT (Systematized Nomenclature of Medicine – Clinical Terms) before storing data in database.

SNOMED CT is the most widely used health care terminology in EHR because it is richer, more granular expression, more familiar to clinicians, hierarchical, and group-able and susceptible to concatenation, which are ideal qualities for decision support analysis and population-based clinical and public health intervention [3]. ICNP (International Classification for Nursing Practice) is the most widely used nursing terminology in electronic nursing record because it allows communicating and comparing nursing data across settings, countries and languages [4].

The SNOMED CT is a systematically organized computer processable collection of health care terminology covering diseases, clinical findings, and procedures. It is designed to capture granular detail and provides common language for clinical data to be indexed, stored, retrieved, and aggregated across specialties and sites of care. Clinical expressiveness of SNOMED CT supports clinical care and drives decision support technology. It is designed for use in electronic medical records, reducing the variability in the way data is captured, encoded and used for clinical care of patients and research.

The SNOMED-CT is a reference terminology that provides a means of integrating healthcare classification and terminologies from different healthcare disciplines. Many healthcare classifications have been mapped into SNOMED-CT such as ICD -9-CM Epidemiological/Statistical Mapping, ICD-O3, ICD-10 (UK edition), OPCS-4 (UK edition), NIC, NOC, NANDA, PNDS, Clinical Care Classification, and The Omaha System.

The ICNP® is a unified nursing language system. It is a compositional terminology for nursing practice that facilitates the development of and the cross-mapping among local terms and existing terminologies. The ICNP Version 1 is comprised of 7 different axes, Focus, Judgment, Means, Action, Time, Location and Client [5].

The ICNP Version 1 is used to represent nursing diagnoses (client status, problems, needs, and strengths), nursing interventions (or nursing actions), and nursing outcomes. The 7-Axis model is intended to facilitate the composition of nursing diagnoses, interventions and outcomes statements. These statements can be organized into meaningful sets for nursing practice, which is called ICNP catalogues [6].

In order to support interoperability of nursing concept with other health care concepts, it is important to have a collaborative effort to come up with principles, processes and strategies to integrate, map and/or model nursing concepts within wider healthcare related concepts. As a part of this described collaborative effort, we would like to propose draft principles, processes and strategies that would be necessary to integrate, map and/or model ICNP Version 1 concepts within SNOMED CT, a copyrighted work of the International Health Terminology Standards Development Organization (IHTSDO). For the purpose of this project, concepts from the ICNP 7-Axis model, will be examined in the context of their potential for addition to a broad healthcare based terminology, SNOMED CT. This process hopes to contribute valuable feedback to the ICN (International Council of Nurses) regarding refining the definitions and hierarchies of ICNP Version 1 concepts. The study also hopes to inform the IHTSDO about the benefits of providing ICNP content to the participating member organizations.

Materials and Methods

We selected the 1658 concepts from the ICNP 7-Axis Model. The first author mapped the ICNP Version 1 concepts with the concepts of the SNOMED CT using Apelon's TermWorks and CLUE browser 5.0.

The first phase of matching is the linguistic matching of concepts based on concept label. Label matching involves putting the label into a canonical form by stemming and tokenization; comparing equality of labels; and matching sub-strings [7]. Concept names with suffix such as verb variation (ex, assessing vs assessment vs assesses) and singular versus plural (medication vs medications), use of preposition (ex, monitoring vs monitoring for,), American English versus British English (ex, diarrhea vs diarrhoea), compound word with or without space (well being vs wellbeing), and compound word with or without hyphen (ex, self toileting vs self-toileting) were treated as linguistically identical. Apelon's TermWorks was used for this phase.

If a concept in ICNP Version 1 matches linguistically with a concept in SNOMED, The next phase is the structural matching of concepts based on the similarities of their context or vicinities in the hierarchy of concepts. In structural matching, parents, sibling and children concepts were examined. If a concept in ICNP Version 1 matches with a concept in SNOMED linguistically and structurally, then it is classified as mapped. CLUE browser 5.0 with SNOMED CT 2007 July release was used for this phase.

