eMed™: Computerised physician drug order entry optimises patient safety

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Summary

Adverse drug events (ADEs) are frequent in hospitals. They can be prevented to a large extent by minimising human errors in the prescription process. The development of a computerised physician order entry (CPOE) was initiated (eMed™, Qualidoc AG, Berne-CH) at the University Hospital of Bern with the support of two national grants (KTI). After comprehensive analysis of the prescription process, the software was designed on the basis of Web services. Simultaneously, the medication database was designed (Hospindex™) in cooperation with the main medical database supplier (e-mediat AG, Schönbiühl CH). Implementation of eMed drug order entry software resulted in an immediate and demonstrable improvement of quality in the medication process. The first and most important step was to eliminate illegible handwritten orders. In addition, most other prescribing errors decreased significantly in the selected categories monitored, i.e., specifically, excessive dosing, incomplete or unclear orders, drug interactions, transcription errors, and drug allergies. Nevertheless, the trial study showed that resistance to implementation of a novel electronic technology should not be underestimated; it also highlighted the need for a sophisticated project strategy involving all categories of medical personnel.

Introduction

Adverse drug events (ADEs) have been shown to be one of the most frequent causes of death in Western industrial nations. In the United States, ADEs cause more fatalities than traffic accidents, AIDS, or breast cancer [1]. Among hospitalised patients in the United States, ADEs cause more fatalities than diabetes and pneumonia [2]. Fattinger et al. reported that 11% of all hospitalised patients suffered clinically relevant ADEs during their stay [3]. According to the latest studies, most of these documented ADEs could have been avoided [4]. As many published studies have already shown, the most efficient tool for increasing safety in the hospital drug administration process is a computerised physician order entry (CPOE) system [5–9]. Illegibility and resultant transcription errors can be effectively avoided in this way [10–13].

On the basis of these results, the Department of Orthopaedic Surgery of the University Hospital of Bern designed a drug order and dispensing system called eMed. The development of eMed is supported by two Swiss Government grants (Bundesamt für Berufsbildung und Technologie KTI Nr. 7428.2 and Nr. 9128.1) and was initiated in December 2005.

The newly developed software is intended for use not only for ordering and documenting medications, but also includes several safety checks such as drug-drug interactions, drug overdose warnings, allergies, renal adaptation, etc. Furthermore, the Swiss Arzneimittelbrevier® and Arzneimittelkompendium® are instantly available within the application to assist users in finding the information needed. This article describes the development process of the eMed software and first results after clinical introduction.

Methods

Context

On the basis of a proposal by the Swiss Federal Department of Home Affairs (FDHA), the Swiss Federal Council approved the National eHealth Strategy for the period 2007–2015. The Swiss eHealth level is generally considered rather advanced, but there have been some delays when compared with foreign activities in the same area. For this reason, the priority is to develop high-quality eHealth solutions to improve efficiency and reduce additional costs (approximately CHF 144 million per year).

The Swiss eHealth strategy has two main facets: first, it provides a somewhat vague roadmap for nationwide implementation of regional electronic medical records (EMRs). In addition, it suggests that the objective should be to build up a Web-based nationwide electronic health platform by the year 2012, with the aim of providing the public with high-quality medical information. The Swiss eHealth strategy says that electronic medical records, which are called “patient dossiers” in Switzerland, should be available for all citizens by the year 2015.
Basic principles

Improving drug safety by computerised prescription and drug management systems

It is widely accepted that electronic prescription and integrated drug information systems can reduce avoidable errors in prescription and dispensing. The specific functionalities needed to improve the safety and quality of drug management have been defined on the basis of an analysis of causes of preventable adverse drug events. These include, for example, retrieval and display of all currently active drugs and automated alerts for relevant prescribing problems (therapeutic duplication, excess dose, dose adjustment for weight, drug-drug, drug-age, and drug-allergy contraindications) prioritised by importance and avoiding transcription errors.

One fundamental aspect of an electronic drug ordering software of this kind is the availability of a national and internationally accepted structured database that includes all relevant aspects (contrainteractions, drug dosages, references). On the basis of a structured data bank of this kind it was possible to create a dosage check by integrating safety-relevant databases into the ordering process and establishing a complex warning and feedback system to inform the user of possible problems with patients' medication. Additionally, a clearly formulated survey of patient medications must be created. This includes easy handling and utilisation and software uniformity, to render the use of eMed uniform in any institution.

Survey of eMed medication software

Because of the complexity of pharmacotherapy, medication software must be as clear as possible while allowing input of complex medication orders. However, knowledge of and experience with computers and software vary considerably among medical personnel. eMed was therefore designed to be similar to the familiar handwritten prescription process (fig. 1). On opening, eMed displays a list of all hospitalised patients of a specific ward. The user can select an individual medication schema for a specific patient, including the name of a drug, dosage, form of administration, and medical advice. Additionally, the contents of a patient's medication chart and information about medication history can be verified. Medicaments that were stopped or modified can be displayed separately.

