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Development and evaluation of data entry templates based on the entity-attribute-value model for clinical decision support of pressure ulcer wound management

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ABSTRACT

Purposes: The purpose of this study was to develop and evaluate the functionality of structured data entry templates using the entity-attribute-value (EAV) model for clinical decision support of pressure ulcer wound management.

Methods: A data set for wound assessment of pressure ulcers that has commonly been recommended by clinical practice guidelines was identified, and then the EAV models on each data were developed. Structured data entry templates and a database were developed based on these EAV models. These were integrated with a knowledge engine into the clinical decision support system (CDSS) to provide patient-specific recommendations on pressure ulcer wound management. The functionality of the EAV model and structured data entry templates for the CDSS was evaluated heuristically by five nurse experts using clinical scenarios.

Results: The data set containing 13 entities was identified and EAV models of these entities were created. Cardinalities and data types of attributes were defined to represent the models in more detail. Terms used in the EAV models were mapped to SNOMED CT concepts. Six data entry templates and the relational database with ten tables were developed. Five nurses successfully entered all data in the scenarios except one data element and retrieved expected recommendations successfully from the clinical decision support system when all data were entered correctly.

Conclusions: The clinical data models and structured data entry templates developed in this study were useful in supporting clinical decision making on pressure ulcer wound management.

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1. Introduction

A clinical decision support system (CDSS) is a computer program that helps health care professionals make clinical decisions and deal with clinical data to provide decision support services in terms of information management and

patient-specific consultation [1,2]. Efforts to use these CDSSs more effectively have continued over 40 years to provide best practices. However, despite many studies aiming to prove the effectiveness of CDSS, several obstacles remain in applying CDSSs at the point of care. One of the obstacles is that there are not enough coded data available with precise meaning which is necessary to provide the service [3,4]. This becomes

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more problematic when providing patient-specific consultation based on clinical practice guidelines. That is to say, the meaning of the data entered by clinicians into clinical information systems must correspond with the meaning of the data used by a CDSS so that the clinical decision support application produce accurate inference results [5,6].

Huff identified several requirements for sharing and exchanging information in CDSSs including standardized coded data for accurate and reliable execution of decision logic, representation of patient data as name-value pairs, and the relationship between terms and information/data models that provide the context of use [6]. The most common strategy to represent data that are sent between different computer systems is sending the data as name-value pairs (also known as entity-attribute-value triplets) such as detailed clinical models of HL7 and the archetype of GEN [7,8]. The entity-attribute-value model is used to represent medical data more clearly and exchange data between data bases and clinical decision support systems to make recommendations at the point of care. To implement the EAV model into information effectively, data specifications, and technical implementation specifications should be added [9,10]. The conceptual framework of ISO/TS 22789:2010 is a good reference model to create the entity-attribute-value model, because it provides greater consistency in structure for entering and retrieving data [11].

Another strategy for obtaining data with precise semantics is using the structured data entry templates, which are a useful interface collecting clinical data based on a data model. Structured data entry allows users to enter data based on pre-defined value sets and this is essential for assuring uniformity of data for decision support and clinical research [12,13].

The aim of this research is to develop and evaluate how clinical data models and structured data entry templates support clinical decision making effectively. More specifically, this study deals with issues such as recording data in a structured way for pressure ulcer wound assessment and obtaining data for clinical decision support for nursing interventions. Pressure ulcers were selected for this study due to their high prevalence rate at 7.4% [14] and the fact that they are one of the most important health problems of homecare nursing in Korea.

Our research questions are as follows:

- Is it possible to create entity-attribute-value models for pressure ulcer wound assessment data?
- Is it possible to implement these entity-attribute-value models into a clinical decision support system via structured data entry templates?
- Are structured data entry templates useful for providing precise semantics for a clinical decision support system?

To answer these questions, we developed structured data entry templates based on data models, and a database for a decision support system for pressure ulcer wound management and tested the usefulness of the data entry templates.

2. Methods

This study comprised four steps: (1) identifying the data set for wound assessment of pressure ulcers; (2) developing

entity-attribute-value (EAV) models of data elements in the data set; (3) developing a clinical decision support system for pressure ulcer wound management by developing structured data entry templates and database, and integrating structured data entry templates and database with a knowledge engine; and (4) evaluating the process of data entry and recommendation retrieval.

2.1. Identifying the data set for wound assessment of pressure ulcers

A data set is required to assess pressure ulcer wounds, to plan treatment and to evaluate wound care progress according to guidelines for pressure ulcer management. In order to identify the data set, three guidelines for pressure ulcer care were reviewed. These guidelines were retrieved from the National Guideline Clearinghouse using the keywords of ‘pressure ulcer’ and ‘bed sore’, and the website <http://www.npuap.org>. Sources for the guidelines were the WOCN [15], Registered Nurses Association of Ontario [16], and NPUAP [17].

The content validity of the data sets identified was evaluated by three home care specialists using 4-point Likert scale with 1 being “least valid” and 4 being “most valid”.

2.2. Developing entity-attribute-value models of data elements in the data set

Entities in the EAV models are the core concepts of assessment items for pressure ulcer wounds in this study. Attributes are the concepts that explain entities in more detail. For example, “body site”, and “laterality” describe the location of ulcers more precisely. A value set is a collection of the concepts that an attribute can have. For example the attribute of “laterality” has ‘right’ and ‘left’ as values.

Entities, attributes and values were identified from the guidelines. The standards document “ISO/TS 22789:2010 Health informatics—Conceptual framework for patient findings and problems in terminologies” was referred to categorize the characteristics of values and keep the naming of attributes consistent [11]. In addition to naming attributes, cardinality and data type of each attribute were defined. Data types of attributes used in this study are from data type list of HL7.

Since the coded data are needed for accurate and reproducible execution of decision logic, all the concepts in the EAV model were mapped to the SNOMED CT, the most widely used reference terminology in healthcare.

2.3. Developing a clinical decision support system for pressure ulcer wound management

The CDSS for pressure ulcer wound management was developed by integrating structured data entry templates, a database, and a knowledge engine. Structured data entry templates were designed based on the documentation process of the pressure ulcer care by home care nurses and the EAV models of each data element. A relational database was developed using MYSQL. The tables and fields in the relational database were defined corresponding to entities and attributes in EAV models. The knowledge engine used in this study was u-BRAIN

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