Building Bridges between Pharmacists and Physicians: An Exploratory Investigation via Field, Usability Studies & Control Task Analysis To Enhance Pharmacy Management System Requirements

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Miscommunication between healthcare professionals can impact patient care and is costly. The information systems used in pharmacies and hospitals can contribute to this miscommunication. The present research is an initial attempt to investigate the reasons leading to lack of communication between pharmacists and physicians. Twenty-five pharmacists were interviewed to understand how pharmacists use pharmacy management systems (PMS), as well as to explore why communication issues may occur between prescribers and pharmacists. The field study data was transcribed and interview results were organized into three categories. Next, a human factors analysis was completed to understand pharmacists' needs and challenges with the current PMSs and finally Control Task Analysis was performed to discover weaknesses in the information systems. After discovering the usability issues with PMSs and reasons for miscommunication, mock ups were designed for a decision aid tool called Communication Summary. The intent of the Communication Summary is to enhance pharmacists' workflow and their communication with prescribers. The mock ups were evaluated in a simulated pharmacy management task by senior pharmacy students. The results suggested that more information on pharmacist-prescriber communication may help in pharmacy management.

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Dedication

This Master’s thesis is dedicated to my wonderful grandparents: Sabiha and Vasfi Kerestecioglu who were great people, teachers and friends and made me who I am today and loved and believed in me unconditionally. They taught me and made me get interested in science, art and poetry since a very young age and encouraged me to follow my passions in life and never get discouraged. My grandfather, who was a teacher and then a lawyer, was also a poet and the most cheerful, smart and funny person I have ever met yet. My super-grandmother who was also a teacher, was an amazing cook and craft artist and the most talented and hard-working person I have seen yet in my life. It was and always will be an honor to be their granddaughter... I am missing both more and more each day…

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Chapter 1 Introduction: Miscommunication between Healthcare Providers

Medications prescribed by healthcare professionals are the most expensive part of Canadian healthcare (Rotermann et al., 2014). In 2014, 12% of youngsters were on a prescribed medication, which is expected to rise to 83% when they reach 65-79 (Rotermann et al., 2014). Furthermore, polypharmacy is reported for more than 7% of Canadians, meaning that seven out of every 100 Canadians take more than four medications per day. This is an important fact to keep in mind since one of the three main reasons patients go to emergency rooms (ER) is due to medication-related issues such as drug reactions, non-adherence or incorrect use of medication (Samoy et al., 2008). In 2011 alone, Canada spent $2.6 billion on medication-related hospitalization expenses and more than half of these patients have polypharmacy (Hohl et al., 2011). Similarly, in the USA, medication-related errors affect about 1.5 million patients annually (Aspden, 2006) and in Australia, it was found that 1% of all hospital patients experienced adverse events due to a medication error (Agrawal, 2009). Thus, medication-based misunderstandings and issues impact patient care but also contribute to rising healthcare costs.

One of the main reasons leading to medication-based misunderstandings could be the lack of communication between healthcare providers from different professions (Kerestecioglu, Chin, Grindrod, Burns, 2017). As an example, miscommunication between a family physician and a pharmacist when making a decision regarding a patient's health and medication therapy might confuse the patient and might result in medication misuse.

Additionally, Canadian primary care has experienced a series of policy regulation changes in the past; causing a change in healthcare and the process of health policy development (Hutchison, Abelson, Lavis, 2001). These changes in healthcare regulations across Canada is another reason that can lead to a lack of communication between a pharmacist and a physician. Pharmacists have different regulations and responsibilities in each province in Canada and this situation makes it harder to advance the pharmacist-physician relationship (Figure 1). For instance, pharmacists can provide prescription refills in Ontario but not in Quebec and the Yukon (Canadian Pharmacists Association, 2016). Likewise, pharmacists can prescribe medication for minor conditions and interpret lab test results in Alberta but not in Ontario (Figure 1.). This situation leads patients to doubt what pharmacists can do, and also leads other healthcare providers got confused about the responsibilities of a pharmacist.

Pharmacists' Scope of Practice in Canada

	Scope of Practice [1]	BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL	NWT	YT	NU
Prescriptive Authority (Schedule 1 Drugs) [1] — Initiate [2]	Independently, for any Schedule 1 drug	X	✓ [5]	X	X	X	X	X	X	X	X	X	X	X
	In a collaborative practice setting/agreement	X	✓ [5]	✓ [5]	✓ [5]	X	X	✓	✓	X	X	X	X	X
	For minor ailments/conditions	X	✓	✓	✓ [5]	X	✓	✓	✓	✓ [5]	✓	X	X	X
	For smoking/tobacco cessation	X	✓	P	✓ [5]	✓	✓	✓	✓	✓ [5]	✓	X	X	X
	In an emergency	X	✓	✓	✓	X	X	✓	✓	✓	X	X	X	X
Adapt [3]/ Manage	Independently, for any Schedule 1 drug [4]	X	✓ [5]	X	X	X	X	X	X	X	X	X	X	X
	Independently, in a collaborative practice [4]	X	✓ [5]	✓ [5]	✓ [5]	X	X	✓	✓	X	X	X	X	X
	Make therapeutic substitution	✓	✓	✓	X	X	X	✓	✓	✓	✓	X	X	X
	Change drug dosage, formulation, regimen, etc.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X
	Renew/extend prescription for continuity of care	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X
Injection Authority (SC or IM) [1,5]	Any drug or vaccine	X	✓	✓	✓	X [7]	X [7]	✓	X	✓	✓	X	X	X
	Vaccines [6]	✓	✓	✓	✓	✓	X	✓	✓	✓	✓	X	X	X
	Travel vaccines [6]	✓	✓	✓	✓	✓	X	✓	✓	✓	✓	X	X	X
	Influenza vaccine	✓	✓	✓	✓	✓	X	✓	✓	✓	✓	X	X	X
Labs	Order and interpret lab tests	X	✓	P [8]	✓ [9]	X	✓	P	P [8]	P	X	X	X	X
Techs	Regulated pharmacy technicians	✓	✓	✓	✓ [10]	✓	X	✓	✓	✓	✓	X	X	X

1. Scope of activities, regulations, training requirements and/or limitations differ between jurisdictions. Please refer to the pharmacy regulatory authorities for details.
2. Initiate new prescription drug therapy, not including drugs covered under the *Controlled Drugs and Substances Act.*
3. Alter another prescriber's original/existing/current prescription for drug therapy.
4. Pharmacists independently manage Schedule 1 drug therapy under their own authority, unrestricted by existing/initial prescription(s), drug type, condition, etc.
5. Applies only to pharmacists with additional training, certification and/or authorisation through their regulatory authority.
6. Authority to inject may not be inclusive of all vaccines in this category. Please refer to the jurisdictional regulations.
7. For education/demonstration purposes only.
8. Ordering by community pharmacists pending health system regulations for pharmacist requisitions to labs.
9. Authority is limited to ordering lab tests.
10. Pharmacy technician registration available through the regulatory authority (no official licensing).

✓ Implemented in jurisdiction
P Pending legislation, regulation or policy for implementation
X Not implemented

Canadian Pharmacists Association / Association des Pharmaciens du Canada

Figure 1. Pharmacists' Scope of Practice across Different Provinces in Canada (Canadian Pharmacists Association, 2016)

Another major issue across Canada leading to miscommunication between healthcare providers is whether or not the technology used in pharmacies, hospitals and family health clinics are connected and whether or not healthcare providers have access to those systems. While in Alberta, a nurse, a physician or a pharmacist can access patient's health information via the electronic health records system (EHR) known as Netcare, in Ontario this is not the case (Robillard & Tolfree, 2015).

EHRs are regional health record systems that not just include hospital data but also include lab data and radiology (CT scans) results and these data can be accessed by healthcare providers such as a physician, nurses, midwives or long-term care homes in Alberta. However, in Ontario, pharmacists do not have any access to the regional EHRs and pharmacy management systems (PMS) used in pharmacies are not linked to EHRs either. Thus, the technologies used in pharmacies, hospitals and family health clinics are not connected to each other. In other words, a pharmacist in Ontario cannot access to any past patient medical history data, patient's lab tests or any type of information to understand why a general practitioner or a specialist prescribed a certain treatment for this specific patient. Thus, some responsibility for this lack of communication between pharmacists and physicians in Ontario might reside in the technology involved, which is often designed from a single professional perspective (either for a pharmacist's use only or for a physician's use only).

More studies researching inter-professional relationships between family physicians and pharmacists are necessary to understand the hindrances and the reasons leading to the communication problems between them. It can be argued that building strong inter-professional communication between pharmacists and physicians by encouraging acting as a healthcare team rather than as individuals would substantially improve medication therapy management and overall healthcare in Canada.

This Master's Research was dedicated to investigate the relationship patterns between pharmacists and family physicians in Ontario. The goal of this research were to understand the main reasons causing the miscommunication between them and exploring the design requirements for an improved and efficient PMS. In the first phase, a field study approach was used to determine usability issues with the current PMSs and the possible reasons leading to communication gaps. In the next phase, one possible design solution to potentially address those usability problems related to physician-pharmacist relationship was studied in depth by proposing a new decision aid tool "Communication Summary" to help pharmacists to enhance their communication with prescribers. The Communication Summary was evaluated by pharmacy students as expert users and the results showed that it helped the students better predict and understand prescribers' behavior including the best day to contact prescribers. Furthermore, a correlation was observed between how fast a prescriber responds to an inquiry and pharmacist's motivation to collaborate with the prescriber.

