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## E-Prescribing Errors in Community Pharmacies: Exploring Consequences and Contributing Factors

**Olufunmilola K. Odukoya, BPharm, PhD.,**

University of Pittsburgh, Pharmacy and Therapeutics, School of Pharmacy, 3501 Terrace St, Salk Hall 720, Pittsburgh, Pennsylvania 15213, USA, oodukoya@pitt.edu Telephone: 412-648-1982

**Jamie A. Stone, MS.,** and

University of Wisconsin-Madison, Social & Administrative Sciences, School of Pharmacy, 777 Highland Avenue, Madison Wisconsin 53705, USA, jastone2@wisc.edu Telephone: 608-262-3312

**Michelle A. Chui, PharmD, PhD.**

University of Wisconsin-Madison, Social & Administrative Sciences, School of Pharmacy, 777 Highland Avenue, Madison Wisconsin 53705, USA, mchui@pharmacy.wisc.edu Telephone: 608-262-0452

### Abstract

**Objective**—To explore types of e-prescribing errors in community pharmacies and their potential consequences, as well as the factors that contribute to e-prescribing errors.

**Methods**—Data collection involved performing 45 total hours of direct observations in five pharmacies. Follow-up interviews were conducted with 20 study participants. Transcripts from observations and interviews were subjected to content analysis using NVivo 10.

**Results**—Pharmacy staff detected 75 e-prescription errors during the 45 hour observation in pharmacies. The most common e-prescribing errors were wrong drug quantity, wrong dosing directions, wrong duration of therapy, and wrong dosage formulation. Participants estimated that 5 in 100 e-prescriptions have errors. Drug classes that were implicated in e-prescribing errors were antiinfectives, inhalers, ophthalmic, and topical agents. The potential consequences of e-prescribing errors included increased likelihood of the patient receiving incorrect drug therapy, poor disease management for patients, additional work for pharmacy personnel, increased cost for pharmacies and patients, and frustrations for patients and pharmacy staff. Factors that contribute to errors included: technology incompatibility between pharmacy and clinic systems, technology

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Correspondence to: Olufunmilola K. Odukoya.

#### Author's contributions

All authors of this manuscript contributed to the (1) conception and design of the study, or acquisition of data or analysis and interpretation of data, (2) drafting of the article or revising it critically for important intellectual content, and (3) final approval of the version to be submitted.

#### Conflict of interest statement

No authors or contributors to this manuscript have any financial or personal relationships with other people or organizations that could inappropriately influence (bias) this work, including but not limited to the following: employment, consultancies, stock ownership, honoraria, paid expert testimony, or patent applications/registrations.

design issues such as use of auto-populate features and dropdown menus, and inadvertently entering incorrect information.

**Conclusion**—Study findings suggest that a wide range of e-prescribing errors are encountered in community pharmacies. Pharmacists and technicians perceive that causes of e-prescribing errors are multidisciplinary and multifactorial, that is to say e-prescribing errors can originate from technology used in prescriber offices and pharmacies.

### Keywords

Electronic Prescribing; Medication Errors; Medication Safety; Contributing Factors; Consequences

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## 1. Introduction

The Institute of Medicine's 2000 report on the quality of care in the United States found that over one million injuries and at least 44,000 deaths occur annually as a result of medical errors [1]. Medication errors are a major category of medical errors that cause over 7,000 deaths per year [1]. Medication errors are a frequent type of medical error that can induce adverse drug events, lead to inappropriate medication use, and cause harm to patients [2] and [3]. Consequently, medication errors are associated with increased length of hospitalization and higher costs of hospital treatment [4].

Prescription errors are a subcategory of medication errors that are often encountered in community pharmacies [5], [6] and [7]. Of the over 3.5 billion prescriptions received in community pharmacies annually, it is estimated that prescription error rates range from as low as 0.23% to as high as 11% [6], [8], [9], [10], [11], [12], [13], [14] and [15]. Despite the recent introduction of electronic prescribing (e-prescribing) in community pharmacies, the rate of medication errors has remained the same [16]. E-prescribing systems enable physicians to electronically generate and transmit prescriptions to community pharmacies [17] and [18]. In 2012, 788 million e-prescriptions were transmitted to community pharmacies in the United States, compared to only 29 million in 2007 [19]. Currently, 93% of community pharmacies (including 85% of independent pharmacies) and 10 mail order pharmacies in the United States have e-prescribing capabilities [19].

One purpose of e-prescribing is to reduce medication errors [20]. The few studies that have explored e-prescribing in community pharmacies indicate that its benefits include elimination of medication errors caused by illegible physician handwriting. However, these studies were conducted when e-prescribing was not yet implemented or used by most community pharmacies, particularly independently-owned pharmacies. Although errors associated with illegible handwriting were eliminated by e-prescribing, the technology also introduced new kinds of e-prescribing errors related incorrect entry of drug information [21] and [22]. As e-prescribing becomes more common, examining and understanding the types of e-prescribing errors encountered in community pharmacies can help us to identify ways to prevent such medication errors from reaching patients.

Careful examination of e-prescribing use in healthcare settings is imperative to ensure that this technology guarantees patient safety rather than cause added burden or unintended consequences. The main purpose of this study was to identify, in real time and retrospectively, medication errors associated with e-prescribing in community pharmacies, as well as their potential consequences and contributing factors using a variety of data collection methods. This can provide insight into how future e-prescription errors in the medication use system can be prevented before they occur. This study was part of a larger project that used the three-step error recovery theoretical framework to explore how community pharmacy personnel detected and resolved e-prescription errors [23].

## 2. Methods

### 2.1 Data collection and setting

A convenience sample of five community retail pharmacies in Southwest Wisconsin, located at separate sites from prescriber offices, were recruited to participate in the study. Human subjects' approval was granted by the Institutional Review Board at the University of Wisconsin-Madison. Following completion of data collection, each participant was remunerated \$50 for participating in the study.

