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Mapping of Wound Infection Concepts

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Abstract. Wound infection is a serious health care complication. Standardized clinical terminologies could be leveraged to support the early identification of wound infection. The purpose of this study was to evaluate the representation of wound infection assessment and diagnosis concepts (N=26) in SNOMED CT and ICNP, using a synthesized procedural framework. A total of 13/26 (50%) assessment and diagnosis concepts had exact matches in SNOMED CT and 2/7 (29%) diagnosis concepts had exact matches in ICNP. This study demonstrated that the source concepts were moderately well represented in SNOMED CT and ICNP; however, further work is necessary to increase the representation of diagnostic infection types. The use of the framework facilitated a systematic, transparent, and repeatable mapping process, with opportunity to extend.

Keywords. Wound infection, SNOMED, International Classification for Nursing Practice, Nursing Informatics

1. Introduction

Complications associated with wound infection, such as increased levels of pain, increased use of medications (e.g., antibiotics), amputation and death, have become a multi-billion dollar health care expenditure worldwide [10; 12]. Early identification of wound infection is crucial to improve the health and well-being of patients [2]. Advanced health information technologies, embedded with computer-readable assessment concepts, could be positioned to identify and monitor wound infection in patients (e.g., data analytics, machine learning, and predictive modeling). However, a necessary pre-requisite is a better understanding of the adequacy of representation of relevant clinical concepts in information systems. The purpose of this study was to evaluate the rate of equivalence between wound infection concepts and standardized clinical terminologies, using a synthesized mapping procedural framework.

2. Methods

This study used a descriptive concept mapping approach. There is no single methodological approach directing standardized clinical terminology mapping activities. However, researchers have demonstrated various techniques and provided several recommendations to increase the inference, quality and trustworthiness of their work [1; 3-5; 7-9]. The authors of this study have synthesized different terminology and ontology

mapping methods, along with experiential reflection to create and apply the following procedural framework for standardized clinical terminology mapping (Table 1, Figure 1). The authors NH, LC, and SW are senior nursing researchers. LB and CR are emerging nursing researchers. As this was a quality improvement activity with no human subjects or derived data, the project was exempt from university ethics approval [6].

Table 1. Described procedural framework for standardized clinical terminology mapping.

Procedure	Application of Procedure
1. Identification of Source Concepts	Sample concepts (N=26) representing assessment findings and diagnosis of a local wound infection, spreading wound infection, and systemic wound infection (source) were extracted from an international best practice consensus document [12]. Concepts were identified by LB and validated by CR. Each concept was given a clinical definition based on the source document and related literature.
2. Conceptual Model	A Unified Modeling Language (UML) class diagram was created to depict the hierarchical relationships of the selected concepts from the perspective of the source document (as opposed to the existing hierarchy pre-determined in the target terminology). The model was developed by LB and validated by the research team.
3. Scope of Target Terminology	After categorization and development of the conceptual model, it was determined that SNOMED CT (International, July 2019) would be the target terminology for all source concepts (n=26) (i.e., SNOMED CT is designed to represent a wide spectrum of clinical concepts) and the International Classification for Nursing Practice (ICNP, 2019) would be the target terminology for diagnosis concepts (n=7) (due to the ICNP structure to model nursing diagnosis, outcomes and interventions).
4. Mapping Style	The first two authors (LB, CR) manually mapped wound infection concepts to the target terminologies. The use of further mapping techniques (e.g., semi-automated mapping, comparison to existing reference sets) were outside the scope of this study.
5. Mapping Coordination	We used pre-coordination mapping, where each source concept was mapped to a complete concept in the target terminologies (e.g., local wound infection (source) to local wound infection (target)). This is opposed to post-coordination where the source concept or the target concept may be mapped in parts (e.g., 'wound' + 'local infection' as two concepts).
6. Hierarchical Mapping Awareness	Mapping the source concept to the target terminology also included an awareness of the concepts' hierarchical placement in the conceptual model (e.g., erythema was conceptually described to be a clinical assessment finding in the source document and was therefore mapped in position to the target terminology assessment finding hierarchical group).
7. Systematic Search Strategy	Using online browsers, the researchers applied a systematic process of manual searching by: a) using the exact lexical arrangement; if no exact match, then, b) using a clinical synonym; if no exact match, then, c) using the exact lexical arrangement; if no broader than or narrower than match, then, d) using a clinical synonym; if no broader than or narrower than match, then, e) conclude there is no match.
8. Mapping Cardinality	Mapping of the source concepts to the targeted terminologies used the criteria of exact match, narrower than match, broader than match, or no match. An exact match meant that the target terminologies' conceptual term and hierarchical representation had an exact match to the source concept. A narrower than match meant the target terminologies' conceptual term and hierarchical representation were more granular than the source concept. A broader than match meant the target terminologies' conceptual term and hierarchical representation (e.g., infection diagnosis) were less granular than the source concept (e.g., spreading infection diagnosis). A no match result meant that there were no matches in the target terminology.
9. Evaluation of Mapping Results	After LB and CR completed their independent mapping activities, the results were statistically compared for agreement. The final mapping list was developed through a review of all the results and discussion between the researchers (LB, CR). This process was repeated until consensus was attained for all source concepts. The completed list was then reviewed by the larger research team (NH, SW, LC) for verification and face validation. The principles which guided this decision-making process included: a) reflexivity towards the group dynamic of an experiential authority gradient (e.g., perception that the 'other person' has more experience than the other, leading towards a potential for one person to defer to the decision to the 'higher' authority) and b) iterative