This study reveals the significant reasons causing the communication gap between physicians and prescribers and human factors and usability issues with PMSs. Furthermore, it was illustrated with an example how redesigning the system based on the user expectations and needs could improve the user satisfaction and aid physician-pharmacist's relation patterns.

Chapter 2 Background: Pharmacy Management Systems and Tasks of a Pharmacist

A complicating factor in medication management is the design of the pharmacy management system (PMS). Traditional PMSs are ubiquitous in pharmacies and their primary functions include inventory management and medication dispensing. During dispensing, PMSs help pharmacists to access a patient's medication history as well as support medication consultations (National Association of Pharmacy Regulatory Authorities, 2016) while also working to reduce adverse events related to duplicate therapy, allergies and errors. A traditional PMS needs to support the workflow of the pharmacy but it is not designed to support pharmacists in managing the health of a patient or to support pharmacy-prescriber relations.

In recent years, a pharmacist's scope of practice has been rapidly growing to include services outside dispensing including medication reviews, disease management, immunizations and consultation (Houle, Grindrod, & Tsuyuki, 2014). PMSs need to evolve to support these new services. However, early research in other areas of health care have shown that there are times electronic health records (EHRs) impede effective treatment (McDonald, 1997). Not only has the rapid adoption of EHRs in healthcare resulted in the reduction of traditional face-to-face interaction with patients, but also poorly designed user interfaces and limited access to patient data has created room for prescription errors (Ludwick, Doucette, 2009; Kuqi et al., 2013). Therefore, it is important to know how to improve PMS design to better suit the changing roles of pharmacists while also simplifying the complex daily tasks of pharmacists such as supporting communication with prescribers.

There are many studies investigated the role and decision-making processes of different healthcare providers such as physicians (Effken et al., 2011; Efken et al., 2002; Lopez et al., 2010; Burns et al., 2008), primary care providers, cardiac care nurses (Burns, Enomoto, Momtahan, 2008) and teamwork patterns in healthcare settings (Grindrod et al., 2015; Ashoori et al., 2014), but the roles of pharmacists, their daily routines and the steps they go through while making decisions and the problems that gets in the way of their communication with prescribers remained relatively unexplored.

One of the reasons pharmacists have not gained as much attention in healthcare might be that pharmacists have traditionally been seen as a retailer more than a healthcare provider since they dispense prescription medicines as well as provide over-the-counter medication and offer healthcare advice. This misperception is perpetuated by the fact that *"pharmacy is the only health profession that is reimbursed for its sale of product rather than provision of a service"* (Rigby, 2010). However, pharmacists play a very important role in the healthcare of their patients. They do not only "sell" over the counter medications but also make drug-related recommendations, make dose adjustments, optimize safety and efficacy the administration of prescribed medications and provide medication-related consulting (Bedouch et al., 2008).

To understand and analyze the complex routine tasks and decision making processes pharmacists go through daily, to develop an explicit representation of pharmacist-prescriber relations and pharmacists’ interaction with PMSs, Control Task Analysis (ConTA) was chosen to be one of the main methods of analysis in this research.

ConTA is one of the five steps of Cognitive Work Analysis (CWA). CWA is a commonly applied cognitive engineering method to understand the hidden constraints in the complex systems getting in the way of team work (Grindrod et al., 2015; Jamieson et al., 2007; Naikar et al., 2006; Vicente, 1999) and communication between healthcare providers and patients in the healthcare settings (Rezai, Burns, 2014; Ashoori, Burns, 2012; Burns, Enomoto, Montahan, 2008; Hajdukiewicz et al. 1998; St. Maurice and Burns, 2015). There are five different methods of analysis under CWA including Work Domain Analysis (WDA), Control Task Analysis (ConTA), Strategies Analysis, Social Organization and Cooperation Analysis and Worker Competencies Analysis.

In this thesis, only ConTA from CWA is applied to analyze and model the cognitive decision making methods of pharmacists as it allows us to focus specifically on identifying the weaknesses in the design of the PMS. The main purpose of ConTA is to better understand the steps and actions to accomplish a cognitive task, with the aim of gaining deeper understanding of the functional purpose of a work domain (Bisantz, Burns, 2009). Decision Ladders (DL) in the ConTA are used in the following to understand the information processing flow of some pharmaceutical practices and eventually to gather requirements to redesign PMSs. This use of DL in the current thesis to explore different design solutions is consistent with the design research approach proposed by St. Maurice and Burns (2015).

Work Domain Analysis (WDA) is excluded from this study since reasonably similar work domain analysis in healthcare settings has already been modeled in detailed in other research studies (Burns, Enomoto, Momtahan, 2008; Ashoori, Burns, 2012) and the knowledge from these WDA was available to the author. The remaining steps of CWA were simply not applicable for the current research.

In addition to ConTA, interview analysis and a human factors analysis of the user experience problems with PMSs were conducted to understand the reasons leading to a communication gap between prescribers and pharmacists in Ontario, to tackle users’ challenges and usability issues with the current PMSs and finally, to understand the design requirements to enhance pharmacists’ communication with prescribers. All three methods of analysis will be explained in detail in the following chapters (Chapter 3, 4, 5 and 6).

Chapter 3 Field Study - Methods

To be able to design an improved PMS, first one needs to understand the internal and external workflows of pharmacists, how and when pharmacists contact prescribers and the advantages and disadvantages of the currently used PMSs. Two different research methods were used to examine the work life of pharmacists, their communication patterns with prescribers and barriers leading to miscommunication between pharmacists and prescribers: an exploratory field study (described in Section 3.1) and an experimental lab study (described in Section 7.3).

3.1 Field Study

Between December 2015 and June 2016, two researchers (including the author of this thesis and one other researcher)[1] visited twenty-five pharmacists and ten physicians in Ontario at their place of work. Pharmacists were observed in pharmacies that varied in size and location including community pharmacies, local independent pharmacies, large chain pharmacies and team-based primary care clinics. Similarly, physicians and nurse practitioners were observed at the private practice, team-based primary care clinics and hospitals. Each field study varied from two to four hours depending on how busy the pharmacy or clinic was and the number of participants interviewed at each site.

3.1.1 Pharmacists

Twenty-five pharmacists in Ontario participated (14 female & 11 male). The age of the participants ranged between 27 to 60. Eight of our participants worked at private pharmacy chains, 14 were independent pharmacy owners (no chain pharmacy, no community clinic / hospital pharmacy) and three were part of a team-based primary care clinic. The highest degree the pharmacists in our study obtained was Bachelor of Science in Pharmacy. On average our participants had 16 years of experience in their field (Range 1.5 to 46). All pharmacists were interviewed in their place of practice to understand their decision-making process, needs and the particular challenges they face while using a PMS.

3.1.2 Prescribers

Eleven prescribers in Ontario were participated (seven female & four male). The age of the participants ranged between 31 to 57. Eight of the participants were family physicians and three were

[1] Most of the time , the primary researcher was the author of this thesis and either a Post-Doctoral Fellow also working on this project from the Advanced Interface Design Lab or a Co-op Student from the School of Pharmacy helped.

MDs (unspecified). Eight participants worked at a team-based primary care clinic and two worked at a hospital. On average our participants had 12.5 years of experience in their field (range 2 to 30). All physicians were interviewed in their place of practice to understand their relationship patterns with pharmacists.

3.1.3 Procedure

Each field study followed the same procedure, shown in Figure 2.

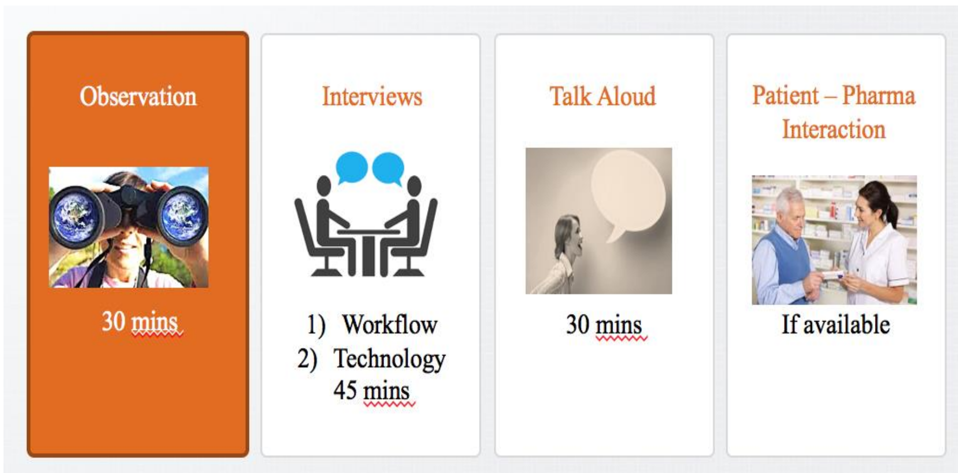

Figure 2. Steps followed in the Field Study

Each session began with a 30 minute observation. During the observation phase, the researchers stood back and observed how pharmacists interacted with patients, technicians, other healthcare providers (on site) and prescribers (phone or fax) or how physician interacted with patients, other healthcare providers (on site) or community pharmacists (phone or fax). Furthermore, researchers took notes about the layout of the pharmacy or clinic and any strategies used to keep track of medications, patients and physician-pharmacist interactions. Researchers did not interact with others present in the pharmacy/clinic at this stage.

Next was a semi-structured interview with the participating pharmacist or physician. The interview took place in an empty room in the pharmacy or clinic (mostly the consultation room or the office of the pharmacist or physician) to have privacy and less distraction. Throughout the whole study pharmacists' and physicians' time and work were respected and they were free to leave the room if it was necessary. The interview took approximately 45 minutes. The questions were divided in two sections (Appendix B). The first half of the questions were regarding the workflow and communication patterns with other healthcare professionals. The second half was designated for the use of technology in their pharmacy/clinic. All questions were open-ended to give pharmacists and physicians more freedom to share their experiences.