Characteristics of the participating pharmacies are shown in Table 1. Three of the pharmacies were independent pharmacies while two were chain pharmacies. Participating pharmacies were a variety of owner/corporation models with different dispensing computer systems—two pharmacies with PDX, two pharmacies with Pharmaserv, and one pharmacy with the Rx30 dispensing system. All pharmacy information systems allowed for integration of e-prescriptions received from prescriber offices into their computer system. The volume of e-prescriptions received daily by these pharmacies ranged from 30% to 60% of their total prescription volume. Additional information about specific processes used by these pharmacies to address e-prescription errors has been reported in a previous publication [23].

Data collection was conducted by two researchers (one pharmacist trained in human factors engineering and one human factors engineer). The observation and interview guides (see Appendix A and B) were piloted and underwent expert review by two pharmacy researchers, two practicing pharmacists, and one human factors researcher. Several iterations were revised based on feedback from these reviews in order to improve the accuracy, clarity, validity, and usefulness of the protocol prior to data collection.

**2.1.1 Direct observations**—Direct observations are commonly used to understand and interpret human behavior and how people function within a particular context or process [24]. Pharmacy personnel in each pharmacy were observed on two separate days. Two researchers simultaneously observed how e-prescriptions were processed and the type of e-prescription errors that were detected by pharmacists and technicians. Participants were responsible for indicating to the researchers when they detected an e-prescription error, how the error was detected, and where the error originated. A total of 10 separate periods of observations were conducted for a total of 45 hours (9 hours of observation per pharmacy). Twenty-six pharmacy personnel participated in the direct observations (11 pharmacists and 15 technicians). Using field notes and the information prompts provided on the observation

sheet, researchers documented what was observed. Field notes were transcribed within 24 hours of the observation.

**2.1.2 Interviews**—Data obtained from the observations served as a background to inform the semi-structured interviews. An interview guide (Appendix B) was developed to enable participants to recall past experiences with e-prescription errors and potential causes and consequences of these errors. Interviews were conducted by two researchers (one pharmacist and one human factors researcher) with 11 pharmacists and 9 technicians that participated in the direct observations. One researcher facilitated the interview while the second researcher took notes and assisted in asking questions and using probes [25] to elicit more information from the interviewees. Each interview lasted about one hour. The interviews were audio-taped and audio recordings were professionally transcribed. Transcriptions were verified by researchers for accuracy.

## 2.2 Data analysis

Analysis was conducted by two researchers (OO, JS) by reading through observation field notes and interview transcripts. Observation field notes and interview transcripts were entered into NVivo 10 qualitative analysis software for content analysis [26]. Codes were created in NVivo to identify types of errors, drugs that were implicated in the errors, and participants' perceived contributing factors and consequences of errors. Identified codes were grouped into themes, vetted by a third researcher (MC), and refined based on feedback. For further analysis, codes related to e-prescribing errors were entered into an Excel spreadsheet. The categorization of types of errors identified in the data was guided by the definitions provided by the World Health Organization [27]. MD Consult® was used to categorize medication names that were implicated with these e-prescribing errors. Finally, all three researchers (OO, JS, and MC) met to discuss inconsistencies and outliers in the data categorizations and to review the interpretations of identified codes and themes.

## 3. Results

### 3.1 Description of e-prescription errors

The categorization of e-prescription errors reported in this study was guided by the World Health Organization (WHO) classification of common prescribing errors [27] as described in Table 2. During the 45 hours of observation, 75 e-prescription errors were documented (Table 3). During the follow up interviews with 20 participants, all participants reported that they encountered e-prescription errors on a daily (approximately 5 out of 100 e-prescriptions) or weekly basis (5 to 15 errors per week) in their practice setting. A total of 107 e-prescription errors were described during these interviews.

A total of ten types of errors were found across the observations and interviews (Table 3). Of the 10 types of errors, six were documented during observations by the researchers. Participants described four additional types of errors during interviews that had not been documented during observations: wrong drug, wrong strength, wrong pharmacy, and wrong prescriber notes. The four most common errors observed were: wrong drug quantity (40%),

wrong duration of therapy (21%) wrong dosing directions (19%), and wrong dosage formulation (11%).

When participants were asked to describe common and challenging errors encountered in their practice, wrong drug quantity (33%), wrong duration of therapy (5%), wrong dosing directions (28%), and wrong dosage formulation (16%) were most frequently discussed. Table 3 shows specific examples of e-prescription errors that were observed or mentioned by participants during interviews. For example, wrong quantity errors typically involved the e-prescription having the wrong package size or the wrong number of tablets based on the dosing directions. On the other hand, errors related to wrong dosing directions typically involved receiving duplicate or conflicting dosing directions or dosing directions that were over the normal range of use for patients (overdose). For wrong dosage formulation errors, the e-prescription either had the incorrect drug form, extended release instead of regular release, or the drug form prescribed was no longer being manufactured. Wrong duration of therapy errors were detected by pharmacy personnel when the number of days the patient was to receive the medication was inaccurate. E-prescription errors that were encountered less frequently in the pharmacies were wrong patient and wrong drug strength.

### 3.2 Drug classes commonly implicated with e-prescription errors

Table 4 shows the main drug classes that were typically implicated with e-prescription errors. The top drug classes included antiinfectives, cardiovascular agents, respiratory agents (particularly inhalers), gastrointestinal agents, hormones and hormone modifiers, psychotropic agents, neurological agents, ophthalmic agents, and topical agents. Antiinfectives, inhalants, topical agents, and hormone modifiers were the drug classes most implicated with wrong dosing directions and wrong drug quantity errors.

During observations, cardiovascular agents, inhalers, and hormones and hormone modifiers were the most common drug classes that were observed to have errors. During the interviews participants discussed e-prescription errors that represented these main drug classes. For example, wrong quantity errors were the most frequently occurring errors and occurred mostly with antiinfective agents, hormone modifying agents, inhalers, and topical agents. Pharmacists and technicians stated that they sometimes paid more attention to medications that were prone to e-prescription problems during the entering and dispensing phases. Participants sometimes performed additional tasks such as double checking of the prescription and careful review of the patient's profile in the pharmacy to ensure that e-prescription errors were identified.

