Addition of electronic prescription transmission to computerized prescriber order entry: Effect on dispensing errors in community pharmacies

Thomas T. Moniz, Andrew C. Seger, Carol A. Keohane, Diane Lew Seger, David W. Bates, and Jeffrey M. Rothschild

Most health care is provided in the ambulatory care setting, and prescription medications were discussed at approximately 71% of outpatient visits in 2007. In 2009, 3.9 billion prescriptions were filled in the ambulatory care setting in the United States, 40% of which were new prescriptions. A 2003 study found that 3% of new prescriptions in chain pharmacies were associated with dispensing errors. These data suggest that more than 45 million dispensing errors occur annually when filling new prescriptions. Many types of errors can occur in the medication-use process, and the Institute of Medicine has ranked medication errors among the leading causes of preventable death in the United States.

Dispensing errors are believed to be on the rise for several reasons, including increasing prescription volumes per pharmacy, pharmacist

Purpose. The addition of electronic prescription transmission to computerized prescriber order entry (CPOE) and its effect on dispensing errors in community pharmacies were evaluated.

Methods. A controlled, before-and-after trial to measure the effect of electronic prescribing on dispensing errors in two control clinics and one e-prescribing clinic already using CPOE was conducted between January and November 2006. Prescriptions documented within the CPOE system were reconciled with dispensed prescription information from participating pharmacy chains via a national pharmacy information exchange network. Dispensing errors were defined as discrepancies between the prescriber's written orders and the dispensed prescription information. Prescriptions filled at nonparticipating pharmacies were not analyzed.

Results. A total of 11,447 prescriptions were written in the control clinics, and 29,575 were written in the e-prescribing clinic. During the intervention period, 2,179 (22%) of 9,905 intervention clinic prescriptions were electronically transmitted, including 621 (28%) available for analysis. There was no significant difference in the dispensing-error rates between the baseline and intervention periods for the control clinics. Similarly, the dispensing-error rates did not differ significantly for the e-prescribing clinic between the baseline and intervention periods for prescriptions that were not electronically transmitted. The e-prescribing clinic's dispensing-error rate for electronically transmitted prescriptions during the intervention was significantly lower than its baseline dispensing-error rate ($p = 0.03$).

Conclusion. Electronic transmission of prescription data from physicians' offices to a pharmacy nearly halved the risk of dispensing errors compared with generating the prescription with outpatient CPOE and printing it and giving it to the patient.

Index terms: Computers; Dispensing; Errors, medication; Medication orders; Pharmacy, community; Physicians

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Dr. Bates serves on the clinical advisory board for IntelliDot, which makes bar-coding applications for hospitals. He formerly served as a consultant for Cardinal Health, which manufactures i.v. drug delivery systems. The other authors have declared no potential conflicts of interest.

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Electronic prescription transmission

system. All sites used a common and well-established CPOE system developed at BIDMC. The two control clinics included a general internal medicine clinic and a geriatric internal medicine clinic. The e-prescribing clinic was an internal medicine teaching site with resident physicians. The most active physicians in the e-prescribing clinic were approached for consent to participate in this study.

The study was conducted between January and November 2006. During a two-month baseline period, prescriptions at all three clinics were generated with CPOE and given to the patient or faxed to his or her pharmacy. Development, implementation, and testing of the electronic prescription transmission functionality occurred over the following six months. During the two-month intervention period, prescriptions at the control clinics continued to be printed and handed to patients. At the e-prescribing clinic, participating physicians’ eligible prescriptions were electronically transmitted to participating pharmacies. Prescriptions were ineligible for electronic transmission if the patient’s pharmacy was not using electronic transmission technology or the prescribed medication was not approved for electronic transmission. At the time of the study, Schedule II substances, such as oxycodone, were not permitted to be prescribed electronically. These prescriptions were printed and handed to the patient during all stages of the study.

After the study began, we learned that seamless interoperability of prescribing and pharmacy information systems had not been fully achieved. The majority of the pharmacies processed prescriptions by first printing a paper-based copy of the electronically transmitted prescriptions and then reentering prescription data into the pharmacy system.