After the interview, pharmacists and physicians were asked to perform a talk-aloud exercise during a routine medication-related task. They were instructed to "teach us as if we (the researchers) were students doing an internship at this pharmacy or hospital and would like to learn the PMS or EHR[2]." During the talk aloud phase, pharmacists and prescribers walked us through their health records systems used in their work environment and they explained each step they took and why they did so.

Next, we observed and recorded an interaction between the participating prescriber or pharmacist and a patient.[3] To obtain the recording, a voice recorder was left in the room where a pharmacist or prescriber interacted with a patient and researchers left the room to let them hold a conversation alone and to minimize any pressure, stress or anxiety on the patient.

Once all the field studies were completed, the interview, observation, talk-aloud and interaction data were transcribed and analyzed using three different methods:

1) Categorization of transcribed and qualitatively analyzed data into the main reasons leading to miscommunication (Chapter 4);
2) Thematic analysis to identify the main usability issues with the health records systems (Chapter 5)
3) Decision Ladders modelling to understand the weakness and hindrances in PMS-pharmacist and pharmacist-physician relationships (Chapter 6).

It is important to note here that the main goal of the current research was to design a decision tool for pharmacists to support them in communicating with physicians. In order to accomplish this goal, it was necessary to understand the reasons for miscommunication between pharmacists and physicians. Thus, the first method of analysis was focused on both pharmacists' and physicians' behavior and their decision-making processes and interaction patterns with each other. Later, the focus narrowed to pharmacists to understand the design requirements for improved decision-making support to help them enhance their relationship with physicians.

[2] PMSs are used in the pharmacy and the EMRs are used in the physician's clinic. In addition, there's a regional EHR that some professionals have access to. But in Ontario pharmacists do not have any access to regional EHRs.
[3] Due to running an ethnography study in real word conditions, I was not always able to record a patient-pharmacy/prescriber interaction. Reasons included that: A) the patient or the pharmacist/prescriber was not comfortable participating, or B) no patient visited the pharmacy/clinic during the field study.

Chapter 4 Field Study Results I: The Reasons for Miscommunication between Pharmacists and Physicians

Once the field study was completed, all the interviews and recordings were transcribed. Next, the transcribed data was organized into three categories based on the reoccurring themes in the interviews. These three categories below emerged from the field study data and indicate the most frequently repeated issues between physicians and pharmacists. Thus, they are proposed to be the main reasons triggering pharmacist-physician miscommunication in Ontario. Each will be explained in detail in the following chapter:

1. Pharmacy – GP Relation Patterns
2. Main Ways of Communication Between Healthcare Providers (Prescribers & Pharmacists)
3. Communication Between Physicians

This first step of the analysis was a general exploration to understand the reasons leading to miscommunication between both parties (pharmacist-physician). Each category is explained in detail below. The following results was also published in Human Factors and Ergonomics Society (HFES) Healthcare Symposium in 2016 (Kerestecioglu, Grindrod & Burns, 2016).

4.1 Reasons for Miscommunication

4.1.1 Pharmacist – GP Relation Patterns. The pharmacists in our study viewed physicians as unreceptive and hard to reach. During the interview, one pharmacist mentioned that some pharmacists felt that their ideas and suggestions were not taken seriously by physicians. The pharmacist recalled a time when she recognized a medication error on a prescription and when she tried to resolve the problem, she was treated badly and felt the physician did not take her opinions seriously. She explained: *"…it was just one of those moments where you felt very frustrated, because you're really trying to do what is best and what we should be doing. We're drug experts, that is 100% a pharmacy problem right there and you almost felt like you were being a pain in the butt for doing it".*

Another barrier pharmacists face are that they have limited information about why a patient is taking certain medications or why the prescriber decided to make changes to a prescription. The pharmacists noted that prescriptions do not include a description or explanation about why the medication is being prescribed. As a result, it is common that pharmacists do not understand the treatment rationale while distributing the medication. Furthermore, it came across numerous times that the pharmacists were very aware that physicians are overwhelmed and that there may be errors on the prescription. One pharmacist commented: *"If I see that prescription, sometimes from the dosing you can make an educated opinion on what is it for, but I would never trust that opinion because doctors don't always get prescribing things right"*. Therefore, it is very common for a pharmacist to need to contact the family physician to ask for medication-related clarifications. Furthermore, since pharmacists are aware that physicians have limited time during a patient visit, the pharmacist usually spends a while to get to know the patient and the treatments they are on before calling the physician.

Compared to physicians, pharmacists work with little information about a patient's health. Most pharmacists in community practice are not able to access lab reports, radiology reports or other information related to the patients' medical history through the PMSs. By comparison, most physicians, nurses have access to patients' medical history data via their electronic records. To close this information gap, some community-based pharmacists were beginning to purchase point-of-care lab testing machines and additional clinical software to monitor anticoagulation therapy as a strategy to obtain information and reduce the burden on physicians.

On a similar note, the physicians argued that it was hard to reach out pharmacists. One physician commented that he had issues calling pharmacists *"all the time. I got a call in today. I tried… They were closed last night when I tried to call them."* Although phones are a good and personal way of communication, since it is rare they could reach a pharmacist over phone, physicians wanted to have a more direct way of communication. On the other hand, physicians were found to be very happy that pharmacists are reaching out and asking for confirmations and informing them about any errors on the prescriptions.

The main reasons for a physician to contact a pharmacist included checking on medication adherence, providing a refill prescription, discussing possible medication-related options and checking drug plan coverage for their patients. In our interviews, the physicians claimed that it was very rare for them to disagree with a pharmacist's suggestions. However, our interview results with pharmacists showed that this feeling is not mutual. Also, although physicians are eager to collaborate with pharmacists on medication management, our study indicated that physicians still prefer to work on medication-related problems alone first and then, as a last resource, discuss their options with a pharmacist. Lastly, it was found that the reason physicians do not always accept a pharmacist's suggestions was that physicians spend more time with their patient and claimed that they know their patient's habits and psychology (such as whether or not they will accept this treatment). In recalling a time, they rejected a pharmacist's recommendation, one physician explained: *"They started the* *medication I prescribed, they changed the dose because they thought it was for something else, another indication. The patient had come back in, and through talking and through looking at what they were taking we figured that out. That's one instance that sticks in my mind. I wasn't very happy with that."*

4.1.2 Main Ways of Communication between Healthcare Providers. The main ways pharmacists and physicians communicate are through written prescriptions or through the patient. The preferred way for physicians and pharmacists to contact each other for clarifications are through fax and phone. It was found that the pharmacists fax family physicians, and family physicians fax specialists to get a confirmation or ask for a clarification. While pharmacists prefer phoning physicians directly to get a faster solution to the related problem, physicians do not like getting phone calls since they find it distracting. One pharmacist mentioned, "*it is hard to get a GP on the phone unless he/she is calling you.*"

Another barrier between pharmacists and physicians are the receptionists and nursing staff in the physicians' clinic. Another pharmacist mentioned that first they need to pass through the receptionist, then they will be transferred to a nurse, if they can convince the nurse it is important, they will be transferred to another nurse and at the very end they will be told that physician is very busy, and to fax their inquiry.

How long it takes for a physician to reply a pharmacist's question and fax back to the pharmacy is dependent on the physician and the physician's work schedule. Furthermore, it was found that physicians have a way of confirming whether the other party received the sent fax, whereas this was not the case for pharmacists. A pharmacist usually faxes the problem to the physician, waits for two days and then faxes it again, if they have not heard back from the physician for a while the pharmacist then tries to phone them. On the other hand, one pharmacist mentioned that he has all the personal phone numbers of the physicians and he suggested that the reasons he has their phone number was *"because doctors know I'll not waste their time, I will only call for emergencies and they trust me".*

Finally, it was found that both physicians and pharmacists want a direct way of communication through the health management systems used in their stores and clinics. It was also noticed that, other than contacting pharmacists or seeing something out of place on the lab results (too late), there is no way for family physicians to detect medication adherence.

4.1.3. Communication between Physicians. Considering that the main mechanism for communication between physicians and pharmacists is through paper-based prescriptions, we observed that two of the main contributors to miscommunication are illegible hand-writing and the lack of information about the indications for a particular treatment. We also observed a lack of communication between family physicians and specialists and between the physicians seeing the same patients in different clinics and hospitals. With the current electronic records, a family physician can see any detailed explanation or any notes made by other doctors who saw a patient in a single clinic. However, since most medical records are not linked to each other, there is a knowledge gap when more than one physician is involved in a patient's health and treatment. Based on our interviews, it is typical for specialists to send a consulting report back to the patient's family physician that summarizes the details of the visit. It was found that specialists send consulting reports either too late (a very long time after the patient's visit) or family physicians never receive it. Thus, it was found to be common for family physicians to receive a refill request from a pharmacist despite not having sufficient information to confirm the refill. Family physicians were worried the lack of communication between physicians might lead to errors on prescription and with a patient's treatment. This issue was brought up by pharmacists as well. Due to the fact that often there are many physicians involved in a patient's medication treatment as well as the aforementioned lack of communication between physicians, it is very complicated for pharmacists to change a very simple mistake on a prescription.

