Report on the study:

Impact of Electronic Prescribing on Patient Safety and Pharmacy Workflow in Community Pharmacies

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PROJECT SYNOPSIS

Background: The volume of electronic prescriptions being processed across community pharmacies in the United States is increasing. This is as a result of recent allocation of funds to hospitals and enforcement of regulations by the federal government to expand the adoption of electronic prescribing (e-prescribing) technology nationwide. Theoretically, e-prescribing can improve safety and efficiency. However, questions have arisen regarding the impact of e-prescribing on community pharmacies.

Objectives: The primary purpose of this study was to gain insight into design features of e-prescribing that may pose a risk to safe delivery of patient care and its impact on community pharmacy workflow. The study aims are: (1) to evaluate the design and performance of various e-prescribing systems; (2) to characterize pharmacy workflow when processing e-prescriptions; (3) to explore the impact of e-prescribing on safety and quality of the dispensing process; and (4) to provide best practice redesign recommendations.

Methods: This study was guided by a human factors engineering framework, the Sociotechnical Systems Theory (STS). Pharmacists and technicians were recruited from seven community pharmacies in Wisconsin using three commonly used pharmacy dispensing systems (PDX, QS/1, and Pharmaserv). Data collection was performed in two phases. Phase 1 of data collection included direct observations and think aloud protocols to elicit verbalizations and the thought process of participants when processing five e-prescriptions. Phase 2 of data collection involved the interviewing of four pharmacy staff members from each pharmacy. Data collection procedures involved the use of standardized data collection tools: an instruction guide for the think aloud protocol, an interview guide, and a participant demographics form. Think aloud protocols and pharmacy team meetings (in-depth group interviews with four staff members) were recorded and transcribed. Transcripts were analyzed qualitatively using thematic analysis. Themes were identified in the transcripts and aligned with the components of the STS framework.

Results: A total of nine themes were identified from the think aloud observations and eleven themes were identified from the pharmacy group interviews. The results were as follows:

<u>Aim 1</u>: The positive aspects of e-prescribing systems design that facilitated pharmacy work included: legibility, ease of archiving, quick access to prescriptions, and consistency in format of e-prescriptions. Design weaknesses and potential technology hazards associated with e-prescribing systems were attributed to incompatibilities between pharmacy and prescriber computer systems. Incompatibility issues resulted in selection of wrong patient or drug (name, directions, dose, strength, formulation, package sizes). This was also due to the manner in which pharmacists, technicians, and prescribers viewed e-prescription information and selected their choices from the list of available options. The most frequent problem in pharmacies was duplicate or incorrect drug directions. In addition, e-prescription design created inaccurate patient profiles in the pharmacy and hindered pharmacists' ability to accurately review patient medication history.

<u>Aim 2</u>: E-prescribing technology frequently required less data entry into the pharmacy computer. This reduced the number of physical tasks pharmacy personnel had to perform because e-

prescription information was auto-loaded into the pharmacy dispensing software. Despite the original intent for e-prescribing technology to reduce the need for paper archiving, all pharmacies still printed e-prescriptions to paper. E-prescriptions had to be printed to paper to verify the accuracy of the prescription, to view aspects of the prescription that were cut off on the computer screen, and to archive the prescription. Receiving an overwhelming number of problematic e-prescriptions at the same time negatively influenced pharmacy workflow. Current e-prescribing technology necessitated workarounds, increased cognitive burden, and required significant vigilance to compensate for poor design features and to prevent errors.

Pharmacists perceived that they were less informed about and more distant from individual patient care with e-prescriptions than conventional prescriptions (paper, faxed, or called in), in part because e-prescribing resulted in less communication with prescribers. However, because technicians were primarily responsible for processing e-prescriptions, pharmacists needed to communicate more with technicians regarding e-prescriptions to be better informed about the nuances associated with the prescription or the patient's profile, and feel comfortable and confident when counseling the patient. Pharmacists also perceived that use of e-prescribing reduced their ability to recognize, interpret, and anticipate situations about individual patient care because technicians were mostly responsible for processing e-prescriptions.

Aim 3: E-prescribing did not always improve safety and quality of the dispensing process but in fact, created new kinds of technology hazards that could easily result in medication errors. Sometimes these errors were not caught in the pharmacy and led to patients receiving incorrect medications. Greater vigilance and patient counseling were required to catch errors with e-prescribing technology during the dispensing process when compared to paper prescriptions. This was the case because participants did not fully understand the root causes of new problems and errors created by e-prescribing technology.

Aim 4: The input of community pharmacy personnel was important to identify redesign recommendations for safer e-prescribing systems. Redesign changes that were suggested include: provision of formal training with supplemental continuing education for all users and fine-tuning the information provided and accessed on e-prescriptions.

Conclusion: The use of the STS framework provided a clear understanding of the significance of the challenges presented by introduction of new technologies to community pharmacy settings. The main conclusion from this study was that the current design and use of electronic prescribing technology in community pharmacy practice has created many challenges. This is primarily due to incompatibilities between pharmacy and prescribers' computer systems and a lack of understanding of pharmacy workflow and information needs by e-prescribing system designers. The findings suggest that e-prescribing technology can cause disruptions in pharmacy workflow and presents new threats to safe dispensing of medications. E-prescribing promised to improve safety and efficiency in quality of patient care in outpatient settings like community pharmacy; however, it has generated new kinds of errors and disruptions to pharmacy workflow. In order for e-prescribing to be successfully integrated into pharmacy practice, due consideration must be given to the impact of its design's on day-to-day dispensing activities.

EXECUTIVE SUMMARY

INTRODUCTION

Healthcare settings are increasingly adopting health information technology (HIT) to improve the safety of the medication use process. One such HIT that is being mandated for use across all healthcare settings by the federal government is electronic prescribing (e-prescribing).[1,2] Community pharmacy was the first healthcare discipline to significantly adopt technology to support their dispensing tasks so as to improve patient desired health outcomes.[3] The use of technology in pharmacies to improve patient care and support pharmacists' work date back to the 1970s with the advent of computer dispensing systems, automated dispensing robots, and online real-time third party adjudication of prescriptions.[2] However, despite early and significant adoption of technology, there has been almost no research investigating how health information technology (HIT) benefits or burdens work conducted in community pharmacy settings. Electronic prescribing (e-prescribing) is one emerging HIT and its use in pharmacy is growing exponentially.[4] In 2010 alone, over 320 million prescriptions were routed electronically. HIT use is generally linked to improved efficiency in clinical settings. E-prescribing in particular has been recommended as a technology that can improve pharmacy personnel's ability to process higher number of prescriptions.[5] However, questions have arisen regarding e-prescribing technology's ability to facilitate dispensing practices.

A primary reason for adopting e-prescribing technology was to reduce medication errors associated with illegible handwritten prescriptions. This is particularly important since pharmacists are charged with the responsibility of intercepting prescribing errors before they reach the patient and cause harm.[6] However, little is known about medication errors that result from e-prescribing use in community pharmacies and how these errors can be mitigated to improve patient safety. Little is also known about the extent to which the design of e-prescribing technology facilitates community pharmacy practice.

AIMS

The purpose of this study is to explore medication safety problems with e-prescribing in community pharmacies by assessing design characteristics of e-prescribing and workflow issues that impact timely delivery of care by community pharmacists.

1. Assess the design of various e-prescribing systems.
2. Describe changes required in workflow when processing e-prescriptions compared to conventional paper prescriptions.
3. Explore the impact of e-prescribing on safety and quality of dispensing process.
4. Elucidate best practice redesign recommendations for improving e-prescribing.

METHODS

Conceptual model

Adoption of technology in healthcare settings impacts not only the technical but also the social aspects of the work system. To guide this investigation, an adaptation of the sociotechnical system (STS) approach was used as the conceptual framework. This approach was developed by human factors engineers to characterize, evaluate, and improve human-technology interactions.[7] A sociotechnical approach, as shown in Figure 1 in the appendix, assumes a systems perspective which takes into consideration the social, technical, and environmental work elements of a user's interaction with technology. This analysis focused on the social subsystem.

Design

Experts in human factors engineering have found that qualitative (observational) methods provide direct information about the human-technology interaction. These methods tend to have strong face validity.[8] We sought to use a qualitative approach to understand the impact of e-prescribing on patient safety and pharmacy workflow.

Sampling

Pharmacists were initially recruited by a solicitation through the Pharmacy Society of Wisconsin (PSW) Fast Facts listserv, a weekly electronic newsletter distributed to all PSW members via email in December 2010. A follow up invitation was sent to pharmacists on the PSW listserv one month after the original invitation in order to recruit more pharmacists. Pharmacists representing 19 pharmacies responded to the PSW solicitation to participate in this study, but all but four of these pharmacies did not meet the study criteria and thus were excluded from the study, primarily because they printed e-prescriptions and handled them as traditional paper prescriptions. A targeted snowball sampling was then used to recruit additional pharmacists. Pharmacists were identified and recruited based on the study criteria in order to have at least two pharmacies with the same dispensing system in the study. Once the pharmacist agreed to participate in the study, we received permission to recruit the other pharmacists and technicians that worked in the pharmacy. A total of fourteen pharmacists and sixteen technicians from seven retail pharmacies participated in this study

Data collection procedures

Data collection was done in two phases. Phase 1 involved direct observations and think aloud verbal protocols. Phase 2 involved pharmacy group interviews involving two pharmacists and two technicians.