### 3.3 Consequences of e-prescription errors

Table 5 reports verbatim quotes from participants.

#### 3.3.1 Potential consequences of errors for patients

**Increased likelihood of patient receiving incorrect drug therapy:** Pharmacy personnel were concerned that if they did not pay close attention when working on e-prescriptions, e-prescription errors would be less likely to be detected, and patients could receive an incorrect therapy (too much, too little, or the different drug than intended by the prescriber).

Participants expressed that if patients did not receive correct drug therapy, this could lead to poor disease management or worsened disease conditions for patients.

Pharmacy personnel also noted that failure to correct an e-prescription error could lead to poor disease control, poor medication compliance, or adverse side effects for the patient due to incorrect drug therapy. In one scenario, the pharmacy received duplicate e-prescriptions for antihypertensive medications that could have led to significant decrease in the patient's blood pressure if both medications had been dispensed by the pharmacy.

**Patient frustration due to delayed dispensing of e-prescription:** Pharmacy personnel reported that patients assumed that prescriptions that were sent electronically would be ready to be picked up when they arrived at the pharmacy. They were not always aware that errors with the e-prescription could delay the dispensing of their medication(s). Patients blamed both the pharmacy and prescriber's office for delays in the prescription error being addressed, even in circumstances when the pharmacy had been proactive in contacting the prescriber's office before the patient arrived at the pharmacy. A delay in response from the prescriber made pharmacists and technicians unable to move forward with dispensing the patient's medication until the questions about the e-prescription were answered.

**Increased medication cost for the patient:** Pharmacy personnel noted that e-prescription errors could lead to increased cost for patients due to excess drug quantities or dispensing an incorrect dosage form that was more expensive for the patient. For example, one participant stated that the potential consequence of dispensing the wrong quantity (if an excess quantity is dispensed) was that this could lead to wastage of medication if the patient did not need to use all of the medication. Pharmacies were focused on attempting to save money for patients by making sure to review the e-prescription order to ensure that the patient received the most affordable drug prices.

### **3.3.2 Potential consequences of errors for the pharmacy and pharmacy personnel**

**Slows down pharmacy workflow and results in additional work:** Both pharmacists and technicians expressed that encountering an e-prescription error slowed down and disrupted their work due to the additional time and effort necessary to resolve the error. A typical consequence of the e-prescription error involved the technician re-entering the e-prescription information after receiving clarification from the prescriber. Often, technicians attempted to address the e-prescription error during data entry prior to the medications being filled to avoid double work at the filling stage of the dispensing process. Participants stated that encountering an e-prescription error added another layer of work stress. In addition, participants explained that they sometimes forgot to address the e-prescription error, when other competing priorities and tasks came up that needed to be addressed. Because e-prescription errors slowed down pharmacy workflow and resulted in additional work, this led pharmacy personnel to experience emotional consequences such as confusion and frustration.

**Confusion and frustration for pharmacy personnel:** Pharmacy personnel indicated that many times the e-prescription errors were often confusing and stated that they felt frustrated or annoyed when the error could not be easily addressed. For example, one of the most common problems was receiving an e-prescription with dosing directions that did not match the quantity of tablets prescribed. Another issue was when pharmacies received back-to-back e-prescriptions for the same patient, the same drug or drug class but different dosing directions, which led to the pharmacist or technician unable to determine which prescription should be filled. In such cases, the pharmacist would contact the prescriber to determine what was intended for the patient.

Not being able to resolve the e-prescription error in a timely manner was also a source of frustration for pharmacy personnel. For example, participants explained that e-prescriptions were put on hold in the pharmacy workflow until the prescriber could be reached to determine what needed to be changed to dispense the medication to the patient. E-prescription errors for medications such as antibiotics were prioritized in the pharmacy workflow as this drug class indicated that the patient would likely come in immediately to pick up the medication. In certain cases, pharmacists were compelled to dispense the e-prescription prior to receiving clarification from the prescriber if the patient needed to start the medication immediately.

**Increased cost, audit and insurance billing issues for pharmacy:** Participants expressed that the use of e-prescribing was a significant cost for pharmacies. Pharmacies paid monthly maintenance fees for e-prescribing to their vendors and also paid a transaction cost for each e-prescription received from prescribers. Pharmacy personnel explained that the pharmacy was billed about 20 to 25 cents for every e-prescription received. Consequently when prescribers had to correct an e-prescription error by sending a new e-prescription, this was an additional charge for the pharmacy. Some pharmacists preferred to receive a verbal correction of the e-prescription via phone so as not to incur an additional charge for a new e-prescription transaction. One pharmacist noted that although e-prescribing was a government mandate, pharmacies were bearing the cost without any financial support to implement this health information technology (health IT).

Participants also expressed that e-prescriptions could lead to inaccurate billing for the pharmacy and issues during external audit. This was particularly important when the wrong quantity package size was prescribed for medications such as ophthalmic agents, topical agents, inhalers, and insulin. For instance, e-prescriptions for inhalers were often received with a drug quantity of “1”. However, insurance companies required that the drug quantity be listed as the actual unit size of “18gm”.

### 3.4 Factors contributing to e-prescription errors

Although pharmacy personnel seemed to be more focused on fixing e-prescription errors rather than understanding why the error occurred, participants provided their insight on the factors that they perceived led to errors in the e-prescriptions received in their pharmacies. Pharmacy staff attributed most errors to issues on the prescribers' end including auto-population of information and inadvertent entry or selection of wrong information. They

also commented that mismatch of information could occur during transmission between the prescriber's computer system and the pharmacy's computer system. Pharmacy personnel perceived that physician offices had more control over minimizing e-prescription errors because most of the e-prescription errors appeared to be related to how the information was entered. Some pharmacists and technicians attributed e-prescription errors to how the systems in pharmacies and physician practices were designed by e-prescribing vendors, while others attributed e-prescription errors to how the clinic implemented the e-prescribing system or how it was used by individual prescribers.