4.2 Conclusion

This research chapter specifically focused on the issues leading to miscommunication between pharmacists and prescribers and indicated that there are not only miscommunication between prescribers and pharmacists but there are communication issues between prescribers. This exploratory analysis helped us in particular to identify that we need to address the issues casued by the pharmacist – family physician relation patterns and the main ways of communication between healthcare providers to enchance physician-pharmacist relationship with the help/use of tehcnology. Thus, in our attempts to design a decision/communication tool to support pharmacists' decision-making processes and their relationship with prescribers, the main focus will be on the pharmacist – prescriber relationship challenges and their preferred method of communication. Also, in the following chapters, the results will be mainly analyzed from the pharmacists' point of view to investigate how technology might help to improve pharmacists' relations with prescribers, with a focus on family physicians.

Chapter 5 Field Study Findings II: Usability Issues and User Challenges with PMSs in Ontario

After establishing the reasons leading to a communication gap between physicians and pharmacists, the next step was to understand the advantages and disadvantages of the current PMSs used in Ontario. The goal was to explore how the technology used in pharmacies gets in the way of communication between healthcare providers and what are the pharmacists' needs from a PMS. In this chapter, only the field study transcripts from pharmacists were considered for analysis.

The following results exploring the usability issues with current PMSs in Ontario is currently in preparation to submit to Canadian Pharmacist Journal, 2017. Only the results and conclusion sections of the proposed paper are shared in the following section to eliminate redundancy and not to repeat aforementioned details (background, method/participant/procedure of the field study).

5.1 User Experience Problems with Pharmacy Management Systems in Ontario: Human Factors Analysis – Results & Discussion

Nielsen (1995)'s Heuristic evaluations are used to analyze the usability issues with the current PMSs in Ontario. The results revealed that there are 12 main issues with the PMSs, which will be explained in detail in the following. To keep the software names confidential, the results will be explained in general but, as a result, the following points might be true for all or only true for one of the three PMSs observed in the present study. Additionally, software is frequently revised, so these observations only reflect issues observed at the time of the study.

1) **The order that prescriptions need to be prepared/ prioritized was not indicated in the software*:*** There was often no indication of which medication needs to be prepared first, based on the patients' anticipated arrival time. Although, some PMSs currently have a queue system on the main page presenting the number of prescriptions that have to be prepared, it does not prioritize urgent prescriptions on the list. Further the prescription queue feature was not turned on by default and could be hidden in the crowded interface. As one pharmacist commented: *"You end up spending hours filling maintenance meds for patients that won't be coming in for a week without ever even being able to see that there are a bunch of prescriptions (Rxs) for antibiotics waiting just below them*"

   Furthermore, the PMSs that had a queue system only indicated the prescriptions to be picked up for the same day and did not include the prescriptions for the next morning. This does not support the pharmacist's ability to prepare prescriptions for the next day. One pharmacist described this issue:

"If you go according to what the system tells you, it only will prompt this to you when it comes up. Things that are due tomorrow, let's say at 8AM, will never be on the screen until 4AM. Nobody's here. When you come in at 8AM, all of them are here. They're all red. Basically it's, all of a sudden, now you have to do all of these. If it's one hour, it'll only print off if you've already verified within the last 20 minutes before it's due. You feel like you're constantly doing reds, you're constantly working in the moment. You never catch up unless you go out of your way to make sure everything is done. It's never presented to you. I don't like that."

2) ***No way of tracking the interactions between pharmacists and prescribers:** Current PMSs do not track or record the interactions between pharmacists and healthcare providers regarding treatment plans or changes in the prescription. The pharmacist may not even have the opportunity to attach notes to the record. One pharmacist described this issue:

   "Not being able to record the notes of a discussion. If I send a fax to a doctor, I am not able to record in either system. My thoughts of that meeting are gone. If it is 6 months down the road and I'm talking to the guy and now he's on all those meds and I had a plan of follow up, A, B, C, I don't have that plan. I'd have to actually dig up the original prescription. If the doctor was okay with it. If he wasn't okay with it, it's gone forever. No record of it."

   This inability to record of interactions between pharmacists and prescribers might trigger miscommunication problems between pharmacists and prescribers as well as lead pharmacists to waste their time by doing the same actions (going over the patient profile, finding old prescriptions and trying to reaching out prescribers) repeatedly for a reoccurring issue.

3) ***No indication of fax status**: Many PMSs do not keep track of when prescriber was contacted, the reason for contact, and whether the issue was resolved or still pending. Furthermore, if the issue was resolved, there is no way to update the system automatically.

4) ***No confirmation of received information**: For a pharmacist, there may be no way of knowing whether their fax was received or read by prescribers. The only method of confirmation currently is the "sent" message appeared on fax machines, but even then it is unknown whether it was faxed to right location or whether it was received by the prescriber.

5) **Lack of documentation and support for over the counter (OTC) medications:** It is very common for patients to take OTC medications such as vitamins, health supplements, or cough and cold medications. Currently, a pharmacist can only see the prescribed medications the patient is taken under the patient's profile. Unless the pharmacist asks specifically for OTC medications and makes a note of this under the patient's profile, there is no indication of any OTC medications. The semi-structured interviews revealed that pharmacists would like to get more assistance about counseling for OTC medications throughout the PMSs.

6) **PMSs cannot distinguish current and old prescriptions on patient's medical history**: Some PMSs were observed to have "inactive Rx", and "active Rx" tabs to separate current and old prescriptions but the system was not updated automatically and the user had to discontinue the old prescriptions manually. When the discontinuation action is manual, it increases the likelihood that the medication will not be discontinued, increasing the risk of a medication error. Describing this issue, one pharmacist commented:
"The system itself doesn't pick up for you that there has been a change in dose and doesn't do that for you. It's really important, as a pharmacist, that you're checking to see that there aren't old prescriptions that are still active, because there's then the risk of someone filling off the old prescription."

7) **Cannot track medication adherence and early requests for refills**: The only way of catching medication adherence with most of current PMSs is to check the last refill date of the medicine and calculate it manually from there. It was also found that there may be no alert or warning in the system for early refills requests by patients. It creates extra work for pharmacists and the system relies on pharmacists to calculate whether it is right time to refill the medication each time there is a refill request.
Only one PMS was observed to have an alert feature in case of an early refill request, however, even this system had its problem that it would not monitor information from other pharmacies when the patient record has been transferred.

The following quote illustrates this problem: *"It was filled 6 days ago for 50 tabs, BID. She wants some more. She's 19 days early. How did I specifically figure out that problem? Days intervals, extremely short […] Was there any kind of alert on the system? No. Okay. She has just transferred in from another pharmacy, so it doesn't alert. It only alerts on our system."*

8) **Transfer Patients: PMS cannot screen for interactions:** If a patient recently transferred from another pharmacy, pharmacists can request to transfer that patients' medical history. However, there may be no way of transferring and updating this information between systems

automatically. The pharmacist may have to enter all information manually on the PMSs as if creating a new patient profile. This is not only inefficient and costly in time, it also creates complications and that could increase the risk of errors:

"If they don't remember what other medications they're on, or if they go to another pharmacy that has their full profile, we can't screen for interactions. That's a difficult issue for us, because we don't have electronic PMS or any kind of database like that for us to screen for that. We base it off of the patient's recollection."

9) **The quantity of medication (on the PMS software) is insensitive to what's actually inside the batch**: It was recorded with one of the PMSs that it automatically batches each prescription for 28 days and even when the pharmacist enters a different quantity, the PMS automatically changes it back to 28 by thinking it was an error.

10) **Cannot modify previously created prescriptions:** It was noted that one of the PMSs was unable to make small adjustments related to billing (such as change in the insurance plan, doctors' name, address or payment methods etc.). Once a prescription is entered in the system, the system is assigned a number code for it. If there is a need to change any billing related information, the system generates a new number and treats it as if it's a new prescription. Thus, a pharmacist has to enter all the prescription related information from scratch. This situation also leads to inefficiency in workflow and is costly in time and effort:

    "[the] patient didn't have a drug plan before and he paid always cash, so we know that he doesn't have one but let say now he has a new one! When we put it as a cash and then he comes in for payment and says he has a drug plan. I have to cancel the prescription and do it all over again."

11) **Lack of flexibility in search under patient profile**: In one of the PMSs it was observed that pharmacists can only search for patients with their birthday (month, day and year in this specific order). It's impossible to run the search with the patient's name, surname or address. This forces pharmacists to memorize and recall all the patient information rather than aiding the pharmacists by capitalizing on recognition skills.

12) **Unnecessary Pop-ups**: One of the common issues observed with all these PMSs was the high number of pop-ups in the system. These are mostly used for warning, alert or confirmation purposes. Although they are important to have in a pharmacy management system, many

pharmacists told us that sometimes they can be redundant and pharmacists stop paying attention to them:

"When you have to okay six times to do a prescription… They should only pop up if there's an error. They're saying it went okay through to DIS. Good to know, but I wasn't worried about it. It doesn't have to tell me it went through DIS. It just has to tell me if it doesn't. The balance is the number of pop ups, so you don't pay attention anymore."

5.2 Conclusion

Twenty-five pharmacists were interviewed and observed in their work environment to gather a deeper understanding of usability issues with the current PMSs and to understand user needs for improved PMSs in the future. Although these results are limited to three most commonly used PMSs in Ontario only, the findings revealed important design requirements. There is a need to limit the number of pop-ups on the PMSs as they are found to be very exhausting and distracting as well as it was found that there is a very limited user flexibility when pharmacists making modifications on the previously created prescriptions. Furthermore, PMSs are needed to be designed to help pharmacists to prioritize prescriptions based on their significance and urgency level and the systems should be able to keep track of previous interactions between physicians and pharmacists, track the indication of fax status and provide more documentation for OTC.

