Report on the study:
Examining Causes, Consequences, and Interventions to Address E-Prescribing Errors in Community Pharmacies

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PROJECT SYNOPSIS

Background: Electronic prescribing (e-prescribing) was among the health information technologies (health IT) that were expected to enhance medication safety, reduce call-backs from pharmacy due to poor prescriber handwriting, and lower medication cost. E-prescribing technology allows for direct computer-to-computer transmission of prescriptions from prescriber offices to community pharmacies. The purpose of adopting e-prescribing is to improve work efficiencies and decrease medication errors. However, findings from numerous studies have revealed significant problems associated with implementing and using e-prescribing that may easily result in medication errors and patient harm.

Objectives: The primary purpose of this study was to examine how e-prescribing errors are detected and prevented in community pharmacies, potential causes and consequences of these errors, and provide additional information on how e-prescribing has been incorporated into pharmacy settings. The specific study aims and research questions:

Study Aim 1: Characterize e-prescribing errors in community pharmacies
- Research Question 1a: What types of e-prescribing errors are prevented in community pharmacies?
- Research Question 1b: What factors contribute to e-prescribing errors?
- Research Question 1c: What are potential consequences of e-prescribing errors?

Study Aim 2: Examine the process of addressing e-prescribing errors in community pharmacies
- Research Question 2a: How do community pharmacy personnel prevent e-prescribing errors?
- Research Question 2b: What work system factors facilitate or hinder prevention of e-prescribing errors?

Study Aim 3: Identify interventions to reduce e-prescribing errors encountered in pharmacies
- Research Question 3: What are potential interventions to ensure e-prescribing safety for patients?

Methods: This study was guided by two human factors engineering (HFE) frameworks, namely: (1) a three-step error recovery model; and (2) a sociotechnical systems model - the SEIPS (Systems Engineering Initiative for Patient Safety) work system and patient safety model. A total of 13 pharmacists and 14 technicians from five community pharmacies in Wisconsin participated in the study. Participating pharmacies used three commonly used pharmacy dispensing systems (PDX, Pharmaserv, and RX30). A combination of data collection methods were employed which included direct observations, interviews, and focus groups. Data collection procedures also involved developing appropriate documentation tools such as observation protocols, interview questions, and a focus group guide. Direct observations involved documenting e-prescribing errors that were detected by pharmacy staff during the 45 hours (10 separate periods of 4.5 hours) of observation period by one pharmacist researcher and one human factors researcher. Follow-up one hour audio-recorded interviews were conducted with 20 study participants. Transcripts from observations and interviews were subjected to thematic analysis using NVivo 10. Extensive field notes were taken during direct observations and interviews and focus groups were audio-
recorded. Recordings were transcribed and subjected to content and thematic analysis guided HFE frameworks. Themes were identified in the transcripts and field notes that aligned with the constructs of the frameworks.

**Results:** The findings of this study have been organized according to the research questions related to the three main specific aims and are described below.

**Aim 1:** Pharmacy personnel detected 75 e-prescription errors during the 45 hour observation period. The most common e-prescribing errors were wrong drug quantity, wrong dosing directions, wrong duration of therapy, and wrong dosage formulation. The drug classes that were commonly implicated in the e-prescribing errors were antiinfectives, inhalers, ophthalmic and topical agents. Pharmacists and technicians indicated that the potential consequences of these errors on patients and pharmacies included increased likelihood of the patient receiving incorrect drug therapy, poor disease management for patients, additional work for the pharmacy, increased cost for pharmacies and patients, and frustrations for patients and pharmacy staff. Pharmacists and technicians indicated that factors that contribute to errors were: technology incompatibility between pharmacy and clinics systems, technology design issues, such as, use of auto-populate features and dropdown menus, and inadvertently entering incorrect information.

**Aim 2:** Most of the e-prescription errors were detected during the inputting of information into the pharmacy system. These errors were detected by both pharmacists and technicians using a variety of strategies which included: (1) performing double checks of e-prescription information; (2) printing the e-prescription to paper and verifying the information on the computer screen with information on the paper printout; and (3) using colored pens to highlight important drug and patient information. Strategies used for explaining errors included: (1) careful review of patient’s medication history; (2) pharmacist consultation with patients; (3) consultation with another pharmacy team member; and (4) use of online resources. In order to correct e-prescription errors, participants made educated guesses of the prescriber’s intent or contacted the prescriber via telephone or fax. When e-prescription errors were encountered in the community pharmacies, the primary goal of participants was to get the order right for patients by verifying the prescriber’s intent.

The findings in this study indicate that organizational factors such as communication, training, teamwork, and staffing levels play a significant role in detecting and correcting e-prescription errors. Other factors that could positively or negatively affect recovery from e-prescription errors include: level of experience, knowledge of the pharmacy personnel, availability or usability of tools and technology, interruptions and time pressure when performing tasks, and noise in the physical environment.

**Aim 3:** Redesign suggestions were focused primarily on improving the software on the physician and pharmacist sides, as well as the intermediary transfer service that is used to send e-prescriptions from a physician to a pharmacist. Participants cited usability issues as one of the contributors of errors and thus suggestions centered on improving usability as well as decision support. Also suggested was a need for pharmacists to understand what the interface looks like for physicians as well as for physicians to understand how what they enter in the electronic health record appears in the pharmacy. Pharmacists and technicians suggested that the vendors of
e-prescribing software on both the physician and pharmacist side take time to better understand the errors that are occurring and how the software is used so that improvements can be made. It was also thought that the pharmacy information network that route e-prescriptions from prescribers to community pharmacies needs to better address how data is translated from the physician’s electronic ordering system into the pharmacy’s software. Along these lines, pharmacists suggested that there be a mechanism that allows them to communicate directly back to the physician through the e-prescribing system if there is an error. Training and procedures within the pharmacy and the prescriber’s setting were also suggested as a way to help reduce errors. Lastly, pharmacy staff noted that some of these training and technology issues could be eliminated by larger health care system changes.

Conclusion: This research sheds light on the important role that community pharmacy personnel play in preventing and mitigating e-prescribing errors. This study explored the strategies used for recovery from e-prescription errors encountered in community pharmacies. Study findings shed light on patient safety strategies used to prevent errors from use of health IT by prescribers and pharmacies. This study showed that a variety of e-prescription errors are encountered in community pharmacies, such as, wrong drug quantity, wrong dosing directions, wrong duration of therapy, and wrong dosage formulation. However, most of these errors were detected by pharmacy staff and do not reach patients. Pharmacists and technicians perceived that poor design of e-prescribing systems in physician practices contribute to the occurrence of e-prescription errors. Findings suggest that implementation of health IT like e-prescribing in work systems does not always yield improved patient safety but instead can introduce new kinds of safety hazards that need to be studied and addressed. Thus, e-prescribing designers may need to explore potential solutions to e-prescription errors by eliminating problematic features of these systems. Additionally, the SEIPS model was used to highlight key factors that may influence recovery from e-prescription errors in pharmacies including the environment, teamwork, communication, technology, tasks, and other organizational variables. To be successful in detecting and correcting e-prescription errors, pharmacies must provide the appropriate working conditions that support recovery from errors. Further research is needed to better understand work system factors that may strengthen or weaken recovery from errors in community healthcare settings.
EXECUTIVE SUMMARY

INTRODUCTION

Electronic prescribing (e-prescribing) is the health information technology (health IT) that enables prescribers to electronically write and transmit prescriptions to community pharmacies. The rationale for using e-prescribing is to enhance patient safety by eliminating medication errors primarily caused by poor and illegible handwritten prescriptions. Consequently, the use of e-prescribing has been implemented across many healthcare settings in the United States to prevent medication errors and improve efficiency of healthcare professionals (Surescripts, 2012). However, it is now known that this health IT may not only prevent medication errors but may lead to new kinds of prescription errors when used to generate and transmit electronically written prescriptions (e-prescriptions) to community pharmacies (Warholak and Rupp, 2009). The use of e-prescribing by prescribers and community pharmacists has increased remarkably over the past decade (Surescripts, 2012). In 2012, 788 million e-prescriptions were routed to community pharmacies nationwide, compared to 570 million in 2011, 326 million in 2010, 191 million in 2009, 68 million in 2008, and only 29 million in 2007 (Surescripts, 2012). On average, it is estimated that over 1.5 million e-prescriptions are routed to community pharmacies daily.

Over the past decade, patient safety researchers have directed considerable attention has been directed at determining the extent and scope of medication errors. However, the process of recovering from prescription errors in community pharmacies has not been extensively studied. Investigating the errors that are still encountered with e-prescribing in community pharmacies and how these errors are managed by pharmacy personnel can provide valuable information on how to build safer pharmacy work systems.

AIMS

The purpose of this study is to understand the process by which community pharmacy personnel prevent potentially harmful e-prescription errors and to identify elements of the pharmacy work system characteristics that may act as barriers and facilitators to error prevention. This was done taking an exploratory approach and employing human factors concepts and techniques to address three main research aims:

Study Aim 1: Characterize e-prescribing errors in community pharmacies
- **Research Question 1a:** What types of e-prescribing errors are prevented in community pharmacies?
- **Research Question 1b:** What factors contribute to e-prescribing errors?
- **Research Question 1c:** What are potential consequences of e-prescribing errors?

Study Aim 2: Examine process of addressing e-prescribing errors in community pharmacies
- **Research Question 2a:** How do community pharmacy personnel prevent e-prescribing errors?
- **Research Question 2b:** What work system factors facilitate or hinder prevention of e-prescription errors?

Study Aim 3: Identify interventions to reduce e-prescribing errors encountered in pharmacies
- **Research Question 3:** What are potential interventions to ensure e-prescribing safety for patients?
METHODS

Conceptual framework
This study was conceptualized using two important concepts that originate from the field of human factors engineering that have been used to understand safety problems in hospital settings. First, the concept of “error recovery” (Henneman et al., 2010) was employed to explore processes used by pharmacy personnel to detect, explain, and correct e-prescription errors. Second, the “Systems Engineering Initiative Patient Safety and Work System (SEIPS)” model (Carayon et al., 2006) was used to shed light on work system factors that influence error recovery in community pharmacies. These concepts were employed to better understand how e-prescription errors that are encountered in community pharmacies are managed to prevent patient harm. The guiding framework developed for this study by combining these two concepts is depicted in Figure 1 (see appendices). Applying this framework, allowed the researchers assume a systems perspective in understanding this phenomenon.

Design
Human factors patient safety experts recommend the complementary use of observational data with interview data to understand healthcare professionals’ interaction with technology during patient care (Carayon et al., 2004). For this study, the research design involved a qualitative examination of e-prescription processing in community pharmacies using a combination of data collection methods: direct observations, follow-up semi-structured interviews, and focus groups. Qualitative data collection requires selecting participants who are conversant with a particular phenomenon or process that is to be studied (Sandelowski, 1995).

Recruitment
The research coordinator contacted the pharmacy managers of five community pharmacy sites in south-west Wisconsin community pharmacies where prior existing relationships had been established. The pharmacies had to meet the following criteria were targeted to participate in the study: (1) be located at separate sites from prescriber offices; (2) process a minimum of 10 e-prescriptions daily; and (3) have no access to electronic health records. These pharmacies used three common e-prescribing interfaces used in community pharmacies: PDX, Pharmaserv, and Rx30. Two of the pharmacy sites were chain pharmacies that used the PDX e-prescribing interface; one of the independent pharmacies used the Rx30 interface, while the other two pharmacies used the Pharmaserv interface. Additional details on characteristics of participants and pharmacies are provided in Table 1 and 2 respectively. The pharmacy managers indicated to the research coordinator which pharmacists and technicians in their respective pharmacies would be interested in participating in the study. In October 2012, letters of support were obtained from all five pharmacies that agreed to participate in the study in order to receive ethical approval for the study.

Data collection procedures
Data collection was done in two phases.

Phase 1: Observations and interviews
The first phase of data collection consisted of observing 13 pharmacists and 14 technicians in five community pharmacies in their work environment for about 4.5 hours. The observation
Phase 1: Observations
The phase involved documentation of work system data using unstructured field notes. A total of 10 separate periods of observations were conducted by one pharmacist and one human factors engineer. The purpose of the observations was to understand how pharmacists and technicians responded to e-prescription errors in their natural work environment and to provide appropriate context of information described by participants during follow-up interviews and focus groups. Individual follow-up semi-structured interviews with 12 pharmacists and 9 technicians (each interview lasted about one hour) were also conducted. The purpose of the interviews was to further investigate specific aspects of the work system that influenced detection and correction of e-prescription errors. Two focus group sessions were held in addition to the individual interviews to enable participants from different pharmacies discuss as a group work system factors that influence preventing e-prescribing errors in community pharmacy settings.

Phase 2: Focus groups
The first focus group was held with technicians eight weeks after conducting the last one-on-one interview. During the eight weeks, researchers spent time analyzing data from interviews and observations. The researcher coordinator worked with the five pharmacies to recruit pharmacists and technicians to participate in two separate focus groups (a pharmacist focus group and a technician focus group). Twelve participants (eight pharmacists and four technicians) that participated in the observations and interviews volunteered to participate in the focus groups. For this study, a focus group guide (see appendices) was developed to facilitate discussion of work system barriers and facilitators to preventing from e-prescription errors in community pharmacies. The focus group guide and other materials (summaries of information from interviews and observations) were created to elicit information from participants about barriers and facilitators to detecting or correcting e-prescription errors (see appendices). Three researchers met to review the focus group questions and summary data documents prior to the focus groups. The focus group questions and documents were emailed to participants one week before the focus group.

The technician focus group took place in March, 2013, while the pharmacist focus group was held a week later in April, 2013. Eight pharmacists participated in the pharmacy focus group (one pharmacist joined the focus group via telephone) and four technicians participated in the technician focus group. The focus groups were held at noon and took place in a private conference room to provide privacy and an environment conducive to discussion (limited extraneous noises or distractions). Focus groups were facilitated by the pharmacist researcher and two assistant researchers were responsible for managing the tape recorder, taking field notes, providing additional clarification to questions, and ensuring that the research facilitator kept to time.

Three researchers were present during each focus group. One researcher acted as the facilitator, asking questions, another researcher served as the time keeper and was also responsible for managing the tape recorder, and the third researcher was the note taker. During the focus groups, participants were provided with examples of work system components and were asked to describe how any of the components might contribute to the detection or correction of e-prescription errors. Probes and prompts used by researchers during the focus group discussions were based on the five main components of the work system model: people, organization, technology/tools, tasks, and environment (Carayon et al., 2006). The room used for the focus
groups had a large whiteboard that was divided into different sections of the work system. As participants made statements in reference to a work system component, the note taker documented in the appropriate section on the whiteboard.

Participants were presented with descriptions and examples of each component as may relate to the pharmacy work system. Each focus group lasted for about 90 minutes. Immediately after the first focus group, the research team held a debriefing session to address issues that came up during the first focus group with technicians. The researcher team reviewed focus group questions and discussed changes to be made to improve clarity for participants in the second focus group with pharmacists. Audiotapes were checked for clarity, and the second session was reconstructed as necessary. All responses were tape-recorded and transcribed verbatim by a professional transcriptionist. The pharmacist researcher listened to the tape recordings from the two focus groups and read through the transcripts to ensure the accuracy of the transcriptions. At the completion of both focus groups, a comprehensive summary was generated. This summary included transcripts of audiotapes as well as anecdotal and field notes.

