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Development and Evaluation of a Prototype CDSS for Fall Prevention

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Abstract

We developed a prototype CDSS that 1) provides tailored recommendations by combining a fall-risk prediction model, patients data, and evidence from CPGs, and 2) helps nurses to plan nursing care and document their activities for fall prevention. The accuracy of rules in knowledge base and inference engine was verified using ten scenarios and heuristics of user interface evaluated by four experts. We are currently evaluating the effects of the system on nurses' workflow and patient outcomes.

Keywords:

Accidental falls; Decision support systems, Clinical; Evidence-based nursing

Introduction

According to the AHRQ, the learning health system is a system that integrates internal data and experience with external evidence, and puts that knowledge into practice. As a result, patients receive higher quality, safer, and more efficient care.

We have been working to develop a small scale of learning health system to prevent falls, which is the most common adverse event threatening patient safety in the acute care settings. In our learning health system, EHR data as 'internal data' is integrated with nurses' clinical experience and clinical practice guidelines (CPGs) for fall prevention as 'experience' and 'external evidence', respectively. A fall prevention clinical decision support system (CDSS) is a tool that enables knowledge to be put into practice. The fall prevention CDSS might allow nurses to provide a high quality of care for fall prevention and improve patient safety and efficiency of workflow.

Existing fall prevention CDSSs could not provide tailored actionable recommendations based on evidence at the point of care. Furthermore, CDSSs could not automatically extract patient data which was already inputted into EHR system, so users had to input data manually. To be able to 'learn' in the learning health system, the results of practice must be recorded.

Our final goal is to develop a near real-time fall prevention CDSS that provides tailored nursing recommendations by combining fall-risk model, EHR data, and evidence from CPGs, and supports nursing care plan and documentation. On that journey, we have developed a prototype CDSS.

Methods

Figure 1 represents three components of the fall prevention CDSS which we are developing as a final goal. A fall-risk prediction model (component A.) was developed and validated. In this article, we focused on how we developed a knowledge base, an inference engine (component B), and an user interface (component C).

The scope of development of a prototype CDSS is identical with the fall prevention CDSS except for automatic extraction of EHR data. Finally, we evaluated an accuracy of rules in knowledge base and inference engine, and heuristics of user interface.

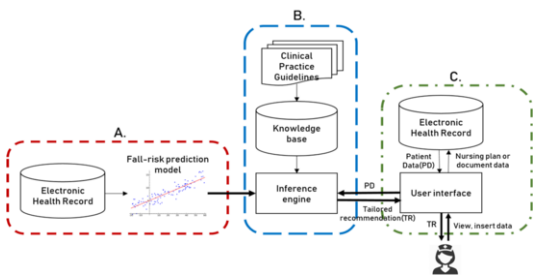

Figure 1-Components of the fall prevention CDSS

We developed the prototype CDSS in accordance with the following four stages of the system development life cycle.

Plan - functional requirements analysis

We examined a variety of tools CDSS encompassed from the literature [1] and specified functions of this system in detail through interviews with three nurses.

Design

Knowledge base

Published CPGs on fall prevention were retrieved from the National Guideline Clearinghouse and Google scholar. Knowledge was extracted from the selected 7 CPGs using MS Excel.

The knowledge was represented by decision rules using the IF-THEN rules.

User interface

Reflecting the results of the functional requirements, we designed a user interface. With our user interface, a nurse can modify information of a patient's fall-related variables and can plan nursing care and document their activities for fall prevention. The user interface was developed using Visual Studio 2017/2017 C#, NetFramework 4.0, and DevExpress 17.2 tools.

We have aligned recommendations with nursing statements the study hospital uses in order to document nursing activities performed according to the CDSS's recommendations. For recommendations not mapped to existing nursing statements, we have added new nursing statements.

Implementation

The fall-risk model, patient data, and knowledge extracted from CPGs were combined in order to provide tailored nursing recommendations by risk group and risk factors a patient has. For example, the process of inferring a patient with 'a high risk of falling' and providing recommendations for them is as

follow: First, patient data is entered into the fall-risk prediction model and the risk of falling is calculated. If the risk of falling is greater than or equal to the cutoff, the patient is identified as 'a high risk of falling'. Then, knowledge on nursing intervention for patient with 'a high risk of falling' is extracted from knowledge base and printed on the screen.