If a new drug is prescribed by a physician, a red marker appears next to the patient’s name. The new drug is in red in the medication list and must be signed by the nurse (fig. 2). The clear overview given by the software is one basic precondition for minimising transcription errors.

Electronic prescription capabilities

The user can generate electronic prescriptions by finding and selecting a drug name (by entering the first three letters of either the generic or the brand name). Physicians can also select a drug from a so-called parameterisable quick order entry (fig. 3). Here most common drugs of a department are displayed in a touch-screen mode presenting the right dosage, form, and frequency. Both prescription processes are designed to guide users in obtaining a complete and flawless prescription. If one essential declaration is missing, the user is immediately informed.

User-selectable alerts filtering for potential prescribing problems

The drug information database uses documented allergies, verified diseases, age, gender, weight, and all active prescribed and dispensed medications as input to assess a potential prescription problem, such as drug-disease, drug-age, drug-allergy, and drug-drug interactions, duplicate therapy, cumulative toxicity (multiple drugs with the same side effect, e.g., sedation), and drug dose (too high, too low) for a specific selected patient. The drug information database is questioned using Web services with each new prescription. Alerts are displayed as pop-up messages and can be recalled accessorially (fig. 4). Interactions are classified into three levels of severity: (1) severe interaction (absolutely contraindicated), (2) moderate interaction (should be avoided if possible), and (3) mild interaction (use with caution). Physicians can selectively filter the severity of alerts to be displayed and suppress any given alert for a particular patient or patient group if they consider it to be clinically irrelevant.

Alerts can be displayed when opening a patient file, when viewing a drug profile, and when generating a prescription.

Another powerful safety check is the age and weight adapting dose check developed in this project (fig. 5). Warnings are accompanied by a display of detailed information about usual doses classified by age and weight. Using a so-called security cockpit, the software generates a current risk profile with regard to contraindications or the recommended dose. In situations involving patients aged over 65, potential renal and/or liver insufficiency, or pregnancy and lactation periods,
the security cockpit graphically displays the different risks. The Schweizer Arzneimittelbrevier and Arzneimittelkompendium of Switzerland can also be accessed electronically within the application for immediate online information concerning the medication chosen.

Design

The performance, acceptability and use of the eMed system was assessed in a longitudinal 4-month follow-up study (December 2005 to March 2006) by a medical project manager, a pharmacist, a nurse and a medical software engineer. From this information the analysis and design of the software was defined. The already existing medication module of the clinic information system Qualicare® (Qualdoc AG, Bern, Switzerland) was used as a basis for further development and improvement.

The software prototype was installed after a phase of intensive testing and evaluated in a hospital orthopaedic ward for a period of 4 months. For scientific purposes, all entered data, drug interactions and dose warnings were recorded in a logfile. The 20-bed pilot station was equipped with two desktop computers and four notebook computers. To achieve better mobility for all participating members (physicians, nurses), a wireless LAN was installed prior to the start of the pilot trial.

During the preparation phase, the ward physicians (15 min) and the nursing staff (30–45 min) were introduced to and trained on the software prototype. A 24-hour on-call service was provided to resolve problems and answer questions during the pilot trial. The study was approved by the competent authorities of Bern University Hospital.

Results

During the 4-month trial period, a total of 4,662 datasets were gathered. In total, 4,014 new drug orders (e.g., drugs, infusions, blood products, ointments, etc.) were assigned to 214 patients. On average, patients received 19 different drugs during their stay. A total of 650 orders (16%) were modified; 1,530 orders (22%) were stopped.

Transcription errors

Because of the clear overview of medication, all computerised drug order entries were flawlessly readable at any time for all participants. Transcription errors, as mentioned, were completely eliminated by use of the newly developed software.
Prescription handling

One of the most difficult objectives of the eMed project was easy handling and usability of the prescription functions. In addition to the alert function, it was important to offer drug relevant information provided by the Swiss Arzneimittelbrevier and Arzneimittelkompendium when a prescription was written. Physicians could easily be informed of specific drugs and indications. Also, the two possibilities for ordering drugs, especially the fast entry screen, received highly favourable feedback from physicians and nursing staff. The aim of the quick prescription program, to simplify drug orders and fulfill house-intern pharmacotherapy guidelines, was fully met. As intended, the quick prescription order entry was used for most standard medications (>80%).

Alerts and drug modification

As mentioned, a total of 4,662 datasets were gathered and 4,014 new drug orders were assigned. Analysis of these datasets in reference to the alert function and security checks revealed the following.