Procedure	Application of Procedure
	review the conceptual model, target terminologies, and independent mapping results. While we recognize this process introduced bias, the overall process allowed for the application of investigator triangulation principles between the researcher group (e.g., emphasized opportunities to sort out relevant information) [11].

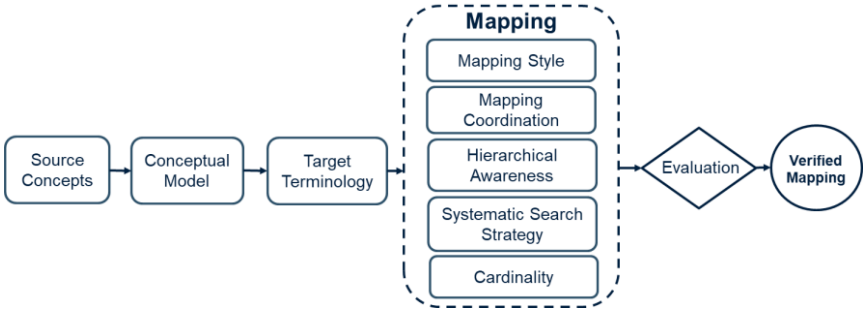

Figure 1. Procedural framework for standardized clinical terminology mapping.

3. Results

Evaluation and consensus development of the mapping results occurred over two meetings between LB and CR. During the first meeting, the researchers combined and compared the results of their SNOMED CT content. During the second meeting, the researchers combined and compared the results of their ICNP content. The initial mapping agreement between the two researchers was 17/26 (65%) for SNOMED CT and 4/7 (57%) for ICNP. After discussion, the researchers came to consensus and the overall mapping results are as follows: a total of 13/26 (50%) wound infection assessment and diagnosis concepts had exact matches in SNOMED CT (Tables 2 & 3). Specifically, SNOMED CT diagnosis concepts had 6/7 (86%) exact matches and assessment concepts had 7/19 (37%) exact matches. A total of 2/7 (29%) wound infection diagnosis concepts had exact matches in ICNP (Table 3).

Table 2. Consensus mapping results for wound infection assessment concepts.

Source	SNOMED CT July 2019	Cardinality
Wound Assessment Signs & Symptoms		
New or increasing pain	No match	N/A
Wound breakdown and enlargement	22247000 | Dehiscence of surgical wound (disorder)	Narrower than
Wound breakdown with or without satellite lesions	No match	N/A
Bleeding, friable granulation	No match	N/A
Hypergranulation	31825002 | Abnormal granulation tissue (disorder)	Exact
Epithelial bridging and pocketing in granulation tissue	No match	N/A
Pocketing in granulation tissue	No match	N/A
Increasing malodour	447547000 | Offensive wound odor (finding)	Broader than
Purulent discharge	225550006 | Purulent discharge from wound (finding)	Exact
Swelling	449740008 | Swelling of periwound skin (finding)	Exact
Local warmth	No match	N/A
Erythema	239163008 | Wound erythema (finding)	Exact
Extending in duration +/- erythema	420356000 | Persistent erythema of skin (finding)	Narrower than

