journal homepage: www.intl.elsevierhealth.com/journals/cmpb

A smart medication recommendation model for the electronic prescription

Shabbir Syed-Abdul[a], *Alex Nguyen*[a], *Frank Huang*[a], *Wen-Shan Jian*[b], *Usman Iqbal*[a], *Vivian Yang*[c], *Min-Huei Hsu*[a,*], *Yu-Chuan Li*[a,*]

[a] *Taipei Medical University, College of Medical Science and Technology, Graduate Institute of Biomedical Informatics, Taiwan*

[b] *Taipei Medical University, School of Health Care Administration, Taiwan*

[c] *College of Medical Science and Technology, Institute of Biomedical Informatics, Taiwan*

ARTICLE INFO

Article history:
Received 13 January 2014
Received in revised form 4 June 2014
Accepted 27 June 2014

Keywords:
NHI database
Medications
Inappropriate prescription
Diagnosis-Medication association
Smart medication recommendation model

ABSTRACT

Background: The report from the Institute of Medicine, To Err Is Human: Building a Safer Health System in 1999 drew a special attention towards preventable medical errors and patient safety. The American Reinvestment and Recovery Act of 2009 and federal criteria of 'Meaningful use' stage 1 mandated e-prescribing to be used by eligible providers in order to access Medicaid and Medicare incentive payments. Inappropriate prescribing has been identified as a preventable cause of at least 20% of drug-related adverse events. A few studies reported system-related errors and have offered targeted recommendations on improving and enhancing e-prescribing system.

Objective: This study aims to enhance efficiency of the e-prescribing system by shortening the medication list, reducing the risk of inappropriate selection of medication, as well as in reducing the prescribing time of physicians.

Method: 103.48 million prescriptions from Taiwan's national health insurance claim data were used to compute Diagnosis-Medication association. Furthermore, 100,000 prescriptions were randomly selected to develop a smart medication recommendation model by using association rules of data mining.

Results and conclusion: The important contribution of this model is to introduce a new concept called Mean Prescription Rank (MPR) of prescriptions and Coverage Rate (CR) of prescriptions. A proactive medication list (PML) was computed using MPR and CR. With this model the medication drop-down menu is significantly shortened, thereby reducing medication selection errors and prescription times. The physicians will still select relevant medications even in the case of inappropriate (unintentional) selection.

* *Corresponding authors.*
E-mail addresses: drshabbir786@gmail.com (S. Syed-Abdul), alexnthhp@gmail.com (A. Nguyen), frank0202@gmail.com (F. Huang), jj@tmu.edu.tw (W.-S. Jian), usman.iqbal85@gmail.com (U. Iqbal), vyang@tmu.edu.tw (V. Yang), 701056@gmail.com (M.-H. Hsu), jaak88@gmail.com, jack@tmu.edu.tw (Y.-C. Li) .

http://dx.doi.org/10.1016/j.cmpb.2014.06.019
0169-2607/

1. Introduction

Electronic Prescription (ePrescription, eRx) is one of the functionality/module of the computer-based order entry (CPOE) or electronic health record system (EHR) used by health providers for prescribing, transferring, dispensing and monitoring of the medications [1]. Barach et al., reports that nearly 100,000 individuals die per year in the U.S. due to preventable medical errors [2], and medication errors were found to be a major type of medical error [3]. The release of the Institute of Medicine report, To Err Is Human: Building a Safer Health System in 1999 drew a special attention towards preventable medical errors and patient safety [4]. The advancement in the information technologies, particularly health information exchange within and among hospitals has been proven to significantly reduce medical errors and improve patient safety [5]. A decade later, under the American Reinvestment and Recovery Act of 2009 and federal criteria of 'Meaningful use' stage 1, e-prescribing was mandated to be used by eligible providers in order to access Medicaid and Medicare incentive payments [6,7].

Reduced medication errors and improved patient safety have become the important indicators used for evaluating hospital performance and for approval of 'meaningful use' accreditations. Studies have reported more than an 80% of decrease in the medication errors in the in-patient settings with the use of ePrescription system [5,8,9]. Therefore, e-prescribing has been promoted as a potential information system in order to reduce medication errors and increase patient safety [8,10].