Pharmacy personnel expressed interest in visiting physician offices to better understand how and why errors might occur and how e-prescriptions were generated and transmitted to pharmacies. Some participants did note that a few e-prescription errors could have been attributed to errors of entering information by the pharmacist or technician or to misinterpretation of the intention of the prescriber by the pharmacy personnel. These factors will be discussed in more detail below (see Table 5 for verbatim quotes from participants).

**Incorrect calculation or entry of information**—Pharmacy personnel perceived that one contributing factor that led to e-prescription errors involved how e-prescriptions were entered by prescribers or how information was translated from the prescriber system to the pharmacy system. Based on pharmacy personnel communication with prescribers, they noted several reasons for incorrect selection of information. For instance, errors were attributed to the use of drop-down menus by prescribers, a prescriber being in a hurry or not paying attention, a prescriber being unfamiliar with their e-prescribing system, or a prescriber inadvertently selecting incorrect drug or patient information. Some pharmacists expressed that if a prescriber is not used to drop-down menus it could lead to the selection of a wrong drug name or drug dose. Pharmacy personnel stated that such dosing errors could also lead to medication errors in the community pharmacy by increasing the likelihood of errors in prescriptions dispensed to patients.

**Auto-population of e-prescription information**—Another contributing factor to e-prescription errors was the use of auto-populated fields in the e-prescribing systems. E-prescribing systems often auto-populated patient information or drug information such as incorrect drug dosing directions, which presented an additional potential for errors. Some participants believed that prescriber offices may have the ability to turn off the use of auto-populated information to prevent errors related to conflicting dosing directions.

Pharmacy personnel also indicated that prescribers sometimes forgot to remove auto-populated information that was either obsolete or inaccurate. Pharmacists and technicians explained that it is common practice for prescribers to use old e-prescriptions to generate a refill e-prescription. Consequently, when the pharmacist contacted the prescriber and received a verbal change to an e-prescription error, prescribers were less likely to make changes to the e-prescription in their system. This led to e-prescription errors when prescribers used old prescriptions with imbedded errors to generate new or refill e-prescriptions. Some pharmacy personnel suggested that it was preferable not to receive a verbal change to an e-prescription error to prevent future errors being sent over to the pharmacy.



**Mismatch of e-prescription information between prescriber and pharmacy systems**—E-prescription errors also arose due to a mismatch between the drug and patient information in the prescriber system and the pharmacy system. The pharmacy computer systems attempted to match the information from the e-prescription sent by the prescriber but sometimes this was translated inaccurately into the pharmacy system. This contributed to errors related to wrong drug quantity package size, drug name, and patient name. The mismatch of information between pharmacy and prescriber system was more challenging for pharmacy personnel to handle in cases where specific medications occur in a variety of drug quantity package sizes. Prescribers were frequently unaware of the particular package sizes available for these medications in pharmacies and thus would make educated guesses of the quantity package size.

#### 4. Discussion

In this study, pharmacy personnel estimated that on average, 5 e-prescription errors are encountered for every 100 e-prescriptions received from prescriber offices. Using the WHO taxonomy of prescribing errors [27], the e-prescription errors reported by pharmacy personnel were similar to prescribing errors that occur with traditional handwritten prescriptions with the exception of errors related to wrong pharmacy, wrong prescriber notes, and duplicate therapy. Of the 10 types of errors that were described, the most common appeared to be wrong drug quantity and wrong dosing directions. It has recently been reported that 11.7% of e-prescriptions received in community pharmacies have errors [16]. Two other studies found that the most frequently reported types of e-prescription errors encountered in community pharmacies include wrong drug, wrong dosage, wrong dosage formulation, wrong dosing directions, wrong duration of therapy, and wrong patient, which are in line with findings from this study [21] and [22]. In this study, e-prescription errors were more likely to be found with certain drug classes. For instance, wrong drug quantities and wrong dosing directions prescribed were found to most frequently occur with e-prescriptions for antiinfectives, inhalants, topical agents, and hormone modifiers. This finding is consistent with a report that evaluated e-prescription errors in one ambulatory pharmacy [28].

Additionally, findings from the study indicate that e-prescription errors can have negative consequences for patients such as an increase in the likelihood of patients receiving incorrect drug therapy which could lead to poor disease management. According to the American Society of Hospital Pharmacists, medication errors compromise patient confidence in the healthcare system and increase health-care costs [29]. Other negative consequences for pharmacies include pharmacist frustration when the error could not be quickly addressed, slowing down of pharmacy workflow, additional work, cost issues, and billing issues. Consistent with findings from this study, Warholak and Rupp found that e-prescription errors may lead to lengthy delays for patients as pharmacists wait for clarification from prescribers [22]. The time required for resolving e-prescription errors could range from 6.07 to 10 minutes per prescription resulting in an incremental dispensing cost of \$4.74 to \$10 per prescription for the community pharmacy [22].

Many factors may contribute to e-prescription errors encountered in community pharmacies. Pharmacy personnel in this study attributed most e-prescription errors to use of drop-down menus leading to incorrect entry of information. Several studies examining the use of e-prescribing in physician settings have reported that the use of drop-down menus is a major e-prescribing challenge that easily results in inadvertent selection of wrong information [30], [31] and [32]. For example, drop-down menus designed into physician e-prescribing systems can lead to the wrong drug or dose being prescribed and sent to pharmacies [33]. Other factors that appear to contribute to e-prescription errors include auto-populated information and inappropriate translation of e-prescription information between prescriber and pharmacy systems.