**Data analysis**
Observation field notes and transcripts from interviews and focus groups were read several times and then entered into NVivo 10 qualitative analysis software. The pharmacist researcher trained in human factors engineering (OO) independently coded all transcripts to based on the research questions of interest. All initial codes were vetted by two other researchers (one human factors engineer and another pharmacist). These codes and the corresponding statements were then thematically analyzed and further organized according to the corresponding components of the conceptual framework. Using thematic analysis (Patton, 1990), two researchers (OO, JS) identified common patterns and themes in the data. Once the thematic analysis was conducted, the coding was discussed among three researchers to review themes for consistency in the descriptions. Agreement was reached on how best to classify statements into themes and components after further deliberation among the three researchers.

**RESULTS**

Results are presented in accordance with the three main research questions. Table 1 and 2 show the characteristics of participants and pharmacies respectively.

**Study Aim 1: E-prescribing errors, contributing factors and potential consequences**

**Frequency of e-prescribing errors detected in pharmacies**
During the 45 hour observation period in all five pharmacies, 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 basis and a total of 107 e-prescription errors were described during these interviews (Table 3). These errors were categorized using the World Health Organization’s classification for errors (WHO, 2009). Pharmacists and technicians reported encountering e-prescription errors on a daily basis (approximately 5 out of 100 e-prescriptions) or weekly basis (5 to 15 errors per week) in their practice setting. Participants reported that the frequency of e-prescription errors encountered varied with the time of day and the number of e-prescriptions sent from physician offices.
Pharmacist: “Once a day. On a bad day, five times, you know, it's just, some days it [number of e-prescriptions received in pharmacies] just almost seems relentless.”

**Description of e-prescription errors**

The 10 main types of e-prescription errors that were encountered during the observations and were reported during the interviews are shown in Table 3. Of the 10 types of errors, six recurring errors were documented during observations by the researchers. Participants described four additional types of errors that were not observed (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. E-prescription errors that were encountered less frequently in the pharmacies were wrong patient and wrong drug strength. 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.

**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. As depicted in Table 4, antiinfectives such as antibiotics and antifungal agents were the drug classes most implicated with the frequently encountered e-prescribing errors, such as, 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. A list of all drug names and drug classes by type of error are provided in the appendices. During the interviews, participants discussed e-prescription errors that represented these main drug classes with the exception of neurological agents such as anticonvulsants. For example, wrong quantity errors were the most frequently occurring errors and occurred mostly with antiinfective agents, hormone modifying agents, inhalers, and topical agents.

**Factors contributing to e-prescribing errors**

Incorrect calculation or input of information

Pharmacy personnel perceived that one contributing factor that led to e-prescription errors involved how e-prescriptions were inputted 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 in a hurry or not paying attention, a prescriber unfamiliar with their e-prescribing system or inadvertently selecting incorrect drug or patient information. Some pharmacists expressed that if a prescriber is not familiar with the use of drop-down menus it could lead to selection of the wrong dose or drug. Pharmacy personnel stated that such dosing errors could account for some of the e-prescription errors encountered in the community pharmacy; thereby putting pharmacy staff at a disadvantage by increasing the likelihood of errors in prescriptions dispensed to patients.

Pharmacist: “The main impression that I get from the nurses or staff that we talk to is that they simply 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.”

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; this 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 receiving conflicting dosing directions.

Pharmacist: “You’ll see something where you have two totally conflicting instructions and, you know, and I’ve had doctors say, oh, that’s something that’s automatically put in there. And you just want to go, please put it out...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. But I think there’s a switch that they can turn on where the normal sig goes in, or the usual sig. Like if you do doxycycline, it automatically comes up, take one twice a day, and then they put in the day supply or something. So if that is true, that needs to be accurate.”

Technician: “We hear a lot when I call it’s, oh, it defaulted into that, or I don't know how to get that out of there, or whatever may be. So I'm thinking they don’t have a lot of control sometimes, so.”

Pharmacy personnel also indicated that prescribers sometimes forgot to remove auto-populated information that is 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 e-prescriptions with errors to generate new or refill e-prescriptions sent to community pharmacies. Some pharmacy personnel suggested that it was preferable not to receive a verbal change of an e-prescription error to prevent future errors being sent over to the pharmacy.
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.”

Mismatch of e-prescription information between physician and pharmacy systems

E-prescription errors also arose from mismatch of drug and patient information between the physician and pharmacy systems.

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.”

Consequences of e-prescription errors

Researchers noted potential consequences of e-prescription errors during observations and also obtained the perceptions of participants during follow interviews.

Potential consequences of errors for patients

Increased likelihood of patients receiving incorrect drug therapy and poor disease management

Pharmacy personnel were concerned that if they did not pay close attention when working on e-prescriptions, patients could receive incorrect drug therapy (too much, too little, or a different drug than intended by the prescriber) if e-prescription errors were not detected. In addition, this would lead to the patient not being adequately treated for the ailment, which could be worsened by the patient not receiving the appropriate drug regimen.

Technician: “They [patient] would get the wrong thing if we don't catch it.”

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 ineffectiveness of 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. As indicated by one pharmacist, e-prescribing errors could potentially lead to patients’ experiencing adverse side effects of medications.

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.”
Patient frustration due to delayed dispensing of e-prescription
Pharmacy personnel reported that patients assumed that prescriptions that were sent electronically would be dispensed and 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 expressed frustration when their medications were not ready to be picked up at the pharmacy. Patients perceived that both the pharmacy and prescriber’s office were responsible for delays in the e-prescription error being addressed. Sometimes patients blamed pharmacy staff for delays in receiving their medications despite being 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. Pharmacy staff perceived that the delay for patient to receive their medications was an inconvenience for patients.

*Pharmacist: “If it's something [medication] they [patients] need right away, it's a great inconvenience.”*

*Pharmacist: “Well, they [patients] are inconvenienced certainly. They may have to come back or wait. And, you know, it could be Friday night at 5:00 o’clock, you know, and then it’s Monday before we would know. I have had instances where there were things we were waiting on, and it was a Friday.”*

Increased medication cost for patients
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 carefully review the e-prescription order to ensure that the patient received the most affordable drug prices.

*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, so?”*

Potential consequences of errors for pharmacy and staff
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 that was confusing for pharmacies was receiving an e-prescription with dosing directions that did not match the quantity of tablets prescribed. In such cases, the pharmacist would contact the prescriber to determine what was intended for the patient.
Technician: “Well, first, quantity of one. It's like you really weren't sure. And then you saw the three packs, and it was like then you're all confused, because you started to fill it for one pack, and then you saw that. And it's like, oh, what do they mean?”

Pharmacist: “So it was resolved finally at the end, after several repeated, at least two calls, to the doctor's office to get clarification on this one. So needless to say, there was definitely frustration from our side, because, you know, I guess our main thought process was it really shouldn't have taken this many steps. I mean, it [e-prescription error] should have been resolved, literally, the day of or at least the very next morning when they called it in the second time.”

Most errors were resolved by contacting the prescriber for further clarification. In particular, errors related to conflicting or duplicate dosing directions or receiving multiple e-prescriptions were confusing for pharmacy staff. Pharmacies sometimes 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 being unable to determine which prescription should be filled and dispensed to the patient.

Pharmacist: “We do see that there will be an order that comes in, and then just two seconds later, there’ll be another order that comes in for the same thing. Those can be very confusing too, because you’re not sure what they’re intending… there's not really a good way to tell which came first and which came second.”

Technician: “The common ones are like the antibiotics. They say take one [tablet] 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? So we usually call, usually pass it down the line to the pharmacist, who calls to make sure.”

Pharmacy personnel also expressed frustration when they were unable to resolve the e-prescription error and therefore could not dispense the medication to the patient. For instance, 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.

Pharmacist: “Well, there's really no moving forward when you encounter one of the errors, so you can't do anything with the prescription until it's done.”

Pharmacist: “A lot of e-prescription errors are things that occur that make the prescription unfillable because…it is makes it inaccurate to fill the way it is.”

Pharmacist: “Everything translates to I can't fill this with a patient, or it's lost time, because I have to get hold of a prescriber.”

The e-prescription errors were sometimes easy to fix and other times rather challenging to resolve, depending on whether the pharmacist or technician could reach the prescriber to clarify
the intended drug regimen. E-prescription errors for medications such as antibiotics were prioritized in the pharmacy workflow to be addressed immediately as these drug classes indicated that the patient would likely come immediately to pick up the medication. Often the antibiotics would have issues related to wrong drug quantity, dosing directions, or duration of therapy; this was often frustrating for pharmacy staff if the patient arrived in the pharmacy before the e-prescription error could be addressed.

*Pharmacist:* “I think really for me the frustration is it really, it's [addressing e-prescription errors] always about timing. Something always happens. Guess what, it's an antibiotic...you're trying to get, whether or not you've faxed or called the physician back, the problem is this is not something where it can be done immediately...And, of course, and at that point, the patient's mother is walking in, and now I have to tell this person that, guess what, it's going to get delayed for I have no idea how long. And, hey, the child is sick, you know. They want to get home. And so it's frustrating that way that. I think that if the error had not been an issue in the first place, guess what, everyone would be happy. We wouldn't be having this problem.

*Pharmacist:* “…Especially in like a short-term situation like the antibiotic for a kid. They're waiting there, and you're just like, give me the verbal, let's go. They're like, no, no, we have to send over a new e-prescription. Then you got to wait 15 more minutes or whenever it finally gets sent through. And it's just, it's frustrating.”

In certain cases, pharmacists were compelled to dispense the e-prescription prior to receiving clarification from the prescriber if the medication was needed to be taken by the patient immediately.

*Technician:* “We would much rather at least get them [patient] started on the pills, instead of making them wait even longer, especially if it's, you know, the flu or something really bad.”

*Pharmacist:* “The patient now comes in before the next morning and wants this, okay, for his mother, who is not feeling well. So now you're, okay, do I? I don't have any further directions. Do I dispense it as is, or do I tell the patient to wait and possibly experience, you know, more issues throughout the night? So that's what I, that's the kind of dilemma I'm left with, you know. And in this case right here, what I did was actually I left instructions with the son that for the moment it says four times a day for five days. I want you to at least take this home to her and at least go with the initial instructions. When I get clarification tomorrow, like whether that's going to be ten days, I will give you call, you know.”

Slows down pharmacy workflow and results in additional work
Both pharmacists and technicians expressed that similar to handling non e-prescription errors, 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
inputting prior to the medications being filled to avoid double work at the filling stage of the dispensing process. Participants stated that encountering the e-prescription error added another layer of work stress. One pharmacist specifically stated that he hated e-prescription errors that involved receiving duplicate directions.

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.”

Technician: It slows it [inputting prescriptions] down. It does. I mean, that person running scripts, you know, if you have to stop and call or, you know, and sometimes it can be a lengthy, it slows it right down, I mean, our workflow comes to a halt.

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 more urgently.

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. And they're annoyed, and, you know, 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?”

Increased cost, audit and insurance billing issues for pharmacies

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 to avoid an additional charge for a new e-prescription transaction. One pharmacist noted that although e-prescribing was a government mandate, pharmacies bear the extra cost without any financial support to implement this health IT.

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.”

Although not unique to prescriptions that are sent electronically, participants 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 insulins. For instance, e-prescriptions for inhalers were often received with a drug quantity of “1gm”, this was perceived to be an error by pharmacy staff. Consequently, insurance companies required that the drug
quantity be listed as the actual unit size of “18gm”. Thus, pharmacy personnel stated that insurance played a big factor in e-prescription errors. This was because insurance companies had specific regulations on what drug quantity that could be prescribed by physicians or dispensed in the pharmacies, and what medications were covered for patients. One participant suggested that insurance drug formulary for individual patients are incorporated to physician e-prescribing systems to provide information on what medications were covered for individual patients. Participants perceived that increasing mandates requiring use of different generic versions of medications or prior authorization by insurance company policies were additional complications to addressing e-prescription errors.

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 a 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.”

Pharmacist: “I’m not losing, these boxes of pens, especially with, in this insulin situation, it’s $200, $250. Well, if that insurance company comes back and says, you did this wrong, and we have, I mean, it happens, it does happen all the times that they do this, I can’t afford that. So it’s, and it’s, you know, it is frustrating. It’s frustrating for us. It’s frustrating for them. But it’s, it really, it’s just a detail, I know, but it’s, it needs to be done correctly.”

Pharmacist: You almost have to recalculate inhalers, eyedrops. You know, if it's a tablet, that's pretty easy, but yet you would have to kind of watch those things. Because otherwise you get audited and it's not, it doesn't match up. There goes your money.”

Pharmacist: “As a business owner or pharmacy owner, we’ve been through audits before...for auditing purposes, they always tell you to have as specific as a quantity as you can.”

**Study Aim 2: E-prescribing process, error prevention, and associated work system factors**

**E-prescription processing: How are e-prescriptions handled in community pharmacies?**

The general process for processing e-prescriptions in the five community pharmacies was observed and participants were asked to provide further descriptions during the one-on-one interviews. On average, participating pharmacies processed about 120 to 400 e-prescriptions daily. E-prescription errors were detected and corrected during different phases of the e-prescription process. E-prescriptions were received directly into a queue in the pharmacy’s computer system from physician offices at the input computer terminal. During observations researchers noted that pharmacy personnel had incorporated a work around into their e-prescribing workflow that involved printing e-prescriptions to detect errors. Once received, e-prescriptions were first printed and the information either manually re-inputted or electronically auto-populated into the patient’s profile in the pharmacy system (the inputting phase). For pharmacies in which e-prescriptions were first printed, participants gave three main reasons for printing e-prescriptions, which are as follows: 1) to prevent errors during inputting of information, 2) for easy verification of information, and 3) for record keeping purposes. The
input technician then checked the e-prescription to ensure that information such as a patient’s or physician’s information (name, date of birth, address, telephone number) and drug information (name, strength, dosing directions, quantity) entered the pharmacy system correctly. Such information sometimes had to be manually typed into the patient’s prescription profile in the pharmacy system.

**Pharmacist:** “We actually keep the actual physical paper...we manually file them for five years.”

**Pharmacist:** “We omit a lot of the potential errors that would come up in the computer...they list the generic name before the actual product name, and we avoid any of those errors simply because we don't use the computer to render that data. So that’s one way we avoid detecting them.”

**Technician:** “We just don't fill them from the e-prescription...The directions, if you do fill it off of [the computer], without printing it out, all those directions will be on there. So if you, let's say, don't catch the two different directions on there, both directions are going to be on that prescription for that patient unless you would delete it or change it. So nothing is, you know, there isn't one thing that would probably ever be right if you were to fill it off of an e-prescription.”

**Technician:** “And so I print out the hard copy, and then I go through and, I'll actually use the computer, I'll take the hard copy and then just use that to compare against what comes up on the screen for the patient and everything... Then you look at the physical prescription there. And then you look down at the doctor's name, make sure that that matches up. And then I usually give the prescription one more look-over. I'll circle the date on the front of the prescription”

Technicians played a significant role in processing and detecting e-prescription errors during inputting and filling through verification of prescription information. The technician typically initiated the inputting of the e-prescription into the pharmacy system; however in one pharmacy the pharmacist was responsible for inputting e-prescriptions into the pharmacy system. There was with little or no variation in the information inputted into the pharmacy systems across all five pharmacies.

**Technician:** “Most of the time, they enter so fast, which is a nice thing. I mean, it takes you like 30 seconds to enter an e-prescription. So you can do them fast.”

**Pharmacist:** “Technicians typically at this store do not really play much of a role at all. We are, the pharmacists are the ones who are entering, looking at the prescriptions, entering the data into the computer, so we are the ones who are dealing with it.”