If a concept in ICNP Version 1 does not match linguistically or structurally with a concept in SNOMED, next phase is the semantic matching of concepts. Semantic matching is an approach where semantic relations are examined between concepts (not between labels) based on textual definition or usage in nursing practice and hierarchical relationship of the concept with other concepts [8, 9]. For semantic matching, we traced back to the original source of the ICNP Version 1 concepts, examined the display name of the concept in the source language and then tried to map the display name to SNOMED CT concept. Possible semantic relations are equivalence, more general, less general, mismatch, and overlapping. Again CLUE browser with SNOMED CT 2007 July release was used for this phase.

For our study, mapping results were classified as following. If an ICNP Version 1 concept is matched linguistically and structurally to a SNOMED CT concept, it is classified as lexically mapped. If an ICNP Version 1 concept matched semantically to a SNOMED CT concept, it is classified as semantically mapped. If an ICNP Version 1 concept matched to a more general SNOMED CT concept, it is classified as mapped to broader concept. If an ICNP Version 1 concept matched to a less general SNOMED CT concept, it is classified as mapped to narrower concept. If a concept is a compound concept or has text definition describing more than one concept we mapped to more than one concept of SNOMED CT (ex, 'Craving' mapped to 'Craving for food or drink' and 'Craving for drugs'). In this case, we classified as one-to-many mapped. However, we tried not to map to either a broader or a narrower concept as much as possible. Otherwise, it is classified as not mapped.

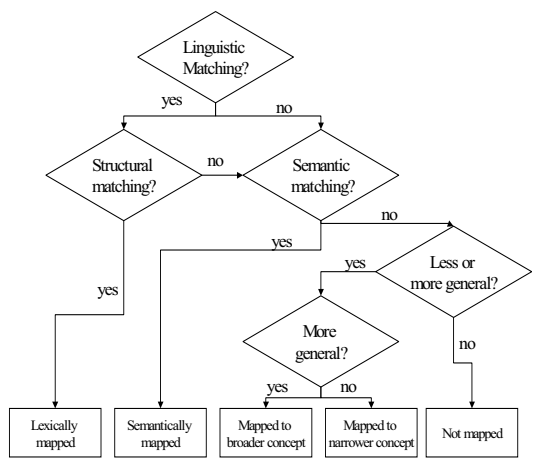

Figure 1- Mapping process of ICNP Version 1 concepts to SNOMED CT concepts

The mapping was validated by a team of SNOMED and ICNP experts including the second and third authors by more than fifteen 1-2 hour web conferencing such as GoToMeetings and four two day face-to-face meetings. If there was any disagreement during validation process, we convened another meeting to reach a consensus.

During mapping, we used the text definition of ICNP concept as our first mapping criteria. If an ICNP concept does not have a working definition, we tried to find where the term came from and how it is being used in nursing practice. If we could not find how it is being used in nursing practice, we did not attempt to map the concept. If possible, we tried not to map to either a broader or a narrower concept.

Results

Concepts in the Focus, Mean, Time, and Location Axis were mapped to more than one SNOMED CT hierarchies. Concepts in the Focus Axis were mapped to Clinical findings, Observable entity, Body structure, Environment, Event, substance, Organism, Physical force, Specimen, and Qualifier value hierarchies. Concepts in the Mean Axis were mapped to Physical object, Procedures including Regime/Therapy, Social context - occupation, Substance, Product, Staging and scales including Assessment Scales, and Qualifier value hierarchies. Concepts in the Time Axis were mapped to concepts in the Qualifier value and Event hierarchies of the SNOMED CT. Concepts in the Location Axis were mapped to concepts in the Body structure including Morphological abnormality, Environment, Qualifier value, Findings, and Physical object hierarchies of the SNOMED CT. Concepts in the Judgment, Action and Client Axis were mapped to one hierarchy of the SNOMED CT, the Judgment Axis to Qualifier Value hierarchy, the Action Axis to the Procedure hierarchy, and Client Axis to the Social context hierarchy of the SNOMED CT.