Phase 1

Qualitative data were collected using direct observations and think-aloud verbal protocols between January-February, 2011.The duration of observation ranged from two to five hours depending on frequency of receiving e-prescriptions. The researcher also observed general pharmacy workflow practices that pertained to use of e-prescriptions. E-prescribing workflow includes the time from when an e-prescription is received in the pharmacy to the time the patient receives the medication. Each participant was observed processing at least five consecutive e-prescriptions.

Think aloud verbal protocol is an observation methodology that provides empirical and procedural information about human interaction with technology. The goal of using the think aloud protocol for data collection was to provide objective information on how pharmacists and pharmacy technicians interact with e-prescribing technology. For example, how e-prescriptions are handled real-time in pharmacies, workflow challenges that emerge, mental recall, and information needs of the pharmacy staff when handling e-prescriptions.

During the think-aloud process, participants were instructed to verbalize their thoughts as they process each e-prescription and to highlight the signals that help or hinder them from processing prescriptions accurately and efficiently. With every step in the dispensing process, participants was asked to verbally state what they were thinking about, what information they needed to fulfill each step, what questions they had, and how they would proceed to the next step. The average duration for each think aloud protocol ranged from 3 to 7.5 minutes. The time that it took to complete each think aloud protocol was dependent on the type of prescription, interruptions in the environment, and pharmacy workflow. Recording of each think aloud protocol began when the participant started processing the e-prescription on the computer queue and ended when the participant indicated that they were done with e-prescription processing. Additional information was also collected by the researcher using field notes to contribute to the responses that were audio-taped and digitally recorded.

Phase 2

The Group interviews were scheduled shortly after the think aloud observations were conducted, so that specific scenarios or issues that came up during the observations were fully fleshed out. Pharmacy Group interviews took place between February-March, 2011 and were in-depth group interviews were with four members (two pharmacists and two technicians) of the pharmacy team familiar with e-prescribing processing in community pharmacies. The interview questions consisted of neutral, open-ended questions, carefully constructed to avoid eliciting socially desirable responses and the questions were structured in seven parts:

- Positive and negative experiences with e-prescribing
- Evaluation of design characteristics of e-prescriptions
- Workflow issues related to e-prescribing
- Medication safety problems with e-prescribing
- Communication patterns with e-prescribing
- Organization impact on e-prescribing
- Recommendations on improving e-prescribing

The combination of the three data collection methods provided information and triangulation on the workflow challenges, mental recall, and information needs of pharmacy personnel when processing e-prescriptions. All responses, observations and interviews were audio recorded and transcribed for analysis.

Data analysis

Field notes and audio-recordings were transcribed and transcripts were originally coded according to the five main elements (environment, people, technology, tasks, and structure) the STS framework and key interactions were identified through by a detailed content analysis. Transcripts were then subjected to qualitative thematic analysis to link the key interactions identified to their impact on e-prescribing processing, pharmacist performance, possible impact on patient safety. Thematic analysis is an analytical method in qualitative research which involves identifying themes or patterns within data. In conducting the analysis, several themes and sub-themes relevant to the sociotechnical aspects of e-prescribing in retail pharmacies were identified and annotated in the margin of the transcripts. Verbatim quotes from participants were provided so that readers can assess the correspondence between original data and the researchers' interpretation. Triangulation was done with two methods of data collection: direct observation and think aloud verbal protocol. Triangulation involved the comparison of the data obtained from the two methods of data collection to ensure cross validity between the recurrent themes identified. Data obtained from the individual pharmacies were compared for accuracy and precision in describing use of e-prescribing technology in pharmacies.

RESULTS

Results are presented in accordance with the four primary aims of this study. Table 1 and 2 show the characteristics of pharmacies and participants respectively. Sample quotes from participants are provided in Table 3.

Aim 1- Assess the design of e-prescribing systems

Three major themes closely related to design emerged from the data. Based on the themes identified, the primary STS interactions that were found are between three constructs: technology, people, and tasks. The design of the e-prescribing technology in each pharmacy affected how the participants performed their tasks related to processing of prescriptions; it also influenced their performance, and likelihood of making an error. The themes described below are patterns that were seen across all pharmacies.

Theme 1: Design strengths of e-prescriptions

Consistent sequence

Although there were slight differences in the physical presentation of each prescription in the pharmacy dispensing systems, the cognitive sequence of processing an e-prescription on the computer was the same for pharmacists and technicians in all pharmacies using different dispensing systems. The consistent flow of information was viewed as an advantage that allowed participants to adapt quickly to processing e-prescriptions irrespective of the dispensing system. Participants processed e-prescriptions on the computer in this sequence: Patient name→Date of birth→Drug name→Drug Strength→Drug formulation/route→Drug directions→Drug quantity/package size/days supply/duration→Physician name→Dispense as written code. This was not the case with conventional prescriptions, where pieces of information were rarely presented in the same location on the paper or faxed prescription.

Ease of legibility

Improved legibility was cited numerous times by participants as a key benefit of e-prescriptions. This was the case because e-prescriptions were generally easier to read and therefore faster to process when compared to other types of prescriptions whereby interpretation of prescriber handwriting was an issue.

Ease of archiving

An unanticipated positive consequence of e-prescribing use in retail pharmacies was time saved in retrieving old prescriptions. Prior to e-prescriptions, pharmacy staff either had to look through stacks of chronologically archived paper files or manually search for scanned prescriptions saved on their computer to retrieve old prescriptions. In contrast, e-prescriptions allowed for immediate storage and retrieval of hardcopies of electronically received prescriptions in the exact form in which they were sent. This enabled easy and quick access e-prescriptions on the computer when needed.

Theme 2: Design challenges with e-prescribing

Incompatibilities between pharmacy and prescriber systems were primarily responsible for design challenges that participants encountered while processing e-prescriptions. These resulted in difficulty in retrieving complete information sent electronically to the pharmacy.

Mismatch in textbox size

A mismatch between textbox sizes for prescription information in the prescriber and pharmacy system was observed numerous times. As a result, pharmacy staff was unable to visualize complete e-prescription information such as drug names or instructions. When the pharmacy textbox was not long enough to fit the length of the drug directions written by the prescriber, the screen cut off parts of the directions or appeared as "see long drug name". The participants could only view the truncated drug directions in full when the e-prescription was printed on paper. In addition, when long drug names were sent from prescribers, the participants were not immediately aware of what the prescriber had ordered. This was common with drug combinations such as a fluticasone-salmeterol inhaler, or ear/eye drops with common active ingredients but different routes of administration.

Mismatch in patient/physician names

Frequently, there was mismatch between how names of patients or physicians were saved in the pharmacy's and the prescriber's system especially when abbreviated names or initials were used in either system. This led to difficulty in finding the patient's or prescriber's names in the pharmacy system as e-prescriptions were being processed. Pharmacy personnel also sometimes selected the wrong patient or prescriber when there were many people bearing similar names (potentially because duplicate names were added in the past). In such cases, the pharmacy staff took extra steps to retrieve the patient's date of birth from a different screen to verify the correct patient. This problem also proved to be a challenge when pharmacists had to contact the prescriber for clarification on e-prescriptions. If participants could not find the right name of the prescriber they were unable to find the correct contact information. This required more steps to process the e-prescriptions. This distracted participants and prevented them from attending to more pressing issues in the pharmacy, and resulted in delays in patients receiving their medications.

Mismatch with drug quantities

When processing prescriptions, pharmacist and technicians typically have to calculate or infer the days' supply of the medication from the directions and quantity requested by the prescriber for purposes of insurance adjudication (i.e., a direction of "take one tablet every four-six hours" with a quantity of thirty was calculated as a seven days' supply). When prescribing traditional dosage forms such as tablet or liquid, prescribers are used to ordering a standard quantity such as thirty tablets or four ounces (of liquid). However, for more atypical dosage forms, such as inhalers, eye drops, and insulin needles, prescribers typically order units (i.e., one inhaler, one box of needles) on paper prescriptions.

Pharmacists know that the actual quantity is the weight of the inhaler, for instance "Combivent inhaler quantity #1" is actually "15gm" and transcribe the correct quantity when they manually enter the paper prescription into the computer system. However, with e-prescriptions, the quantity is auto-loaded and therefore more easily missed. This led to wrong days' supply entries, incorrect pharmacy billing, inventory problems, and insurance rejections. Participants had to be extra vigilant in checking the correct drug quantity and to recalculate when necessary.

Inability of the technology to discontinue old prescriptions
Every e-prescription sent to the pharmacy implies a new prescription for the patient. There is nothing on the e-prescription that denotes whether the prescription is in fact a refill authorization for a medication currently being taken by the patient. The technology design could not identify similar e-prescriptions for the same patient in the pharmacy system. As a result, for every new e-prescription that was received in the pharmacy, participants were required to review past e-prescriptions to verify that this was truly a new prescription and keep patient profiles up-to-date and accurate. If old prescriptions were not discontinued by the participant, this led to inaccurate patient drug histories in the pharmacy system and inadequate drug utilization reviews by the pharmacist. Hence, when participants were processing an e-prescription they had to always back track into the patient's profile and inactivate a previous e-prescription similar to the new one received, taking several additional time-consuming steps in the prescription dispensing process.