During the inputting phase, the input technician or pharmacist ensured that the e-prescription information as it was updated in the patient’s profile in the pharmacy system and then printed the appropriate labels. During inputting, the patient’s medication profile was sometimes reviewed to determine if the prescription was appropriate for the patient. For example, the inputting
technician checked for patient allergies to the prescribed medication, reviewed how often the patient was receiving the prescriptions, and compared past dosing regimen with the e-prescription being inputted if the patient had a previous medication history in the pharmacy. Pharmacists and technicians stated that they sometimes paid more attention to medications that were prone to e-prescription problems during the inputting and dispensing of the medication.

Technicians: “The e-prescriptions are seen by the technician first.”

Pharmacist: “The primary responsibility for processing prescription is the technicians. So generally they will receive the notification that there is an e-prescription in the queue, and then they will process it in the computer. And after they processed it, a paper version of the e-prescription will print out to be used as a check during the checking process and filling process of the prescription. And then as the pharmacist, we'll receive the paper version that's been printed off and use that to check the accuracy of the filled prescription.”

The filling phase (second check) was the next step; this was done mainly by the designated filling technicians. The input technician placed the e-prescription (printed from the pharmacy computer system) and medication label in a dispensing bin that was then passed down to the fill technician. The fill technician was responsible for picking medications from the shelves or dispensing robot, counting medications and placing them in dispensing bottles, attaching appropriate labels, and ensuring that the number of counted pills filled matched the printed e-prescription label. Once the prescriptions were filled and labeled, they were put into specific colored dispensing bins and passed down the workflow for final check and review by the pharmacist.

Different colors of dispensing bins were used to notify the pharmacist of the type of prescription or if the patient was waiting to pick up their medications. All pharmacies used colored bins but the colors were different at the pharmacies. For example one pharmacy used the pink dispensing bins to indicate that patients were waiting in the pharmacy to pick up the prescriptions, and used green colored dispensing bins to indicate that an e-prescription had an error or an unresolved problem. Another pharmacy used white bins to indicate that the e-prescription was a refill medication, and a red bin meant the patient was waiting to pick up the medication. Other pharmacies did not always use colored dispensing bins to denote an e-prescription error in their workflow.

Technician: “What we do also is when we fill the prescription in the computer, and then we actually count out the pills ourselves and then pass it down to the pharmacist. But what we do when we’re filling too, after we’re done, we’ll take the bottle, look at the NDC, underline the NDC number, make sure we got the right bottle off the shelf to match your label, and then we circle the quantity and make sure we had counted out the right quantity, so it eliminates the error there.”

The next phase was the pharmacist overall review of the e-prescription and filled medication (third check). Pharmacists were primarily responsible for checking the accuracy of the e-prescription filled and inputted by the technicians; this was commonly described by participants
as performing “DUR”, drug utilization review. The pharmacist’s review of the e-prescription consisted of checking the following: (1) information entered by the input technician; (2) the corresponding medication filled by the fill technician; (3) drug-drug interactions; (4) dosage changes; and (5) overall medication profile history of the patient. Finally, pharmacists bagged the prescription and proceeded to counsel the patient before dispensing the medication to the patient. During patient counseling, the pharmacist discussed with the patient about the prescribed medication and how the medication was to be used appropriately.

Pharmacist: “So the technician will open up the file, the queue, that shows that there's e-prescriptions. The technician will open the e-prescription, starting that process of e-prescription filling and print the e-prescription to paper and then cancel the e-prescription filling process and then restart filling the prescription as a paper prescription. The technician will process the prescription, input the data into the computer, adjudicate the claim, fill the prescription, and then send the hard copy or paper prescription, the medication, the stock bottle, and the label down to the pharmacist for the pharmacist to verify and do a DUR.”

**E-prescription error prevention**

**Pharmacy staff goals**
The main goals of pharmacists and technicians were to get the right order for the patient and to understand and verify the prescriber’s intent when e-prescription errors were encountered. Specifically, participants contact prescribers for the following reasons.

To:
- Get the right medication for the patient before they arrive in the pharmacy
- Ensure patient’s drug therapy is not delayed
- Obtain a new e-prescription that contains no errors
- Minimize confusion for the patient and improve the patient’s understanding of the prescriber’s intention of how the medication is to be taken
- Ensure that both patient and pharmacy were billed correctly
- Correct the error as quickly as possible

In summary, participants were focused on giving the correct drug and dosing regimen, and ensuring that there were no negative consequences of e-prescription errors for patients.

*Pharmacist: “My goal on every prescription is that the patient gets the medicine that the doctor orders, and it's the right medication, and they understand the directions.”*

*Pharmacist: “Again, contacting the prescriber. We need to either get them to reissue a new electronic prescription or at least a phone call to let us know from their office what it is.”*

**Phases of e-prescription error recovery**
The e-prescription error recovery process was conceptualized as three main phases: detection, explanation, and correction. However, recovery from e-prescription errors sometimes involved only the detection and correction phase. Recovery from e-prescription errors sometimes took minutes or days; this was dependent upon whether or not the pharmacy could resolve the error.
with or without contacting the prescriber, if the prescriber’s office was still open, and how long it took prescribers to respond to the pharmacist’s questions.

Pharmacist: “Somebody also mentioned accessibility of the clinic staff to be able to resolve it in a timely manner, especially when somebody's waiting for you to get it fixed. And if you can't get a hold of them right away, sometimes, you know, we'll, you don't even get somebody who's a nurse. You just get somebody at the front desk. And then they have to leave a message for a nurse, and then they have to call you back, and then they have to talk to a physician. And, you know, sometimes it just takes hours or days instead of the minutes that it could have taken had you been able to get a hold of someone right away.”

Detecting e-prescription errors
Participants perceived that it was their responsibility to detect e-prescription errors and that it was rare for e-prescription errors to go undetected in the pharmacy. However, one participant stated that the pharmacy may not catch all e-prescription errors. Pharmacists and technicians reported encountering e-prescription errors on a daily (approximately 5 errors out of 100 e-prescriptions) or weekly basis (5 to 15 errors per week) in their practice setting. Participants reported that the frequency of e-prescription errors encountered varied by time of day and the number of e-prescriptions sent from physician offices. Pharmacists and technicians encountered a variety of errors: wrong drug quantity, wrong dosing directions, wrong dosage formulation, wrong patient, duplicate therapy, wrong drug, wrong strength, wrong pharmacy, and wrong prescriber notes.

Most e-prescription errors were detected during the inputting of the e-prescription information into the pharmacy systems. Of the 75 errors that were detected during the observation period, 92% were detected at the inputting phase of processing the e-prescription. Fewer errors (7%) were detected during pharmacist review of the prescription (particularly if the pharmacist inputted the e-prescription), and 1% of the errors were detected when dispensing medications to patients. One technician described how errors are often addressed before the patient arrived at the pharmacy.

Technician: “Usually not. Like I said, sometimes the patients will come in and say, I'm not, you know, they'll sometimes catch it as well. Like if we haven’t caught it up on the processing portion, they'll come in and say, I’m not supposed to have a change, and then we'll stop and call the doctor. But generally, it's try to be noticed before it gets to the patient level.”

Since the input technician first encounters the e-prescription, 76% of observed errors were detected by technicians, while 23% were detected by the pharmacist (in one pharmacy, only pharmacists input e-prescriptions into the pharmacy system). Most errors detected by technicians were related to wrong quantity or wrong duration of therapy. Pharmacists detected errors mostly related to wrong dosing directions and wrong dosage formulation. Although technicians detected e-prescription errors, one participant stated that technicians were not expected to detect e-prescription errors due to their limited pharmacy education and training.
E-prescription errors detected by pharmacists and technicians were not tracked or reported in any error reporting system. Errors with dosing directions or drug strengths within the appropriate recommended dosage or dosage form for use were harder to detect. Some errors were conspicuous or salient to detect, for example conflicting dosing directions, wrong quantity errors (quantity “1”) or errors whereby the calculated drug quantity prescribed did not match the prescribed duration of therapy and dosing directions. Past encounters with such errors easily enabled participants to look out for such errors during the inputting of the e-prescription. While detection of errors was sometimes based on a feeling or suspicion that the e-prescription information was inaccurate. In summary, examples of strategies used to detect e-prescription errors included but were not limited to, “suspicion” followed by careful review of the e-prescription and appearance of conflict in information such as dosing directions and drug quantity on the e-prescription.

Pharmacist: “To detect them. I mean, if there is a wrong product ordered, but it’s ordered correctly, I mean, it’s the right directions, the right quantity, everything else, but it’s really the wrong drug, there’s really no way that I would necessarily know that when I saw the order. That, in that case, I mean, those are rare, but it does sometimes happen, and that you would hope to catch on a consult, say, okay, this is what this is for. And the patient may say, well, no, that’s not what I, so that would probably be a hard one to detect.”

Specific strategies used for detection
Three main strategies were used to detect e-prescription errors.

1. Double checks
There are several accuracy checks that have been built into the e-prescription processing workflow in the pharmacy. The e-prescription received from physician offices is typically reviewed by three pharmacy staff (two technicians and one pharmacist). Participants noted that these built-in double checks in the e-prescription workflow and a team approach to handling e-prescriptions helped pharmacy staff to detect e-prescription errors before they reached the patient. Based on their previous experience and suspicion that an e-prescription error was likely to happen, pharmacy personnel performed additional double checks when dealing with e-prescriptions for certain drugs. These types of drugs included medications with a narrow therapeutic index (for example, warfarin), drugs that typically have wrong dosing directions, and drugs with multiple dosage forms participants. For instance, for drugs with multiple dosage forms, participants ensured they verified that the dosage form on the e-prescription was consistent with the dosage form that the patient received during the last refill of their medication in the pharmacy. This verification process typically clued in pharmacists to wrong dosage form errors.

Pharmacist: “Definitely drugs that have multiple dosage forms, like the venlafaxine or Wellbutrin, or creams and ointments that come in different package sizes. Because those, that type of stuff, either package size or directions get screwed up a lot. High-risk medications I tend to pay a little bit more attention to. For example, warfarin, I want to make sure that the prescription that we receive is consistent with what they’ve been on in the past, otherwise, unless they indicate there’s been a change. Then I’ll call to verify any
changes just to make sure any changes are intended. When I'm processing the prescription, I spend a little bit extra time, just to make sure that I'm selecting things correctly. And then when I'm checking the prescription and doing a profile review, I double check through their profile just to make sure, whereas, I may, for some of the other more, you know, regular prescriptions that tend to have less errors, I may just do my regular check and profile review. But sometimes, I'll take a double check or double look, just to make sure if there's any changes I identify that. You know, if I do identify a change during the profile review, I'll go back and look at the hard copy of the prescription that printed out, to make sure that the e-prescription, there was no error filling it. So then I sort of check back on the process to make sure that we didn't screw anything up.”

Technician: “The quantity thing, like on a Prednisone prescription that comes through, I'll always do the math myself just to double check it. I never sort of assume that the doctor or even, I mean, I'll always, I'll double check the pharmacist, because I know they do it as well but just another set of eyes, just making sure that, you know, take three for three days, because you'll sometimes end up with five or six lines with a taper, I'll just make sure that there's actually enough medicine there to do what they want. So that's another eyes-on sort of thing.”

2. Print e-prescription to paper hardcopy
Participants perceived that having a printed version as opposed to an electronic version of the e-prescription made it easier to detect errors; this enabled them to review the e-prescription twice during their dispensing process. Participants also stated that printing the e-prescription helped them to perform double checks of the information. Printing the e-prescription helped participants verify patient and drug information because this was harder to verify on the computer screen. One technician stated that if the pharmacy did not print e-prescriptions, many errors would not be detected. Some participants thought that printing the e-prescription, inputting the information into the computer, and then verifying patient and drug information allowed them to more easily identify discrepancies between the original and inputted e-prescription. This is in contrast to viewing the inputted e-prescription next to the original text e-prescription on the same screen because information was sometimes cut off on the computer screen. One pharmacist stated that it was harder for her to detect e-prescription errors on the computer because she wasn’t born in a generation that frequently used computer screens.

Technicians: “The easiest way to identify the error is the actual printed version of it, because it's just all right there and you can just look at the, all the patient information. And then you just go down to the drug and then down to the doctor. Really, you never, I never look at the doctor info. So I usually just look at the top like two-thirds of the page and just ignore the bottom. So I guess the easiest way to like determine the error would just be looking at it at that time, right at the paper. And I always do like look at the paper before I actually look at the screen, just because usually when you start to enter the e-prescription, as you guys know, the thing pops up for you to pick the drug.

3. Highlight information on the printed e-prescription
Participants stated that it was important for pharmacy staff to be aware of what information was reviewed when other staff processed e-prescriptions. Therefore, another strategy used to detect errors was highlighting relevant drug or patient information on printed e-prescription using colored pens or highlighters when processing e-prescriptions. This strategy assisted participants in the double checking of e-prescription process. For example, participants highlighted the drug dosing directions, the type of drug formulation, the drug strength, and the patient’s name.Highlighting these key parts of the e-prescription made information easier to read and errors easier to identify. Also, participants highlighted drug and patient information on e-prescriptions with errors that were faxed back to prescribers.

_Pharmacist: “We actually use highlighters when the prescription is input by either a pharmacist or an input technician, and then the technician who fills it is another person [fill technician]. And then the person who's filling it actually, we like them to match the label with the hard copy and highlight it as they read it, showing that they did double check it. So it's a part of our process. And when the pharmacist checks it, it shows us that two sets of eyes looked at it, or you know there was another set of eyes that looked at it and checked it for errors.”_

**Explaining e-prescription errors**

Participants described the process of explaining the e-prescription error as, “you need to do some detective work”. Once the error had been detected by one pharmacy staff, explaining and correcting the error usually involved a team approach.

_Technician: “I would say it usually involves more than one staff person. I will usually enter the instructions that I think are most reasonable and then consult the pharmacist who will, in turn, either have me or they call the doctor's office for the clarification.”_

Typically, the input technician communicated the error to the pharmacist, and they discussed the next step of action. This usually involved contacting the prescriber via telephone or faxing the e-prescription error to the prescriber’s office highlighting on the faxed e-prescription the error that was detected. Participants also used notes to communicate e-prescription errors to staff beginning a new shift. Technicians passed on more challenging or difficult e-prescription errors to pharmacists.

_Pharmacist: “Technicians will consult with another pharmacist or even another technician, but usually the pharmacist. If the pharmacist catches it, there's less likelihood that they would consult with another team member, although they would sometime pass it off to the technician to make the phone call. So there still is potentially two people involved, just because that way the pharmacist can go back to doing the things that the pharmacist is legally only allowed to do, where the tech can make the call and leave a message just as well as anybody. And then the pharmacist would be the one who took the return call and clarified with the nurse.”_

The most common response to explain errors was to call or fax the prescriber. Pharmacy staff waited for a response from prescribers before refilling the e-prescription. Participants ensured
that prescriber corrections to e-prescription errors were communicated to other pharmacy staff and documented, stating the corrected details, name of the prescriber, date, time, and initials of pharmacist or technician that communicated with prescriber. The technician then scanned and re-entered the revised e-prescription into the pharmacy system.

Pharmacist: “...Documenting everything on the hard copy...I always, you know, confirmed with nurse, this is a change, my date, the date, my initials, the time, just making sure that’s all a part of it...I have the technician do it too, document that on the hard copy, who you talked to, what the conversation was, what happened.”

Technician: “Sometimes we write on the prescription, ask them, you know, what do they mean? Do they, you know, ask them if they want so many days or so many pills, and then we fax it to them. And then they end up either faxing a new one back over, or e-scribing a new one back over, or they’ll just call us. And then we’ll make documentations on the prescription so when we scan it we know what was done.”

