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Decision Support for Medication Use in an Inpatient Physician Order Entry Application and a Pharmacy Application

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Abstract

Studies have shown that adverse drug events are common, expensive, and due to causes that can be remedied by information technologies. At our institution we have developed a physician order entry application and a pharmacy application designed to decrease the risk of such adverse drug events. In this paper, we describe the applications, with attention to the clinical decision support features present in each. We also describe the manner in which the two applications interact.

Keywords

Physician Order Entry, Clinical Decision Support, Pharmacy Applications, Adverse Drug Events

Introduction

Recent studies have demonstrated that adverse drug events (ADEs) in hospitalized patients occur commonly [1, 2, 3], are a major source of morbidity, and may account for US$4 billion in annual costs in the United States, half of which is preventable. [4] Systems analyses have determined that a small number of defects in hospitals' systems account for the majority of the preventable ADEs. [5] Examples of systems failures that lead to ADEs are deficiencies in drug knowledge dissemination, poor dose and patient identity checking, unavailability of patient information, transcription errors, and lack of allergy defense mechanisms. All of these categories of failures can be addressed with advanced information technologies such as computer physician order entry and clinically oriented pharmacy information systems.

Computer physician order entry (POE) [6-8] is an application that allows orders to be entered into the computer system by physicians interactively. The motivations for POE include: 1) the ability to provide real-time decision support to physicians as part of the ordering process, 2) more timely communications of orders to nursing and ancillary departments (e.g., lab and pharmacy), 3) improved legibility and decreased transcription errors, 4) the easy availability of ordering data for statistics and research, and 5) remote access to physician ordering data for activities such as utilization review and quality management. POE can be used in either the inpatient or outpatient settings; in this paper we refer only to the inpatient setting. POE is still relatively uncommon in the United States but its popularity is growing.

Inpatient pharmacy applications primarily support administrative functions of hospital pharmacies such as dispensing, billing, label printing, and reporting. However, clinical functions such as detection of drug-drug and drug-allergy interactions, and the presentation of relevant clinical data to the pharmacist at the time of dispensing are also desirable in pharmacy applications and have been provided by many pharmacy application vendors.

At Brigham and Women's Hospital in Boston, Massachusetts, an internally developed POE application has been in place since 1993. In 1994, work began to replace the aging, internally developed pharmacy application with a new internally developed application. The new pharmacy application was intended to have an interface to physician order entry and the patient database to convey ordering data to pharmacists and to provide pharmacists with access to detailed clinical data. The new pharmacy system went live in late 1996. We report here on clinical decision support features in POE and the new pharmacy application designed to minimize the risk of ADEs, as well as the interaction between the two applications.

Materials and Methods

Background

Partners Healthcare System is an integrated healthcare delivery network in Boston, Massachusetts. It is comprised of two large academic hospitals (Brigham and Women's Hospital and Massachusetts General Hospital), several smaller community hospitals and other affiliated institutions (e.g., rehabilitation and psychiatric hospitals), and a large affiliated physician network. Partners were formed in 1993 and the various institutions still have distinct information systems. The work in this paper was carried out at Brigham and Women's Hospital (BWH).

BWH is a 700-bed hospital with 35,000 admissions annually. The information system at BWH is known as BICS, for Brigham Integrated Computing System. BICS runs on a LAN with Intel-based servers and clients; currently there are 150 servers and 6,000 clients. BICS software is written in Mumps and Visual Basic with a Mumps database. BICS provides