It is recommended that PMS software companies keep these suggestions in mind when designing an efficient PMS in the future. Pharmacists have a right to expect the software they purchase to work with them to make their workflow more efficient, not add additional workload, and help them with better decision making. The scope of pharmacy practice is continually evolving, and new systems should incorporate features such as better pharmacist-prescriber communication that would enhance situation awareness for pharmacists and prescribers. Pharmacy systems need to adapt to the realities of patients who take OTC medications, move between care providers and pharmacies, and expect greater levels of consultation from their pharmacists.

5.3 Summary of the Design Requirements

This master's thesis research seeks to find ways to improve prescriber-pharmacist interactions with the use of technology. Twelve usability issues were detected with the current PMSs used in Ontario as it was explained above. These user challenges included issues related to pharmacists' internal workflow (issues 1, 5, 6, 7, 8, 9, 10, 11, 12) and pharmacist-prescriber relationships (issues 2, 3, 4). Since the main focus of this research is to enhance prescriber-pharmacist interactions with the use of technology, only issues related to physician-pharmacist communication (issued 2, 3, 4 and indicated with "*" above) will be considered as design requirements when designing a decision aid tool for pharmacists' use in the following chapters.

Chapter 6 Findings from the Field Study III: Control Task Analysis - Decision Ladders

So far, in the previous chapters I have investigated the reasons leading to miscommunication between prescribers-pharmacists and explored the reasons of miscommunication due to the design of PMSs, this chapter studies the weaknesses in the information systems (PMSs) and pharmacists' cognitive decision-making processes to understand the hidden hindrances leading to a communication gap and design ideas for a future PMS.

As previously explained in Chapter 2, ConTA is chosen and used as the main method of analysis to model the cognitive decision making process of pharmacists. Therefore, decision ladders are used to analyze the information processing activities and states of knowledge of three pharmaceutical tasks. These three tasks were observed to be the most common parts of a pharmacist's daily practice according to field study data and therefore they are used to model the DLs. Furthermore, these ladders in particular revealed differences as a result of pharmacists' interaction with PMSs, pharmacists' interaction with prescribers as well as these DLs revealed significant design requirements. These tasks are: Medication verification, follow-ups with patients taking special medications only and medication review.

The DLs are based on the data acquired through the interviews and talk aloud with pharmacists in the field study and the results are explained below. This research paper is submitted to SMC 2017 conference. Similar to previous chapter, only the results and discussion sections of the proposed paper are shared in the following to eliminate redundancy and not to repeat aforementioned details.

6.1 Results

This present paper shows how ConTA can investigate weaknesses in information systems design. The DLs revealed the following significant limitations regarding the design of PMSs and each limitation will be explained in detail:

1. PMSs have missing information that requires additional human work (task: medication verification).
2. The design of PMS causes distribution of work (task: patient follow-up)
3. It is a design with missing information (task: medication review)

6.1.1 Medication Verification: Missing Information That Requires Additional Human Work

Analysis of the DLs revealed that there can be missing information and steps in the design of PMSs that requires additional human work. In particular, we noted where the additional work that could be performed by a well-designed information system. This limitation can be illustrated using the DLs of the medication verification task in PMS_A (Figure 3) and PMS_B (Figure 4).

As seen in both figures, pharmacists' complete medication verification while dispensing medication orders. There are common states, processes and transitions with both PMSs ($PMS_{A\&B}$), which are shown in thicker black lines. However, the task flows also differed as shown in green (PMS_A) in Figure 3 and blue (PMS_B) in Figure 4.

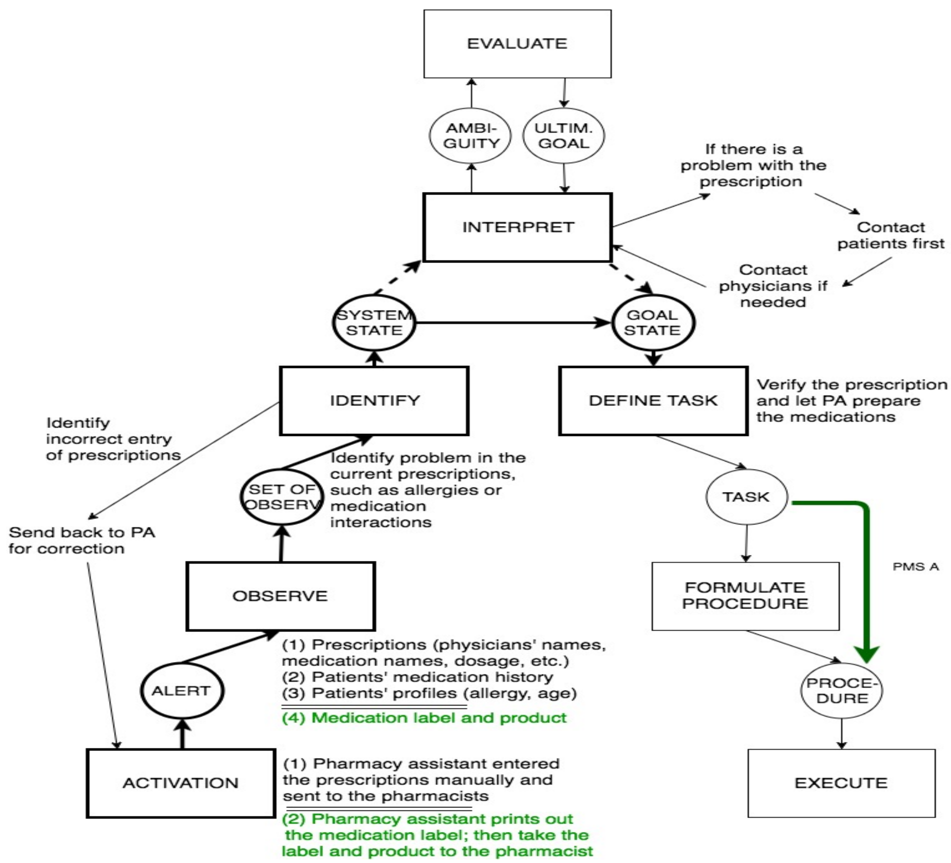

Figure 3 The DL representing missing information in PMS_A's design requiring additional human work. PMS_A is indicated with green.

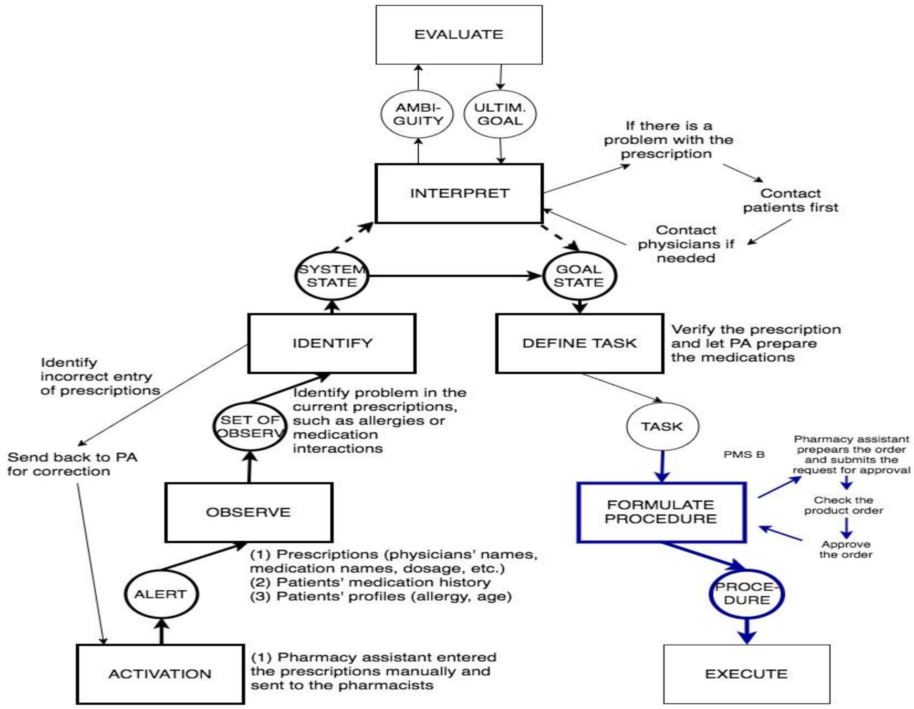

Figure 4 The DL representing missing information in PMS_B's design requiring additional human work. PMS_B is indicated with blue

Pharmacists begin by reviewing the prescriptions that are entered by pharmacy assistants manually. In some of the PMSs, (such as with PMS_B) pharmacists can see the scanned prescriptions on the PMS screen while they are reviewing the entered data from the assistant. If a pharmacist finds any mistakes between the original prescription and the transcribed information in the PMS, they return the entered prescription back to the pharmacy assistant via the PMS for correction. This return can be seen by the *shunt* from *identify* to *activation* on the left of the both figures. Once the PMS information is verified, the assistant prints the labels and prepares the medication.

By comparison, in PMS_A, the medication verification follows the traditional pharmacy workflow. In this case, the pharmacist verifies the prescription using the finished, labelled product. The pharmacist begins by reviewing the prescription details in the PMS, though scanned prescription is not visible on the screen and the pharmacist instead compares the information to the original paper prescription. Therefore, by the time the pharmacist reviews the prescription, the medication labels and the products are already prepared by pharmacy assistant (text in green). In the case of missing information, the information needs to be added and new labels need to be printed. This missing information is the first example where additional human work is needed to print out the additional work (label and product) for pharmacists to review the prescription details rather than finding this information on the PMS.