Participants provided a wide variety of explanations and interpretations for the e-prescription errors encountered in their respective practice settings based on their past experience and communication with prescribers. These explanations were often dependent on the type of error. Examples of participants’ descriptions of e-prescription errors included: wrong strength (abnormal dosing – dose too low or too high), wrong pharmacy (e-prescription sent to the wrong pharmacy that was previously used by the patient), wrong dosing directions (prescriber forgets to remove incorrectly auto-populated information), and wrong quantity (incorrectly calculated or inputted by the prescriber or the prescriber does not know quantity unit package size available in the pharmacy).

Pharmacist: “It seems like a lot of the errors occur, they're like inadvertent selection of the wrong drug or the quantity is calculated inappropriately based on directions, a pre-populated sig or something, part of the directions being worded unusually. Because like I said previously, like I assume it’s pre-populated on their end, and they just don’t delete it or they don’t modify it enough to make it make sense before sending it to us.”

Technician observation: Trimethoprim-sulfamethoxazole (bactrim DS) 800-160 tablet, the sig (dosing direction) states “take 1 tab by mouth 2 times daily for 10 days, Qty 10. As the input technician is entering the prescription she notices the quantity should have been 20 to have enough medication for 10 days. The technician immediately calls the doctor’s office and the nurse picks up, who transfers the phone to the doctor. The doctor says “he is not so good at math”.

Pharmacist: “I don't think prescribers are aware of what package size of drugs are, you know, to put that in on their end”

Technician: “I don't know how they see it on their end. And I think it's just, I mean, this is just me personally. I just don’t think they know how things are packaged. And maybe they don’t need to. You know, I don't know. It's just like eye drops, they're either 5 ml or 10 ml or 15 ml. You know, and then they send over one [quantity]. Which one? You
Specific strategies used for explanation
Four main strategies were used to explain e-prescription errors.

1. Review patient’s medication history
Another common strategy used by pharmacy staff to explain or interpret e-prescription errors involved carefully reviewing the patient medication history or profile available in the pharmacy database. This was only useful if the patient typically used the pharmacy. This strategy was also used to detect e-prescription errors. If the e-prescription information appeared different from what was presented in the patient’s pharmacy medication profile, this clued pharmacy staff that there might have been an unintended or inadvertent error.

Pharmacist: “I detected the error initially during profile review.”

Pharmacist: “Look alike, sound alike is always an issue. Like one time we had a hydralazine that was supposed to be hydroxyzine. And if you look at the dosage, okay, there's a hydralazine 25, there's a hydroxyzine 25, which makes it really nice, okay, in this case. And I believe that there's also a, I thought there was a hydroxyzine 10 and a hydralazine 10 too. In other words, one thing you could look at as well, the tablet strengths may be different. In this case, boy, it matched up, literally. And we just noticed this because, simply, because when we looked at it we did a profile review. We noticed that they'd been getting hydralazine all the time. Where is this hydroxyzine coming from all of a sudden? Same directions, quantity, so you're thinking, okay, did something happen? But at the same time too, wow, the directions don't seem unusual for a hydroxyzine dose. I guess we'll just have to ask the patient, you know, what is the medication for?”

Technician: “I think reviewing the patient's profile, especially if it's something that they've been on, if it's like a little bit different or the directions have changed, then you can look at their profile and know that you should probably call the prescriber, because it's different than it was last time. And then it also kind of gives you something to work off of.”

2. Pharmacist consultation with the patient
Participants stated that patient information, such as, diagnosis would be helpful to assess the accuracy of an e-prescription and this rarely present on e-prescriptions. Consequently, one of the common strategies used by pharmacists and technicians to detect or explain e-prescription errors was talking to patients when they arrived at the pharmacy to pick up their medications. It was an important procedure in pharmacies for pharmacist to perform consultation with patients before medications were dispensed. During the course of pharmacist consultation, the pharmacist could elicit information about patient’s interaction with the prescriber. This strategy was used by pharmacy staff because they perceived the patient had been in communication with the prescriber and might be informed about the appropriate drug treatment regimen intended by the prescriber. This strategy was particularly useful if the patient did not have a medication profile or
history in the pharmacy. Although pharmacy staff communicated with patients about e-preservation errors, they did not always rely on statements from patients to correct the error; pharmacists preferred clarifying with prescribers.

One participant stated that it was a top priority for pharmacists to spend time on patient consultations to detect errors. This was typically the second option for pharmacy staff to explain errors once they had carefully reviewed the patient’s medication profile. This strategy was particularly useful in explaining all kinds of e-prescription errors such as wrong dosage form and receiving multiple e-prescriptions. Participants noted that a majority of patients were well informed about their medications or sometimes the prescriber’s intent. During pharmacists’ consultation with patients, pharmacists performed “show and tell”, which involved showing patients their medications and counseling them on how to take these medications. Participants stated that performing show and tell helped patients to identify if there was an e-prescription error. Show and tell is performed by the pharmacist at the end of the e-prescribing process in the pharmacy. One pharmacist stated that performing show and tell in addition to reviewing the patient’s medication profile were the two biggest areas that helped detect e-prescription errors in the pharmacy.

\[\text{Technician: “If the patient is there [in the pharmacy], you can always ask them.”}\]

\[\text{Technician: “Either that or just double check with the patient and say, hey, did the doctor tell you how many days? Because a lot of times, they will tell the patient, like you're taking it for this many days.”}\]

\[\text{Pharmacist: “Patient consultation as well, asking them questions about, you know, if we identify anything in the profile review that maybe sets off a small alarm, we can ask the patient. And sometimes the patients will say, yes, this was intended, or sometimes they'll just, you know, I have no idea what you're talking about, this wasn't supposed to be changed. And that will cue us to an error as well.”}\]

3. Consult with another pharmacy team member

Technicians often investigated e-prescription errors by consulting with another technician or pharmacist. Technicians tended to consult with a pharmacist rather than another technician because they perceived that the pharmacist had more pharmacy educational training about drugs. Technicians expressed that they did not always ask the pharmacist about the e-prescription errors but sometimes directly contacted the prescriber. Pharmacists were less likely to consult another pharmacy staff but relied more on immediately contacting the prescriber to explain the error. However, one pharmacist stated that it was helpful when the pharmacy had more than one pharmacist on duty to consult with on e-prescription errors.

\[\text{Technician: “Usually we'll consult the pharmacist. I'll usually process it with what my best guess is, but then put the prescription on hold and not actually fill it and consult the pharmacist for what they think.”}\]

\[\text{Technician: “Especially on e-prescriptions, it isn't like you're going to your fellow tech and saying, what do you think that says on there? You know, so you almost would be}\]
checking with the pharmacist on an e-prescription. I don't think I've ever asked a fellow tech on an e-prescription. If I had a question I think I always went to the pharmacist.”

Technician: “It depends on the e-prescription. I mean, it depends on, I mean, I don't always ask the pharmacist just because I can go pick up the phone, and I can call the nurse if I'm, you know, if I don't know. And I can say, ‘I got two scripts here. They're two different things. Which one did you intend?’ And then, I get, ‘Oh, I'm sorry, sent one I shouldn't have.’ And then I just throw the other one away, and I may document on the script, per nurse, this is the one that she wanted to have. I don't know that it necessarily takes a two-person thing. I just, you know, I'm sure the pharmacist would say no because it ends with them, you know. But for me as a technician, I am probably asking more questions because, you know, the schooling obviously that they have had or whatever, you know, they have to make sure it's correct. So, yes, I am going to defer to the pharmacist probably more.”

Pharmacist: “Well, in our setting, we have two pharmacists available for quite a bit of the day. And so there's someone to bounce questions, ‘What do you think? What, you know, this seem odd to you? This seems odd to me.’”

4. Use of online drug information tools
Another strategy used by pharmacists and technicians was use of resources such as online drug references, checking the manufacturer’s or wholesale’s drug database. One pharmacist stated that it was important for pharmacy staff to have internet access to access such tools. Tools such as Micromedex® were used to verify prescribed drug doses for certain diagnoses. Checking the manufacturer database was useful in detecting or explaining wrong drug formulation errors. Pharmacy personnel used this strategy especially when dealing with dosing direction errors with duplicate or conflicting directions.

Pharmacist: “Well, first thing, we look in our database to find the drug, and it wasn't in there. Then we go to the wholesaler's order entry system to see if it's available from the manufacturers or our wholesaler. And if we see it there and see that it's an injectable-only drug, and it's not usually given by people themselves, or in this case we couldn't even find it, then we figure there must be a mistake.”

Technician: “We actually look things up on the internet related to looking up prescriptions. The pharmacy has intranet not internet, so they can block websites. So if you wanted to go and look something up you might not be able to get all the way into the website to find what you wanted. So, you know, we have the basics, facts and comparison and a few of those, so...And I don't think, I think there are very few things that we do on paper, mostly would be things that you could look up.”

Correcting e-prescription errors
E-prescriptions errors were usually corrected before the patient arrived at the pharmacy. If the patient arrived in the pharmacy before the error was addressed, patients were either dispensed some medication to last for a short period of time (less preferred alternative) or were called to pick up their medications after the error had been corrected in the pharmacy. Participants stated
that they appreciated when prescriber offices also contacted patients to communicate that the e-prescription error was being addressed. Under certain circumstances whereby the patient needed to begin the medication immediately, the pharmacist dispensed a one to two days quantity of the medication for the patient.

Pharmacist: “If we can't resolve it, patients have to come back. Occasionally, I have dispensed it and basically, if like if the directions didn't make any sense, I will dispense it the way the directions said as long as I know that they have enough drug...But I don't like to do that, things go out the door not right...If the doctor's office calls back after the drug has been dispensed, I let patients know that we dispensed the drug as they [the doctor’s office] prescribed, and that we would call . . . the patient, but they should call the patient too.”

The recovery process used by participants for all e-prescriptions errors were generally similar; however recovery strategies or processes sometimes varied based on participants past experience, type of error, and individual preferences. For example, some participants preferred faxing the prescriber the e-prescription error while others preferred calling the prescriber. Some participants perceived that calling rather than faxing the prescriber helped to correct e-prescription errors faster. While other participants preferred to fax or combine faxing and calling the prescriber about the e-prescription error so that the prescriber could see the error and possibly prevent future similar errors. All participants preferred calling the prescriber to address errors for antibiotic medications to ensure patient could begin drug therapy as soon as possible.

Technician: “Prescribers just don't respond. And we had like a file system, and we'd write the date when we'd fax it. And that's when I started just calling, because a lot of times if you fax something so that, they, I think faxes come after calls, so I usually never fax anything. I just call, because otherwise it's going to be sitting there three days later when I come back to work. So, I mean, if you need them to see like the error, you can, I usually would fax it, like circle it, and then call them right away. I just faxed you this. What does it, you know, can we clarify or whatever?”

Pharmacist: “It's hard to do via fax, so, yeah, but I prefer the fax over calling, just because it's simpler. It's easier for everyone. It works into their workflow, and it works into my workflow better.”

Pharmacist: “I always, as long as I can wait until I hear back from them, I will, you know, wait for them to respond and then fill the prescription as it should be. If there is a question of not being able to wait, that the patient is standing there, I will call, make that phone call and get the correct directions.”

To correct e-prescription errors, participants typically called the prescriber. However, for certain errors such as wrong quantity package size (e-prescription received with quantity “1”), participants did not contact the prescriber but corrected the error in the pharmacy by using the medication package size available from the drug manufacturers. Participants preferred not to assume the intent of the prescriber but rather to call or fax the prescriber to clarify the e-prescription error.
Specific strategies used for correction
Two main strategies were used to correct e-prescription errors.

1. Educated guess of prescriber’s intent
In order to correct some e-prescription errors, pharmacy staff sometimes made educated guesses of the prescriber’s intent based on past experience and professional judgment. Some errors, such as conflicting or poorly worded dosing directions, pharmacists decided not to change and to dispense “as is” to the patient, assuming that the prescriber made it clear to the patient how to use the medications. This was common with errors related to wrong quantity “quantity 1”, and duplicate dosing directions. When e-prescription errors were corrected and therefore changed by making educated guesses, participants sent prescribers the notification of changes via fax. Participants stated that they did not want to make a habit of making assumptions of the prescriber’s intent but sometimes it was a waste of time to call the prescriber on every e-prescription error. This was particularly common with wrong quantity errors for creams and ointments. Participants made educated guesses also based on other details about the drug information provided on the e-prescription. For example, participants used the dosing directions to estimate the intended quantity prescribed. One participant noted that it was preferable to contact the prescriber rather than make an educated guess to correct the e-prescription error.

   Pharmacist: “So we get prescriptions for all those different quantities. And if we called every time to verify what they really meant, it would just be a huge waste of time. So, you know, we go with the best guess as what they meant was one box, they meant five pens, they meant 15 mL, they meant this many units. And a lot of prescriptions, like it’s funny when they do these insulin pens, for instance, they want a 90-day supply, but they can’t figure out mathematically how many units that takes.”

   Pharmacist: “Sometimes they forget to shut off the automatic sig, and they type in the freehand sig, and let’s say it’s once a day for 14 days, then stop for 7 and start again. Well, then when we get it, it would say take one tablet twice a day, take one tablet daily. And so it has like two sigs on there. And after dealing with this for a period of time, we’ve come to realize that the first sig is usually an error.”

   Pharmacist: “I guess that comes down to your professional judgment and what you feel comfortable with. If the second sig and the quantity match up, the first sig and the quantity don’t match up, it’s a pretty good indication. And if you’ve gotten it several times from the same doctor where they’re not shutting off the sig [drug dosing directions].”

2. Contact the prescriber via telephone or fax
Participants reported that their main way of explaining and determining corrections to e-prescription errors encountered was to contact the prescriber via telephone call or faxing the e-prescription back to the prescriber. However, some participants preferred using a combination of both telephone and fax to obtain a quicker response from the prescriber, while others preferred using only one method. Of all the strategies used to correct e-prescription errors, contacting the prescriber was the most frequently used by pharmacists and technicians, particularly accessing
the prescriber’s office via telephone calls. Some participants perceived that telephone calls elicited a faster response from the prescriber, particularly if the patient had arrived in the pharmacy to pick up the medications.

Other participants preferred faxing the e-prescription error so that the prescriber could see the e-prescription error. This saved pharmacists the time required to call on every e-prescription error. One participant stated that it was important for the prescriber to see the e-prescription error to prevent future errors. Participants included details of e-prescription error that required clarification from the prescriber and highlighted important information for the prescriber by underlining or circling the relevant part of the e-prescription. Thus, faxing the e-prescription error was useful for the following: (1) enabled the prescriber to view the e-prescription error and hopefully prevent future errors; (2) minimized misunderstanding during communication between prescriber and pharmacist; and (3) was useful for relaying information when prescriber office was closed and pharmacists could not get hold of prescriber via phone. Participants perceived that prescribers were not aware of some of the e-prescription errors encountered in pharmacies. When participants called prescriber offices to address errors, the receptionist or nurse had to relay the e-prescription error to the prescriber. Prescriber offices sometimes faxed revised e-prescriptions back to the pharmacy or contacted the pharmacy via phone to address the error.

Pharmacist: “Well, it isn’t that it’s, we have to really call a lot of the times or make a change, or it’s not a correction.”

Technician: “Other errors, I guess the double sig still comes up. You have, you know, take one tablet daily. Take three tablets daily, you know, and then whether you look back at what they were taking before or if you just, you know, make the call to call the nurse, and so that they verify it with the doctor. But we still get double sigs quite a bit. So I would say that’s a just discrepancy too, yes”

Pharmacist: “My favorite is, still is faxing the prescribing the e-prescription, that, so that they can see what is coming through. I still think that's a really, in my experience, the most effective, so that they can hopefully change the behavior or change the order is what we're going for on their end.”

Pharmacist: “Well, we frequently fax a doctor if, and we can put notes on the fax that would indicate what our question is, and then they get back to us. So we don't always have to call.”