Pharmacy personnel attributed errors related to duplicate dosing directions to the use of the auto-population feature of physician e-prescribing systems. For example, e-prescribing systems used by physicians may automatically populate the common dosing direction when a particular medication is being prescribed. Duplicate dosing directions on e-prescriptions may occur when a physician desires to enter a different dosing direction from the one auto-populated and does not or cannot delete the auto-populated dosing directions before transmitting the e-prescription to the community pharmacy. Such e-prescribing features or capabilities designed into physician's e-prescribing systems can lead to e-prescription errors being received in pharmacies [34].

The mere use of drop-downs and auto-population features of e-prescribing systems may not be the only issue. Other design issues such as inadvertent mouse wheeling changing the information selected can also affect the use of drop-down menus and auto-population of information. Therefore, important consideration must be given to how these features are designed into e-prescribing systems in order to prevent errors. It is necessary to further explore these factors that pharmacies perceive to be sources of e-prescription errors. In summary, consequences of errors can be multidisciplinary, affecting both pharmacists and physicians. Additionally, the contributing factors are multifactorial, that is, they could occur from lack of knowledge, substandard performance and mental lapses, and/or defects or failures in systems [29]. As reported by studies exploring physician experiences with e-prescribing in ambulatory care, the transition to this health IT has not been seamless [35], [36], [37] and [38]. There are usability features of e-prescribing systems that need to be improved upon to ensure efficient and safe provision of care [37] and [38].

#### 4.1 Study limitations

There are several limitations to this study that should be acknowledged. First, this study was restricted to five pharmacies in one state, limiting the generalization of findings to other settings. Second, pharmacies were observed for two separate periods of five hours of observations which may explain why fewer errors were found in this study, compared to e-prescription error rates reported in other studies [16] and [22]. The study design allowed for detection of e-prescription errors that were identified by pharmacy personnel which may only be a small proportion of possible error types. It is possible that pharmacy personnel did not detect or notify researchers of other types of errors such as: drugs prescribed for an incorrect diagnosis, drug-allergy or drug-interaction problems, errors in electronic

transmission, or errors occurring by actions of pharmacists within the pharmacy. Finally, physician perspectives of e-prescription errors were not examined. As a result, the information gathered on the reasons for errors detected in community pharmacies are based on the perceptions pharmacists and technicians have of the physician's use of e-prescribing. Future studies should follow the e-prescribing pathway from prescriber through to pharmacy to better understand how and where errors occur in this process.

#### 4.1 Future research

E-prescribing is proposed as one of the applications of health IT that is cost-effective and delivers a significant reduction in medication errors and adverse events. As with other types of health IT, findings from this study indicate that e-prescribing produces certain types of medication errors. Additional evidence is needed to better understand the risks and benefits of e-prescribing. It is particularly important that we gain insights into the "unintended consequences" of e-prescribing as distinct from prescribing generally. For instance, there is need to explore in greater depth what errors are peculiar to e-prescribing when compared to manual forms of prescribing. Thus, further investigation by researchers should provide additional evidence on the contribution of e-prescribing to improving the overall quality of patient care. Specifically, future research should examine the relationship between physician e-prescribing systems and e-prescription errors encountered in community pharmacies. Our planned future work will leverage these study findings to explore e-prescribing use by physicians, particularly focusing on the types of errors introduced with use of this health IT.

## 5. Conclusion

This study showed that a variety of e-prescription errors are identified and resolved in community pharmacies. The four main types of e-prescription errors were wrong drug quantity, wrong dosing directions, wrong duration of therapy, and wrong dosage formulation. Factors that contributed to e-prescription errors included technological incompatibility between the pharmacy and clinic systems as well as usability issues that could lead to incorrect drug or patient information such as auto-populate features and dropdown menus. Pharmacy personnel perceived that e-prescription errors, when not detected, could have negative consequences for patients such as poor disease management or failed drug therapy.

Strategies used to reduce the incidence of medication errors when using e-prescribing need to become a national priority. An implication of the study findings is the need to implement a national reporting and learning system for e-prescription errors. In conclusion, pharmacy personnel, as users of e-prescribing, can be a useful source of information to further understand how best to make e-prescribing safer for patients.

