International Journal of Medical Informatics 102 (2017) 103–110

Contents lists available at ScienceDirect

International Journal of Medical Informatics

journal homepage: www.ijmijournal.com

Development and validation of detailed clinical models for nursing actions in perinatal care

Joo Yun Lee, Hyeoun-Ae Park*

College of Nursing, Seoul National University, 103 Daehak-ro, Jongno-gu, Seoul 110-799, South Korea

ARTICLE INFO

Article history:
Received 11 November 2016
Received in revised form 16 March 2017
Accepted 20 March 2017

Keywords:
Semantics
Concept formation
Terminology
Nursing action
Documentation

ABSTRACT

Objectives: The aim of this study was to develop and evaluate detailed clinical models (DCMs) for nursing actions in perinatal care. We propose the use of action-target dyads as entities in DCMs for nursing actions.
Methods: We identified action and target concepts, attributes, and value sets by analyzing nursing documentation and reviewing the wider literature, in addition to published standards and models. We developed the DCMs by linking entities, attributes, and value sets. DCMs were classified by action type based on the Clinical Care Classification, and by target type based on the axes of the International Classification for Nursing Practice (ICNP). Attributes in the DCMs were also classified by ICNP axes. The quality of the DCMs was evaluated by domain experts, and their coverage was evaluated by mapping narrative nursing statements.
Results: Nursing DCMs consisting of 233 entities (dyads comprising 34 action and 212 target concepts), 214 attributes and 541 values were developed. The most frequent action type was hands-on care (43.3%). The focus axis was used most frequently for the targets (51.9%) and attributes (38.8%). The quality scores of the DCMs ranged from 0.80 to 0.96. Most (174/192; 90.6%) of the statements were fully mapped, while 7 (3.7%) were partially mapped and 11 (5.7%) were not mapped. We modified the DCMs in accordance with these results.
Conclusions: In total, 240 DCMs were developed with action-target dyads as entities. The DCMs developed in this study could be implemented in an electronic nursing record system to enhance nursing practices and ensure semantic interoperability of nursing data.

What was already known on the topic

- Nursing DCMs are effective at achieving semantic interoperability of nursing data for describing the health status of patients and associated nursing activities.
- Nursing DCMs for a patient's health status have been developed and implemented in ENRs.
- Efforts for developing nursing DCMs have mainly focused on nursing concepts of the patient status, and so DCMs need to be developed for nursing actions.

What this study added to our knowledge

- The ideal structure for the entity of nursing actions differed from the entity of patient health status. Action-target dyads are proposed as an appropriate entity of DCMs for nursing actions.
- Developed DCMs were arranged in a hierarchy using action-target dyad, which was helpful in creating new models based on the existing models.
- The developed nursing DCMs for a patient's health status can be reused in the development of a nursing action model.

1. Introduction

The rapid adoption of electronic health records, combined with the introduction of clinical data repositories, has made it possible to collect and utilize large quantities of clinical data [1]. Clinical data repositories can be used to ensure high-quality clinical care, as well as in studies that yield evidence to improve clinical practice [2]. Clinical data can be utilized more effectively if the embedded information is exchanged and understood independent of the system in which it was generated [3]. That is, semantic interoperability can be ensured, which has been defined as "the ability of infor-

* Corresponding author.
E-mail addresses: jylee3130@gmail.com (J.Y. Lee), hapark@snu.ac.kr (H.-A. Park).

http://dx.doi.org/10.1016/j.ijmedinf.2017.03.009
1386-5056/

mation systems to exchange information on the basis of shared, pre-established, and negotiated meanings of terms and expressions" [4].

To achieve full semantic interoperability, three layers of artifacts are needed to represent the meaning of clinical information [5]: (i) a reference model that provides a logical structure for exchanging information across systems, (ii) clinical terminology that conveys the meaning of information in a consistent manner via a systematized and controlled vocabulary, and (iii) an agreed data structure (clinical model) that connects reference models and clinical terminology by representing specific concepts within a conceptual model, including the data elements, structures, and relationships.

There are ongoing efforts to develop these three layers of artifacts with the aim of achieving semantic interoperability of nursing data pertaining to patient health status and nursing actions. One such nursing reference model is the International Organization for Standardization (ISO) 18104:2014 standard, entitled "Health Informatics: Categorial Structures for Representation of Nursing Diagnoses and Nursing Actions in Terminological Systems" [6]. Nursing terminology standards include NANDA-I, NIC, and NOC (together known as NNN) [7], the Clinical Care Classification (CCC) [8], and the International Classification for Nursing Practice (ICNP) [9]. The applicability of standard terminology has been tested with reference to nursing documentation [10–12].