If pharmacists identify some problems with the prescriptions, our interview results revealed that they often contact patients first to confirm whether the prescription is correct (*interpret*) and then, pharmacists will phone or fax the prescriber (i.e.; family physician) who resolves the problems in the prescription (*goal state*). This is the second example of missing information in PMS's designs leading to additional work for pharmacists. Both $PMS_{A\&B}$ cannot directly communicate with the medication management systems used by physicians (electronic health recording systems – EHR). This missing link between management systems requires pharmacists to use another medium such as phone or fax to reach out the prescribers.

Next, if there is no problem present in the prescription, the pharmacist verifies the prescription and the medical order (*define task, task*). For PMS_A, once the pharmacist verifies the prescription, the medication order is finalized. However, for PMS_B, after verification of the prescription, the pharmacist then lets the pharmacy assistant prepare the products. Once the pharmacist receives the approval request from the pharmacy assistant, they check the product order by verifying the pictures of pills from the PMS_B (*formulate procedure, procedure*) and then the medication order is finalized. Now, in the case of PMS_B, it can be seen that there is a repeated cycle of additional work that has to be completed not only by the pharmacy assistant but also the pharmacist.

The DL shows how missing information (the inability to scan/present prescriptions on the PMS_A, no connection between PMSs-EHRs, and repeated approval cycle on PMS_B) might require additional human work to accomplish simple tasks. As shown in the model, there are multiple activities where pharmacists need to wait for a response from other team members (such as the pharmacy assistants and physicians/prescribers) in order to proceed to the next step, especially in the $PMS_{B.}$ Furthermore, a more serious workflow disruption occurs when there is no way of confirming whether the prescriber received the inquiry from the pharmacist or how long will it take for prescriber to response back to solve the problem (missing information: PMS-EHR not connected).

The PMSs we observed do not support these requirements and as it can be seen in Figure 3 and 4, the lack of a confirmation system and not knowing the status of inquiry (pending, resolved) with prescribers might result in a long wait time between *interpret* and *goal state* and might freeze the process temporarily and eventually affect the patient's treatment. Therefore, the efficiency of data sharing and coordination of tasks among multiple team members can be greatly influenced by the design of the PMS.

Finally, the design of workflow also creates different demands on the pharmacists. For PMS_B, the task has been divided into more subtasks than PMS_A, in which the preparation of products cannot be started before receiving the verification of prescriptions. Based on our observations in different pharmacy settings, PMS_B is used in a larger-scale pharmacy with more pharmacists and pharmacy assistants available to distribute work, so the divided workflow may work better in this larger team. On the other hand, PMS_A is used in a smaller-scale pharmacy. Though this is based on early findings, while evaluating the PMSs the different contexts of the pharmacies needs to be considered. A social organization and co-operation analysis would be a good follow up analysis to this work.

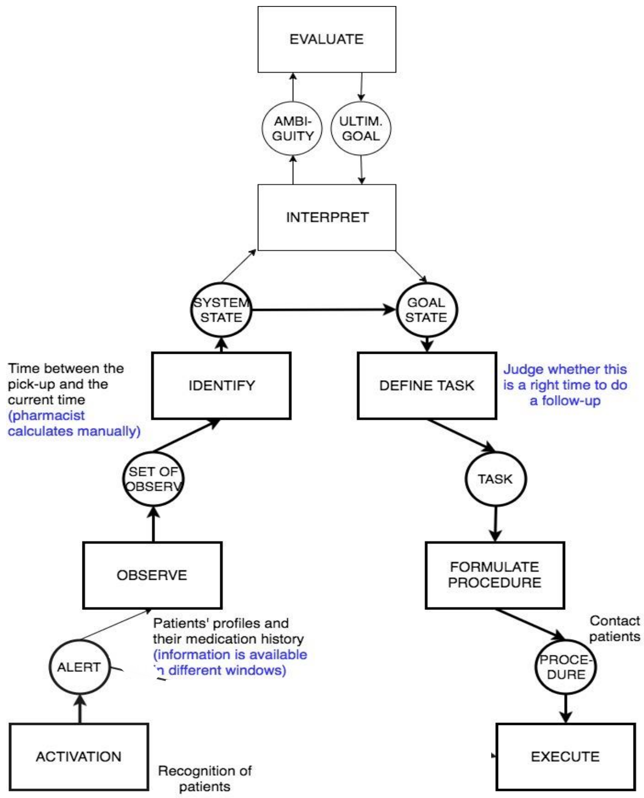

Figure 5 The DL for patient follow up

6.1.2 Patient follow-up: The design of PMS causes distribution of work

The next DL (Figure 5) outlines the workflow involved in patient follow-up as it relates to the design of both PMSs (A&B). Follow-up is seen in cases where a patient needs special attention such as having been prescribed an antibiotic or insulin injection.

During a follow-up, pharmacists begin with accessing the patient's profile and medication history in the PMS (*observe, set of observations*). They identify the nature of the prescribed medications (such as antibiotics) or the relevant characteristics of the patients (e.g. first time use). Our observations revealed that in some cases, pharmacists put notes in patients' profiles for the purpose of reminding themselves to follow-up. The pharmacist then checks the time duration (*observe*) from the last pick-up time and the current time (*identify*) to judge whether she needs to contact patients to follow up their conditions (*system state to goal state evaluation*). Noted that, the information about medication history (the date on the medication prescribed and the date it was picked up) and patients' profiles were distributed in different pages in PMSs, in some cases. This is another example of where the design of PMS causes distribution and interruption of work by forcing pharmacists to check different tabs to search for the necessary information.

Also, the design of PMSs do not automatically calculate the days between last and current pick up times and requires pharmacists to do it manually when assessing for non-adherence to therapy.

If a pharmacist decides that it is the right time to do the follow-up (*define task, task*), they contact the patient through phone calls (*formulate procedure, procedure*). If they cannot reach the patient, they leave voice messages, then make a note for themselves in the patient's profile that patient was not available and there is a need to do the follow-up on another day (this would require a return to the same task on another day as the task was not executed). In our observation, when patients were well known to a pharmacist, the follow-up process is demonstrated much faster. Interestingly, pharmacists do not rely on the external information from the PMSs, if they know the patients for whom a follow-up is necessary. Therefore, the pharmacist contacts the patients directly without checking back with the data in the PMSs. This situation was observed often in small pharmacy settings (non-chain pharmacies as well as chain pharmacies in small cities).

The DL showed that it is common for pharmacists to write small reminder notes on the patients' profile as a part of the follow up process; however, it was found that the PMSs we observed did not have a reminder function to ease and fasten this process. Furthermore, the inefficiency of having necessary information in multiple different pages was revealed by the DL as well.

6.1.3. Medication Review: Missing Information

In the last model (Figure 6), a case of missing information during a medication review with a patient is shown. A medication review is a 30-45-minute-long session between a pharmacist and a patient, in which the pharmacist goes over all the medications (prescription medication and over the counter medications) the patient currently takes and collects information on how the patient takes the medications at home as well as answers any questions patient might have.

Blue lines in Figure 6 represents the medication review process in which pharmacist recognizes an issue (such as misuse of medication or medication interaction). This task can be initiated by patients, patients' relatives, patients' doctors or by pharmacists and starts at *Alert*. Once the medication review is requested, the pharmacist first identifies the task itself (*Task)*, which is in this case conducting a medication review and then moves to *Observe* to understand why the medication review is requested. The pharmacist checks carefully the patient's medication history and all the medications patient is currently taking. If the pharmacist catches any medication interaction, medication adherence or medication misuse, they take a *shunt* from *Identify* to *Procedure* and start asking further questions to the patient for clarification purposes. If the patient is uninformed about this issue, the pharmacist contacts the prescriber by phone or fax and the task freezes until the prescriber resolves the issue.

It was observed during the interviews that the current PMSs do not keep track of the interactions between prescriber and pharmacist. When contacting a prescriber for medication interactions, there is no place to document the conversation between the pharmacist and prescriber. It is inefficient for pharmacists to go through the same path from *Alert* to *Identify* and to *Procedure* each time if there is a re-occurring medication adherence or medication interaction.

Furthermore, there is no way of predicting prescribers' behavior and response time. This might result in long wait times for patients in this process and freezes their treatment plan until they hear back from the prescriber, which might take up to 15 days in some cases.