Table 1 shows the mapping result. In total, 1381 out of 1658 concepts were mapped. (83%). Mapping rates range from Axis to Axis. While most of concepts in the Judgment and Location Axis were mapped to concepts of the SNOMED CT (94%), the Action Axis has the lowest mapping rate (66%).

Table 1-Mapping results of ICNP concepts to SNOMED CT concepts

Mapping Result		Focus	Action	Means	Time	Judg-ment	Loca-tion	Client
Mapped	LM	345	20	122	22	15	153	18
	SM	304	111	115	21	17	68	1
	BT	20	2	5				
	NT	10	7					
	1:n Map	2	1				3	
Not Mapped	add new con-cept	122	3	18	18	1	8	8
	No usage	13	70	9		1	6	
Total		816	214	269	60	34	238	27

In detail, Focus concepts describing disease, disorders, signs and symptoms were mapped concepts in the Finding hierarchy of SNOMED CT. 'Community leadership', 'management', 'participation', 'law', 'committee, and policy' were mapped to Community Resource findings of the Finding hierarchy.

Focus concepts with neutral connotation such as Process, Function, Status and Pattern related concepts were mapped to concepts in the Observable entity hierarchy of SNOMED CT. 'Process' concepts of the ICNP Version 1 were mapped to Function concepts of the Observable entity hierarchy of SNOMED CT, because they are describing body function (ex, cardiac process). 'Status' concepts of the ICNP Version 1 were mapped to concepts in the Observable entity of SNOMED CT (ex, respiratory status). 'Pattern' concepts of the ICNP Version 1 were mapped to concepts in the Observable entity hierarchy (ex, eating pattern).

System concepts of the Focus Axis were mapped to concepts in the Body structure hierarchy of SNOMED CT (ex, cardiovascular system). Morphological abnormalities without any judgment or body sites were mapped to concepts in the Morphologic abnormality of SNOMED CT, which is part of Body structure (ex, ulcer).

Focus concepts describing pressure, radiation, light, and weather were mapped to concepts in the Physical force hierarchy of SNOMED CT. Focus concepts describing abuse, suicide, and environmental events such as flood, earthquake, and wind were mapped to concepts in the Event hierarchy of SNOMED CT. Focus concepts describing agricultural development, industrial development, residential development, recreational development, infrastructure, food supply, and foul odor were mapped to concept in the Environment hierarchy of SNOMED CT.

Focus concepts describing Body secretion, gastric contents, body fluid, and body material were mapped to concepts in the Substance hierarchy of SNOMED CT. Concepts describing animal, microorganism, and plant were mapped to concepts of the Organism hierarchy of SNOMED CT. Specimen concept was mapped to hierarchy of the Specimen of SNOMED CT. Social status concepts of the Focus Axis were mapped to Social context hierarchy of SNOMED CT. Focus concepts describing Services (ex, funeral service), rate and ratio were mapped to concepts in the Qualifier value hierarchy of SNOMED CT.

All of concepts in the Judgment Axis except 'Positive or negative judgment' and 'Potential for enhancement' were mapped to concepts in the Qualifier value hierarchy of the SNOMED CT. 'Positive or negative judgment' is a compound concept used as a grouper in the Judgment Axis. We did not map this concept to SNOMED CT. 'Potential for enhancement' can be modeled as a child concept of 'Finding context value' of the Qualifier value hierarchy of SNOMED CT.

Means Axis of the ICNP consisted of artifact, care provider, health service, material, technique and therapy. Artifact concepts were mapped to Physical object and Qualifier value hierarchies, care provider concepts to Social context hierarchy, health service concepts to Qualifier value hierarchy, material concepts to Substance and Product hierarchies, and technique and therapy concepts to Procedure hierarchy of the SNOMED

CT. We did not map compound concept in the Mean Axis used as a grouper to organize concepts. Examples of compound concepts are 'Absorbing or Collecting Device.' 'Meal' concept was not mapped to SNOMED CT because it has IS-A relationship problem with its parent concept, 'Nutrient.' There are synonymous concepts in the Means Axis. For example, 'Hemostasis technique' and 'Hemostasis technique for patient' are synonymous.