Theme 3: E-prescriptions in different pharmacy prescription processing systems
Pharmacy prescription processing systems are used to support and document the work conducted in pharmacies such as prescription filling, prescription pricing, third party claim processing, refill authorizations, data reports, reconciliation and inventory management. All e-prescriptions contained similar information. However, e-prescriptions were presented differently in each of the three pharmacy system and this influenced how they were processed. Participants identified aspects of the e-prescriptions design that resulted in delays in dispensing of medications. See Figures 2 to 4 in the appendices for screenshots of e-prescriptions in different pharmacy computer systems.

PDX pharmacy computer system - When e-prescriptions are transmitted to pharmacies with the PDX computer systems, the computer screen is divided into a left and right section with similar text box information. On the left-hand side is the e-prescription transmitted from physician offices while on the right-hand side is the e-prescription that is to be manually inputted into the pharmacy system and dispensed to the patient. The pharmacy staff then enters information into each part of the prescription only on the right-hand side of the computer screen. Pharmacy staff simultaneously compares each text box on the left-hand side with what is being entered on the right hand side. Some aspects of the e-prescription on the left-hand side could be autoloaded to the e-prescription on the right-hand. There were quick codes that pharmacy staff had memorized, to search for relevant information on patients' profiles.

The primary advantage of this system design is that it allows for immediate simultaneous comparison of information being inputted by the pharmacist or pharmacy technician and information sent by prescriber. The computer monitor is split into two screens as shown in figure 2. However, a primary design flaw with this system was that unlike other systems where information was auto-loaded from the e-prescription to the pharmacy system, participants had to manually re-enter more information. Participants stated that errors could easily occur when re-inputting information.

QS/1 pharmacy computer system - In order to fill an e-prescription using in the QS/1 system, e-prescription processing occurred in many steps because information on the original e-prescription sent from the prescriber was separated into different screens. For example, the initial screen showed only the prescriber and patient name, while the second screen showed only the drug name without the patient or prescriber's information.

Pharmacy staff had to constantly flip between at least three different screens to view and manually input all the information on each e-prescription (such as drug name or doctor's name) This forced participants to memorize parts of the e-prescription that were not always on display. This design flaw prevented participants from having a holistic view of the entire prescription and assessing if the totality of the prescription information fit together safely and effectively for the patient. For instance, participants might ask if the dose was appropriate for a pediatric patient.

PharmaServ pharmacy computer system – Unlike the PDX or QS/1 systems, PharmaServ is a windows-based system. The monitor presentation contain clearly marked sections that contain detailed information such as patient profile, medication order, and drug cost information. However, some of the information provided is not necessarily for immediate processing of the e-prescription, such as driver's license ID and social security number. Such information overload was a distraction and prevented participants from focusing their attention on more important parts of the e-prescription. Another problem with this design was that it easily resulted in wrong selection because it required frequent use of dropdown menus.

One unique characteristic of this system was the colored buttons at the bottom of the computer screen that indicate the status of e-prescriptions. These colored buttons provided quick access to real time numbers on e-prescriptions yet to be filled, successfully filled or rejected by insurance with the use of colored icons on the screen (see figure 4). It was more appealing in its presentation and ease of use for participants.

Aim 2 - Changes in pharmacy workflow when processing e-prescriptions

Prior to the advent of e-prescribing technology, pharmacies received prescriptions via paper, telephone or facsimile. All prescriptions were processed in a similar dispensing sequence. However, the use of e-prescribing technology was found to add new nuances to the dispensing process of medications. Pharmacy personnel had to adjust to the incorporation of this technology to their previous dispensing workflow practices. Issues that arose in the pharmacy workflow due to the use of e-prescribing technology were categorized into two major themes: workflow issues stemming from the prescriber and other factors within the pharmacies.

Theme 1: Challenges in pharmacy workflow stemming from prescribers

Time delays associated with e-prescriptions

Pharmacies experienced delays in receiving e-prescriptions from physician offices which slowed down pharmacy workflow and resulted in time delays for patients at the pharmacy. Participants stated that it was normal for all patients' e-prescriptions to not come in a timely manner. Sometimes patients would be waiting in the pharmacy, while the pharmacy personnel attempted to reach the physician to remind them to send the e-prescriptions.

Pharmacy personnel had no way of knowing how many e-prescriptions each patient was to receive from the prescriber. Unlike paper, fax, or phone prescriptions where all medications for a particular patient were bundled at the same time either physically (paper) or temporally (phone, fax), e-prescriptions for the same patient could be sent at different times. To compound the issue, controlled substance prescriptions could not be sent electronically and pharmacy personnel were frequently unaware that there may be controlled substance paper prescriptions in addition to e-prescriptions that they needed to fill.

In addition, prescribers sometimes delayed sending e-prescriptions and invariably sent an overwhelming number of e-prescriptions at once or late in the work day. One participating pharmacy reported receiving 25 or more prescriptions at once, significantly more than was possible with conventional prescriptions (paper, fax, or phone). Pharmacy personnel were then unable to manage their workload efficiently and safely; this resulted in patients having to wait long periods in the pharmacy to receive their medications. Also, the uncontrollable increase in the number of e-prescriptions received at one time point created tension in the pharmacy environment as participants struggled to process each prescription rapidly and safely.

Confusing or inaccurate e-prescriptions

The prescription (drug) directions portion of e-prescriptions proved to be the most problematic for pharmacy personnel. E-prescriptions were received in the pharmacy with incomplete or duplicated directions or dosages in the prescription direction textbox, possibly from auto-loaded directions. Another source of inaccurate e-prescriptions was prescribers selecting wrong drug name or patient or dose.

Poorly written drug directions sent from prescribers were sometimes misinterpreted in the pharmacy or were written in a format that could not be easily understood by patients. Pharmacy personnel were required to stop their dispensing process and call prescribers to clarify prescription directions numerous times. In some cases, participants had seen recurrent problematic e-prescriptions from the same prescriber and made assumptions about the directions (i.e., the prescriber probably provided an explanation of the medication to the patient). Participants typically cleared out all of the directions and re-entered new directions in a way that could be easily understood by the pharmacist and patient.

Theme 2: Challenges in pharmacy workflow stemming from prescribers

Challenges in pharmacy workflow from within the pharmacy

Overall participants stated that e-prescriptions marginally increased workflow efficiency, particularly when e-prescriptions were problem free. However, because of the number of e-prescriptions received daily with significant ambiguity, this led to numerous disruptions in their dispensing workflow.

Pharmacy workflow was found to be influenced by participants’ lack of knowledge and skill in using available e-prescribing technology. Participants reported that they received little to no training on e-prescribing technology. Participants were expected to “figure it out” as e-prescription technology was implemented in their pharmacies. New employees had no formal training in part because computer terminals were used to fill prescriptions and none could be dedicated to training. These individuals instead learned on the job as they filled prescriptions. As a result, not all participants knew all of the nuances, special features, quick short cuts and codes that were available in the e-prescribing technology. The speed of processing an e-prescription was reduced if pharmacy personnel did not have a good understanding of how to maneuver challenging aspects of the available e-prescribing technology.

The presentation of e-prescriptions on the computer screen significantly influenced how fast or slow e-prescriptions were processed. Because of the manner in which e-prescriptions were presented, it required participants to cautiously navigate the e-prescription in order to prevent errors as they ran the prescription through the dispensing computer system. Characteristics such as ease of legibility and consistency in sequence of information presentation were found to speed up the e-prescription processing. On the other hand, small screen size, inability to view prescriber's comments, having to flip through multiple screens to view the e-prescription in order to accurately dispense the medications were found to slow down or hinder pharmacy workflow. E-prescription presentation issues were frustrating for pharmacy personnel and frequently resulted in repeated calls to prescriber's offices to clarify confusing information on e-prescriptions. Because of the inability to see the entire e-prescription, all participants reported printing e-prescriptions to paper to double check their accuracy.

Aim 3 – Safety concerns with e-prescribing on quality of dispensing process

Theme 1: Memorization as a cognitive process

As participants processed e-prescriptions, they memorized information needed to process the prescription that was not transparent or easily visible on the computer screen. Participants frequently memorized information on e-prescriptions when they needed to search for patient or drug information on multiple screens. When the drug name was too long for the textbox, participants had to search for the drug name on one screen, memorize the drug name and input it into another screen containing the original e-prescription. In addition, participants memorized available drug package sizes to be able to detect mistakes in drug quantities sent from physician offices so the pharmacy could be billed correctly for the medication. Participants memorized in-house pharmacy "sig codes" which were used to populate drug directions on the e-prescriptions. Participants memorized patient names, drug names, and insurance issues with e-prescriptions that were predictably problematic to save time. Participants in pharmacies with dispensing robots memorized which e-prescription drugs were filled by the robot and those to be filled from the stock shelf. Participants also memorized how many e-prescriptions a patient was to receive if patients were to receive prescriptions by multiple avenues (e-prescriptions and faxed prescriptions –mainly with controlled substances).