Agreed data structures have been developed with numerous names, such as detailed clinical models (DCMs), clinical elements, care information models, clinical content models, clinical templates, and archetypes, but work on these data structures remains in the early stage [13].

The DCM, one of an agreed data structure [13] is "a relatively small, stand-alone information model designed to express a clinical concept in a standardized and reusable manner [14]". DCMs consist of entity-attribute-value (E-A-V) triplets, in which an entity is the core data element, an attribute is a qualifying concept that explains the entities in more detail, and the value set is a uniquely identifiable set of values that an attribute can have [15].

Nurses document each patient's health status, the nursing actions that have been carried out, and the impact of these actions on patient outcomes in nursing records [16]. Nursing DCMs have been developed to describe the status of stroke patients [17], breast cancer patients [18], cancer survivors [19], perinatal patients [20], and patients at admission [21]. The DCMs developed to date have been used to generate nursing narratives via natural language generation technology [22,23]. DCM-based nursing narratives have been implemented in electronic nursing records (ENRs) for structured data entry [15]. To the best of our knowledge, development and use of DCMs has mainly focused on nursing concepts relevant to patient health status, and only a few reports are available on DCMs for nursing actions [24].

The first task when developing a DCM is to identify a core concept. In DCMs pertaining to the health status of patients, the core concepts belong to the focus category of the ISO reference model for nursing diagnoses [25]. Nursing actions are defined as "Acts performed by or under the direction of a nurse, with the intention of directly or indirectly improving or maintaining the health of a person, group or population." by the ISO reference model for nursing actions [6]. According to this model, "a nursing action expression shall have a descriptor for action and at least one target descriptor." Thus, a nursing action core concept can either be an "action" or a "target". A previous study of DCMs of nursing actions [24] used action concepts as the core concept, with target concepts represented as mandatory attributes. One problem with this approach is that it requires attributes qualifying other categories than the "action" category. For example, in the action "inserting indwelling urinary catheter," 'inserting' is a core concept and 'indwelling urinary catheter' is a target concept. However, the attribute "depth of inserting indwelling urinary catheter" qualifies neither an action (i.e., "inserting") nor a target (i.e., "indwelling urinary catheter"), but it does qualify the nursing action of "inserting indwelling urinary catheter".

Another problem is that the attributes of nursing actions vary depending on the mandatory target concept. For example, the core concept of "measuring" can have "body temperature", "respiration rate", "pulse rate", "blood pressure", "urine output", or "wound size" as its target. Based on the target, attributes such as "device", "posture" or "anatomical site" could be added to the model.

These problems can be solved if an entity is composed of action-target dyads (e.g., measuring body temperature) with attributes used to qualify these dyads in more detail. The approach of using action-target dyads as entities fits well with the ISO reference model for nursing actions [6]. Studies of actual nursing actions [26], and of nursing narratives describing nursing actions [27,28], have reported that nursing actions always include action and target concepts. These studies support the use of action-target dyads as a core concept of nursing actions.

With this background, we propose the use of action-target dyads as an entity in DCMs for nursing actions. The aim of this study was to develop and evaluate DCMs for nursing actions during perinatal care to be implemented in ENRs as a follow-up study of DCMs pertaining to the health status of patients [20].

2. Methods

This study was divided into development and evaluation phases, as described below.

2.1. Development

2.1.1. Identifying action, target, attribute, and value terms and concepts

We identified action and target concepts, attributes, and value sets by analyzing nursing documentation and reviewing the wider literature, in addition to published standards and models.

First, we collected 27,596 narrative statements, used to document nursing activities, from the ENRs of 63 women who were hospitalized and gave birth from March 1 to April 30, 2012 at a tertiary teaching hospital in Korea. Unique nursing statements were extracted from these statements by removing lexical redundancies. We then decomposed the unique statements into meaningful terms.

Second, we reviewed the literature on perinatal care, including a book on perinatal nursing published by the Association of Women's Health, Obstetric and Neonatal Nurses (AWHONN) [29] and a book on the fundamentals of nursing [30]. We also analyzed 843 nursing activities of 26 NIC interventions [31] that were relevant to perinatal care and extracted meaningful terms related to nursing actions from the literature. Terms taken from nursing documentation and the wider literature were classified into actions, targets of actions, and attributes, with values sets describing the nursing actions in more detail.

Third, we extracted additional terms for attributes and values by reviewing published terminology standards, such as the "Conceptual Framework for Patient Findings and Problems in Terminologies" of the ISO [32], and models, including DCMs, pertaining to patient health status [20].

This process involved extracting terms for actions, targets, attributes, and values. These terms were used to identify concepts for actions, targets, attributes, and values after removing syntactic and semantic redundancy. The authors, who have experience in health terminology and DCM development, extracted the terms