The Action Axis has the lowest mapping rate because concepts in the Action Axis are mainly gerund form of verbs used to as a building block to populate nursing intervention catalogue concepts rather than actual nursing intervention or nursing activity (ex, facilitating, promoting, and collaborating). These verb concepts are very ambiguous and can be used only when they are combined with concepts from other axis. There are over 200 verbs in the Action Axis. Some of these verbs are very difficult to distinguish from one another. One example is 'Teaching', 'Educating', and 'Instructing'. Another example is 'Describing', 'Documenting', and 'Recording'. On the contrary, there are very specific concepts in the Action Axis which has more detailed granularity than the other verbs. Examples are 'Alcohol life style prevention', 'Contamination prevention', 'Fall prevention', 'Safety measure', and 'Anticipatory guidance.' These concepts can be moved to the ICNP nursing intervention catalogues. There are compound verb concepts with unnecessary word 'act' attached (ex, 'Setting up act', and 'Giving act'). For these concepts removing the word 'act' would not change the meaning of the concepts.

Concepts in the Time Axis were mapped to concepts of the Qualifier value and Event hierarchies of SNOMED CT. 'Birth', 'Death', 'Fall', and 'Rite of passage' were mapped to concepts of the Event hierarchy of SNOMED CT. Most of the Time Axis concepts were mapped to the Qualifier value hierarchy. However, for the Time concepts not mapped to SNOMED CT such as 'Always', 'Never', 'Future', 'Today', 'Tomorrow', 'Yesterday', 'Toddler period', 'Pre school childhood', 'School childhood', 'Duration of operation', 'Examination', 'Delivery' and 'Menarche' can be added to the Qualifier value hierarchy of the SNOMED CT. There are synonymous concepts in the Time Axis. For example, 'Neonatal period' and 'New born period' of ICNP are synonymous and mapped to 'Neonatal (qualifier)' of SNOMED CT.

Concepts in the Location Axis were consisted of construction, position and structure related concepts. Construction related concepts were mapped to the Environment hierarchy of SNOMED CT. Position related concepts were mapped to the Qualifier Value and the Findings hierarchies of SNOMED CT. Structure related concepts were mapped to the Body structure including Morphological abnormality, the Qualifier value and the Physical object hierarchy of SNOMED CT. Concepts not mapped to SNOMED CT includes grouper such as 'Body opening', 'Structure', 'Social structure', and 'Diagnostic department'. Also, there is a problem of hierarchical relationship among 'Parenteral route', 'Intravenous, Intramuscular', and 'Subcutaneous route' of ICNP Version 1. These four concepts were treated as siblings even though 'Parenteral route' and three other routes should have a IS-A relationship.

Concepts in the Client Axis consisted of fetus, group and individual. All the concepts except 'Fetus', 'Couple', 'Nuclear family', 'Extended family', 'Single parent family', 'Female headed single parent family', 'Adolescent community', 'Family caregiver' were mapped to concepts of the Social context hierarchy of SNOMED CT.

Discussion

Mapping ICNP Version 1 concept to SNOMED CT was a very challenging task because two terminologies covers different domains and areas of focus, and have different structures. SNOMED CT is a very broader healthcare terminology covering nursing as well, however ICNP is a nursing terminology. ICNP is consisted of 7-Axis (Focus, Judgment, Means, Action, Location, Time and Client) to represent nursing diagnoses, nursing interventions and nursing outcomes and SNOMED CT is consisted of 19 hierarchies to represent diagnosis, procedures, anatomy, chief complaints, vital signs, physical findings, plans, problem list, history, allergies, immunization and medication management.

Also, the two terminologies have different areas of focus. ICNP covers not only critical care nursing but also community health nursing; however SNOMED CT focuses more on critical care. Also, a concept with same label has different meaning in the two different terminologies. For example, 'depression' in medical domain means 'depressive disorder', however 'depression' in nursing means 'sadness'.

Mapping was also very challenging because it was hard to understand different hierarchies of SNOMED CT. Same concept label was found in different hierarchies. Especially it was hard to distinguish the Finding hierarchy from the Observable entity hierarchy when mapping concepts of ICNP Focus Axis and the Procedure hierarchy from the Qualifier value hierarchy when mapping Service related concepts.