Source	SNOMED CT July 2019	Cardinality
Crepitus	164601001 | On examination - soft tissue crepitus (finding)	Broader than
Delayed wound healing beyond expectations	275952008 | On examination - wound healing delayed (finding)	Exact
Systemic Assessment Signs & Symptoms		
Lymphangitis	No match	N/A
Inflammation, swelling of lymph glands	No match	N/A
Malaise/lethargy or non-specific deterioration	367391008 | Malaise (finding)	Exact
Loss of appetite	79890006 | Loss of appetite (finding)	Exact

Table 3. Consensus mapping results for wound infection diagnosis concepts.

Source	SNOMED CT July 2019	Cardinality	ICNP 2019	Cardinality
Systemic Diagnosis				
Severe sepsis	91302008 | Sepsis (disorder)	Exact	No match	N/A
Septic shock	76571007 | Septic shock (disorder)	Exact	10017898 Septic Shock	Exact
Organ failure	57653000 | Multiple organ failure (disorder)	Exact	No match	N/A
Death	419620001 | Death (event)	Exact	10005560 Death	Exact
Wound Infection Diagnosis				
Local infection	76844004 | Local infection of wound (disorder)	Exact	10023032 Infection (Diagnosis/Outcomes)	Broader than
Spreading infection	No match	N/A	10023032 Infection (Diagnosis/Outcomes)	Broader than
Systemic infection	91302008 | Sepsis (disorder)	Exact	10023032 Infection (Diagnosis/Outcomes)	Broader than

4. Discussion

Wound infection assessment and diagnosis concepts were moderately-well represented in SNOMED CT and ICNP. SNOMED CT had strong representation of diagnosis concepts (exact matches 6/7, 86%) with the assessment concepts less defined (exact matches 7/19, 37%). The assessment concepts from the source document also presented mapping challenges as related to conceptual blurring and presentation of more than one meaning (e.g., Wound breakdown with or without satellite lesions) [3]. ICNP had one concept related to the nursing diagnosis of infection; however, it did not have the specific concept of 'wound' infection nor types of wound infection. These findings point to ongoing opportunities to expand concept coverage in standardized clinical terminologies. This expansion is especially important given the use of SNOMED CT and ICNP to develop decision support, machine learning, and natural language processing. For example, an alert linking interventions to wound infection would be significantly different if the person presented with localized versus systemic symptoms. Having clear, codified concepts available to differentiate between these types of diagnoses is clinically necessary for primary and secondary uses in advanced information technologies [3].

During the mapping activity, the researchers included candidate matches with a cardinality of broader than and narrower than (e.g., ICNP *Infection 10023032*). These findings were purposefully separated in the overall reporting of exact matches in order to provide insight to the hierarchical placement of missing concepts in the target terminologies (e.g., ICNP *Infection 10023032* could become the parent concept to local,

spreading and systemic wound infection concepts). As well, this type of precise mapping could be used to inform the data aggregation of broader administrative reporting (e.g., local, spreading, and systemic wound infection concepts aggregated into ICNP *Infection 10023032* to report on the overall rate of infection in a population).

Finally, the proposed procedural framework for standardized clinical terminology mapping allowed the researchers to complete a systematic, transparent, and repeatable research process. Its use was instrumental in supporting the decision-making processes of mapping. However, the researchers felt further methodological development was necessary. For example, there is need to explicate *how* judgment informed mapping decisions (i.e., how did knowledge or stimuli inform decisions?). While further work is necessary to address these complex processes, the framework offers a promising and replicable procedure which future researchers can use and potentially extend.

5. Conclusion

Wound infection is a significant health care complication. This study evaluated the representation of wound infection assessment and diagnosis concepts in SNOMED CT and ICNP, using a synthesized and explicit mapping procedural framework. The target terminologies had moderate concept coverage, suggesting further development is necessary to adequately codify wound infection concepts.

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