SureScripts, a national pharmacy information-exchange network founded by chain retail pharmacies in 2001, provided the pharmacy dispensing data. SureScripts uses the National Council for Prescription Drug Program standards within a secure electronic network between prescribers and pharmacies. The network is designed to facilitate electronic prescribing and refilling of prescriptions and provide prescribers with pharmacy dispensing histories and third-party-payer formulary and eligibility data for individual patients.

We adopted the following definitions for this study. Prescribing history was prescription information documented in the CPOE system. Dispensing history was pharmacy prescription information provided by SureScripts. Dispensing errors were discrepancies between the prescribing and dispensing histories for a drug such that the two were not therapeutically equivalent. Clinically significant dispensing errors were those dispensing errors where the wrong drug, the wrong dose, or the wrong instructions were dispensed to the patient. Corrected prescribing errors were prescriptions in which the medication order contained a potentially harmful error that was resolved, presumably by the pharmacist, in the dispensed prescription. Prescriptions for review were prescriptions with a dispensing history generated within 30 days of the prescribed date. When prescribing or dispensing histories indicated multiple instances of a medication being dispensed within 30 days, the two prescriptions with the fewest number of days elapsed between prescribing and dispensing were considered associated and reviewed. When multiple dispensing or prescribing histories were created on the same day, the histories without an error (or the fewest errors) were reviewed. Prescriptions not for review—prescribing histories associated with dispensing histories in which all relevant dispensing data were not available—were

Methods

Prescribing data were collected from one e-prescribing clinic and two control clinics in the Beth Israel Deaconess Medical Center (BIDMC) network of pharmacies and an increasing number of sound-alike and look-alike medications. Clearly, improvements in the ambulatory medication-use system are needed.

Electronic transmission of prescriptions represents one potential system improvement. During electronic prescription transmission, prescriptions generated within an outpatient computerized prescriber-order-entry (CPOE) system are electronically transmitted directly to pharmacies. This process has the potential to streamline dispensing within pharmacies by decreasing the number of prescriptions telephoned in from physician offices and reducing the time pharmacists spend entering prescription information into the pharmacy information system. To realize these benefits, pharmacies must have adequate equipment, software, and training to permit seamless data transmission from prescribing to dispensing medications. Many clinicians believe that the electronic transmission of prescriptions can significantly reduce the frequency of community pharmacy dispensing errors—beyond those seen with CPOE alone—in part by eliminating pharmacist transcription and data entry. In addition, transmitting prescription information directly to pharmacies may decrease the number of lost prescriptions or those not presented to the pharmacy when doses are adjusted.

Few data are available regarding the effect of electronic prescription transmission on dispensing errors. The objective of this study was to measure the impact of adding electronic prescription transmission functionality to a preexisting CPOE system on the rate of dispensing errors.
excluded from analysis, because all data points could not be re-viewed. Patient-centered errors were instances in which the dispensing history matched a previous dispensing history but not the most recent prescribing history or in which a dispensing history differed in more than one aspect from the most recent prescribing history. These instances suggested that the prescription in question may not have been presented to the pharmacy by the patient or may have originated outside of the study clinics. An example of this would be a dosage change in the prescribing history that did not appear in the dispensing history. Patient-centered errors were excluded from the analysis of dispensing errors.

The analyzed components of a prescription included the drug, strength, dosage form, dose, route, and frequency. Prescriptions written for a 90-day supply are often dispensed as a 30-day supply due to third-party payer policies. As a result, the quantity dispensed was not included in the analysis. Also, we chose to include only those prescriptions dispensed within 30 days of prescribing.

One study pharmacist reviewed all prescriptions by reconciling prescribing histories with dispensing histories. Another study pharmacist reviewed a convenience sample of 100 prescriptions to test interrater reliability. The kappa statistic was used to determine the interrater reliability for determining dispensing errors. Dispensing-error rates were compared using chi-square analysis. The a priori level of significance was 0.05.

**Results**

The control clinics were staffed by 6 full-time attending physicians. The e-prescribing clinic included 300 part-time and full-time physicians, with 55 full-time equivalents.