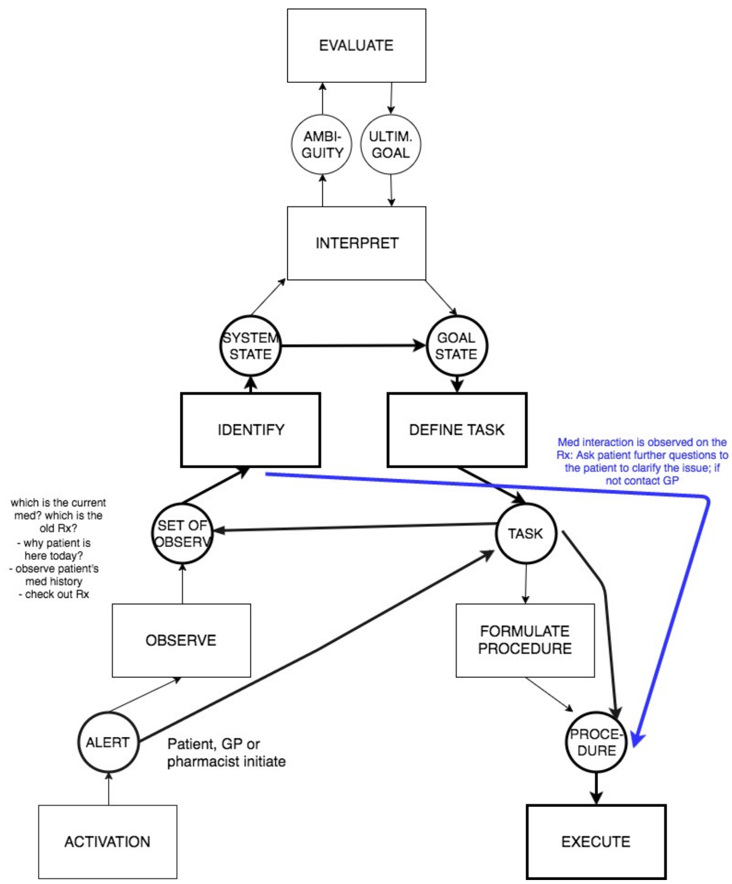

Figure 6 . Missing Information. The blue line shows a processing chain when searching for information

6.2 Discussion

We used DLs to identify the information processing constraints that reside in the common practice with the use of current systems. Although there is little discrepancy across the PMSs, the analyses share some common suggestions on the design of the PMSs for pharmacists. This use of the DL solutions is consistent with the approach proposed by St. Maurice and Burns (2015) who suggested that the DL could be used to compare similar systems and look for more effective practices or designs. The DL was able to identify several common types of problems with information systems, particularly poor information design, missing information, and designs that create inefficient work.

Redesigning the system to better integrate and present the information needed for a specific task should benefit pharmacists to achieve higher efficiency in completion of their daily practice. It was apparent that the workflow for routine pharmaceutical practice varies with different PMSs. In some of the PMSs, the task has been distributed into multiple subtasks. This model is more suitable for a pharmacy with multiple pharmacists and assistants where work can be distributed. However, for a smaller-scale pharmacy, having the tasks over-fragmented may create redundant costs of time and efforts for the same healthcare practitioners to access the PMSs.

Furthermore, it was also observed that in smaller scale pharmacies, pharmacists know their patients well and there are times they might contact patients directly without relying on the PMSs, it could be argued that while redesigning the PMSs the context, location (smaller vs. larger scale pharmacy), and number of employees in the pharmacy should be considered.

Additionally, the DLs revealed design requirements that are important to address when redesigning the PMSs in Ontario: In some of the PMSs the information was distributed between different pages with multiple tabs forcing pharmacists to switch between windows back and forth to search for information. This may create additional workload and inefficiency for pharmacists to search for the information as well as result in additional cognitive load when integrating the information through memory. This particularly might result in wastefulness of time in Community Pharmacies in Ontario, who have more than 100 prescriptions per day. Therefore, it is important to design PMSs that are not loaded with unnecessary information and in which pharmacists can access related information on the same screen instead of going through many tabs.

Current PMSs in Ontario is lack of important information such as no confirmation system to update pharmacists on the system status of their inquiry to prescriber. There is a need of developing a system that represents whether their inquiry is received / read by prescribers as well as whether the issue is resolved or still pending to prevent long wait times and to provide the fastest and safest patient care.

Decision ladders indicated another missing information that there is a need to record and keep track of pharmacist-prescriber interactions including reasons of contact and the date of each contacts. Based on the results of decision ladders, it might be a good idea to have a system that can record and predict prescribers' response times and most responsive days. This will assist pharmacists to have a better estimation of when they will hear back from the pharmacists, thus inform the patients more precise on when they should come back to receive their treatment / medicine.

These design requirements gathered through field studies in combination with Decision Ladders to illustrate how ConTA can investigate weaknesses in information systems design and can be used to explore different design solution for complex systems in healthcare.

To sum up, three main problems are investigated with ConTA about the design of PMSs: (1) there are missing information that requires additional human work in the task of medication verification, (2) the poor design of PMS causes distribution of work and leads to waste of time and inefficiency in a pharmacy while doing patient follow ups and (3) there are missing information in the design of PMS (cannot predict prescriber's behavior, no confirmation system, cannot keep track of physician-prescriber interaction)

It is recommended to consider these requirements when redesigning a pharmacy management system to improve pharmacists' internal work as well as pharmacist-prescriber communication. More fieldwork and thorough analysis will be needed in future research to redesign the workflow of the PMSs to improve the efficiency of pharmaceutical practice. This paper was an initial attempt to illustrate the ease and usefulness of ConTA to address the design solutions in complex systems in healthcare. This work did not compare the effectiveness of the DL with other human factors techniques such as task analysis but it would be expected that task analysis would also have revealed these problems. However, for practitioners following a CWA approach, this work provides insights into maximizing the results from the CWA approach.

Chapter 7 Experimental Lab Study: A Decision Tool to Aid Pharmacists-Prescribers Communication: Communication Summary

7.1 Summary of the Design Requirements

The main goal of this thesis research is to investigate the reasons causing to miscommunication between prescribers and pharmacists and understand how to design a communication/decision tool to help pharmacists to enhance their relations with prescriber and to overcome the communication barrier. Therefore, the discussion below considers only the design solutions that are related to prescribers and pharmacists' communication issues, the requirements related to pharmacists' internal workflow or physician to physician communication issues are excluded. Also, the proposed solutions are constructed from the pharmacist's perspective. The design solutions recommended by each method of analyses was put together in the Table 1

Table 1 Summary of the Design Requirements gathered through different analyses from field studies. Only design solutions related to physician-prescriber miscommunication are indicated in the table.

(1) Main Reasons Leading to Miscommunication between Pharmacist – Prescriber Chapter 4	(2) UX Issues with PMSs Chapter 5	(3) Decision Ladders Chapter 6
Pharmacist-GP Relation Patterns: hard to reach out to other healthcare providers.	No way of keeping track of interaction between pharmacist-physician	Missing information that requires additional human work: High cognitive workload for search (related information are located in multiple tabs)
Main ways of communication: fax or phone	No method to track the status of fax (pending, resolved?)	Missing information in the design of PMS: No method to keep track of pharmacist-physician interaction
	No confirmation of sent fax (cannot predict prescriber's behavior)	No confirmation system to update pharmacists on the system status of their inquiry to prescriber.
		Missing information in the design of PMS: No way to predict prescriber's response time

Since we know now what are the limitations and issues triggering miscommunication between prescribers and pharmacists, it is proposed to design a communication-aid tool for pharmacists that will address the aforementioned design requirements and help to document the communication history between pharmacists and prescribers, indicate the status of fax, predict prescribers' behavior including the response time and have the relevant information on the same window. It is proposed that such a decision-making tool would ease pharmacists' workflow, help them to become more efficient and productive in their practice and increase their trust and motivation against the prescribers they work with.

7.2 Need for A Change in PMSs

Based on the discussed findings and design solutions, a mockup of an improved PMS was created to test my prediction that a decision/communication aid tool (a.k.a. Communication Summary) addressing the weakness in PMSs, would improve physician-pharmacist communication as well as pharmacists' workflow. Four main features were the design focus in the mock up: (a) Keeping track of interaction between physicians-pharmacists (b) Predicting prescribers' response time and day (c) Providing information about prescribers (d) Providing a confirmation system to illustrate whether the issue was resolved or pending.

The first wire-frames were sketched with pen and paper and they were very exploratory. They were evaluated with talk a loud protocol with Advanced Interface Design Lab members. Based on the feedback received, the high level mockup was designed with Sketch software and it can be seen in Figure 9.

Once the final mock-up of the Communication Summary was designed, it was tested with 20 pharmacy students attending University of Waterloo School of Pharmacy to evaluate the usability of the Communication Summary. Pharmacy students were chosen since they are expert users of pharmacy management systems. Pharmacy school is a post-undergraduate degree and many pharmacy students have real work experience in pharmacies using PMSs (due to Co-ops or personal interest).

The following paper explaining the usability study details and its results was also submitted to SMC 2017 conference and is shared in this chapter to present the results of the lab study.

7.3 A **Decision Support Tool to Aid Pharmacist-Physician Communication: Communication Summary**

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7.3.1 Abstract

Miscommunication between healthcare providers can impact patient care and increase health care costs. This miscommunication and communication delays between physicians and pharmacists have been documented [1, 2]. One of the factors contributing to this communication gap in Canada is the technology used in pharmacies. Current pharmacy management systems do not support pharmacist-prescriber interactions. This study is an initial exploration of design ideas for pharmacy management software interfaces to improve prescriber-pharmacist relations. Previous research had identified three main requirements for improving physician-pharmacist communication [1]. A mockup was designed to mimic an existing pharmacy management system with the addition of graphical elements to address these requirements. A test was conducted evaluating the mockup with the communication summary against a condition with no communication summary in a simulated multi-day pharmacy management task. The results of the study indicated that the use of the communication summary helped pharmacists to be more aware of the response time and behavior of prescribers. Furthermore, the response time of prescribers affects the method of communication as well as pharmacists' motivation to collaborate.

Keywords— Pharmacy management system; pharmacists; prescriber; communication; miscommunication, user experience; usability.

7.3.2 Introduction

Miscommunication between prescribers and pharmacists can be attributed to the technology used in their workplace [1], [2]. A previous study found that current Pharmacy Management Systems (PMSs) do not support communication between prescribers and pharmacists [1], [2]. There is a need to redesign PMSs with a focus on improving and supporting healthcare providers' communication across different practice sites, allowing pharmacists to speedily provide the best patient care and reduce possible medication complications arising from miscommunication.