Theme 2: Mental calculations as a cognitive process

A frequently noted cognitive burden performed by participants was the mental calculation of drug quantities and days' supply based on memorized drug package size. This was done to ensure that the pharmacy was billed correctly by insurance companies. This was common for drugs which had dosage forms that were not easy measured, such as inhalers, creams and eyedrops. For example, an inhaler that contains 8.5 grams was written by the prescriber as 8 grams; on a paper prescription, the prescriber would have said #1 inhaler, and the pharmacist would not have scrutinize this to prevent sending the wrong quantity to insurance company.

Theme 3 - Communication issues with e-prescribing use

Several communication issues were identified with e-prescriptions which are discussed below.

Communication issues with prescribers
Participants reported that the use of e-prescribing led to less communication with prescribers. This was because there were less phone calls and therefore less conversation between the pharmacy and the prescriber's office. Pharmacy personnel reported that frequent conversation with the prescriber had previously allowed them to be more informed about their patients. When pharmacy personnel communicated with the prescriber's office, conversations were not as constructive as they were now more focused on fixing problems with e-prescriptions as opposed to collaborating about the patient. They also perceived that prescribers took longer in responding to their questions with e-prescriptions than with paper prescriptions, because the prescriber had to send an entirely new e-prescription even if issues were clarified verbally. Time constraints in the pharmacy, pressure from patients to dispense their medications, and delays in prescriber response discouraged participants from always contacting the prescriber. This led to participants frequently making assumptions as to what the prescriber intended to prescribe based on their past experiences.

Communication issues with patients
Unlike other types of prescriptions, pharmacists typically did not see the e-prescription until it was about to be dispensed to the patient. This might be due to the nature of the e-prescription being on the computer monitor and did not travel with the label, stock bottle, and prescription vial during the dispensing process unless printed to paper. As a result, pharmacists perceived that they were less involved with patient care and remembered less about their patients. Two pharmacists reported feeling less confident about answering patient questions because they rarely processed e-prescriptions and only received the prescription at the end of the pharmacy workflow, where they ultimately did not have enough time with the prescription to develop a full understanding of the patient's situation or profile.

Unlike paper prescriptions where a patient can read the prescription as they take it from the prescriber's office to the pharmacy, patients may be unaware of what they were prescribed or were not familiar with the workings of the e-prescribing process; this lead to additional confusion during patient counseling.

Communication among pharmacy personnel
E-prescribing required louder communication among pharmacy personnel. With paper prescriptions, technicians typically would walk across the pharmacy with the paper to the pharmacist to obtain clarification quietly. This was not possible with e-prescriptions because they are fixed in the pharmacy computer. One participant stated that in her pharmacy, computer terminals were placed at both ends of the dispensing process. Pharmacy personnel, locked into filling e-prescriptions directly from the computer, were more likely to violate HIPAA laws by clarifying confusing information aloud to other members of the pharmacy team when other patients were within hearing distance.

Theme 4: Interruptions in the environment
Participants were frequently interrupted or stopped in the middle of processing e-prescriptions by calls from physician offices and patients arriving in the pharmacy with questions about their medications.

Interruptions take place whether pharmacists are handling paper or e-prescriptions. However, when handling a paper prescription, the participants appeared better able to accommodate interruptions more fluidly than with e-prescriptions. For example, a pharmacist that was filling a paper prescription was able to carry the paper around the pharmacy while talking to a technician or answering the telephone. As a result, the paper prescription stayed in the foremost mind of the pharmacist and he was less likely to forget about the prescription. An e-prescription is locked onto the computer monitor and was not portable or mobile in the pharmacy. This led to participants having to stop mid-way into filling the e-prescriptions to attend to other pressing issues in another part of the pharmacy. Participants frequently forgot where they were in the process of dispensing the e-prescription and had to start over again. Sometimes the participant completely forgot about the outstanding e-prescription when distracted by another issue.

Aim 4 - Redesign recommendations for improving e-prescribing

As participants discussed barriers and challenges to using e-prescribing during the team meetings, they provided numerous suggestions for improving this technology. A list of respondents recommendations are provided below.

General recommendations

- Educate prescribers on what constitutes problematic e-prescriptions
- Create standards on how e-prescriptions should be written before sent to pharmacies
- Standardization of e-prescription formatting in all pharmacies
- Reduce incompatibilities between physician and pharmacy systems
- Improve integration of pharmacy database with physician database to allow for frequent update on drug dosage form and quantities available in the pharmacy

Specific recommendations for pharmacy systems

- Improve visual appearance of e-prescriptions: differentiate each section of an e-prescription to draw pharmacy eyes to important fields (use colors or bolded lines)
- Create links between old and new e-prescriptions to keep patient profile updated
- Allow pharmacists to make corrections on previously received e-prescriptions
- Make drug name visible when e-prescriptions are in the queue
- Increase font size of e-prescription text
- Compartmentalization of e-prescribing queue to properly distinguish between patients: allow for more space or use different colors
- Prevent two people from simultaneously processing an e-prescription
- Make comment fields more visible and prevent information from being cut off
- Reduce truncated information fields to decrease need to print e-prescriptions

Specific recommendations for prescriber systems

- Institute a forcing function to ensure physicians preview e-prescriptions before sending to pharmacy
- Remove pre-populated drug directions to prevent having conflicting instructions
- Create a bundle of e-prescriptions for each patient
- Introduce a forcing function to prevent prescribers from simultaneously e-prescribing for multiple patients
- Include additional information fields for more patient information (clinical diagnosis, child weight, allergies, kidney/liver condition, insurance coverage)

- Alert physician when e-prescription is not received in the pharmacy
- Include information field to indicate urgency of prescription
- Include more physician information (NPI, DEA number)
- Create notification for changes made to old e-prescriptions
- Reduce information on e-prescriptions not used by pharmacists
- Indicate total number of prescriptions each patient is expected to receive
- Create a backup system to be used when e-prescribing systems shuts down
- Use only generic drug name to eliminate drug specificity issues, giving pharmacists more flexibility to choose the drug name is in their database

DISCUSSION

Aim 1 – Assess the design of e-prescribing systems

Many studies conducted in hospital settings have identified design flaws in health information technologies (HIT) such as Computerized Physician Order Entry (CPOE).[9,10] These design flaws have been linked to poor clinical outcomes which can easily lead to patient harm.[2] Consequently, poorly designed HIT can negatively impact clinical practice. Our findings show that the current design of e-prescribing systems have design flaws that may result in new kinds of unintended technology hazards in community pharmacies that were previously not envisioned. These technology hazards can easily lead to medication errors and patient harm which can be physically and emotionally devastating for patients and medical personnel involved in such incidents. Poor design of e-prescribing technology can negatively impact pharmacy workflow and can hinder pharmacist ability to efficiently process prescriptions and safely dispense medications to patients.

Aim 2 – Changes in pharmacy workflow when processing e-prescriptions

Consistent with studies that have evaluated implementation of new technologies in health care settings[11], this study found that the use of e-prescribing does not always improve efficiency in pharmacy workflow. There are several reasons why this might be the case. First, the advent of e-prescribing technology has led to tighter coupling between prescriber and pharmacy computer systems. Pharmacies can now receive large number of prescriptions from prescribers faster than was previously possible with paper prescriptions. Receiving an overwhelming amount of ambiguous e-prescriptions with issues related to drug directions, package size, quantity or incomplete information can severely disrupt pharmacy workflow.

Second, the use of e-prescriptions requires pharmacists to adapt to a new mental model for processing prescriptions. This is because unlike other types of prescriptions, e-prescriptions are unique in their mode of presentation and transmission. For example, e-prescriptions for one patient can be transmitted to the pharmacy at different times. This is atypical since prescriptions for a particular patient are typically bundled. Also, pharmacists appear to evaluate each piece of the prescription (drug, dosage, direction, etc.) as they view the entire prescription. This holistic approach helps the pharmacist determine appropriateness of the medication (i.e., is the physician the appropriate specialist for this type of medication, or is the dosage form appropriate for a pediatric patient). However, the piecemeal nature of providing information on some e-prescribing computer screens requires pharmacy personnel to flip back and forth between screens to verify information. Training on how to use e-prescribing technology appears to be an important element that influences pharmacy workflow. Unlike other healthcare settings where formalized training is seen as an essential component of HIT implementation, pharmacy organizations are yet to fully recognize and capitalize on the benefits of providing adequate training in order to improve workflow efficiency.

Aim 3 – Safety concerns with e-prescribing on quality of dispensing process

Significant evidence in the human factors literature shows that reliance on vigilance to catch errors is unreliable when users perform tasks that require high cognitive load in a busy and chaotic work environment.[12] This is because humans are only capable of retaining limited information in their working memory per time. Pharmacy personnel face similar cognitive burdens with current e-prescribing systems which require high cognitive effort to prevent and catch medication errors. With e-prescribing, we are demanding more from pharmacists than with traditional prescriptions and there is no way for pharmacists and technicians to meet the hypervigilance requirements of this technology. The interruptions reported in the pharmacy environment also prevent pharmacy personnel from meeting these demands. Furthermore, it has been shown that humans have very limited insight into their own performance with HIT. Indeed, participants indicated that they were unaware of the high amount of memorization required to process e-prescriptions.