**Work system factors that influence prevention of e-prescribing errors**

The SEIPS model shown in Figure 1 was useful in capturing themes related to important factors within the work system related to the detection and correction of e-prescription errors in community pharmacies. Importantly, the interviews and focus groups enabled researchers to capture barriers or facilitators in the pharmacy as well as from the prescribers work system. This model helped to identify constraints in the work system due to people, use of the e-prescribing technology, organizational policies, physical and external environment. For each component, descriptions are provided for how specific themes identified by pharmacists and technicians can
facilitate or hinder the recovery from e-prescription errors. It is important to note that although themes have been grouped under specific components, there are overlaps and interactions between each component.

Component 1: Person
In the SEIPS model, people are at the center of the work system. People in the pharmacy that handle e-prescriptions include the pharmacist and the technician.

Level of experience and training (in experience or past experience)
One particular characteristic that impacted the detection and correction of e-prescription errors was the level of experience of the pharmacy staff. Participants in this study had a range of 3 to 9 years working with e-prescribing. It was noted by participants that experience with processing e-prescriptions or dealing with errors could be a facilitator or barrier to detecting or correcting errors. Pharmacy staff with longer years of experience or more frequent past experiences with e-prescription errors were reported to be better able to deal with e-prescription errors. However, a lack of experience with e-prescription errors presented a challenge for pharmacy staff. Pharmacists’ also noted that more experienced technicians had more confidence in detecting or correcting e-prescription errors because they were more familiar with recurring e-prescription errors and communicating with prescriber offices to address these errors. Technicians explained that their level of experience, level of formal training (for example, receiving technician certification), and on the job training was important to detecting and correcting e-prescription errors. In addition, pharmacists mentioned that an important personal attribute of technicians that helped with e-prescription error recover was having a higher level of commitment to their job.

Pharmacist: “So there's somebody that has a lot of experience dealing with e-prescriptions, so they're familiar with a lot of the common issues. And they're, they tend to be more experienced technicians as well, so they, they're helpful at identifying issues or supporting me when I need to address an issue and contact a physician.”

Pharmacist: “And along with that, more exposure to e-prescriptions, because you may be familiar with how the other types of prescriptions work. But if you don't have a lot of experience with e-prescriptions, then it makes it more challenging, because there are a lot of, you know, we say an error, and we all sort of nod our heads, like, yeah, I see that all the time. But if you don't see these all the time, then you're not going to know what to look out for.”

Pharmacist: “I'll start off with technicians. It's level of experience, for one. The longer they've been in this field or in its employ, that is tremendous. Those who are, those who have been, are certified technicians, have also indicated, you know, a higher level of commitment. I look at that as someone has a higher level of commitment, you know, in wanting to make this and everything more of a career for them. So I think that helps tremendously. So I'll start off with technicians there.”

Technician: “I think experience, training. If you have good training and somebody who's been able to work with you for a while...this helps you, or maybe somebody doesn't
always process the e-prescriptions. If you just are patient with them and so, but, yeah, experience. Again, I have to go back to experience. You know, the longer you're in it, you know what you're looking for, you know what you got to do.”

Another “person” characteristic important for recovering from e-prescription errors was knowledge about drugs and e-prescription errors. The level of education or clinical drug knowledge of a technician with regards to appropriate dosage regimens was important for identifying an e-prescription error. Lack of knowledge about certain drug therapies was stated to be a barrier to recovering from e-prescription errors, while knowledge about appropriate drug dosing saved pharmacy staff time in having to contact the prescriber on all e-prescription errors. However, from past experience with frequently occurring e-prescription errors, the technician could detect the error. It appeared that experience with e-prescribing was a facilitator that helped counteract the barrier associated with knowledge gaps.

Both pharmacists and technicians also noted that their lack of knowledge of the prescriber’s e-prescribing process was also a barrier to understanding or correcting e-prescription errors. Pharmacy staff stated that it would be beneficial for them to shadow prescribers to better understand how e-prescription were generated and transmitted to pharmacies.

Technician: “... So not knowing what it looks like, what eScribe [e-prescription] looks like from the other side, I don’t know. Do they have an option to send in the correct thing or not, so...Well, I guess I don't really understand because I don't know what that nurse or that doctor's looking at from there. Do they just put nifedipine in, you know, ER and just let it go [pharmacy received another dosage form of nifedipine with a different mechanism of action than the nifedipine form on the patient’s pharmacy medication profile]? So is it okay? Was that really an error, like those drugs would do the same thing in the end, but the way they're released in the body, is that, would that be, you know, so I don't know without really seeing that other side.”

Component 2: Tasks
In the SEIPS model, the tasks component describes the content and characteristic of tasks that is the amount of variety, the challenges with performing tasks, and time pressure. Two main themes emerged related task factors that affect recovery from e-prescription errors, namely, interruptions and time pressure and high workload (backlog of e-prescriptions).

Interruptions
Interruptions were frequently reported to be a barrier when recovering from e-prescription errors and they affected both detection and correction of errors. Interruptions occurred due to the pharmacy receiving telephone calls, patients walking into the pharmacy, and interruptions by other pharmacy staff. Both pharmacists and technicians expressed that interruptions were the nature of the pharmacy job and they perceived that they had very little control over how frequently they were interrupted and had adapted to this aspect of their job. Participants perceived that interruptions slowed down their work particularly when they had to correct an e-prescription.
Pharmacists and technicians explained that each time they were interrupted it took longer to contact a prescriber’s office regarding an e-prescription error. Interruptions also reduced how much attention pharmacists and technicians gave to reviewing e-prescriptions for errors and this sometimes prevented them from having a holistic evaluation of the e-prescription. Thus, interruptions during e-prescription processing sometimes made participants cut corners and not fully review the e-prescription for errors. In addition interruptions often led to double work for the pharmacist or technician. Participants expressed that multitasking when handling e-prescriptions was sometimes a consequence of being interrupted frequently and this led to the pharmacy staff being distracted when handling e-prescription errors.

**Technician:** “You're, yeah, I'm entering or looking at your script that you want to enter, and if the phone is ringing or whatever, you have to stop, so sometimes you can lose your spot or don't finish typing so then you pass it down, and it doesn't make sense or something, but I just think the phone interruption is big.”

**Pharmacist:** “Because you may get interrupted in the middle of checking a prescription, and what would have been an obvious error, when you read the whole thing together, it would be an error. But when you look at the pieces, like the, just the directions or just the drug or just the quantity, it doesn't click that it's a problem.”

**Time pressure, high workload, multitasking, and prioritizing tasks**

Another factor that pharmacy staff perceived that affected recovery from e-prescription errors was time pressure to complete their tasks. Time pressure occurred due to patients waiting in the pharmacy and having a high workload in form of backlog of prescriptions waiting to be processed. Pharmacists and technicians stated that certain days of the week, in particular Mondays, were high time pressure days because the pharmacy typically received higher number of prescriptions. However, this sometimes varied by time of day or day of the week. On such busy days, pharmacies did not always have more staff on shift to compensate for the increased workload. Participants expressed that it was difficult to determine task priorities under high time pressure environments. In addition, time pressure made it more challenging to detect e-prescription errors. High pressure periods in the pharmacy made some technicians feel overwhelmed because of the amount of competing tasks that need to be completed within a short period of time.

**Pharmacist:** “Time pressures for sure make it harder to resolve them. A lot of times they sort of get pushed to the back burner until you're able to deal with more immediate issues for people who are actually waiting in the store, you know, who are coming in right away. The backlog, it's just sort of an indication that you're probably busier at the time, so it sort of rushes you a little bit more again. So I think that might make it a little more difficult, but I don't know that that affects it as much as the time pressures.”

**Pharmacist:** “Probably because you're going faster than when you're not backlogged. Then you would maybe breeze through things or skim things more quickly versus taking the time to read every single detail. You're multitasking, you're trying to get a lot of things done in a short period of time, that that could potentially make it more difficult to catch errors.”
Component 3: Environment
Physical environment of the pharmacy
In the SEIPS model, the environment primarily focuses on the physical environment, including the workstation design, layout, and noise level. Participants stated that small or cramped pharmacy space, noisy environment, poor lighting, and extreme temperatures were barriers to recovering from e-prescription errors. During the observation phase of data collection, researchers also noted environmental factors that could affect e-prescription error recovery such as different types of noise in the pharmacy. A noisy environment was irritating for some pharmacy staff and affected pharmacy staff concentration and conversations with prescriber offices when resolving e-prescription errors. Examples of sources of noise in the pharmacy environment included: music from the radio, conversations with patients or other pharmacy staff, phone conversations, noise from the dispensing robot, and noise from the street or larger store. One participant stated that loud noise in a community pharmacy was unfavorable and unprofessional. On the other hand, adequate lighting, appropriate temperature, consistent workflow layout, and a quieter environment were stated to facilitate recovery from e-prescription errors. In particular, a quieter environment minimized distractions for the pharmacy staff when detecting or correcting e-prescription errors.

Pharmacist: “No one mentioned other things, lighting or whatnot, I mean. But it's adequate lighting. Believe it or not, okay, we had a problem with temperature in the pharmacy. As crazy as that sounds, you know, we had a while there in the middle of the winter, when it was just dead blasting cold outside, and our heat gave out. Okay. Now that was one of the more uncomfortable couple of days I've spent in that place, you know. So that was, I don't know if that would contribute to errors or whatnot, but it certainly contributed to my ire [anger], that's for sure.

Pharmacist: “Another barrier that I've noticed is the drive-through window. I mean, here at my store, we have a window that actually opens to the outside world, so you freeze in the winter, and you die of heat stroke in the summer. And you have patients who are using the drive through most of the time, because they're in a hurry. So they're impatient, you're freezing, or you're hot, and it just leads to a potential of, you know, things being missed.”

External environment
One external environment factor that was frequently noted to affect correction of e-prescription errors were insurance policies that govern medication dispensing practices by pharmacies and prescribers. Insurance policies were reported to be a barrier in correcting e-prescription errors in a timely manner for patients. Insurance policies influenced the type of correction that a pharmacist could make to an e-prescription error without having to contact the prescriber for an official change; this added an additional step and workload to the error recovery process. For example, insurance policies on specific drug quantities that could be dispensed in the pharmacy prevented pharmacy staff from correcting wrong drug quantity errors without receiving a new e-prescription from the prescriber. Consequently pharmacy staff frequently had to redo e-prescriptions to address patient specific insurance policies. Pharmacy staff perceived that prescribers not being aware of specific insurance drug coverage policies for individual patients
also contributed to pharmacies receiving e-prescriptions for medications that were not covered by their respective insurance policies.

Additionally, patients’ insurance drug coverage policies also played an important role in e-prescription error recovery due to issues related to inaccurate billing or audit for the pharmacies. Pharmacies typically bill third party payers, that is insurance companies for medications dispensed or specific cognitive services rendered to patients (Snella et al., 2004). Consequently, pharmacies are audited regularly by external auditors to ensure pharmacy billing of insurance companies and patients are done correctly for each medication dispensed. Participants of this study reported that certain types of e-prescription errors, such as having the wrong drug quantity package size, if undetected by pharmacy staff resulted in wrong billing by the pharmacy when a different drug package size had been dispensed. Pharmacy staff explained that if such billing issues were detected during external audits, it could lead to irregularities in pharmacy financial accounts and the pharmacy may not be reimbursed by the insurance company.

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 a 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.”

Component 4: Tools and technologies
In the SEIPS model, tools and technology include all electronic and non-electronic aids or devices. Participants reflected that certain tools and technology either facilitated or hindered recovery from e-prescription errors.

Dispensing aids and devices
Tools and technologies that were reported to be particularly helpful for detecting or correcting e-prescription errors included devices such as calculators, baskets for organizing prescriptions, online drug references, phones, and the fax machine. Calculators and drug references were used to verify prescribed dose quantities, baskets were used to separate e-prescription errors in the workflow, while phones and fax machines were used to communicate with and receive feedback about e-prescription errors from prescriber offices.

Pharmacist: “Well, the calculator to calculate the dose again, you know, just to double-check. Baskets, if something is, it just separates it from all the other clutter that’s on the counter, and so then I can come back to it when I have more time.”

Pharmacist: “Well, if it’s something that you have a question as far as what is the correct dose or whatever, looking, be it, you know, we’ve got the old Facts and Comparisons book or otherwise going online, and that’s where that laptop or any of the computer stations, checking dosing through Micromedex®, or Interactions is another one. If you’ve got a drug coming in, and it’s not, you know, it’s coming up that they’ve got something similar or whatever, Interactions, those sorts of things so, yeah, just online and some print stuff.”
Pharmacy computer system
Participants identified various aspects of their computer system such as the dispensing system that facilitated or hindered recovery from e-prescription errors. Certain aspects of their computer systems such as the clinical decision support (CDS) flagging inappropriate drug dosing made it easier to detect e-prescription errors. The CDS systems assisted participants to detection of deviations in e-prescription information from what the prescriber intended. Overreliance or complacency from depending on the technology to detect errors was also mentioned as a negative consequence of using technology.

Technician: “Sure, as described like that. And those would be like maybe pack size, like the clinic will put in one, but maybe when you are filling the prescription, a good example would be like a Restatis package. There’s 30 vials in there and it’s processed as 30 for billing. You can’t just put one in there or it’s going to charge for one. Or sometimes if you put the quantity in wrong, it will say, hey, you can’t, you know, you better check that pack size, that’s kind of a default in the PDX system so it may prompt you to look for that.”

However, participants reported many aspects of their dispensing systems that made it more challenging to address e-prescription errors. These included:

A. Poor visibility of e-prescription information on pharmacy computer screen

Pharmacist: “Well, on the e-prescription, you don't see the whole prescription at one time. You don't see the doctor, the patient, and the drug all at the same time at all.”
Pharmacist: “I know we talked a lot about how notes are useful, and our system is nice in having the split screen. But the downside of that is if the text is too long, it removes it from the screen, or it cuts it off and says, you know, hit another button to see the whole thing. And I think because a lot of people don't use the notes, we sort of don't look down there all the time.”

B. Duplication of patient profiles when new e-prescription is received

Technician: “Most of the time, sometimes we have, somebody could add another, add that same person in, so then there's two profiles going for that person.”

Component 5: Organization
In the SEIPS model, organization includes all organizational conditions associated with the work system, such as organizational culture, communication, teamwork, supervisory and management styles, coordination, and collaboration. Participants recognized that overall organization impacted their ability to recover from e-prescription errors. The themes that emerged were classified into communication, teamwork, training, and available staffing.

Communication between pharmacy staff and prescribers
An important aspect of detecting and correcting e-prescription errors was related to communication among pharmacy staff and communication with prescriber offices. Participants expressed that adequate and accurate communication facilitated recovery from e-prescription errors. However, insufficient communication and communication protocols sometimes hindered
recovery from errors due to breakdown in content and flow of information between pharmacy staff or between pharmacy staff and clinic staff. As part of the pharmacy workflow, e-prescription errors identified by technicians were communicated to the pharmacist, who then contacted the prescriber to correct the error. Technicians also contacted prescribers if they perceived that the error was an obvious omission or calculation error by the prescriber. Errors also occurred when e-prescription error information had to be communicated during pharmacy staff shift change due to missing or inaccurate information being communicated.