Evaluation

Rules in knowledge base and inference engine

We tested an accuracy of rules that calculate the risk of falling and provide the tailored nursing recommendations using ten scenarios. Of 15,450 patients' data, we randomly selected ten patients and compared their risk of falling calculated by the system to the risk of falling that we manually calculated. In addition, we manually modified values of the fall-related variables of ten patients and verified whether CDSS printed out nursing recommendations accurately based on modified risk factors.

Heuristics of user interface

In accordance with Nielsen's heurisitcs principles [2], four evaluators who majored in nursing informatics were asked to try the prototype and to rate the severity of each usability problem with a scale from 1 to 4. For principles with an average score higher than 3, the system has been revised to fix that issue.

Results

Plan- functional requirements analysis

We defined 'computerized alerts and reminders to care provider' and 'clinical guidelines' as key functionalities of a fall prevention CDSS. Specified functional requirements of the CDSS were 1) the CDSS is able to calculate the risk of falling using patient data, 2) the CDSS is able to alert nurses to identify patients with a high risk of falling, 3) the CDSS is able to provide tailored nursing recommendations according to risk factors that a patient has, 4) the CDSS allows nurses to manually modify a state of patient if necessary, and 5) the CDSS enables nurses to plan and document nursing care for fall prevention according to the recommendations.

Design

Knowledge base

We extracted 75 specific knowledge related to risk factors and 69 general knowledge related to environment. An algorithm was developed by linking 42 rules defining the value of each variable and 19 tailored recommendations.

User interface

When a patient's condition changes, a nurse can modify values of fall-related variables manually (Figure 2). Then, the system recalculates the risk of falling and displays tailored recommendations. Based on the recommendations, the system enables a nurse to plan nursing care and to document nursing activities for fall prevention.

Implementation

Figure 3 shows a screenshot of the prototype CDSS providing tailored recommendations according to a risk of falling (a high risk) and risk factors a patient has. Nurses can track the trends in a risk of falling and get tailored recommendations by risk factor when they click on the risk factors.

Evaluation

Rules in knowledge base and inference engine

There was no inconsistency between the risk of falling the CDSS calculated and the risk of falling we manually calculated. The CDSS printed out nursing recommendations without errors according to the modified risk factors.

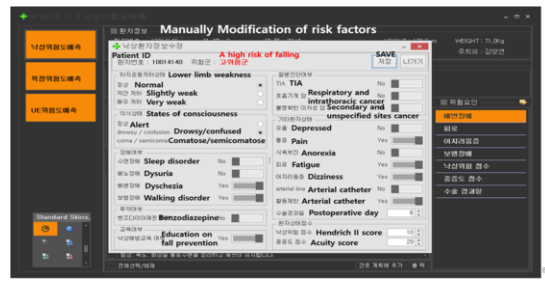

Figure 2-A modification of values of fall-related variables

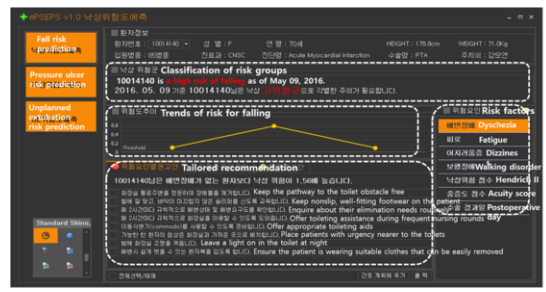

Figure 3-A risk of falling, risk factors, and tailored recommendations,

Heuristics of user interface

Only the 'consistency and standards' principle, which indicates compliance with platform conventions, were lower than 3.

Conclusions

The prototype CDSS has several limitations. First, it cannot extract EHR data automatically. Second, knowledge extracted from CPGs was not tested for its applicability to clinical settings. Thus, a validation of the nursing recommendations by the experts is needed. Nevertheless, this system can help nurses to provide evidence-based tailored nursing for fall prevention without any extra workload.

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