A total of 41,022 prescriptions were studied, including 11,447 prescriptions from the control clinics and 29,575 prescriptions from the e-prescribing clinic (Figure 1). The control clinics provided in the baseline and intervention periods 524 and 569 prescriptions, respectively, that had complete prescribing and dispensing information available for analysis. The e-prescribing clinic provided 4,599 analyzable prescriptions that were not electronically transmitted during the baseline period and 920 in the intervention period. During the intervention period, the e-prescribing clinic provided 621 analyzable electronically transmitted prescriptions. The prescribing histories not available for review resulted from incomplete data from one pharmacy chain, prescriptions filled at nonparticipating pharmacies, prescriptions not filled within 30 days of the date written, or prescription information placed in the electronic medical record only for documentation and future reference. Among the 7,233 prescriptions analyzed, 78 dispensing histories (1.1%) contained discrepancies that indicated a corrected prescribing error and were thus not counted as dispensing errors (Table 1).

There was no significant difference in the dispensing-error rates between the baseline and intervention periods for the control clinics. Similarly, the dispensing-error rates
did not differ significantly for the e-prescribing clinic between the baseline and intervention periods for prescriptions that were not electronically transmitted. However, the e-prescribing clinic’s dispensing-error rate for electronically transmitted prescriptions during the intervention period (1.8%) was significantly lower than its baseline dispensing-error rate (for prescriptions not electronically transmitted).

The most frequent types of errors identified included strength, dose, and frequency errors. Errors involving additional instructions that were incomplete or potentially harmful and without restrictions or limits, such as “as needed for pain,” were generally less common. The interrater reliability for identifying dispensing errors was excellent (kappa statistic, 0.94).

**Discussion**

Dispensing errors in the e-prescribing clinic were reduced by about half when prescriptions were electronically transmitted to pharmacies versus those prescribed with CPOE alone. These findings suggest that electronic transmission of prescriptions to pharmacies has error-preventing benefits beyond CPOE alone, such as the removal of handwriting misinterpretations and the provision of decision support. Future studies may find additional benefits as the technology matures and as pharmacies eliminate the manual reentry of prescription data.

Clinically significant dispensing-error rates were similar to those reported in direct observation studies (1.5–4.9%). An advantage of the current study is that the data source for dispensing errors was the prescription records within each prescriber’s clinic. This methodology

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**Table 1.**

Comparison of Errors in Settings With and Without Electronic Transmission (ET) of Prescriptions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control Clinics (Without ET)</th>
<th>E-prescribing Clinic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline Period (n = 5,093)</td>
<td>Intervention Period (n = 6,354)</td>
</tr>
<tr>
<td>No. pharmacies</td>
<td>80</td>
<td>98</td>
</tr>
<tr>
<td>No. prescription histories available for analysis</td>
<td>524</td>
<td>569</td>
</tr>
<tr>
<td>No. patient-centered errors</td>
<td>Current dispensing history same as previous one</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Wrong dose and frequency</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Wrong strength and dose</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Wrong strength and frequency</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Wrong strength, dose, and frequency</td>
<td>0</td>
</tr>
<tr>
<td>No. prescription histories analyzed</td>
<td>520</td>
<td>554</td>
</tr>
<tr>
<td>No. (%) without error</td>
<td>497 (95.6)</td>
<td>525 (94.8)</td>
</tr>
<tr>
<td>No. (%) with corrected prescribing error</td>
<td>6 (1.1)</td>
<td>8 (1.4)</td>
</tr>
<tr>
<td>No. (%) with dispensing error</td>
<td>17 (3.3)</td>
<td>21 (3.8)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>No. with wrong dose</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>No. with wrong frequency</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>No. with wrong strength</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>No. with inappropriate “as directed” label</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>No. with “as needed” missing or added</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>No. with wrong route</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>No. with other error</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

<sup>a</sup><sup>p</sup> = 0.757 for comparison with baseline period for control clinics.
<sup>b</sup><sup>p</sup> = 0.730 for comparison with baseline period for e-prescribing clinic.
<sup>c</sup><sup>p</sup> = 0.034 for comparison with baseline period for e-prescribing clinic.
allowed more-accurate study of discrepancies between the intended prescription and the dispensed prescription. We are unaware of reports of similar multipharmacy-based studies concurrently analyzing a prescriber’s medical records and a pharmacy’s medication record.