Also, communication issues arise from using of e-prescribing technology that present additional patient safety hazards in the pharmacy. It is known that use of HIT reduces communication among members of the patient care team.[13] Similarly with e-prescribing, pharmacists reported that they communicated less with prescribers and were less aware of individual patient treatment. The need for communication is greater with use of e-prescribing technology and there are no processes in place to facilitate that adequate communication between prescribers and pharmacists. This is particularly important because pharmacies are able to receive prescriptions faster than was previously possible due to tighter coupling between the prescriber and pharmacy computer systems. Communication lapses further lessens a pharmacists' ability to understand, interpret and anticipate the issues with e-prescriptions in order to anticipate harmful medication errors.

This project provides valuable information on characteristics of the pharmacy work system that are associated with patient safety hazards of e-prescribing technology that require urgent attention to prevent patient harm.

Aim 4 - Best practice recommendations for improving the use e-prescribing

The pilot study conducted prior to this research showed that many community pharmacies had chosen to not use e-prescribing as previously envisioned. Many of these pharmacies reported that the current design of e-prescribing was not compatible with their technology and encouraged errors. This led them to abandon the e-prescribing technology and simply treat e-prescriptions as paper prescriptions. Such barriers must be overcome for e-prescribing to be widely embraced in all pharmacy practices. In order for community pharmacies to meet current federal requirement on the use of e-prescribing, software incompatibilities between prescriber and pharmacy systems must be resolved. Redesign of e-prescribing must be targeted towards facilitating and not hindering the work of pharmacists.

Recommendation 1: Standardizing training and policies regarding e-prescription use
The first step in improving e-prescribing in community pharmacy is to implement formal and standardized training of pharmacy personnel on how to use this technology. This study found that most pharmacists had no policies guiding pharmacy staff training on e-prescription processing. Most participants learned by trial and error and were not always aware of all the functional capabilities of e-prescribing technology.

Recommendation 2: Redesign presentation of e-prescriptions in pharmacies
There is room for improvement in the current design of e-prescriptions in pharmacies to enhance patient safety. E-prescriptions should be modified to provide pharmacists with more information such as clinical diagnosis, patient allergies, patient weight for pediatric prescriptions, and National Provider Information (NPI) number. Participants stated that information presented on e-prescriptions that is unnecessary for processing a patient's prescription should be taken out. Pharmacists also recommended that changes be made to important aspects of e-prescriptions such as using bigger fonts and colors to demarcate patient prescriptions and make relevant information more visible. A primary concern for participants was their inability to determine the urgency of prescriptions or prioritize medication orders received. Creating a field which indicates to the pharmacy staff when the patient was likely to pick up their medications would be useful. In order to improve pharmacy workflow efficiency and performance, participants suggested implementing alert systems to notify staff when e-prescriptions were received.

Recommendation 3: Redesign physician systems to be consistent with pharmacist cognitive workflow and information needs
One study suggested that the inputs of pharmacists are necessary to provide necessary improvements on e-prescribing systems to reduce medication errors.[14] Based on the results, most physician software are not fully compatible with pharmacy software. Since national adoption of e-prescribing is on the increase, it is important for pharmacy and prescribers systems to be more fully integrated. The lack of uniform standards among existing information systems make integration difficult.

Participants recommended creating a forcing function that would require prescribers to preview e-prescriptions as they would be received or viewed at the pharmacy before prescribers could send the e-prescription. Pharmacist also recommended that physician systems should be such that prescribers were not forced to send duplicated drug directions arising from pre-automated information. When e-prescriptions are not received in the pharmacy, the prescriber is not aware. A redesign option will be for prescribers to receive a feedback notification when e-prescriptions are received in the pharmacy. Currently there is still no way to track e-prescriptions that are never received in the pharmacy. Patients end up waiting for long periods when pharmacists cannot find sent e-prescription orders in their system.

CONCLUSIONS

The implementation of technology in healthcare should facilitate efficient and high quality health care. Our findings show that overall; the implementation of e-prescriptions has hindered pharmacy workflow. Since the number of e-prescriptions transmitted to community pharmacies will continue to increase due to recent federal government regulations mandating its use; it is essential that the role of e-prescriptions and its impact on community pharmacy work continue to be studied. Further studies can provide evidence of ways to design HIT in community pharmacies to facilitate pharmacy workflow processes since problems in workflow may lead to unintended consequences such as increased medication errors and user frustration and stress.

There are many ongoing barriers to pharmacy use of e-prescribing technology to improve quality and safety. For example, pharmacy organizations are yet to recognize the need to identify and address patient safety hazards related to e-prescribing use. The sociotechnical systems framework was useful in providing an in-depth understanding of the pharmacist and technician's interaction with e-prescribing technology. This examination of e-prescribing can serve a guide to developers to design more efficient and safer system. E-prescribing system developers can use these findings study to identify and apply the most usable features of the three main pharmacy dispensing systems to design systems that support dispensing efficiency and safety. In addition, this study can help inform policy on creating e-prescribing design standards for pharmacy.

As the number of e-prescriptions received in pharmacies annually continues to rise, future research should assess the following: 1) the relationship between e-prescribing technology design and frequency of medication errors; 2) the impact of the design flaws of e-prescribing on safe and efficient delivery of patient care in community pharmacies; and 3) Confirm hazards and identify ways to utilize technology to effectively extend the work conducted in community pharmacies.

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APPENDICES

Table 1. Characteristics of pharmacies

Pharmacies	Dispensing system	eRx experience (in Years)	Daily eRx volume	Daily Rx volume	Daily staffing	Practice setting
1	PDX	2 - 3	33%	150 - 200	1 Pharmacist 3 Technicians	Chain
2	PDX	2 – 2.5	90%	150	1 Pharmacist 4 Technicians	Chain
3	PDX	5	50%	130 - 180	1 Pharmacist 1 Technician	Chain
4	QS/1	2	50%	107 - 614	3 Pharmacists 5 Technicians	Independent
5	QS/1 NRx	0.5	90%	200	1 Pharmacist 2 Technicians	Independent
6	Pharmaserv	1	50%	200 - 450	2 Pharmacists 5 Technicians	Independent
7	Pharmaserv	2	80%	300 - 400	1 Pharmacist 4 Technicians	Independent

Table 2. Characteristics of participants

	Participants					
	Pharmacists (N = 14)			Technicians (N = 16)		
	Mean	Range	Standard Deviation	Mean	Range	Standard Deviation
Age (Years)	40.1	25 - 67	12.8	36.4	21 - 49	9.7
Years in Practice	16.9	1.5 - 43	12.6	11.6	1 - 30	9.2
Years in Pharmacy	6.3	0.5 - 19	5.9	9	1.5 - 28	7.9

Table 3. Verbatim quotes from participants

Related subtheme	Sample Quotes
Legibility	"You don't have to worry about legibility. Legibility doesn't become an issue anymore because everything is all typed in".
PDX	"The way ours is presented its split screen, so on the left is what you get from the doctor and on the right is what we're processing. It's nice to be able to compare it right away, without having to switch between screens".
QS1	"It's kind of awkward because we have to flip through these tabs to see the whole thing" "So now on this screen I don't have the doctor's name. So if I am possibly hurrying I have already typed in the doctor's name but what if I may have forgotten it because I typed it so fast. So now I am wondering who is the doctor who prescribed this." "One of the screens that you fill is the doctor information and then you flip to another screen where you're filling the actual prescription, and by the time you get to the prescription screen, you have forgotten who the doctor is, and you just typed it in two seconds ago."
Mismatch related to textbox sizes	"One thing I don't like about the e-scribe, when you get into the dosage on your sheet, sometimes stuff is cut off. There is not enough room, so you've to go in to check to make sure that everything is in there the way it is written on your hardcopy. I am not sure why. There are only so many characters that can go in there and sometimes not all that comes on." "What I don't like is when the drug names are too long, it tells us to 'see long drug name.' So you have to remember what came up on the first screen and I think there's a lot of opportunity for error if you don't remember what or how it came up".
Mismatch related to drug names	"It doesn't match the drug. It doesn't give me choices like this right away. You have to re-enter the drug. The problem there is that there could be an error. Because I could choose the wrong drug. You know there's no link between the drug that comes in over the e-scribe with the drug that we have in our stock. So I have to choose the drug every time. There's potential for error".
Mismatch related to patient/physician names	"If for example the patient's name is [Jonathan Doe], and the doctor puts the e-scribe in for Jon. It may say you don't have that person in the system because they are writing his short name versus his full name or whatever we have. So then it would tell you we don't have them in there. Or another thing too that is irritating is the doctor's name that e-scribes is just written different than what's in our McKesson system, it will create them again. So when we look into our list of doctors we have one Dr [Jeff] but there might be 7 in there. Each one might have a different fax, might not have a fax number, or has a different fax number... That's one down thing about it is if the doctor that it's faxed from adds like even a middle initial or something like that, it would create them in there again."
Mismatch related to drug quantities	"Doctors will send over Proair® which is an albuterol inhaler. And in their system it may say that it is an 8gm canister. When in fact it's an 8.5gm canister. So we kind of have to know the sizes of these odd ball things. Because if he sends over a quantity authorized 8 and I put 8 in here. Then it's billed improperly. I haven't billed for that 0.5gm. You know it's not right so we have to watch that." "Lantis® injection #2 in this instance is a little deceiving. Our computer has this drug in as 10 because it is a 10ml per vial. So the doctor is trying to tell us 2 vials.Iin other to make that quantity correct, I have to make it 20. Because our computer calculates it by ml and not bottles."
Inability to discontinue old e-prescriptions	"One thing with e-scribe, if this person is on this medication that you've got to e-scribe and you input it in like we just did, it does not DC[discontinue] the old prescription. So you've to go back and look at her profile and see if she's on it… You have to go in and manually do that to keep the profile updated…The profiles I think are a lot more messy when you solely rely on your e-scribe. But we do try to go in and just check." "Another thing that I don't like and I know reasons people or other pharmacists don't use it (e-prescribing) is because a lot of people won't go in and discontinue the previous prescription. So a lot of times the profiles just get super messy because you are not taking the time to go in and make sure that they get discontinued."
Time delays associated with e-prescriptions	"It happens where we are so backed up that we can't get to it. And it's here and patients come in. And we also have where they [patients] are here already and the doctor hasn't sent it [e-prescriptions]."
Confusing or inaccurate e-prescriptions	"Sometimes it might say, take a half tablet and there will be a period and then it will say take two tablets. They will give us two different amounts and we would at that point call." "I don't like the way this sig [drug directions] sounds…The doctor sent it kind of funny… I am going to clean it up a little bit because it came through sort of silly….We rewrote it because we want it to be a little more flowing… make it sound straightforward so the patient is not confused."
Challenges in pharmacy workflow from within the pharmacy	"There's no link between the drug that comes in over the e-scribe with the drug that we have in our stock. So I have to choose the drug every time. There's potential for error".