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## References

1. Kohn, LT.; Corrigan, JM.; Donaldson, MS. To err is human: building a safer health system. National Academies Press; 2000.
2. Ferner R, Aronson J. Medication errors, worse than a crime. *Lancet*. 2000; 355(9208):947–948. [PubMed: 10768430]
3. Phillips DP, Christenfeld N, Glynn LM. Increase in US medication-error deaths between 1983 and 1993. *Lancet*. 1998; 351(9103):643–644. [PubMed: 9500322]
4. Roughead EE, Semple SJ. Medication safety in acute care in Australia: where are we now? Part 1: a review of the extent and causes of medication problems 2002–2008. *Aust New Zealand Health Policy*. 2009; 6(1):18. [PubMed: 19671158]
5. Ashcroft DM, Quinlan P, Blenkinsopp A. Prospective study of the incidence, nature and causes of dispensing errors in community pharmacies. *Pharmacoepidemiol Drug Saf*. 2005; 14(5):327–332. [PubMed: 15386722]
6. Knudsen P, Herborg H, Mortensen AR, Knudsen M, Hellebek A. Preventing medication errors in community pharmacy: frequency and seriousness of medication errors. *Qual Saf Health Care*. 2007; 16(4):291–296. [PubMed: 17693678]
7. Knudsen P, Herborg H, Mortensen AR, Knudsen M, Hellebek A. Preventing medication errors in community pharmacy: root-cause analysis of transcription errors. *Qual Saf Health Care*. 2007; 16(4):285–290. [PubMed: 17693677]
8. Buurma H, De Smet PA, Van Den Hoff OP, Egberts AC. Nature, frequency and determinants of prescription modifications in Dutch community pharmacies. *Br J Clin Pharmacol*. 2001; 52(1):85–91. [PubMed: 11453894]
9. Chen YF, Neil KE, Avery AJ, Dewey ME, Johnson C. Prescribing errors and other problems reported by community pharmacists. *Ther Clin Risk Manag*. 2005; 1(4):333. [PubMed: 18360575]
10. Hawsworth GM, Corlett AJ, Wright DJ, Chrystyn H. Clinical pharmacy interventions by community pharmacists during the dispensing process. *British J Clin Pharmacol*. 1999; 47(6): 695–700.
11. Leemans L, Laekeman G, Veroeveren L, Bulens J, Hendrickx C, Keyenberg W, et al. Frequency and trends of interventions of prescriptions in Flemish community pharmacies. *Pharm World Sci*. 2003; 25(2):65–69. [PubMed: 12774566]
12. Leufkens HGM, Westein MPD, Herings RMC. Determinants of pharmacists' interventions linked to prescription processing. *Pharm World Sci*. 2001; 23(3):98–101. [PubMed: 11468883]
13. Rupp MT, Schondelmeyer SW, Wilson GT, Krause JE. Documenting prescribing errors and pharmacist interventions in community pharmacy practice. *Am Pharm*. 1988; NS28(9):30–37. [PubMed: 3177209]
14. Rupp MT, DeYoung M, Schondelmeyer SW. Prescribing problems and pharmacist interventions in community practice. *Med Care*. 1992; 30(10):926–940. [PubMed: 1405798]
15. Buurma H, De Smet PA, Leufkens HG, Egberts AC. Evaluation of the clinical value of pharmacists' modifications of prescription errors. *Br J Clin Pharmacol*. 2004; 58(5):503–511. [PubMed: 15521898]
16. Gilligan AM, Miller K, Mohny A, Montenegro C, Schwarz J, Warholak TL. Analysis of pharmacists' interventions on electronic versus traditional prescriptions in 2 community pharmacies. *Res Social Adm Pharm*. 2012; 8(6):523–532. [PubMed: 22264963]
17. Lapane KL, Waring ME, Schneider KL, Dube C, Quilliam BJ. A mixed method study of the merits of e-prescribing drug alerts in primary care. *J Gen Internal Med*. 2008; 23(4):442–446. [PubMed: 18373142]

18. Moniz TT, Seger AC, Keohane CA, Seger DL, Bates DW, Rothschild JM. Addition of electronic prescription transmission to computerized prescriber order entry: Effect on dispensing errors in community pharmacies. *Am J Health Syst Pharm*. 2011; 68(2):158–163. [PubMed: 21200064]
19. Surescripts. [Accessed June 10, 2013] The National Progress Report on E-prescribing and Safe-Rx Rankings 2012. Available at <http://www.surescripts.com/downloads/npr/National%20Progress%20Report%20on%20E%20Prescribing%20Year%202012.pdf>.
20. Bell DS, Friedman MA. E-prescribing and the medicare modernization act of 2003. *Health Aff*. 2005; 24(5):1159–1169.
21. Rupp MT, Warholak TL. Evaluation of e-prescribing in chain community pharmacy: best-practice recommendations. *J Am Pharm Assoc*. 2008; 48(3):364–370.
22. Warholak TL, Rupp MT. Analysis of community chain pharmacists' interventions on electronic prescriptions. *J Am Pharm Assoc*. 2009; 49(1):59–64.
23. Odukoya OK, Stone JA, Chui MA. How do community pharmacies recover from e-prescription errors? *Res Social Adm Pharm*. 2013 Epub ahead of print.
24. Mulhall A. In the field: notes on observation in qualitative research. *J Adv Nurs*. 2003; 41(3):306–313. [PubMed: 12581118]
25. Maxwell JA. Understanding and validity in qualitative research. *Harvard Educ Rev*. 1992; 62(3):279–301.
26. Graneheim UH, Lundman B. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse Educ Today*. 2004; 24(2):105–112. [PubMed: 14769454]
27. WHO. World Health Organization; 2009. The conceptual framework for the international classification for patient safety; p. 1-149.
28. Molitor R, Friedman S. Electronic prescription errors in an ambulatory pharmacy. *J Manag Care Pharm*. 2011; 17(9):714–715. [PubMed: 22050398]
29. ASHP. ASHP guidelines on preventing medication errors in hospitals. *Am J Hosp Pharm*. 1993; 50(2):305–314. [PubMed: 8480790]
30. Palchuk MB, Fang EA, Cygielnik JM, Labreche M, Shubina M, Ramelson HZ, et al. An unintended consequence of electronic prescriptions: prevalence and impact of internal discrepancies. *J Am Med Inform Assoc*. 2010; 17(4):472–476. [PubMed: 20595316]
31. Campbell EM, Sittig DF, Ash JS, Guappone KP, Dykstra RH. Types of unintended consequences related to computerized provider order entry. *J Am Med Inform Assoc*. 2006; 13(5):547–556. [PubMed: 16799128]
32. Smith M, Dang D, Lee J. E-prescribing: clinical implications for patients with diabetes. *J Diabetes Sci Technol*. 2009; 3(5):1215–1218. [PubMed: 20144439]
33. Lapane KL, Waring ME, Schneider KL, Dube C. E-prescribing and patient safety: results from a mixed method study. *Am J Pharm Benefits*. 2011; 3(2):24–33.
34. Hincapie AL. e-Prescribing/Patient Safety Analysis utilizing the Pharmacy and Prescriber e-Prescribing Experience Reporting (PEER) Portal. Available at [http://medicationpso.org/documents/Grant94\\_FinalReport\\_September2011.pdf](http://medicationpso.org/documents/Grant94_FinalReport_September2011.pdf).
35. Weingart SN, Cyrulik MC, Isaac T, Morway L, Sands DZ, et al. Assessing the value of electronic prescribing in ambulatory care: a focus group study. *Int J Med Inform*. 2009; 78(9):571–578. [PubMed: 19395307]
36. Lapane KL, Rosen RK, Dubé C. Perceptions of e-prescribing efficiencies and inefficiencies in ambulatory care. *Int J Med Inform*. 2011; 80(1):39–46. [PubMed: 21112243]
37. Goldman RE, Dubé C, Lapane KL. Beyond the basics: refills by electronic prescribing. *Int J Med Inform*. 2010; 79(7):507–514. [PubMed: 20488746]
38. Abramson EL, Patel V, Malhotra S, Pfoh ER, Nena Osorio S, et al. Physician experiences transitioning between an older versus newer electronic health record for electronic prescribing. *Int J Med Inform*. 2012; 81(8):539–548. [PubMed: 22465355]