Communication with the prescriber often involved dealing with several clinic staff (that is, the receptionist and the nurse) before the pharmacist was able to speak to the prescriber; this resulted in significant delays in correcting e-prescription errors. Because e-prescription information was transferred through multiple parties, the information sometimes became inaccurate when the message was received by the prescriber. Participants stated that the most important way to improving recovery of e-prescription errors involved identifying ways to easily access prescribers in order to correct e-prescription errors in a timely manner. Lack of easy communication with prescribers was a barrier to correcting errors, however having good communication with prescribers was reported to be a facilitator to correcting e-prescription errors. Participants stated that an important way of communicating between pharmacy staff and prescribers was the use of the “comments field” by the prescriber. Prescribers sometimes used the comments field to include additional patient or drug information when generating an e-prescription. Pharmacy staff found prescriber use of the comment field of e-prescriptions particularly useful in detecting or correcting e-prescription errors.

Pharmacist: “On occasion, the doctor will write more instructions over in this little note field, which sometimes will clarify things, but usually they don’t, you know. If there is something that doesn’t seem to match up with what the patient had before, there will be note field where sometimes the nurse will put in or the doctor will put in new dose or this is a new strength or something like that, which is really helpful. I really like those notes when the nurse or somebody says, you know, this is something different from what you’ve had before.”

Pharmacist: “Well, we had to establish communication with the doctor himself. We weren’t getting anywhere with the nurse. And I suspect what happened was the wrong strength was dictated by the doctor.”

Pharmacist: “Definitely a lack of easy communication with the prescribing physician or their staff. It would be really convenient if we could just send the prescription back to them and sort of, you know, highlight or circle the areas that are incorrect or just send them a quick question, you know, is this what you really intended to do? Instead, we have to go through the phone dance, and that can take anywhere from five minutes to, you know, five days. So definitely lack of access to the prescribers. And a lot of times, even finding the providers [prescribers] in the first place can be difficult, because we’ll receive e-prescriptions that are populated with contact information, and we’ll call them at that number, and they’ll say, you know, this person is working at their other clinic today. And so you have to call a whole bunch of different clinics to find out which one they’re actually working at. Or maybe it’s a person just there for the day, or a, like an ER
doctor that only works once a week, and so nobody else has any idea what's going on. So definitely getting a hold of the correct prescriber, or somebody who has the authority to make the change.

Teamwork in pharmacy
Pharmacists and technicians relied on a team approach to check and recover from e-prescription errors. E-prescription errors detected by technicians were generally discussed with the pharmacist. The pharmacist or technician then contacted the prescriber’s office. The e-prescription was reviewed by two or three pharmacy staff before medications were dispensed to patients. Using a team approach to address e-prescription errors was particularly important when the pharmacy was busy.

Pharmacist: “Well, again, I think I mentioned this once before, that depending on what the error is and who catches it, if the technician catches something or they question something, oftentimes they'll refer to the pharmacist to verify that what they think is an error is really an error. Or just to get clarification, like how do you interpret this? I interpret this as, well, this, this, and this. Like the one with the directions being kind of different, you know, it's like, well, maybe the tech is like, oh, well, they're just saying in the long term he was going to take it twice a day, and now he's just going to start with one a day, so maybe this makes sense. Maybe we don't really need to call the doctor. So they'll consult with another pharmacist or even another technician, but usually the pharmacist. If the pharmacist catches it, there's less likelihood that they would consult with another team member, although they would sometime pass it off to the technician to make the phone call. So there still is potentially two people involved, just because that way the pharmacist can go back to doing the things that the pharmacist is legally only allowed to do, where the tech can make the call and leave a message just as well as anybody. And then the pharmacist would be the one who took the return call and clarified with the nurse.”

Training of pharmacy staff
Another organizational factor that was reported to be important in recovery from e-prescription errors was formal training available for pharmacy staff on use of e-prescribing and common e-prescription errors. Participants stated that most of their e-prescribing training had been received informally. Participants expressed that receiving formal training on common e-prescribing errors would help them in detecting errors more effectively. Pharmacists and technicians also perceived that it was important for pharmacy organizations to trend common e-prescription errors and use this information during formal training sessions to increase pharmacy staff awareness about how best to address e-prescription errors. Participants stated that receiving formal training on how prescribers generated e-prescriptions that were received in pharmacies was also important to their recovery of e-prescription errors. On the other hand, participants noted that inadequate training could be a barrier in recovery from e-prescription errors.

Pharmacist: “I think people, under people, we could put, in the same sense, while our technicians help us, they can also make a barrier, whether they're not as well trained, or they are overconfident, or they go too fast, or whatever it is, where they're not checking their work, and that could be a barrier.”
Technician: “I would say, I mean, the same case probably. There's nothing, you know, in writing in a manual, but when we train people that's, we're going to train them how to resolve it. But there's no, you know, it's usually on-the-job training.”

Technician: “You know, the thing I thought was interesting about sort of like spend a day at a doctor’s office, and, you know, it almost might be, rather than just observing just be like, as they're typing it in, be like, no, that's not going to fly, just so you know. We're going to be calling you about that. Just, that one might actually be a really good thing, just sort of like a little exchange program just to educate people.”

Staffing levels in the pharmacy
Pharmacists and technicians reported that organizational staffing levels played a valuable role in their ability to efficiently recover from e-prescription errors. Adequate staffing was discussed as a way to enable pharmacy staff to address e-prescription errors more promptly before patients arrived in the pharmacy. On the other hand, inadequate or low staffing levels made correction of e-prescription errors slower, resulting in more interruptions for pharmacy staff, backlog of e-prescriptions, poor training, and pharmacy staff taking shortcuts when checking e-prescriptions for errors. Thus, low staffing levels were reported by participants to result in higher workload for pharmacy personnel.

Pharmacist: “...Staffing levels, obviously, really, really, you know, help too. I'm not saying that we should, I know there's a fine balance between way too much staffing versus way understaffing. But sometimes...it's been a source of frustration sometimes for me at times when I'm beginning to find out that, hey, I'm at that level where I think I can use the extra help. But, unfortunately, somebody else doesn't see it that way, you know. And so, unfortunately, I don't make the rules in that way, so I can't really, I don't have the power and everything to, you know, draw off what I think would be very, very beneficial for a pharmacy and everything to be able to help their patients that come in at the same time but also not get so overwhelmed, okay, that the temptation is to start doing shortcuts on checking or something like that.”

Technician: “...so maybe you started your batch of e-prescribes and maybe you got ten in there. And now you have half a dozen people out there. Well, I can’t just stand there and type. And with decreased staff here, it's very difficult to know where to go sometimes. Should I keep typing because I got, you know, three red bins, which are people who are waiting? But now, you know, the next gal's got six people out there. Well, I should go help her. But now I have maybe some bins that need to be filled, you know, so you're very torn nowadays as to, but before I used to know what the priorities were, and now I really don't. I sometimes just keep doing what I'm doing because I don't think it matters. You have one pharmacist, who often is checking out people, which I don't think is their job. But she has to go down and counsel, you might as well just finish it up. And let us keep going back here. So it's very difficult to prioritize.”
Study Aim 3: Potential interventions to reduce e-prescribing errors

The input of community pharmacy personnel was important to identify interventions that could make e-prescribing systems safer for patients. Redesign suggestions were focused primarily on improving the software on the physician and pharmacist sides, as well as the intermediary transfer service that is used to send e-prescriptions from a physician to a pharmacist. Participants cited usability issues as one of the contributors of errors and thus suggestions centered on improving usability as well as decision support.

**Pharmacist:** Yeah, number one, just definitely from a, the system designer's standpoint, there's no doubt the software has to be improved.

**Pharmacist:** I think notifying prescribers when they order something unusual and like out-of-the-ordinary... because, like I said, they're allowed to customize things too much, so you can just go in and change whatever directions and dosing that you want. And it tends to auto-populate a lot of things... it doesn't really give them any warnings or notices, like, hey, something about this doesn't seem right, you ordered 100 pills for one day... I don't think it notifies them sort of standards of what's going on, standards of practice, or standards for that drug.

**Pharmacist:** I think making things a little more user-friendly, like I said, the comments being more easily visible, or acknowledged. Dealing with long drug names, instead of having to go through a bunch of windows, make it easier to find the additional information you need, and quicker. I like the fact that we have the split screen, because it really helps, I think, reduce input errors, because you can immediately check to make sure everything matches up. I think those are sort of the biggest things.

Also suggested was a need for pharmacists to understand what the interface looks like for physicians as well as for physicians to understand how what they enter in the electronic health record appears in the pharmacy.

**Pharmacist:** It would also be really cool to sit in a room with a doctor and see what the doctor sees and then have them see what we see. That would be awesome. That would be like the ultimate thing, to be able to sit in a workshop and have even small, like even if, let’s say a couple docs and a couple pharmacists or a couple techs and just have them, okay, I just, like have the doc send the script over, have the tech input it, and then see what the pharmacist does. Do you know what I mean?

Pharmacists and technicians suggested that the vendors of e-prescribing software on both the physician and pharmacist side take time to better understand the errors that are occurring and how the software is used so that improvements can be made. It was also thought that the pharmacy information network that route e-prescriptions from prescribers to community pharmacies needs to better address how data is translated from the physician’s electronic ordering system into the pharmacy’s software. Along these lines, pharmacists suggested that there be a mechanism that allows them to communicate directly back to the physician through the e-prescribing system if there is an error.
Pharmacist: “It would be really convenient if we could just send the prescription back to them and sort of, you know, highlight or circle the areas that are incorrect or just send them a quick question, you know, is this what you really intended to do? Instead, we have to go through the phone dance, and that can take anywhere from five minutes to, you know, five days.”

Pharmacy staff also suggested that they may be able to avoid contacting the prescriber all together if they had more information (e.g. diagnosis) by which to interpret prescriptions or if they had access to the electronic medical record.

Training and procedures within the pharmacy and the prescriber’s setting were also suggested as a way to help reduce errors. For example, alerting pharmacy staff as to what common e-prescription errors are and how best to address them. On the prescriber side, physicians having better training on their electronic ordering system (e.g. knowing that they need to delete the auto-populated directions) and having increased knowledge of drugs and how to order them (e.g. package size).

Lastly, pharmacy staff noted that some of these training and technology issues could be eliminated by larger health care system changes. For instance, standardizing drug package size and having both pharmacies and physician offices use the same drug database and NDC numbers.

**DISCUSSION**

It is widely known that medication errors can cause patient harm and can also be costly for the healthcare system (Roughead and Semple, 2009). The outcomes of medication errors on patients may range from mild inconvenience to fatal toxic reactions (Dubey et al., 2006). Previous research conducted in hospital settings has indicated that e-prescribing errors can lead to patient harm due to adverse events (Palchuk et al., 2010). Study aim 1 focused on types of e-prescribing errors, their potential consequences, and contributing factors in community pharmacies. Consistent with previous studies that examined e-prescribing errors in community pharmacies (Gilligan et al., 2012; Warholak and Rupp, 2009), this study found that the three main types of e-prescribing errors encountered in community pharmacies include wrong drug quantity, wrong dosing directions, and wrong dosage formulation. The primary implication of these findings on pharmacy practice is that despite the implementation of e-prescribing systems, there is still potential for patient harm with use of this health IT. Consequently, e-prescriptions need to be checked carefully to prevent errors from reaching patients. Pharmacists and technicians in this study perceived that e-prescribing errors, when not detected in the pharmacy, can have negative patient consequences, such as poor disease management or failed drug therapy.

Study aim 1 also elucidates the many factors that can cause e-prescribing errors. Pharmacists and technicians stated that the factors that contribute to e-prescribing errors include, but are not limited to, technological incompatibility between the pharmacy and clinic systems, and technology design issues that impede usability, such as the use of auto-populate features and dropdown menus. These factors can lead to the inadvertent selection of incorrect drug or patient
information. Similarly, a survey of physicians in primary care settings found that prescribers may quit using e-prescribing systems due to poor design and usability (Wang et al., 2009). More than ever before, it is becoming paramount for e-prescribing designers to take into consideration the usability issues identified by end users, such as physicians and pharmacists, to prevent unintended medication errors.

The findings from study aim 2 helped researchers characterize how community pharmacy personnel prevent e-prescribing errors they encountered in their practice setting. These results suggest that most e-prescription errors were detected during the inputting of information into the pharmacy system. These errors were detected by both pharmacists and technicians using a variety of strategies such as printing the e-prescription to paper and verifying information on the computer screen with information on the paper printout of the e-prescription. Pharmacists and technicians reported that different strategies were used to explain e-prescription errors that were detected, the most important being the review of the patient’s medication history in the pharmacy system. The study also found that the primary goal of pharmacists and technicians was to get the prescription right for the patient by verifying the prescriber’s intent when an e-prescription error was encountered. In order to correct these errors, community pharmacy personnel either made educated guesses of the prescriber’s intent or contacted the prescriber via telephone or fax. In line with other studies that have reported that pharmacy personnel play an active role in preventing medication errors (Buurma et al., 2001; Chen et al., 2005; Hawksworth et al., 1999; Kuo et al., 2008; Rupp, 1992), this study helps to shed light on the important role that community pharmacy personnel play in preventing e-prescribing errors.

Research on the role of community pharmacy personnel in e-prescription error prevention is in its infancy. It is known that studying recovered medication errors is important to learning how to prevent future errors from harming patients (Blumenthal, 1994). Pharmacy personnel in community settings are well positioned to ensure patient safety through the detection and correction of medication errors (Sánchez and Campos, 2011). The study findings provide further evidence for the benefit of studying recovered errors. The American Society of Health System Pharmacists encourages the documentation of instances in which healthcare professionals prevented the occurrence of medication errors to help identify system weaknesses and reinforce the importance of multiple checks in the medication use system (ASHP, 1993). As shown in the study findings, pharmacists and technicians in community settings are the last line of defense in preventing e-prescription errors from reaching patients and thus fundamental actors in successful prevention of e-prescribing errors.

Community pharmacy personnel in this study were acutely aware of the potential for e-prescription errors. They could easily explicate e-prescription error prevention strategies that they used in their practice setting as well as provide reasons for employing these strategies. These strategies represent deliberate and thoughtful approaches that pharmacists and technicians use to keep their patients safe in work environments that are prone to errors. These findings provide evidence that pharmacist and technician vigilance prevents many potentially dangerous medication errors from reaching and harming patients. Findings of this study shed light on the need to explore how best to support prevention of e-prescribing errors in community pharmacies. Consequently, it is important for pharmacy organizations to develop strategies that reduce or eliminate errors and support pharmacy personnel recovery from such errors.
Pharmacy personnel are frequently involved in recovery from e-prescription errors and some of these errors may remain undetected. It is difficult to detect, document, and prevent all medication errors in all healthcare settings, because they are complex work environments (Nolan et al., 2004). Community pharmacy is the frontline of healthcare, making it a particularly important in healthcare settings to study medication errors. They constitute the visible face of neighborhood healthcare and play an essential role in ensuring patient safety in the ever growing and complex healthcare delivery system (Sánchez and Campos, 2011). In an effort to minimize medication errors, many complex healthcare settings use health IT, such as e-prescribing (Kaushal et al., 2010). This research also provides preliminary evidence of work system factors that can facilitate or hinder e-prescription error recovery in community pharmacies.

Also addressed in study aim 2 is the application a human factors model, the SEIPS model (Carayon et al., 2006), to aid the identification of barriers and facilitators to preventing e-prescription errors. It appears that organizational factors such as communication, training, teamwork, and staffing levels play a significant role in recovery from e-prescription errors. For example, adequate communication, staffing, and training facilitate recovery from e-prescription errors while lack of any of these factors hinders recovery from e-prescription errors. The finding that organizational factors are one of the many factors that influence in patient care activities in community pharmacy is supported by another study that also employed the SEIPS model to examine work system factors that influence medication therapy management services offered in community pharmacies (Chui et al., 2012). This study showed that other work system factors that could positively or negatively affect recovery from e-prescription errors. For example, person/people factors such as level of experience of pharmacists and technicians, task factors such as interruptions and workload, and environmental factors such as noise also play a relevant role in recovery from e-prescription errors.