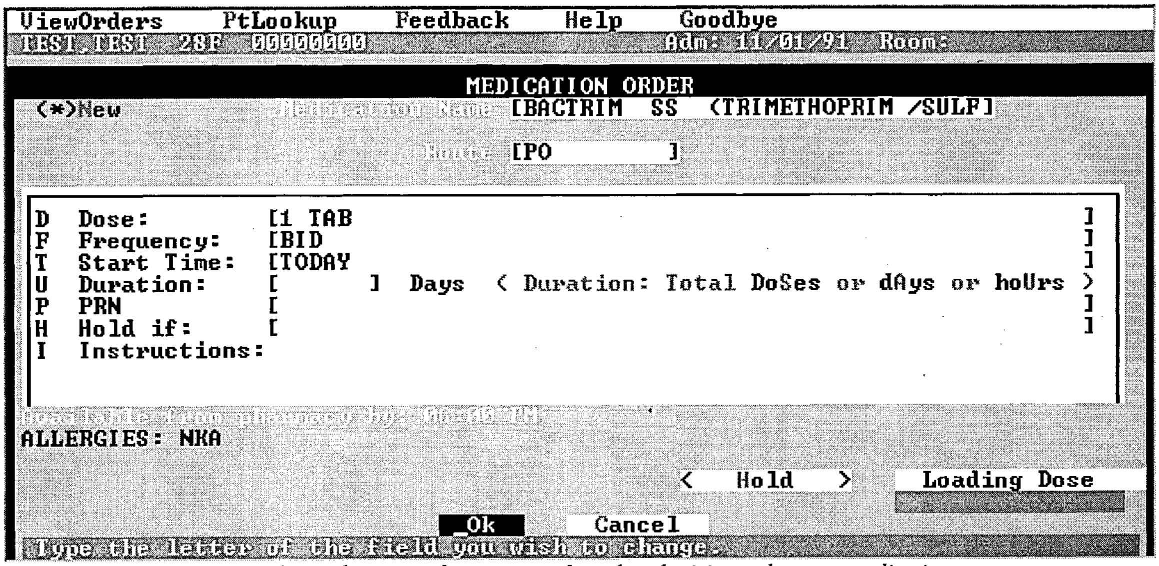

Figure 1 - Medication ordering screen from the physician order entry application.

financial, administrative, ancillary, and clinical functions. The clinical functions include physician order entry, an outpatient medical record, access to educational resources, a patient-provider coverage list application, and an event monitor.

System design

Order entry:

BICS POE allows all types of orders to be entered (e.g., medications, laboratory and radiology tests, nursing orders, etc.). The current user interface was developed with a character-based windowing toolbox. An example of a user dialog box is shown in Figure 1. A new version of POE is under development; the new user interface will be written in Visual Basic and will run in a Windows environment.

The medication order entry function of POE allows the physician to type in the name and the route of the desired medication. Synonyms and trade names are supported. Once the medication is selected, the most common doses and frequencies for that medication are offered to ease the data entry. Additional fields such as duration, special start time, and special instructions are optional. Physicians may enter any dose for any medication they wish; they are not restricted to commercially available formulations.

There are several decision support features integral to medication ordering in BICS. Examples include: 1) drug-allergy interaction checking (Figure 2), 2) drug-drug interaction checking, 3) duplicate medication warning, 4) alternative therapeutic suggestions (for less expensive, bioequivalent medications), 5) counter-detailing educational screens that discourage use of expensive medications and may ask the user to enter reasons describing why the medication is being used, and 6) special chemotherapy data entry screens to decrease the risk of erroneous orders.

Pharmacy system:

The BICS pharmacy application in place prior to 1996 provided only basic administrative functions. Increasingly at BWH, pharmacists are being asked to play a clinical role to assure the optimal use of medications. Certain pharmacists are assigned to specific clinical services, and pharmacists participate in rounds and have high visibility as part of the clinical team. The new pharmacy application needed to support the expanded clinical role of pharmacists at BWH. Specifications for new pharmacy application included: 1) electronically receiving orders from POE, 2) decreasing pharmacist data entry time, 3) displaying a wide variety of clinical data at the time the pharmacists review and approve medication orders, and 4) providing a wide variety of clinical decision support features. To meet these goals, the new pharmacy application needed to be internally developed. Examples of the features of the application that interact with POE will be described.