A total of 1,472 newly prescribed drugs (736 interaction events) were involved in potential interactions. Subdivided among the various severity codes, 296 mild, 421 moderate, and 19 severe potential drug interactions were identified (table 1). The ordering physician was always informed of the occurrence of drug interaction(s). With regard to the online dose check, 15 overdosages were prevented before reaching the patient. The drugs that were overdosed contained strong active and potentially hazardous agents such as furosemide (diuretic), pethidine (morphine derivative), methotrexate (chemotherapeutic agent), and venlafaxine (antidepressant).

Even in a short trial period of only 4 months the safety of medication was increased significantly by the prevention of potential interactions before the relevant drugs were prescribed. These results show a significant impact on patient safety.

Table 1. Drug interactions (n = 736).

<table>
<thead>
<tr>
<th>Class</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>296</td>
<td>421</td>
<td>19</td>
</tr>
<tr>
<td>%</td>
<td>40%</td>
<td>57%</td>
<td>3%</td>
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Setting

At the beginning of the pilot trial, all staff involved needed more time for the drug ordering and documentation process. In particular, during the first 2 months, 24-hour support was needed because new medications were prescribed irrespective of time. As doctors and nurses got used to the new medium, the time needed for working processes decreased considerably after the first month. Physicians and nursing staff agreed on the distinctive advance in safety achieved by the new eMed drug ordering software and, by the end of the trial, medical personnel estimated overall time
Discussion

A series of studies have demonstrated that computerisation of drug ordering has improved medication safety significantly [14, 15]. Early investigations showed that even with limited decision support serious medication errors fell by 55% after the introduction of CPOE [7]. In addition, implementation of clinical decision support such as renal dosing [16] and geriatric dosing [17] results in improved quality of the medication process.

The results of our study agreed fully with these and revealed that after implementation of eMed the rate of medication errors was significantly minimised. In particular, illegibly handwritten prescriptions, which are responsible for the majority of medication errors, were immediately eliminated. The overall effect of this reduction will be published in a forthcoming paper.

Other study groups have evaluated CPOE systems and use of computerised information to reduce the frequency of ADEs and improve care. Tierney et al. found that implementation of a CPOE system in a medical service resulted in a shortening of the average hospital stay [18]. Evans et al. found that implementation of computerised ADE surveillance, coupled with drug allergy alerts to pharmacists, standardisation of antibiotic administration rates, and physician notification of ADEs, reduced ADE rates significantly [19]. Another study found that use of a computer-assisted management programme for antibiotics cut costs substantially while quality of care improved in an ICU, chiefly because allergic reactions to drugs were reduced and accuracy of drug dosing was improved [20].

The eMed programme is in continuous development and, at the time of the study, did not include all the support that will be ultimately available. Nevertheless, implemented basic control functions, such as dose check, interaction check, pregnancy and age control and the security cockpit, have already been rated by all staff involved as increasing the quality of medication significantly. Considering that most of today’s hospitalised patients receive more than 10 drugs during their stay (in this study, 11 or more), it is evident that the complexity of pharmacotherapy precludes safe handling of the prescription process without electronic support.

Other important improvements which we expect to substantially reduce ADE rates are the implementation of drug-laboratory checking and drug-patient characteristic checking, which would include adjustment of dosages for renal failure and age [21, 22]. Despite all the favourable effects resulting from use of electronic drug ordering and documentation software, the problems accompanying introduction of a new information technology should not be underestimated. Several researchers have emphasised that organisational and clinical work issues are more critical obstacles than technical issues [23–25].

The sometimes problematic process of introducing a CPOE may also be related to the initial perception by personnel that an electronic prescription process is more time-consuming than the handwritten process, due to the inflexibility of the application, working through multiple screens, periodic changes in the log-in process, or user password requirements [26]. Callen et al. pointed out that further studies on physicians’ work practices relating to the use of CPOE are needed in order to understand the drawbacks of an electronic drug ordering system of this kind [27]. Our experience during testing of eMed demonstrates that handling of computer systems varies dramatically depending on users’ individual prior knowledge. Individualised instruction and training is needed, with significant 24-hour support, especially at the very beginning. In this study, first-level support decreased from 8 calls per day in the first week to one call per 2 weeks at the end of the 4-month trial. Regarding other problems mentioned above, the impact of resistance to new electronic methods of documentation should likewise not be underestimated. It is very important to include all personnel in dissemination of information about the background and purpose of drug order entry software.

Sophisticated, multilevel project management with a comprehensive information strategy is the essential key to implementing a system of this kind into daily clinical work.

Conclusions

The implementation of drug order entry software such as eMed results in an effective and demonstrable improvement of quality in the medication process. The first and most important step is to eliminate illegible handwritten orders. Furthermore, such systems continually increase the accuracy of prescriptions by integrating security checks and medication knowledge databases into the medication process. Nevertheless, the implementation of a CPOE demands a sophisticated project strategy involving every category of medical personnel.
References