The ICNP concepts were mapped to SNOMED CT concepts based on the definition and/or location of the concept in the hierarchy. Descriptive definitions of ICNP concept was very helpful when mapping to SNOMED CT, however, there are quite a few concepts without text definition (ex, environmental process), with ambiguous definition (ex, obstruction) or more than one definitions (ex, informal settlement). The definitions need to be clarified or new definitions needs to be added.

There was hierarchy problem between parent and child concepts. For example, Integrity was a concept describing a trait of person; however a child concept of Integrity, Skin integrity is a concept describing physical aspect of skin. There are concepts misplaced in wrong Axis. For example, pregnancy prevention, and pregnancy promotion are in the Focus Axis. These concepts should be in the nursing intervention catalogue. Also, there are catalogue concepts in the 7-Axis model. Examples are Alcohol life style prevention, Contamination prevention, and Fall prevention in the Action Axis. They should be in the nursing intervention catalogues.

During the mapping process, we found that SNOMED CT lacks concept describing community health such as health ser-

vices, health policy, community resources, population statistics (e.g., mortality rate, incidence rate, immunization rate, infant death rate, unemployment rate); industrial health, value belief and psychological finding. This can be explained by the history and scope of the two terminologies. ICNP was developed to describe not only acute care setting, but also the community health; however focus of the SNOMED CT has been the acute care setting.

We also found that ICNP concept can be mapped to more than one SNOMED CT concept from different hierarchies. For example, 'specimen' can be mapped to concept in the Substance hierarchy and the Specimen hierarchy. 'Social Status' concept with home ownership, income and social isolation as children concepts can be mapped to concepts of the Observable entity hierarchy and the Social context hierarchy. Concepts describing Services can be mapped to the Regime/Therapy hierarchy and the Qualifier value hierarchy of the SNOMED CT. This is due to the fact that ICNP Version 1 – the 7-Axis model is a building block that can be used to generate nursing diagnosis, nursing interventions and nursing outcomes statements. Thus, a concept can be very ambiguous and not be used before it combines with concepts from other axis.

There are many synonyms in the ICNP Version 1 concepts (ex, 'rash' and 'exanthema'; 'autonomic dysreflexia' and 'dysreflexia'; 'care plan' and 'critical pathway', 'guideline' and 'protocol'). There are concepts hard to distinguish even though their concepts labels are different (ex, 'Tissue perfusion' vs 'Tissue perfusion status', 'teaching' vs 'educating' vs 'instructing'; 'dressing' vs 'getting dressed or undressed' vs 'putting on clothes vs taking off clothes)

There are compound concept which used as a grouper, these concept need to be renamed or divide into two different concepts. Examples are Positive or Negative Judgment from the Judgment Axis, Self dressing or undressing from the Focus Axis, Absorbing or collecting device from the Means Axis, and Heating cooling device from the Means Axis.

When mapping ICNP to SNOMED CT, sometimes parent and child concepts were mapped to different hierarchies of SNOMED CT. For example, 'weight' of the Focus Axis was mapped to Weight in the Observable entity hierarchy; however 'overweight' which is a child concept of 'weight' was mapped to 'overweight' in the Finding hierarchy.

When a concept is not mapped to SNOMED CT concepts and is being used in nursing practice, we either can model the concept in the SNOMED CT or post-coordinated the concept by combining existing SNOMED CT concepts. Examples are pain related concepts such as arthritis pain, cancer pain, and ischemic pain. They can be added under 'Pain (finding)' or they can be post-coordinated by combining 'Pain' in the Finding hierarchy and other concept from other hierarchy. SNOMED CT has atomic concept as well as pre-coordinated concept. Thus, it is hard to decide to add a new concept or post-coordinated a concept by combining two concepts. However, for the concepts from ICNP Version 1 concepts, we have decided to model the concept in the SNOMED CT rather than post-coordinate the concept. We recommended unambiguous fully specified name of the concept and location within the hierarchy to model the concept.

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