Medication orders are transmitted electronically from POE. Pharmacists review new medication orders on a screen with a list box that shows the oldest order first, the number of new orders per patient, and the type of order (e.g., antibiotic, chemotherapy, renewal, etc.). In this way, the pharmacists can act on the most important order first.

A patient summary screen (Figure 3) is available at any time. The patient summary screen shows a wide variety of clinical data. This includes: physician, diagnosis, outpatient data, allergies, height, real weight, ideal body weight, creatinine clearance, flags indicating if the patient is receiving and MAO inhibitor or warfarin, laboratory results, drug levels, microbiology data, and notes about the patient that a pharmacist may have entered previously.

Another screen displays the patient's current medication profile. In certain workflows, this screen must be viewed, forcing the pharmacist to examine the patient's other current medications. The patient's medications may be sorted by a variety of

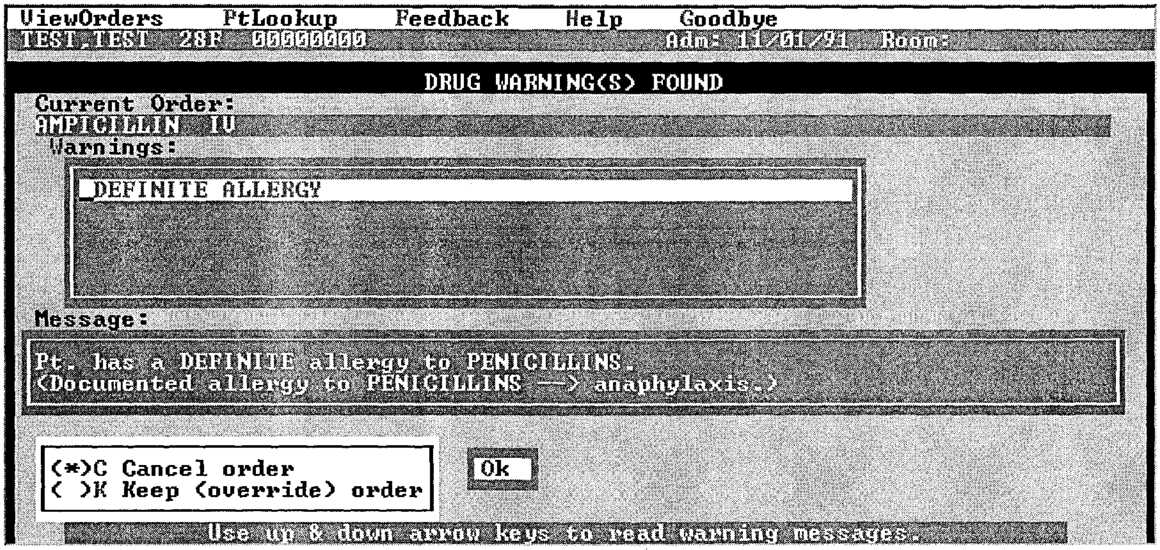

Figure 2 - Drug-allergy interaction screen from physician order entry application

fields including start date, medication name, and category of drug.

The order approval screen (Figure 4) displays the actual order. A "preferred package", if one exists, is also displayed. A dictionary of preferred packages is maintained by the pharmacy that creates a link between common medication orders and the medication package that the pharmacy wishes to dispense for that order. A preferred package is available for about 2/3 of all orders. Also, on the approval screen, the pharmacist may edit the default values for the medication's schedule, and its start and end times, and a note may be entered. If a preferred package is presented and no edits are required, approval of the medication requires only a single keystroke.

Decision support in the pharmacy system:

Having patient data easily available (as in the screens mentioned above), is an important decision support feature for the pharmacists clinical activities. Flags for certain medications such as MAO inhibitors and warfarin are also very helpful. Additionally, if a physician has overridden a drug-allergy, drug-drug, or duplicate therapy warning as part of the ordering process, that information is conveyed to the pharmacist as part of the order. The pharmacist is presented with, and also must override, the warning.