### Highlights

- We examined e-prescribing errors detected by community pharmacy personnel.
- E-prescribing errors include wrong: drug quantity, dosing direction, and drug form.
- Implicated drug classes: antiinfectives, inhalers, ophthalmics, and topical agents.
- Technology limitations and incompatibilities contribute to e-prescribing errors.
- E-prescribing errors have unintended consequences for patients and pharmacies.

**Summary table**

<b>What was already known on the topic</b>	<b>What this study added to our knowledge</b>
<ul style="list-style-type: none"><li>• E-prescribing has now been implemented widely in United States community pharmacies.</li></ul>	<ul style="list-style-type: none"><li>• Findings from this study drill down on the types of errors encountered with e-prescribing in United States community pharmacies.</li></ul>
<ul style="list-style-type: none"><li>• Past studies have reported challenges with using e-prescribing in community pharmacies such as occurrence of medication errors.</li></ul>	<ul style="list-style-type: none"><li>• The study also sheds light on potential consequences on e-prescribing errors for patients and pharmacies.</li></ul>
	<ul style="list-style-type: none"><li>• Possible contributing factors such to e-prescribing errors such as technological incompatibilities with prescriber systems were also identified.</li></ul>

**Table 1**

## Characteristics of pharmacies

Pharmacy	Dispensing system	eRx experience (years)	Daily Rx volume (eRx volume)	Average daily staffing	Practice setting (Region)
1	Pharmaserv	4	150–400 (36%)	3 Pharmacists 5 Technicians 2 Sales clerks	Independent (Rural)
2	Pharmaserv	4	160–200 (30%)	2 Pharmacists 1 Technicians 2 Sales clerks	Independent (Urban)
3	Rx30	3	120–200 (60%)	1 Pharmacist 2 Technicians	Independent (Rural)
4	PDX	3	130–135 (45%)	1 Pharmacist 2 Technicians	Chain (Urban)
5	PDX	7	150–200 (40%)	1 Pharmacist 2 Technicians	Chain (Urban)

\* eRx: electronic prescriptions; Rx: prescriptions (eRx and non eRx)



**Table 2**Taxonomy of common prescribing errors<sup>27</sup>

<b>Error classification</b>	<b>Description</b>
Wrong patient	Patient is misidentified
Wrong drug	Incorrect drug selection
Wrong dose, strength or frequency	Dose or dosage time interval is either above or below the intended prescribed dosage
Wrong dosage formulation	Drug product is the incorrect form intended
Wrong quantity	Drug quantity of the medication dose is either above or below what was intended to be prescribed

**Table 3**

## Types of e-prescription errors encountered

Type of error	Example	Observations (N = 75)	Interviews (N = 107)
Wrong quantity	Drug quantity reads 1gm instead of 6gm for fluticasone nasal spray inhaler.	30	35
Wrong dosing directions	Take 30 capsules by mouth 2 times daily. Take 1 capsule once daily.	14	30
Wrong duration of therapy	Duration of therapy is 5 days instead of 10 days	16	5
Wrong dosage formulation	Drug form reads nifedipine 30mg ER (extended release) instead of nifedipine 30mg XL	8	17
Wrong patient	E-prescription sent for patient "Will" and the system brings up another patient name "William"	4	1
Duplicate therapy	Multiple e-prescriptions sent for the same patient one with doxycycline 50mg and the second with doxycycline 100mg	3	3
Wrong strength	E-prescription sent for omeprazole 20mg instead of 40mg	-	7
Wrong drug	E-prescription sent for fluticasone inhaler instead of fluticasone-salmeterol oral inhaler	-	5
Wrong pharmacy	E-prescription is sent to chain pharmacy instead of an independent pharmacy where patient goes to pick up medications	-	3
Wrong prescriber notes	E-prescription is sent with prescriber's old notes: "patient needs to be seen before more refills" and the e-prescription has one year's worth of refills. Pharmacy calls prescriber and finds out the prescriber notes were not updated."	-	1

**Table 4**

Top 9 drug classes implicated with e-prescription errors

Drug class	Sample Drug name	Observations (n)	Interviews (n)
Antiinfectives • <i>Example: antibiotics</i>	Doxycycline 50mg tablet	15	13
Hormones and hormone Modifiers • <i>Example: antidiabetics</i>	Metformin 500mg tablet	13	10
Cardiovascular agents • <i>Example: antihypertensives</i>	Nifedipine 30mg tablet	6	11
Respiratory agents • <i>Example: inhalers</i>	Fluticasone 50mcg inhaler	9	9
Psychotropic agents • <i>Example: antidepressants</i>	Fluoxetine 10mg tablet	5	8
Topical agents • <i>Example: ointments and creams</i>	Hydrocortisone 1% ointment	7	3
Gastrointestinal agent • <i>Example: laxatives</i>	Docusate 100mg capsule	5	3
Ophthalmic or otic agents • <i>Example: eyedrops and eardrops</i>	Bromfenac 0.09% ophthalmic solution	5	2
Neurological agents • <i>Example: anticonvulsants</i>	Gabapentin 600mg tablet	6	