A 2002 report by an Omaha poison control center found that half of the reports involving pharmacy errors were wrong-strength medications given to the patient, with labeling instruction errors accounting for most of the remaining errors. Using the medication-profiling functionality of electronic prescription transmission that provides prescribers with actual dispensed prescription data, prescribers may be able to detect these errors during clinic visits and intervene before a serious adverse drug event occurs. Awareness of inpatient and community dispensing errors has fostered the development of both technological and nontechnological interventions to decrease dispensing errors, including bar coding, improved manual workflow, separation of look-alike medications, and automated dispensing processes.

As of 2009, 57% of physicians in Massachusetts routed prescriptions electronically. This represents a substantial increase from only 25% in 2007. However, due to a low overall adoption rate of electronic health records and electronic prescription transmission, despite being the leading state in electronic prescribing, Massachusetts was estimated to have electronically transmitted only 13% of eligible prescriptions in 2007 and 32% in 2009. Electronic prescription transmission is receiving growing attention at the national level, with the rate of electronic prescription transmission tripling to 12% between 2008 and 2009 and leaping to 20% nationally during the first quarter of 2010. The Medicare Electronic Medication and Safety Protection Act of 2007 was introduced, which sought to provide funding to physicians to offset the costs of implementation of electronic prescription applications, but never became law. Electronic prescribing is part of the 2011 criteria for meaningful use in the ambulatory care setting.

In addition to clinician- or pharmacist-initiated errors, some of this study’s data may represent patient-initiated errors. In some instances, current dispensing histories matched previous ones but not the current prescribing history. Patients who did not present the new prescriptions at the pharmacy might have accounted for this type of error. Electronic prescription transmission has the potential to eliminate this sort of error, though patients still need to be compliant in picking up the medications from the pharmacy. This study did not evaluate patient compliance in taking the medications and following the prescribing instructions.

An additional benefit of electronic prescription transmission is that it can facilitate communication between pharmacists and prescribers. This functionality allows potential medication discrepancies to be adjudicated without the barriers of time-consuming telephone calls. The effect of this functionality on office practice workflow requires further investigation.

This analysis included chain pharmacies within eastern Massachusetts only, and the results may not be generalizable to other locations. On the other hand, most of these pharmacies were part of national pharmacy chains across the country with identical computer systems and similar workflows. The standardized training and workflow of these pharmacies across the country allow these findings to be generalized to the greater population of chain pharmacies throughout the United States.

Most dispensing errors occurring during the transcription stage include wrong strength and dosage and would have been detected during analysis. Nevertheless, the lack of direct observation within pharmacies was a study limitation.

Patients whose medications were prescribed in the e-prescribing clinic may also have been under the care of other prescribers practicing outside of the study clinics. Unfortunately, prescribing data from these outside prescribers were not available. Dispensing histories with multiple discrepancies compared with current prescribing histories were excluded from analysis because of their low expected rates of occurrence and the possibility of their representing prescribing sources outside of the study clinics. Direct observation studies have estimated rates of multiple errors within a single dispensed prescription to be 0–0.29%. Prescriptions for controlled substances were included in the analysis. The e-prescribing clinic intervention period data were stratified according to whether the prescriptions were or were not electronically transmitted. This stratification may have introduced bias such that a significant difference in dispensing errors between the baseline and intervention periods would be less likely to be detected. Certain narcotic prescriptions could not be electronically transmitted, and pharmacists tend to be more vigilant when dispensing narcotics, especially Schedule II drugs. These factors may have reduced the dispensing-error rate among prescriptions that were not electronically transmitted.

Conclusion

Electronic transmission of prescription data from physicians’ offices to a pharmacy nearly halved the risk of dispensing errors compared with generating the prescription with outpatient CPOE and printing it and giving it to the patient.

References