Although on the one hand there are studies published that have evaluated the ePrescription system and reported the positive results [5,11,12], on the other hand there are studies revealing CPOE systems possess potential risk for 22 types of medication error [13] Up to 35% of prescribing errors were system-related (selection of an inappropriate (unintentional) drug from the drop-down menu next to a likely drug)[14]. Inappropriate prescribing has been identified as a preventable cause of at least 20% of drug-related adverse events [15,16]. A few studies reported system-related errors and have offered targeted recommendations on improving and enhancing e-prescribing system [17,18].

Therefore, this study is aimed to enhance efficiency of the e-prescribing system by reducing the risk of inappropriate selection of the medication and also to reduce the prescribing time of the physicians. In order to do so we proposes a smart model that recommends most commonly prescribed medications in the drop-down menu for a given diseases.

2. Method

Taiwan's national health insurance claim data was used to compute the Disease-Medication association for all prescriptions from 1st January to 31st December 2002. Out of a total of 263.57 million prescriptions from out-patient clinics 160.09 million were excluded for the following reasons: (a) missing/invalid disease code or medication code; (b) medication written in the Mandarin; and (c) prescription of traditional Chinese medications. About 103.48 million prescriptions with the diagnosis in a valid (International Classification of Disease v.9 – Clinical Modification) ICD9-CM code and medications in the national health insurance (NHI) codes were analysed. Taiwan's NHI medication codes were mapped into ATC (Anatomical Therapeutic Chemical) Classification System in order to quantify disease-medication association. Fig. 1 shows the study design. The NHI permits up to three diagnoses, therefore usually a prescription consists of 1–3 diagnoses, and 1–15 medications.

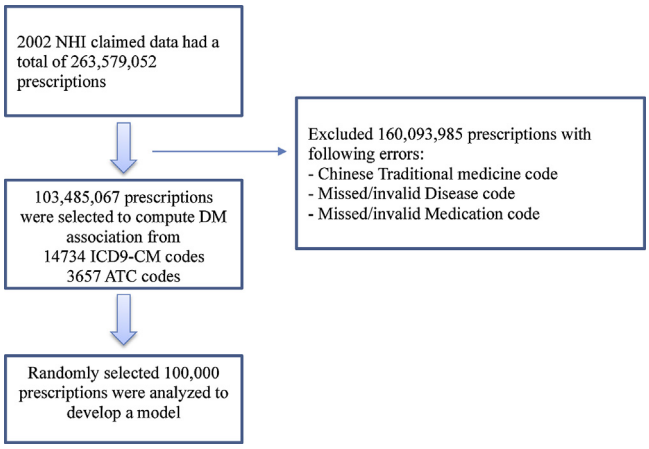

Fig. 1 – Study design.

A smart medication recommendation model was developed by the following steps:

1. To quantify the disease-medication (DM) association frequencies from the 103.48 million prescriptions.
2. To calculate the DM 'interestingness' (lift) value and then ranked value for each of the 14,734 diseases.
3. To compute the Mean Prescription Rank (MPR) and Coverage Rate (CR) of the medications from randomly selected 100,000 prescriptions.
4. To decide Coverage Rate of medications by alphabetical order for the proactive medication list (PML).
5. To demonstrate the user interface of the model.

2.1. *Step 1: To quantify the disease-medication (DM) association frequencies*

All the 103.4 million valid prescriptions were selected in order to compute frequencies of the associations for every diagnosis with all the medications prescribed. Each prescription consists of 1–3 ICD9-CM codes and 1–15 medications. The 103.4 million prescriptions had 14,734 unique ICD9-CM codes for diseases with 3657 ATC codes for medications resulting in 53.8 million unique associations and a total of 798.5 million associations.

2.2. *Step 2: To calculate the DM 'interestingness' (lift) value and ranked for each of the 14,734 diseases*

Association rule mining was performed on structured claim database of the NHI. The popular association measure of interestingness of a rule 'lift' was used [19,20]. A lift value greater than 1.0 indicated that a prescription with diagnosis A tended