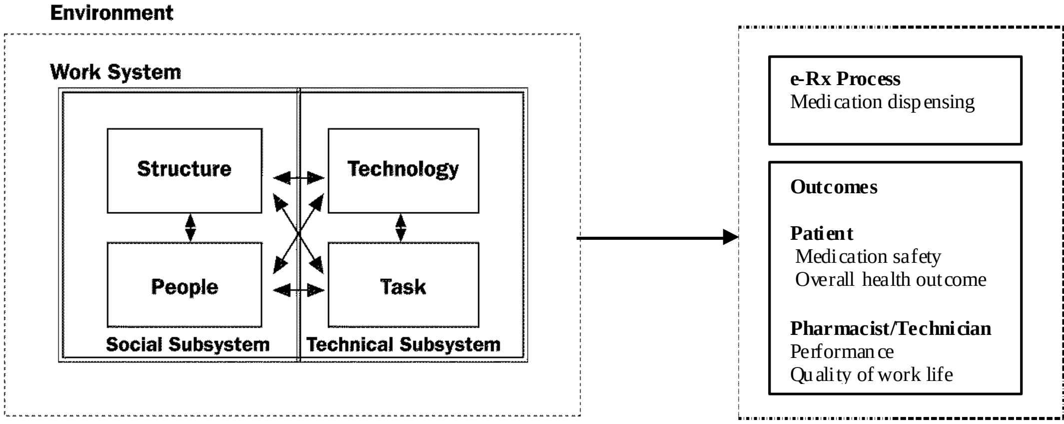
Table 4. Relating themes to the STS Framework

	Themes/Subthemes	Related STS Component
1	Technology design • Advantages • Technology hazards	Technology
2	Problems stemming from prescriber's system • Time Delays • Confusing or inaccurate eRx	People & Technology
3	E-prescribing workflow • Factors influencing eRx workflow	Tasks & Technology
4	Cognitive processes involved in processing eRxs • Memorization • Mental calculations	Technology & People
5	Disruptions in the pharmacy environment	Environment
	Training on e-prescribing technology	Organization

Table 5. Ranking of themes identified from group meetings

Theme Rank	Theme	Occurrence
1	Process related issues with e-prescriptions	91
2	Pharmacy workflow issues with e-prescribing use	74
3	Redesign recommendations	68
4	Advantages of e-prescriptions when compared to traditional prescriptions (paper, faxed, or called-in)	58
5	Design weaknesses of e-prescriptions	54
6	Organizational polices and training for e-prescription processing	51
7	Communication issues with e-prescribing use	41
8	Vigilance the key to catching errors	26

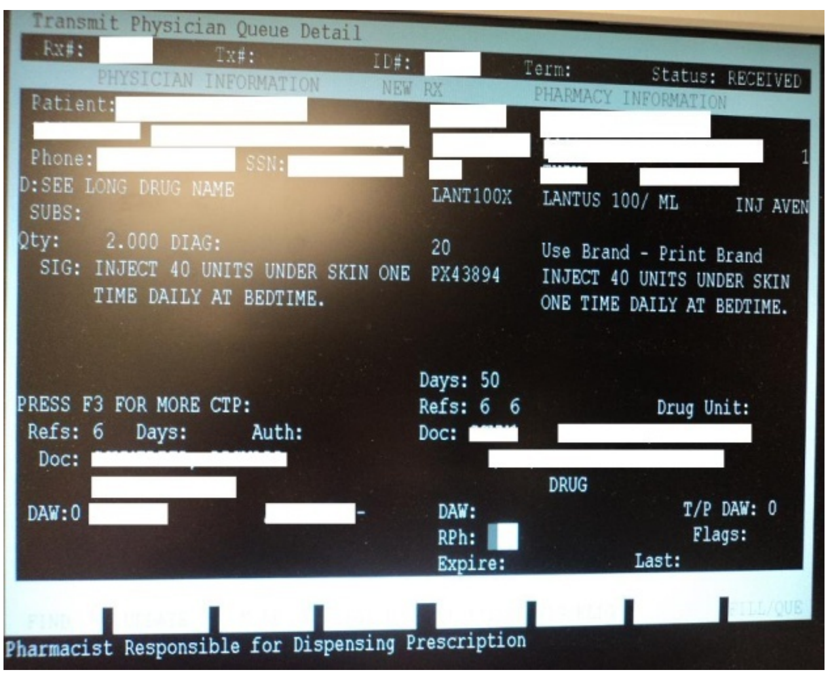
Figure 1. Adaptation of the sociotechnical systems theory



Presentation of e-prescription in dispensing systems

Figure 2. PDX Pharmacy dispensing system

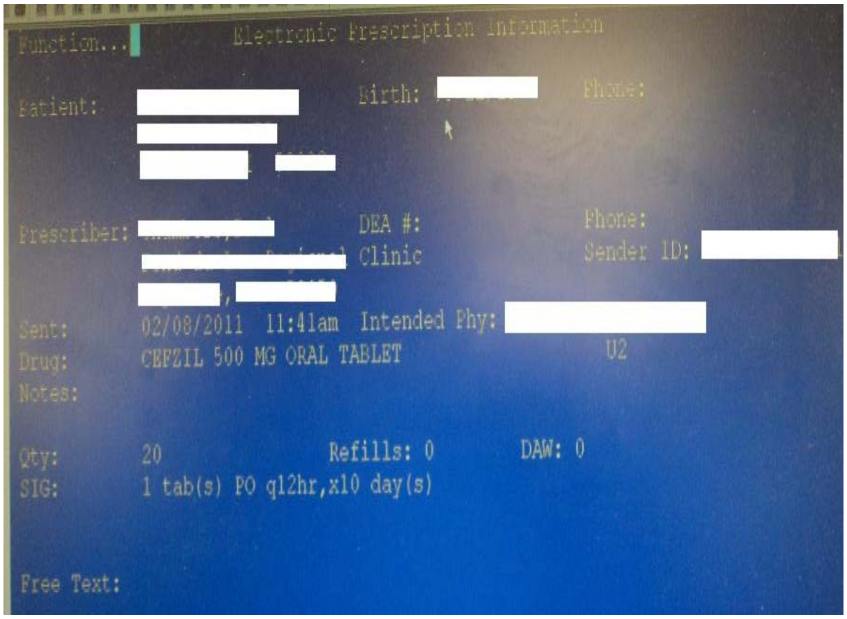
Original Physician e-Rx eRx on Pharmacy system



*Allows for simultaneous comparison of original e-prescription sent by prescriber to patient information being re-transcribed into the pharmacy system.

*Original e-prescription sent by physician e-prescription is on the left side; e-prescription inputted into pharmacy system is on the right.