Although the work system model comprises of five distinct components (environment, organization, person, tasks, and tools/technology), it recognizes the balance and interconnectivity between components. For instance, factors related to people or environment in the work system are also influenced by organizational factors. For example if an organization has a policy that limits staffing levels, this may lead to higher workload and stress for pharmacy personnel. Consequently, for pharmacists and technicians to be successful in detecting and correcting e-prescription errors, pharmacies must provide the appropriate working environments that promote recovery from errors. These findings are consistent with results from a previous study that examined error recovery in a hospital pharmacy that found that the hospital pharmacy needed to reduce negative influences on recovery and reinforce positive influences to improve patient safety (Kanse et al., 2006). In this study, Kanse and colleagues found that a primary negative influence to recovery from errors was the organizational culture of the hospital pharmacy.

It is known that operators in complex systems recover from a large number of errors and the study of recovery from such errors is an important approach to enhancing system safety and reliability (Kontogiannis, 1997). Similarly, many e-prescribing errors are recovered before reaching the patient in community pharmacies. Without studying how people recover from errors, it is difficult to identify practical guidelines on how to support this important process. Consequently, it is important to design health IT within work systems to promote error recovery.
so as to enhance learning opportunities and increase system safety and reliability. Recovering from errors in complex systems often requires cooperation of several individuals, in this case, pharmacists, technicians, physicians, nurses, and clinic receptionists. This raises issues such as preventing communication breakdown and sharing awareness, both of which are necessary components of successful error recovery plans (Kontogiannis, 2011). Thus, conducting more research on error recovery strategies can help human factors and safety experts to develop resilient work system and training solutions for managing errors (Kontogiannis, 1997, 2011).

As recommended by one study, it is important to pay attention to work system factors that influence recovery from errors (Sellen, 1994). Recognizing the work system factors that influence recovery from e-prescription errors can enable pharmacy organizations to effect changes in order to enhance quality and ensure maximum patient safety at the community pharmacy level of the healthcare system. Turning on the practical implications of this kind of research, system designers and pharmacies could benefit by asking how their systems or work environment can be improved upon to better support the detection and correction of e-prescribing errors in pharmacies. Two basic recommendations include: (1) designing pharmacy systems to detect e-prescribing errors or designing pharmacy work systems to augment the pharmacy team’s ability to recovery from errors, and (2) focusing on preventing errors that originate from the prescribing end. Additionally, error prevention processes identified in community pharmacies can provide strategies for future system redesign and training on e-prescribing systems to minimize the negative consequences of e-prescription errors on patients. Furthermore interventions identified by study aim 3, shed light on improvements that can be made to current e-prescribing use.

CONCLUSIONS

In summary, this project emphasizes the role of community pharmacy in the detection and correction of e-prescribing errors. Examining error recovery as an important process in error prevention is a relatively new line of research in community pharmacy practice. It is important for pharmacists and technicians to be aware of the significance of error recovery in order to attain high standards of patient safety and quality of care. Previous research focused on quantifying error recovery without assessing the necessary steps for successful recovery or identifying work system barriers and facilitators to recovery. To the researcher’s knowledge, no previous study has examined the process by which community pharmacies recover from e-prescription errors. This project began to address this research gap in the community pharmacy practice literature. In addition, applying concepts from the field of human factors engineering was beneficial for understanding work system redesign in community pharmacies that may benefit pharmacists’ and technicians’ performance and patient safety. The study findings may provide policymakers with more practical evidence-based suggestions that will enhance e-prescription processes for pharmacies and patients.
REFERENCES


Patton, M. Q., 1990, Qualitative evaluation and research methods. SAGE Publications.


Figure 1. Diagram of conceptual framework

Table 1. Characteristics of participants

<table>
<thead>
<tr>
<th></th>
<th>Pharmacists N = 13</th>
<th>Technicians N = 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Women</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Age (in years)</td>
<td>27 – 69</td>
<td>22 – 59</td>
</tr>
<tr>
<td>Pharmacy experience (in years)</td>
<td>3 – 44</td>
<td>3 – 30</td>
</tr>
</tbody>
</table>

*Pharmacists – Mean age: 45.6 years (Standard deviation – 12.7); Mean years of pharmacy experience: 20.6 years (Standard deviation – 12.9);
Technicians – Mean age: 36.8 years (Standard deviation – 11.7); Mean years of pharmacy experience: 18.1 years (Standard deviation – 12.6)
Table 2. Characteristics of pharmacies

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

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

Table 3. Types of e-prescription errors encountered

<table>
<thead>
<tr>
<th>Type of error</th>
<th>Example</th>
<th>Observations (N = 75)</th>
<th>Interviews (N = 107)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrong quantity</td>
<td>Drug quantity reads 1gm instead of 16gm for fluticasone nasal spray inhaler.</td>
<td>30 (40%)</td>
<td>35 (33%)</td>
</tr>
<tr>
<td>Wrong dosing directions</td>
<td>Take 30 capsules by mouth 2 times daily. Take 1 capsule once daily.</td>
<td>14 (19%)</td>
<td>30 (28%)</td>
</tr>
<tr>
<td>Wrong duration of therapy</td>
<td>Duration of therapy is 5 days instead of 10 days</td>
<td>16 (21%)</td>
<td>5 (5%)</td>
</tr>
<tr>
<td>Wrong dosage formulation</td>
<td>Drug form reads nifedipine 30mg ER (extended release) instead of nifedipine 30mg XL</td>
<td>8 (11%)</td>
<td>17 (16%)</td>
</tr>
<tr>
<td>Wrong patient</td>
<td>E-prescription sent for patient “Will” and the system brings up another patient name “William”</td>
<td>4 (5%)</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>Duplicate therapy</td>
<td>Multiple e-prescriptions sent for the same patient one with doxycycline 50mg and the second with doxycycline 100mg</td>
<td>3 (4%)</td>
<td>3 (3%)</td>
</tr>
<tr>
<td>Wrong strength</td>
<td>E-prescription sent for omeprazole 20mg instead of 40mg</td>
<td>-</td>
<td>7 (7%)</td>
</tr>
<tr>
<td>Wrong drug</td>
<td>E-prescription sent for fluticasone inhaler instead of fluticasone-salmeterol oral inhaler</td>
<td>-</td>
<td>5 (5%)</td>
</tr>
<tr>
<td>Wrong pharmacy</td>
<td>E-prescription is sent to chain pharmacy instead of an independent pharmacy where patient goes to pick up medications</td>
<td>-</td>
<td>3 (3%)</td>
</tr>
<tr>
<td>Wrong prescriber notes</td>
<td>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.”</td>
<td>-</td>
<td>1 (1%)</td>
</tr>
</tbody>
</table>
*Observation data – 15 of the wrong duration therapy errors occurred in pharmacy 1; this may be due a peculiarity in their computer system not being able to translate duration of therapy from the e-prescription sent by the prescriber.

Table 4. Top 9 drug classes implicated with e-prescription errors

<table>
<thead>
<tr>
<th>Drug class</th>
<th>Sample drug name</th>
<th>Observations (N = 75)</th>
<th>Interviews (N = 107)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Antiinfectives</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Example: antibiotics</td>
<td>Doxycycline 50mg tablet</td>
<td>15 (20%)</td>
<td>13 (12%)</td>
</tr>
<tr>
<td><strong>Hormones and hormone Modifiers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Example: antidiabetics</td>
<td>Metformin 500mg tablet</td>
<td>13 (17%)</td>
<td>10 (9%)</td>
</tr>
<tr>
<td><strong>Cardiovascular agents</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Example: antihypertensives</td>
<td>Nifedipine 30mg tablet</td>
<td>6 (8%)</td>
<td>11 (10%)</td>
</tr>
<tr>
<td><strong>Respiratory agents</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Example: inhalers</td>
<td>Fluticasone 50mcg inhaler</td>
<td>9 (12%)</td>
<td>9 (8%)</td>
</tr>
<tr>
<td><strong>Psychotropic agents</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Example: antidepressants</td>
<td>Fluoxetine 10mg tablet</td>
<td>5 (7%)</td>
<td>8 (7%)</td>
</tr>
<tr>
<td><strong>Topical agents</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Example: ointments and creams</td>
<td>Hydrocortisone 1% ointment</td>
<td>7 (9%)</td>
<td>3 (3%)</td>
</tr>
<tr>
<td><strong>Gastrointestinal agents</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Example: laxatives</td>
<td>Docusate 100mg capsule</td>
<td>5 (7%)</td>
<td>3 (3%)</td>
</tr>
<tr>
<td><strong>Ophthalmic or otic agents</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Example: analgesic eyedrops</td>
<td>Bromfenac 0.09% ophthalmic solution</td>
<td>5 (7%)</td>
<td>2 (2%)</td>
</tr>
<tr>
<td><strong>Neurological agents</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Example: anticonvulsants</td>
<td>Gabapentin 600mg tablet</td>
<td>6 (8%)</td>
<td>-</td>
</tr>
</tbody>
</table>
DATA COLLECTION INSTRUMENTS

1. Observation Guide used with Field Notes

Participant code _______ Job of participant staff being observed _______ Gender: _______

Average number of prescriptions processed daily: _______

Observer: _______ Type of prescription: _______ Study ID number #: _______

Time of Observation: Beginning: ___________ End: ___________ Total duration: ___________

<table>
<thead>
<tr>
<th>E-prescription processing</th>
<th>Observer’s comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>E-prescription recovery</th>
<th></th>
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<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Work system factors - (people, tasks, technology, organization, environment)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
Participant/Pharmacy Information Sheet

Pharmacy Name__________________

Daily number of e-prescriptions________________

Daily Rx volume__________________

Daily pharmacy staffing______________________

Participant’s Name__________________  Gender______________  Age _____________  Years in Practice ________________

Years in this pharmacy_______________________

E-prescribing experience (in Years) ______________

Position (Pharmacist or Technician) ______________

How many hours per week do you work? ______________
2. Interview Guide  
Date: __________  Participant Code Number: __________

Thank you for agreeing to participate in this interview. Your experience and opinions are very important to us. Your participation will help us understand how community pharmacies address problems with electronic prescriptions, common e-prescription errors you encountered, and specific steps taken to address these errors. The interview is being recorded so that we can fully capture your thoughts on this topic but what you say is confidential, and your name or the name of your organizations will not be used in reporting findings of the study. The interview may take about 1 hour. Thank you for giving us this time. What questions do you have before we begin?

**Processing of prescriptions**

In this section we are going to ask you questions related to processing of prescriptions.  
*We define e-prescriptions as prescriptions received electronically from physician offices directly into the pharmacy computer e-prescribing queue. Other prescriptions such as paper, faxed, or phoned will be categorized as non e-prescriptions.*

1. On average, how many e-prescriptions do you process daily? How many prescriptions in total do you process daily?

2. Briefly describe how you process e-prescriptions. We have observed this but will like you to describe it in your own words.

3. How is e-prescription processing similar or different to processing non e-prescriptions such as paper, faxed, or phoned?

**E-prescription errors**

Now we are going to ask you questions related to e-prescriptions errors you have encountered.  
*We define e-prescription error is an omission, inaccuracy, or ambiguity in e-prescription information that may lead to inappropriate medication use by a patient.*

4. Do you encounter e-prescription errors? If you do, can you tell me about these errors and why you think they occurred?

5. Thinking of e-prescriptions errors you encountered with the last 30 days, describe one specific incident were by you had to deal with a challenging e-prescription error.

**Probes**

What type of error occurred?

a. How did you realize or suspect the prescription had an error?

b. Was there any information that helped you detect there was an error?

c. How did you go about understanding why it occurred?

d. What was your goal for addressing the error?

e. What did you consider as possible ways to achieve this goal?

f. What did you do decide to do about the error?

g. What was the final outcome?

h. Was there any other information that helped you resolve the error? [Make sure participant elicits steps they went through to resolve e-prescription error]
i. How long did it take to resolve the error? Thinking of from the time you detected the error to the time it was resolved.

j. Did this error remind you of any previous experience?

k. Was there any specific training or experience that was necessary or helpful in detecting or resolving this error?

l. Thinking of what was going on in the pharmacy at the time the error took place, on a scale of 1 to 5, 1 being very low and 5 being very high, how much time pressure did you feel when you were addressing this error?

6. Describe a second incident were by you had to deal with a **challenging e-prescription error**. [Use probes above]

7. When you encounter some of these e-prescription errors, what kinds of prescription information are pharmacists or technicians legally allowed to change without contacting the prescriber? What do you need to call the doctor for before you make changes?

8. In general, are there other things that help you detect e-prescription errors?

9. In general, are there other things that help you resolve e-prescription errors?

10. What kinds of things make it more difficult for you to detect an e-prescription error?

11. What kinds of things make it more difficult for you to resolve an e-prescription error?

12. What are some consequences for the patient if you don’t catch the error?

13. What are some consequences for the patient if you can’t resolve the error?

14. What happens to your workflow if you can’t resolve the error immediately?

15. Are there any medications that you tend to pay more attention to, to ensure you identify any errors? How do you address these kinds of prescriptions differently from other prescriptions that you may be perceived as less harmful?

   a. Probe – high risk medications such as anticoagulants

16. What medications are particularly problematic when using e-prescribing? Why? How do you deal with such e-prescriptions?

**Work system factors**

**Person**

17. Is identifying and resolving e-prescription errors something you can do by yourself or does it involve more than one staff person? If it involves more than one staff person, how do you work as a team?

   a. Probe for differences in responsibility between staff, how communication, coordination of tasks, or handoffs take place
18. Does the pharmacist or technician do similarly or different things to identify and then resolve the e-prescription error? Describe some of these similarities or differences? How and why do they do things differently?

Environment

19. In your own words, could you describe the pharmacy layout or how things are set up in the pharmacy? How do you think the pharmacy set up affects your ability to identify e-prescription errors? How do you think the pharmacy set up affects your ability to resolve e-prescription errors?

20. What are some of the sources of noise you experience while working in the pharmacy and how often do they occur? How do you think the noise affects your ability to identify e-prescription errors? How do you think the noise affects your ability to resolve e-prescription errors?

21. What kinds of interruptions do you experience while working at the pharmacy and how often do they occur? How do you think these interruptions affect your ability to identify e-prescription errors? How do you think these interruptions affect your ability to resolve e-prescription errors?

Tasks

22. How often do you have to do more than one task at a time? How do you think having to do more than one task at a time affects your ability to identify e-prescription errors? How do you think having to do more than one task at a time affects your ability resolve e-prescription errors?

23. How often do you feel time pressured in the pharmacy? How often do you have a backlog of e-prescriptions that you need to fill? How do these elements [time pressure, backlog of e-prescriptions] affect your ability to identify e-prescription errors? How do these elements [time pressure, backlog of e-prescriptions] affect your ability to resolve e-prescription errors?

Technology & Tools

24. In your own words, could you describe your pharmacy computer system and e-prescribing system? Thinking of how the system is designed, what features make it easier or harder for you to identify e-prescription errors? What features make it easier or harder for you resolve e-prescription errors? [Can probe for screen design, text boxes, or use of patient profile lists]

25. Describe some tools that are available in the pharmacy to for processing e-prescriptions. Thinking of these tools, how do they help or make it difficult for you identify e-prescription errors? How do they help or make it difficult for you resolve e-prescription errors? [Can probe for bins/baskets, calculators, highlighting information]

Organization
26. Many pharmacies have different staffing levels, policies/procedures, training, or work schedules. Is there anything that your pharmacy management has in place that makes it easier or harder for you to identify e-prescription errors? Why? Is there anything that your pharmacy management has in place that makes it easier or harder for you to resolve e-prescription errors? Why?