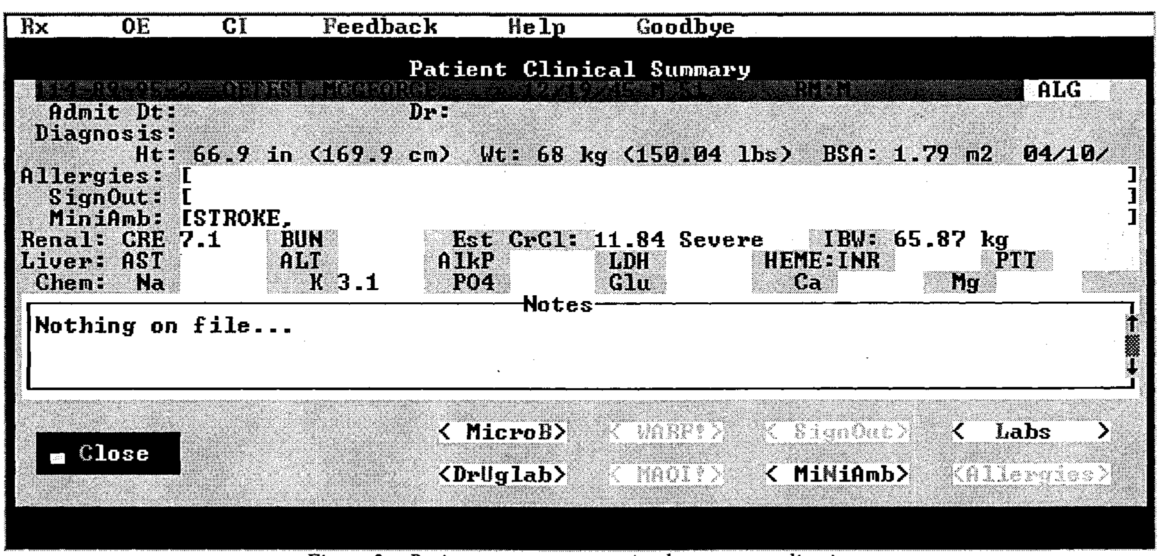

Figure 3 - Patient summary screen in pharmacy application

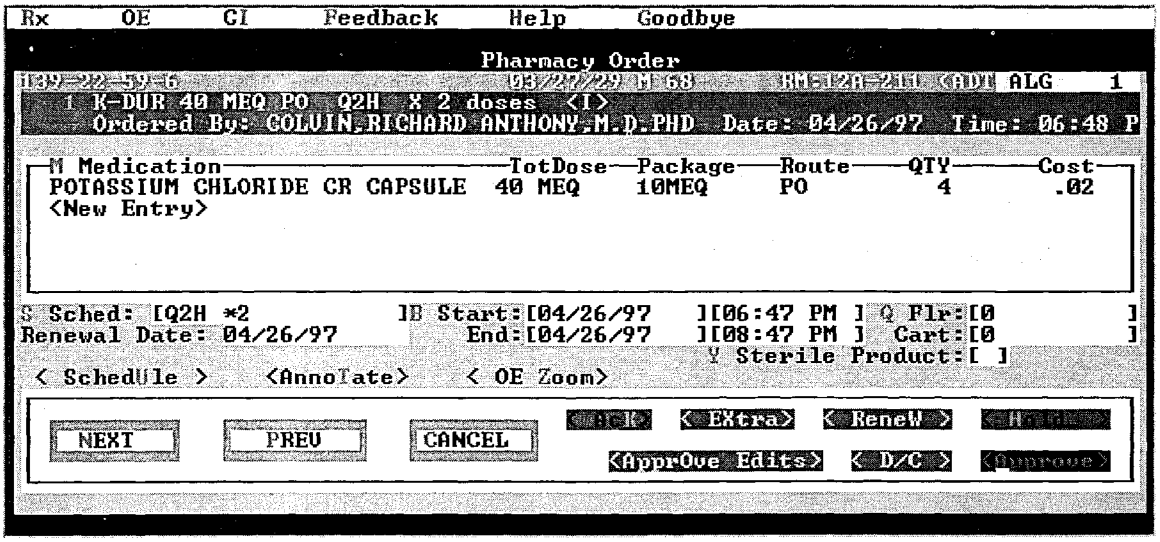

Figure 4 - Order approval screen from pharmacy application

Results

New pharmacy application:

The new pharmacy application has been functioning since December of 1996. In general, the pharmacists are pleased with the application and feel that their workflow has been improved. They feel that they spend less time at data entry though no formal measurements have been carried out. The conversion to a graphical environment (albeit character-based) required significant training.

Impact of POE on the number of pharmacy orders:

POE has led to an increase in the average number of medication orders per patient of about 25%. This is due to the ease with which order sets and templates that contain multiple medications can be ordered. Orders responsible for the increase include, but are not limited to, PRN medications for sleep, indigestion, and analgesia which are now commonly ordered on all patients.

Interaction between the pharmacy application and POE:

The electronic interface between the pharmacy application and POE did indeed lead to more rapid transmission. However, this was a double-edged sword. In the previous, paper-based system, paper orders would be carried to the pharmacy where, intermittently, pharmacists would fill the order and carry it to the floor. Nurses learned to expect a reasonable interval before medications were delivered to the floor. Now, nurses know that the pharmacist has the order instantaneously and call the pharmacy more frequently to see when the medication will be delivered. Some pharmacists have remarked about being "tied" to the computer workstation because they need to check frequently to see if there is any new medication orders. To ease this problem, we are considering interfacing the pharmacy system to the paging system to make the pharmacists aware automatically when there are a certain number of new orders or certain type of important order.

For certain orders, pharmacists have needed to interact with the physician for clarification or to get an order edited. Currently, there is no way for the pharmacist to "send the order back to POE", i.e., there is only a one way interface from POE to pharmacy. There needs to be a way for the pharmacist to send orders back to the MD for revision and this capability is being developed.