Figure 3. QS/1 Pharmacy dispensing system

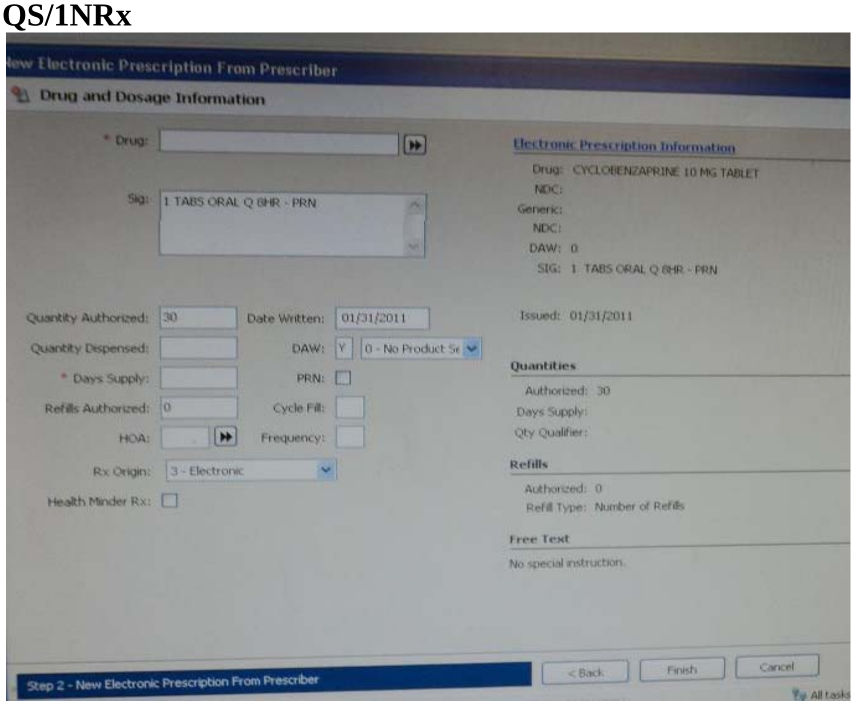


* This screen depicts information from the original e-prescription sent by the physician to the pharmacy.

*From here, the technician or pharmacist must go to a separate screen to input drug name. Then the technician must go to another screen to input the physician name. Each piece of information on the e-prescription is input on separate screens - requiring the users to flip through multiple screens to find information needed to successfully process an e-prescription.

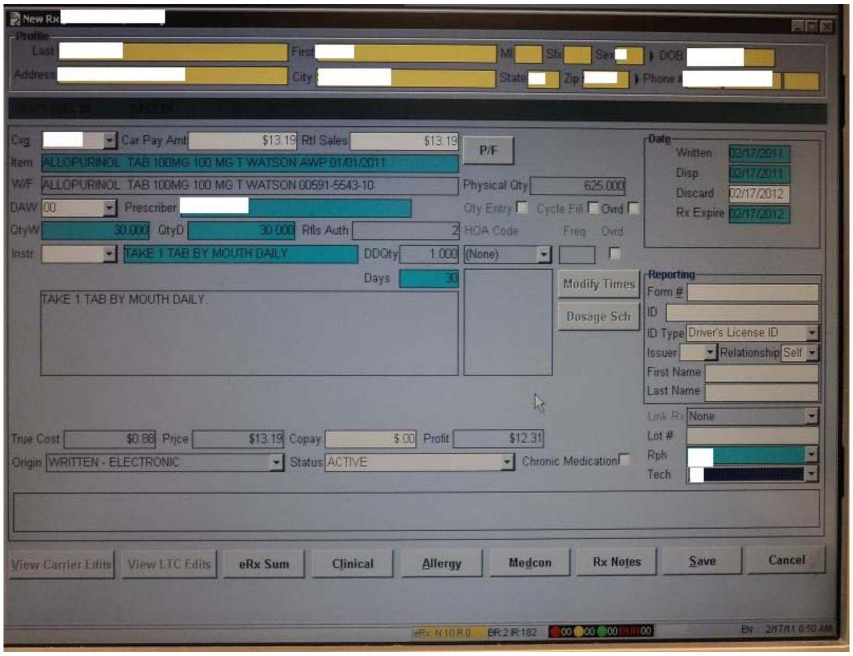
*The original e-prescription must be maintained in the technician's memory to completely fill the prescription.

QS/1NRx



*A newer version of QS/1 Pharmacy Dispensing System - design features are similar to the older QS/1 version.

Figure 4. PharmaServ pharmacy dispensing system

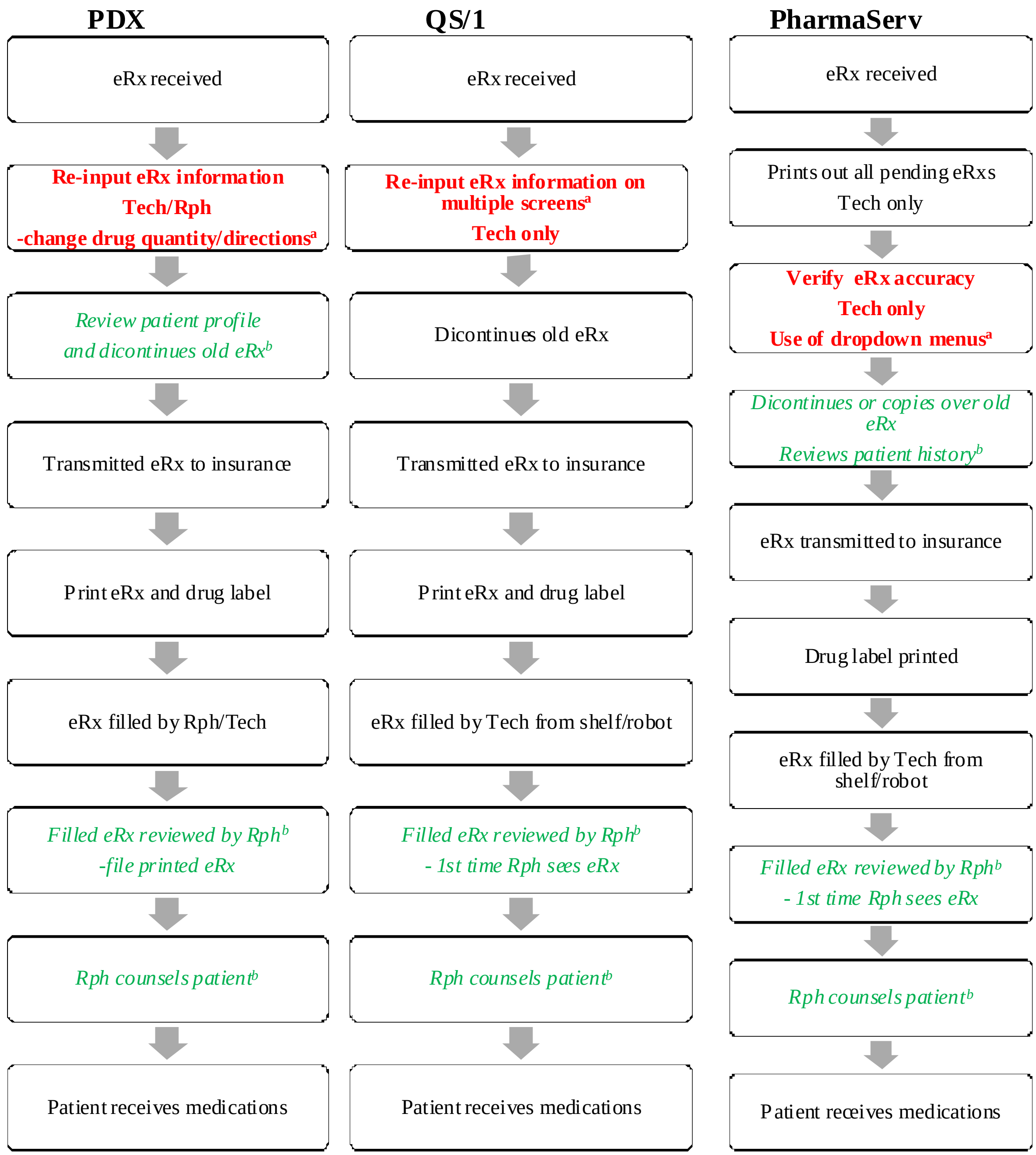


*Window-based system that is more appealing in its presentation and ease of use but it provides redundant and unnecessary information not needed for filling the e-prescription - resulting in information overload.

*The buttons on the bottom of the screen: “yellow, red, green box” - provides a real time queue of the number of e-prescriptions that needed to be filled, that have been filled successfully, or that have been rejected by insurance.

*Requires frequent use of dropdown menus which easily leads to errors caused by wrong selection - For example, allupurinol 100mg was mistakenly selected instead of allupurinol 300mg.

Figure 5. Diagrammatic representation of e-prescription workflow processes



[a] Denote frequent points of error.

[b] Denote points were errors are typically detected.

*Steps needed to process eRx is dependent on design, potential sources of error is also influenced by design

*Making changes to drug quantity and directions was the most frequent problem with e-prescriptions

*Problems with wrong quantity led to billing issues, problems with pharmacy audit and insurance rejections

*One computer system required more tasks because its design has more information overload

*eRx is not truly paperless - still being printed in all pharmacies

Appendix A: Letter of solicitation sent through Pharmacy Society of Wisconsin (PSW)

Community Pharmacy E-prescribing Study

Implementation of e-prescribing has caused new and unanticipated problems and errors resulting in lengthy and frustrating delays for community pharmacists and their patients. We invite you to partner with us to explore the problems with e-prescribing in community pharmacies so that we can identify effective interventions to support pharmacist's interface with e-prescribing. The study will include pharmacists and pharmacy technicians in your community pharmacy that process electronic prescriptions daily. If you and your staff decide to participate, you will be observed in your pharmacy for one hour filling e-scripts and take part in a pharmacy team interview for one additional hour. Each participant (pharmacists and technicians) will receive $50 for participating in this study. Please contact Michelle Chui at UW School of Pharmacy at (608) 262-0452 or mchui@pharmacy.wisc.edu if you would like to participate or have any questions. Thank you for your consideration on this important pharmacy practice issue.