This is the end of the interview. Thank you for your time!
3. Focus Group Guide

Date: __________ Participant Group: __________

Let’s take one minute to introduce ourselves – Mention your name, the pharmacy where you work, and your favorite thing to do in the spring. Focus group moderator will introduce the purpose of the focus group and facilitate the discussion. One researcher will serve as the timekeeper and content and process backup. Another researcher will act as the note taker.

**Goal – Identify barriers and facilitators to identifying and resolving e-prescription errors in community pharmacies**

**Section A – Discuss findings from observation and interviews – the ways that pharmacy staff identity and resolve e-prescription errors (20 minutes)**

**Working definitions**

*E-prescription error* is any omission, inaccuracy, or ambiguity in e-prescription information that may lead to inappropriate medication use by a patient.

*Identifying* means recognizing or sensing there is an error

*Resolving* means an actual decision or action to do something about the error or fix the error

We wanted to share with you all the different ways that pharmacy staff identity and resolve e-prescription errors that we learned about from watching you work and talking with you during our interviews. Please take a few minutes to look through this list (document A).

*Probe questions to determine if everyone identifies and corrects errors the same way*

Let’s go around the room and each person mention:

1. What is your initial gut reaction to these findings?
2. Is there one way that you use the most?
3. If you were to pick the best approach, which would you choose?

**Section B – Discuss barriers and facilitators to identifying and resolving e-prescription errors (40 minutes)**

Now we are going to talk things that facilitate and inhibit identifying and resolving e-prescription errors. We are organizing this into five components of your work such as the environment, technology, people, task, and organization. As we go around the room talking about this, the note taker is going to write on the whiteboard the points that you bring up and try to put them into any one of these five components (document B). The note taker will summarize what has ended up in each category and the moderator will ask if they have any others to add before moving on to the next question. The moderator may point out some of the interesting things (e.g. contrasts mentioned above)

1. **Facilitators to identification** – Remind participants of working definitions. Let’s go around the room and have each person mention one thing that they think makes it easy to identify e-prescription errors. [Note taker take a picture of the whiteboard]

   *Probe if needed:*

   a. Can anyone else think of anything else? What about . . . (You may provide examples things that observed or mentioned during the interviews)

2. **Facilitators to resolution and correction** – Remind participants of working definitions. Let’s go around the room and have each person mention one thing that they think best
helps resolve and correct e-prescription errors. [Note taker take a picture of the whiteboard]

_Probe if needed:_

   a. Can anyone else think of anything else? What about . . . (provide examples things that observed or mentioned during the interviews)

3. **Barriers to identification** – Remind participants of working definitions. Let’s go around the room and have each person mention one thing that they think makes it more difficult to identify e-prescription errors. [Note taker take a picture of the whiteboard]

_Probe if needed:_

   a. Can anyone else think of anything else? What about . . . (provide examples things that observed or mentioned during the interviews)

4. **Barriers to resolution and correction** – Remind participants of working definitions. Let’s go around the room and have each person mention one thing that they think makes it more difficult to resolve and correct e-prescription errors. [Note taker take a picture of the whiteboard]

_Probe if needed:_

   a. Can anyone else think of anything else? What about . . . (provide examples things that observed or mentioned during the interviews)
Focus Group document A: Example of steps to identifying and correcting e-prescription errors - Data from observation and interviews

**Definition of e-prescription error** – An e-prescription error is any omission, inaccuracy, or ambiguity in e-prescription information that may lead to inappropriate medication use by a patient.

- **Identifying the error**
  - Mismatch in information
  - Unclear or confusing information
  - Unable to find information
  - Abnormal dosage
  - Too high or low
  - Quantity, directions, etc

- **Is it really an error?**
  - Review patient profile
  - Call prescriber
  - Fax prescriber e-prescription
  - Ask patient
  - Use wholesaler website
  - Use drug reference books
  - Guess prescriber’s intent
  - Use online drug information tools

- **Correcting the error**
  - Rely on response from prescriber
  - Rely on past experience
  - Notify prescriber of change
  - Rely on available package size in pharmacy
  - Educated guess of prescriber’s intent
  - Leave as it is
  - Assume prescriber provided all information to patient

Pharmacist
Technician
Patient

Pharmacist
Technician

Pharmacist
Technician
Focus Group document B: Examples of different components of the work system

<table>
<thead>
<tr>
<th>PEOPLE/PERSN: Physical or psychological characteristics of the people interacting in the work system – pharmacist, technician, other support staff, patients, clinic staff (nurse, physician/prescriber, or receptionist)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe <strong>Barriers and Facilitators</strong> encountered when handling e-prescription errors.</td>
</tr>
<tr>
<td>Pharmacy staff or clinic staff</td>
</tr>
<tr>
<td>Fatigue Stress Level of education Level of training (formal and on the job)</td>
</tr>
<tr>
<td>Skills - communication or time management skills Motivation and needs</td>
</tr>
<tr>
<td>Psychological characteristics - situation awareness and perseverance</td>
</tr>
<tr>
<td>Patients</td>
</tr>
<tr>
<td>☐ Receptiveness ☐ Perception Participation ☐ Relationship with staff</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ORGANIZATION: Organizational conditions within a pharmacy organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe <strong>Barriers and Facilitators</strong> encountered when handling e-prescription errors.</td>
</tr>
<tr>
<td>Staffing levels Training and learning Feedback</td>
</tr>
<tr>
<td>Organizational support Policies &amp; procedures Organizational culture</td>
</tr>
<tr>
<td>Safety culture Organizational structure Management commitment</td>
</tr>
<tr>
<td>Legislation &amp; regulatory requirements</td>
</tr>
<tr>
<td>Coordination of Resources</td>
</tr>
<tr>
<td>☐ Teamwork ☐ Communication</td>
</tr>
<tr>
<td>Supervisory/Management Style</td>
</tr>
<tr>
<td>☐ Leadership style ☐ Empowerment ☐ Ownership</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TECHNOLOGY/TOOLS: Characteristics of the technology or tools that relate to how it is used, designed, or implemented. For example, parts of the computer screen or pharmacy dispensing software is not clearly visible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe <strong>Barriers and Facilitators</strong> encountered when handling e-prescription errors.</td>
</tr>
<tr>
<td>Usability of e-prescribing technology/computer system</td>
</tr>
<tr>
<td>☐ User friendly ☐ Training ☐ Intuitive</td>
</tr>
<tr>
<td>Characteristics of tools used for processing e-prescriptions</td>
</tr>
<tr>
<td>Non-electronic aids such as calculators, printer, scanner, fax</td>
</tr>
</tbody>
</table>

*Other elements of tools and technology* - Usability, visibility or transparency of information, acceptability, well-designed, drop-down menu, screen design, or availability of information
**TASKS:** Content and characteristics of tasks

Describe **Barriers and Facilitators** encountered when handling e-prescription errors.

- Distribution of tasks
- Changes in workload
- Complexity of tasks

- Content, Challenge, Utilization of Skills
  - Expectations met
  - Challenge
  - Job satisfaction

- Task demands
  - Time pressure/time constraints
  - Physical or mental workload
  - Need for attention

- Performance of tasks
  - Prescription processing
  - Prescription volume or pharmacy business
  - Performing related tasks/additional tasks/competing tasks

**PHYSICAL ENVIRONMENT:** Example - the pharmacy is too loud

Describe **Barriers and Facilitators** you’ve encountered when handling e-prescription errors.

- Interruptions - Telephone Rings
- Other Staff

- Noise level - 
  - Loudspeaker Announcements
  - Telephone Ringing
  - Conversations

- Layout and Work Station Design - Dispensing Area
- Service Area
- Atmosphere - Privacy
- Ambience

- Distractions

- Lighting

*Additional explanations of work system components*

**Physical environment:** For example, the pharmacy is too loud

*Other elements of environment* - Lighting, layout or work station design, noise level, interruptions, distractions, loudspeaker announcements, telephone rings, and conversations

**Tools/Technology:** - Non-electronic aids such as calculators, printer, scanner, fax.

This may also include computerized systems or pharmacy dispensing system, robot.

Characteristics of the technology that relate to how it is used, designed, or implemented. For example, parts of the computer screen or pharmacy dispensing software that is not clearly visible
Other elements of tools and technology - Usability, visibility or transparency of information, acceptability, well-designed, drop-down menu, screen design, or availability of information

Tasks: content and characteristics of tasks such as complexity of tasks, the amount of variety, the challenge and utilization of skills, the level of autonomy and job control, information and the flow of decision processes

Other elements of a task:
Task demands such as – time pressure or time constraints, physical or mental workload, need for attention
Performance of tasks – prescription processing, prescription volume or pharmacy busyness, performing related tasks/additional tasks/competing tasks

Organization: organizational conditions or anything that tells us about the pharmacy organization

Elements of an organization - Staffing levels, training and learning, feedback, organizational support, policies & procedures, organizational culture, safety culture, organizational structure, teamwork, communication, leadership, supervisory or management styles, management commitment, legislation & regulatory requirements

Person: Physical or psychological characteristics of the people interacting in the work system – this may include: the pharmacist, technician, other support staff, patients, clinic staff (nurse, physician/prescriber, or receptionist)

Characteristics of the person- Fatigue, stress, level of education, level of training (formal and on the job), skills and knowledge (may include communication or time management skills), motivation and needs, psychological characteristics (situation awareness and perseverance)
INSTITUTIONAL REVIEW BOARD APPROVAL

1. Notice of Approval

Notice of Action
University of Wisconsin–Madison
Institutional Review Board (IRB)

Principal Investigator: Michelle Chui, PharmD, PhD
Department: Pharmacy, School of
Co-Investigator: Olufunmilola K Odukoya
Point of Contact: Olufunmilola K Odukoya
Protocol Title: Exploring E-Prescription Problems in Community Pharmacies
Protocol Number: SE-2012-0615
IRB: Social & Behavioral Sciences IRB (Contact: 263-2320)
Committee Action: Approved on: October 10, 2012 Expires: October 09, 2013

We have received the information you sent regarding the above named protocol. This information complies with the modifications required by the Institutional Review Board, and your protocol is now approved. You may begin collecting data at any time.

Thank you for your cooperation.

Special Notes or Instructions: The modifications requested have been submitted and this protocol is now approved per 45 CFR, 46.110 (b)(1), 7, as a study of group characteristics involving observation, interviews and focus group methodologies. Participants will sign written consent forms. Signed site permission letters have been provided by the sites where the research will take place. The IRB has determined that this is a minimal risk study.

INVESTIGATOR RESPONSIBILITIES:

Unless this protocol is exempt, or the IRB specifically waived the use of written consent, an approved consent form that is stamped with approval and expiration dates can be found on IRB WebKit. To find the stamped consent form, go to IRB WebKit at https://rcr.gradsch.wisc.edu/irbwebkit/Login.asp. Login and open this protocol number. The link to the consent form can be found on the left side of the page. All copies of the form must be made from this original. Any changes to the consent form must be approved in advance by the IRB.

Any changes to the protocol must be approved by the IRB before they are implemented.

Any new information that would affect potential risks to subjects, any problems or adverse reactions must be reported immediately to the IRB contact listed above.

If the research will continue beyond the expiration date indicated above, a request for renewal/continuing review must be submitted to the IRB. You must obtain approval before the current expiration date. If you do not obtain approval by the expiration date noted above, you are not authorized to collect any data until the IRB re-approves your protocol.

Signed consent forms must be retained on campus for seven years following the end of the project.

If you are continuing to analyze data, even though you are no longer collecting data, you should keep this protocol active.
UNIVERSITY OF WISCONSIN-MADISON
Research Participant Information and Consent Form

Title of the Study: Exploring E-Prescription Problems in Community Pharmacies

Principal Investigator: Michelle Chui (phone: 608-262-0452; email: mchui@pharmacy.wisc.edu)
Student Researcher: Olufunmilola K Odukoya (phone: 6086985054)

DESCRIPTION OF THE RESEARCH
You are invited to participate in a research study about electronic prescription (e-prescription) problems encountered in community pharmacies. You have been asked to participate because of your familiarity with handling e-prescriptions. The purpose of the research is to understand how pharmacists and pharmacy technicians manage e-prescription problems. The research will take place at your pharmacy or any other location of your choosing.
Audio tapes will be made of your participation. Audio recordings will be heard by only the primary and co-investigators of this research. The tapes will be kept for the duration of the study and analyzed, before they are destroyed.

WHAT WILL MY PARTICIPATION INVOLVE?
If you decide to participate in this research you will be asked to take part in one observation, one interview, and one focus group. You will be observed handling e-prescriptions problems for about 2 hours. You will be interviewed for 1 hour on how you manage e-prescription problems. You will also be asked to take part in one focus group session with other pharmacy staff that use e-prescribing. The focus group session will last approximately 1 hour. During these sessions, you will not be sharing any patient specific information or any other identifying information.

ARE THERE ANY RISKS TO ME?
There is minimal risk to participating in this study. All information provided by the participant is confidential and will only be seen by the primary and co-investigators. There is a possibility in risk of a breach in confidentiality during the focus groups. The confidentiality of information shared in the focus group cannot be guaranteed because other members of the focus group may share information outside of the group.

ARE THERE ANY BENEFITS TO ME?
There are no direct benefits to you for participating in this study.

WILL I BE COMPENSATED FOR MY PARTICIPATION?
You will receive $50 for participating in this study. If you do withdraw prior to the end of the study, you will receive no compensation.

HOW WILL MY CONFIDENTIALITY BE PROTECTED?
While there will probably be publications as a result of this study, your name will not be used. Only group characteristics will be published.
If you participate in this study, we would like to be able to quote you directly without using your name. If you agree to allow us to quote you in publications, please initial the statement at the bottom of this form.

WHOM SHOULD I CONTACT IF I HAVE QUESTIONS?
You may ask any questions about the research at any time. If you have questions about the research after you leave today you should contact the Principal Investigator Michelle Chui at 608-262-0452. You may also call the student researcher, Olufunmilola K Odukoya at 6086985054.
If you are not satisfied with response of research team, have more questions, or want to talk with someone about your rights as a research participant, you should contact the Education Research and Social & Behavioral Science IRB Office at 608-263-2320.

Your participation is completely voluntary. If you decide not to participate or to withdraw from the study it will have no effect on any services or treatment you are currently receiving.

Your signature indicates that you have read this consent form, had an opportunity to ask any questions about your participation in this research and voluntarily consent to participate. You will receive a copy of this form for your records.

Name of Participant (please print):______________________________

______________________________________________
Signature  Date

________ I give my permission to be quoted directly in publications without using my name.
3. Pharmacy Support Letter

Date: ________________________

To whom it may concern:

This letter is to inform you that we will allow our clinic site to participate in Dr. Michelle Chui’s project entitled, “Exploring E-Prescription Problems in Community Pharmacies.” I am aware that the research is to understand how community pharmacies manage e-prescription problems. The employability of participants at our site will not be affected by their decision whether or not to participate in this study.

I will support Dr. Chui’s research assistant working on this research project to obtain data through an observation, an interview, and one focus group session. The research assistant will not speak to any patients or practice pharmacy during the study period.

I will ensure that the research assistant will not have access to any patient-specific information or unauthorized data, as specified by patient data privacy agreements, and will not use any patient-specific information for purposes of research.

I am excited about our involvement in this project and hope that the results of this project will provide our clinic with valuable information about ways to improve the design of electronic prescribing technology to foster error-free medication dispensing practices there by providing safer patient care.

Thank you for your consideration.

Sincerely,

______________________________  ______________________________
Signature                  Print Name

______________________________  ______________________________
Pharmacy Name               Pharmacy Address

Please fax this back to Michelle Chui at (608) 262-5262. Thanks!