**Table 5**

Consequences and contributing factors of e-prescribing errors: themes and quotes

Themes	Verbatim quotes from participants
A. Potential consequences of errors	
<i>For patients</i>	
Increased likelihood of patient receiving incorrect drug therapy	<p>Pharmacist: "If we don't catch the error, it could lead to a change in side effects or effectiveness. Or in more serious cases, obviously, you could have worse effects of giving the wrong drug or the wrong dose that could lead to things, you know, depending on the drug. Maybe if the seizure medication, you know, suddenly they have a seizure because they're receiving the wrong dose or something like that."</p> <p>Pharmacist: "So you get the wrong dosage form, you get the wrong directions, and that person would have not been treated for his ailment, and so he would have continued to be infectious, maybe gotten worse, maybe ended up in the ER."</p>
Patient frustration due delayed dispensing caused by e-prescription errors	<p>Pharmacist: "It was an unintended dose increase [from omeprazole 20 mg to a 40mg]. And we took it to be a legitimate dose increase, and it went down to the counter. I said [to the patient] this is a dose increase, and she looked at it and said, that's not right and she was very positive about it. And we said, we will call the doctor's office. And we got a hold of a messaging system, and left the message. And the patient was getting frustrated with it. You know, there isn't any way we can require the doctor to call back quickly. But the nurse called back, and the nurse said, no, the dose was correct. And then the patient said, no, that's not correct. We called back again, and then at that point, the nurse said, I'll have to talk to the doctor. The doctor isn't in until tomorrow. So the next day, we got a call from the nurse, and she said that the doctor had not intended to change the dose and that the patient was correct. So we dropped back down to the lower dose, and everything went well. But that was quite a battle."</p>
Increased medication cost for the patient	<p>Technician: "If we had given her ten days, and she only needed five days, then she had 20 extra pills lying around, and now what's she going to do with them?"</p>
<i>For pharmacy and personnel</i>	
Slows down pharmacy workflow and results in additional work	<p>Pharmacist: "Everything stops at her station until it's addressed. It may slow up the process momentarily and everything, but it's sort of like an assembly line. If you pull the chain that stops it, it stops until it's addressed."</p> <p>Pharmacist: "It's interrupted, because, well, the workflow for that prescription, it gets put aside, and then, frankly, we'll forget about it, because it's not part of the workflow, and then the next thing you know, the patient is standing there, going, I'm here to pick up my prescription. And you're like, oh yeah, we had to call the doctor because something needs to be clarified. You forgot about it, because once you put it out, you know, it doesn't work into your flow, you don't think about it until the patient arrives. And then that makes the pressure go [up], right?"</p>
Confusion and frustration for pharmacy personnel	<p>Pharmacist: "So it was resolved finally at the end, after several repeated, at least two calls, you know, to the doctor's office to get clarification on this one. So needless to say, there was definitely frustration from our side, because, our main thought process was it really shouldn't have taken this many steps. I mean, it should have been resolved, literally, the day of or at least the very next morning when they called it in the second time."</p> <p>Technician: "The common ones are like the antibiotics. They say take one 2 times a day for 7 days, and they'll give the quantity for like a 20-, or a 10-day supply. You're kind of like, mm, what do they want? Do they actually want the ten-day or do they want seven days or what, you know?"</p> <p>Pharmacist: "The patient now comes in before the next morning and wants this for his mother who is not feeling well. So now you're [thinking], okay, do I? I don't have any further directions [from the physician yet]. Do I dispense it as is, or do I tell the patient to wait and possibly experience more issues throughout the night? So that's the kind of dilemma I'm left with, you know."</p>
Increased cost, audit and insurance billing issues for pharmacy	<p>Technician: "The fact that if a doctor messes up and sends us a prescription that's wrong, and they resubmit it, we get charged again, because we get charged for every e-prescription we receive, so when they make a mistake and send us a new one, we get charged again for their mistake."</p> <p>Pharmacist: "We call for pretty much everything because now, if we even change a tablet to a capsule, the, if we bill it to an insurance, and the insurance sees that it's different than what was originally ordered, then it causes an [audit] problem. So we basically have to fax or take care of any changes. It needs to be right because we don't have an awful lot of leeway."</p>
B. Factors contributing to e-prescription errors	

Themes	Verbatim quotes from participants
<i>Incorrect calculation or entry of information</i>	<p>Pharmacist: "The main impression that I get from the nurses or staff that we talk to is that they simply put, selected the wrong drug, or wrong strength, or something like that, when they were inputting the prescription. So it seems to be a lot of the issues on the input end. And then some of them, I think, may be related to translating their information to our system's information."</p> <p>Technician: "Typically, they [e-prescription errors] occur where either the instructions were ambiguous, depending on what the doctor put in there when they ordered it. Sometimes they occur just by omission by the technician, just either a misunderstanding or processing faster than one ought to."</p>
<i>Auto-population of e-prescription information</i>	<p>Pharmacist: "You'll see something like that, where you have totally conflicting instructions and I've had doctors say, that's something that's automatically put in there. I'm just assuming that they have a switch that they can turn on if it says normal sig, or they have to put their sig in. Like if you do doxycycline, it automatically comes up, take one twice a day, and then they put in the day supply or something."</p> <p>Technician: "We hear a lot when I call, it defaulted into that, or I don't know how to get that out of there. So I'm thinking they don't have a lot of control sometimes."</p> <p>Technician: "They tend not to take their notes off new ones. If they fax over something, they'll say, patient needs to be seen before more refills, but they'll give them a year's worth of refills. And then we find out that that note is old, and they just didn't take it off the e-script."</p>
<i>Mismatch of e-prescription information between prescriber and pharmacy systems</i>	<p>Pharmacist: "If we're searching and it's not in our system exactly like it's in the doctor's system, even a patient name, for example, it won't come up with that patient. If it's, say, Cindy Smith but, at the doctor's office, but we have her entered as Cynthia Smith, it won't search for Cynthia because it's searching for Cindy Smith. So then you have to delete out all that information and search for it. Same thing with the drug. If, say, in the doctor's system it says magnesium citrate, and in our system it says mag citrate, it won't find the mag citrate because it's abbreviated differently than what the doctor's office says. So you have to kind of do a modified search in order to find the right drug."</p>