Appendix B: Letter of support submitted by pharmacies

Date: ________________________

To whom it may concern:

This letter is to inform you that I will allow my pharmacy site to participate in Dr. Michelle Chui's project entitled, "Impact of electronic prescribing on patient safety and pharmacy workflow in community pharmacies." The employability of participants at my site will not be affected by their decision whether or not to participate in this study.

I will support Dr. Chui's research assistant acting as an observer on this research project. The research assistant will not practice pharmacy, access the computer system, or speak to any patients during the observation 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 the community of pharmacy with valuable information about ways to improve the design of electronic prescribing technology to facilitate community pharmacy workflow and 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!

Appendix C: IRB approved consent form

UNIVERSITY OF WISCONSIN-MADISON
Research Participant Information and Consent Form

Title of the Study: Impact of electronic prescribing on patient safety and pharmacy workflow in community pharmacies

Principal Investigator: Michelle Chui (phone: 608-262-0452) (email: mchui@pharmacy.wisc.edu)

Co-Investigator/Student Researcher: Olufunmilola Odukoya (phone: 608-698-5054) (email: odukoya@wisc.edu)

DESCRIPTION OF THE RESEARCH

You are invited to participate in a research study about assessing the use of electronic prescribing in community pharmacies. You have been asked to participate because of your familiarity using electronic prescribing.

The purpose of the research is to explore problems with electronic prescribing in community pharmacies.

This study will include pharmacists and pharmacy technicians in community pharmacies that process electronic prescriptions daily.

The research will take place at the community pharmacy or any other location of participant's choosing.

Audio tapes will be made of your participation. The audio recording 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 a think aloud observation and in a pharmacy team interview which will require 2 hours in total.

The think aloud observation will involve you thinking aloud as your process five electronic prescriptions. You will be asked to share the process by which you fill an electronic prescription. You will not be sharing any patient specific information. The think aloud procedure will require 30 minutes and will be conducted in the pharmacy.

You will then be asked to participate in a team interview with your other pharmacy staff which will last approximately 1.5 hours or less. Audio recordings of both procedures will be used for thematic analysis and destroyed at the end of the project.

During the interviews, the participant is NOT to reveal names or any other identifying factors about other colleagues, doctors, patients, etc.

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 project staff.

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 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 presentations and publications as a result of this study, your name and pharmacy name will not be used. Only group characteristics will be published.

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 or the Co-Investigator/student researcher Olufunmilola Odukoya at 608-698-5054. 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. 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

Appendix D: Instruction and interview guide for think aloud process and Interviews

Instructions for think aloud process

Introduce the investigator and the study (title and importance)

I will first observe you process five e-prescriptions and take notes. With the subsequent five e-prescriptions you will take part in the think aloud process.

I will take a picture of the screen of an e-prescription. This process will be audio taped. The recording will only be heard by the investigators of this study. The tapes will be kept only for the duration of the study.

Goal of this process: This process will allow the researchers better understand the process involved in filling an e-prescription. This may give insight to some of the difficulties encountered while filling an e-prescription

Explaining the think aloud procedure to the participant: The think aloud process will involve you thinking aloud as you process five e-prescriptions. Please do not share patient specific information. I will record your verbalization and might ask questions as you fill the e-prescriptions. I might occasionally remind you to please keep talking if you lapse into silence. Please explain in sufficient detail every step taken when processing an e-prescription.

I am not testing your ability to process an e-prescription but to describe how e-prescriptions are processed in various pharmacies.

Please you can stop the task at any time you become uncomfortable. Please feel free to ask questions at any point in the process. I will not tell you when you have completed the task but you must determine this on your own.

I will practice the think aloud task to help the participant get familiarized with the process using how to obtain a number from my cell phone.

Do you have any questions about this process?

You can begin the process.

Please keep talking.

Take notes of everything the user says or does not say.

Thank you for participating in this process. Please can you provide any feedback on how you found this process? Thank you.

Instructions for team meetings

Introduce researcher. Thank you for participating in this study.

Explain the purpose of the interview: Background and importance of the study.

Background: this is a project to evaluate the effects of e-prescribing on community pharmacy practice, in terms of pharmacy workflow and patient safety.

Importance: A better understanding of how e-prescribing has impacted community pharmacy practice is key in discovering ways to improve its design so as to facilitate pharmacy workflow and foster error-free dispensing practices to provide safer patient care.

Explaining Interview Format: This interview is divided into seven parts and should take no longer than 1.5hours. The interview will be recorded. The recordings will only be viewed by investigators of this study and then be destroyed at the end of the project.

Please let me know if you would like me repeat a question or explain more clearly as we proceed. As you respond, please do not reveal any names of colleagues, doctors or patients. Do you have any questions?

Group Interview Questions

- Can anyone give a description of a good experience you had when processing electronic prescriptions? (Elements of importance in the story - what happened, at what time or when it happened, why it was good or bad, what could have been made better)
- Give a description of a bad experience you had when processing electronic prescriptions.

Assessing design (presented/arrangement/format) characteristics of electronic prescriptions

- What are the strengths or positive aspects of the design of electronic prescriptions?
- What are the weaknesses of the design of electronic prescriptions? (in the future you can make these multiple choice questions)
- Are there any gaps in the design that may pose a risk to safe dispensing of the prescription?
- On a scale of 1-5, how would you rate the overall appearance of an electronic prescription? (1 being very bad and 5 being perfect): each person should give an answer.
- Does the current design of e-prescriptions allow for easy identification of information?
- Does its design allow for providing the pharmacist or technician with the right amount of information?
- Do you have to retain a lot of information as you process an electronic prescription? (YES or NO). If yes, Why or give reasons or examples of the information you have to retain?
- Are you more or less vigilant when verifying an electronic prescription as opposed to a conventional prescription?
- Regarding safe delivery of care, how can the design of e-prescriptions be modified?

Workflow issues

- Are there differences between workflow when processing conventional prescriptions (paper, fax or called in) and an e-prescription?
- What are some of the differences?
- What are some problems with e-prescriptions? (Write the list named - with each problem named, ask the question below).
- Are ______ problem with e-prescriptions faster to resolve than conventional prescriptions?
- What changes in workflow has the pharmacy made overtime to accommodate for use of e-prescriptions?
- How does the overall pharmacy environment impact/affect use of e-prescribing?

Medication safety problems

- In the last 30 days, how frequently have you received electronic prescriptions with errors?
- What types of errors occurred? (Write down a list of all the errors)
- How long did it take to resolve? (List each error above). Why?
- On a scale of 1 – 5 (1 being very bad and 5 being perfect) how would you assess the overall quality of e-prescriptions. Why?

Changes in communication patterns

- When handling e-prescriptions, what differences have you observed when communicating with a prescriber when compared to handling paper prescriptions? Why?
- When handling e-prescriptions, what differences have you observed when communicating with a patient when compared to handling paper prescriptions? Why?
- When handling e-prescriptions, what differences have you observed when communicating between pharmacy personnel when compared to handling paper prescriptions? Why?
- How can this be improved upon?

Organizational impact

- What changes has the pharmacy organization have to make to adjust for implementation of electronic prescribing?
- Does your pharmacy have any special policies or procedures for use of electronic prescribing?
- What are they?
- How and why were they created?
- How have they impacted practice or use of the technology?
- Is any formal training required before commencing use of electronic prescribing?
- What were the benefits of the training?
- What were the setbacks of the training?
- How long does it take new pharmacy personnel to become comfortable using this technology?
- Has e-prescribing had any effect on overall team work?

Best recommendations

What ways would you recommend improvements be made on e-prescribing?

Provide feedback about the interview

Appendix E: List of drugs mentioned during think aloud protocol

Prilosec®

Allupurinol

Fluconazole 150mg

Diovan 160

Glucovance 2.55

Metformin 100,

Lisinopril/hydrochlorthiazide 20/12

Potassium chloride SR 10mEq capsule

Fluticasone

Flovent®

Eyedrops

Actose 30mg

Levemir flex pen injection

Pen needles

Promethazine 25mg tab

Combivent inhaler

DuoNeb® solution for the nebulizer

Fluticasone/salmeterol (advair diskus® 250)

Chlorproperazine

Ciprofloxacin

Atenolol/hydrochorthalidone

Prednisone

Cetirizine

Lantus® injection

Appendix F: Participants demographic data collection form

Names	Gender	Age	Race	Years in Practice	Years in this pharmacy	Position	Practice Setting	Region	Phase
Pharmacy 1									
Pharmacy 2									
Pharmacy 3									
Pharmacy 4									
Pharmacy 5									
Pharmacy 6									
Pharmacy 7									