Also, certain procedures in the paper world were forgiving in a way that automated systems are not. For example, physicians often write post-operative orders before the patient goes to surgery. Post-operatively, a physician in the receiving unit may write a set of orders not knowing that orders were written pre-operatively. In the paper-based systems, the pharmacy would realize that the second set of orders was redundant and discard them. There is no way to "discard" orders in the electronic world – they must be handled in some way. This feature has been designed into the pharmacy application.

Discussion

Both of the applications described in this paper have the potential to decrease the frequency of ADEs. POE has the greatest potential for such care improvement because the physician is the primary decision maker; giving him or her useful information at the time of the order minimizes the chance for error. Pharmacists also have an important role to play in the management of medications; at BWH they participate as part of the clinical team. Therefore, giving pharmacists information allows them to act to reduce the risk of ADEs as well.

Studies have shown that adverse events are often due to errors in multiple steps in a pathway [5]. Having redundant systems (e.g., where physicians and pharmacists both can view relevant clinical data and receive automated warning message) is important to help assure error-free medication delivery.

Also, because some errors occur at the time that information is handed off from one party to another (e.g., transcription errors), having automated interfaces decreases the likelihood of medication errors and consequent adverse events.

Although it is likely that these automated systems will decrease the number of adverse events, further research is necessary to confirm that this is the case. Also, as with any new technology, careful evaluation is necessary to confirm that untoward side effects are not introduced.

Conclusions

ADEs are common and expensive and can be remedied by various kinds of information and organizational technologies. We have presented examples of information technologies in place at our institution designed to address the problems. Ongoing study is needed to determine that the interventions have their intended effect and cause no new problems.

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