Kerestecioglu, Grindrod & Burns (2017) found that there are three main features missing from the current PMSs in Ontario that could be contributing to miscommunication between prescribers and pharmacists: (1) No method to keep track of previous interactions with the prescriber (2) No way of tracking or confirming the status of fax communications (resolved or pending) and (3) No ability to predict prescribers' response time.

The current study is aimed at addressing these requirements in order to redesign and reevaluate PMS regarding pharmacist-prescriber communication.

7.3.3 Method

7.3.3.1 Mockup

To implement these ideas, we developed a mockup with Sketch Software on a 13 inch MacBook Pro computer. This mockup was an imitation of a PMS currently used in Canadian pharmacies but is typical of many PMSs, along with the addition of the communication summary shown in Figures 9 & 10. This mockup was shown to the test group. Only the communication summary window was informative, while the rest of the mockup was a shell and the control group did not receive any mockup while working on the task. The design of the communication summary is described in the next paragraphs.

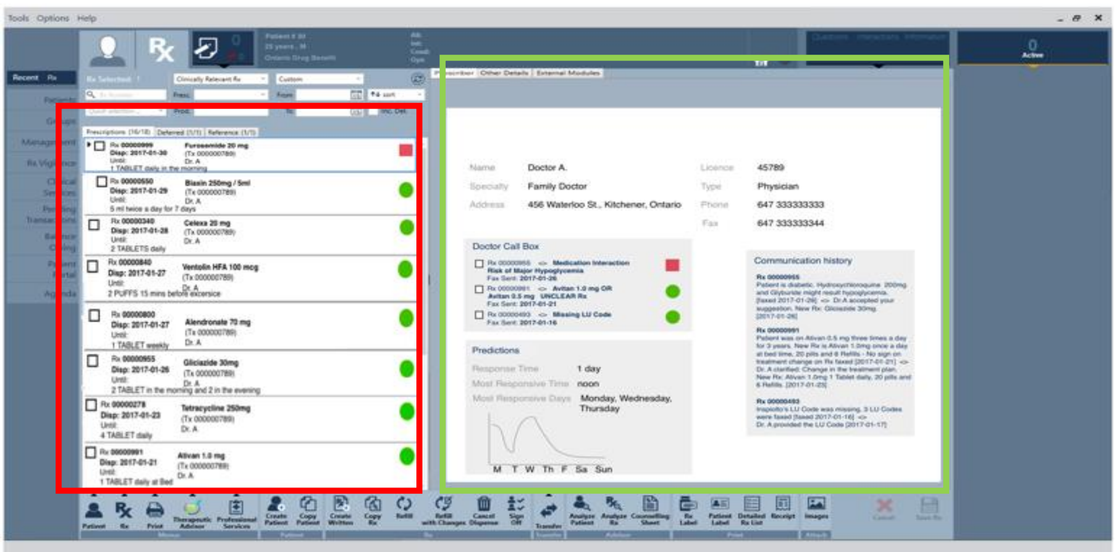

Figure 7 Communication Summary Mockup: The red outline is the list of all patients and the green outline shows the Communication Summary

Figure 9 shows the profile of a prescriber, Doctor A. The red outline is the list of all patients who visited Doctor A, organized chronologically by prescription date. Prescriptions with an issue (such as medication interaction, allergies, missing information or error/typo on the prescription) always appear on the top of the list with a red square. A green circle indicates that there was no problem with the prescription and the prescribed medication has been distributed to the patient.

Figure 8 Details of Communication Summary (1) Prescriber Information, (2) Doctor Call Box, (3) Communication History and (4) Predictions

The green outline in Figure 9 shows the Communication Summary. The Communication Summary consists of four main features: (1) Prescriber Information, (2) Doctor Call Box, (3) Communication History and (4) Predictions (Figure 10).

- *Prescriber Information (represented in Figure 10 -orange):* In this section pharmacists can find basic information about prescribers such as their names, specialties, addresses, phone/fax numbers and their licence numbers.
- *Doctor Call Box (represented in Figure 10 – yellow):* This section shows prescriptions from the patient's list (Figure 9 – red outline) which experienced an issue (e.g.: medication interaction, missing information on the prescription, etc.) that requires prescriber input. Furthermore, the Doctor Call Box indicates (1) whether the issue with the prescription is resolved or still pending (2) why the prescriber needed to be contacted (3) date the prescriber was contacted, if applicable. If the issue is pending, it is indicated with a red square. If the issue is resolved, the red square becomes a green circle and is deleted from the Doctor Call Box within 10 days.
- *Communication History (represented in Figure 10 – blue):* The Communication History is designed to record interactions between the prescriber and pharmacist through transcripts and timestamps.
- *Predictions (represented in Figure 10 – gray):* Predictions indicate (1) the average response time of prescribers (2) a prescriber's most responsive time of the day (3) the most responsive day of the week in writing and visually

7.3.2.1 Participants

Twenty (13 F, 7 M) pharmacy students between the ages of 18 and 40 were recruited. All students were from the University Of Waterloo School Of Pharmacy and had at least eight months experience working in a community pharmacy. Three students self-assessed themselves as experts with pharmacy management software, while fifteen students ranked themselves as familiar and only two students ranked themselves as not familiar.

7.3.2.2 Procedure

The present study was a between-subjects' design, in which the intervention group (10 participants) was exposed to the Communication Summary (CS) and the control group (10 participants) had no communication support (No-CS). Participants were as evenly balanced as possible demographically between the two groups.

The study started with a ranking assignment. Each participant was asked to assess the importance of the following components of a pharmacy management software on a scale of 1-6 (1 being very important to 6 being not so important): (1) Knowing whether the issue with the prescription was resolved (2) Keeping track of prescriptions (3) Keeping track of previous interactions/conversations with prescribers (4) Prescriber's information (5) Predictions about prescribers' most responsive day (6) Predictions about prescriber's average response time.

These six items on the ranking assignment represented separate features of the Communication Summary. This ranking assignment was intended to get participants' initial feedback on these features even before they interacted with the interface. Both groups were asked to complete the ranking assignment.

After the ranking assignment, pharmacy scenarios and in-study questionnaires were presented to participants. Thirty standardized prescriptions with valid medication names and information were presented to participants in order to simulate an authentic pharmacy management situation.

Each participant saw the same thirty scenarios. Participants were told to read each prescription carefully and if they caught any issues (e.g. medication interaction, missing information etc.) they were told to report that there is a need to contact the prescriber. Half of the prescriptions were sent from hypothetical Doctor A and the half by hypothetical Doctor B. One key differentiator is that Doctor A always had a faster response time (24-48 hours), whereas Doctor B was always slower (4 days).

Each prescription had the same information: Medication name, dosage, intended duration of use and the number of refills. Six out of 30 prescriptions had major medication interactions and these prescriptions were equally distributed between prescribers, so each prescriber had three prescriptions with interactions and twelve prescriptions without any complications. The medication interactions were designed to be equally challenging to resolve.

Furthermore, the participants were asked to answer short questionnaires after every sixth scenario throughout the study. In total, each participant responded to five in-study questionnaires measuring their assumptions about prescribers' behavior. These questionnaires included questions such as "*have you heard back from Dr. A/B regarding the clarification of the prescription", "is the issue with the prescription resolved or still pending"* or *"when would you expect to hear back from Dr. A/B"* etc.

Finally, at the end of the study each participant was asked to complete a final questionnaire in which they were asked about their motivation and trust towards each prescriber, the usability of the Communication Summary (Usefulness, Satisfaction and Ease of Use (USE) Questionnaire) (only for the CS) and feedback on the mockup (both groups).
Although the control group was not exposed to the Communication Summary during the study, at the end of the final questionnaire the Communication Summary was shown to them to gather their feedback on the design as well as to test whether the interface was simple enough to understand without any explanation or training.

The study ran for 45 minutes and started with consent and a brief tutorial about the Communication Summary (CS group only) and ended with a debriefing session and compensation. This study was approved by the University of Waterloo ethics committee (the ORE #21924)

7.4 Results and Discussion

This was an exploratory and mainly qualitative study aiming to get expert user feedback as well as to understand user needs on a new pharmacy management software which better supports pharmacist-prescriber relations. Due to its exploratory nature, quantitative analysis was not applicable for the results; instead, frequency distributions of the qualitative questions and descriptive feedback of participants were analyzed.

7.4.1 In-Study Questionnaire

The short questionnaire results indicated that CS participants more accurately predicted prescribers' response time and day. The participants were also better able to follow the resolution status of prescriber inquires over time compared to No-CS participants.

To evaluate changes in the participants' assessment of prescribers over time, the number of correct responses at the beginning of the study (Questionnaire 1) versus the end of the study (Questionnaire 5) was compared and analyzed with Chi Square between groups (No-CS vs. CS).

Firstly, we analyzed how well the participants were able to manage the incoming prescriber responses including prescription status and prescriber response. This was done by performing a chi-square test on the relevant questions from the questionnaire being shown at numerous time intervals. The test revealed that there was no significant difference between groups over time, X^2 (1, N=20) = 0.31, $p > 0.05$. This might be because over time, all participants improved their ability to manage incoming information during the test. However, participants who had the Communication Summary exhibited a marked improvement in predicting prescription status and prescriber's average response time, supporting the notion that the communication summary may have helped with accurately determining the current state of prescriptions.

Next, we analyzed how well the participants were able to predict the response time of prescribers for similar future issues. Both groups were unable to come to a consensus at the beginning of the study, which is expected given their lack of interaction with the prescribers. At the end of the study participants with the Communication Summary reached a stronger consensus on prescriber response times than participants in the control group, which can be seen in Figures 11-14. However, Chi-square did not indicate any significant difference between groups' response over time (X^2= *(1, N=20) =0.05, $p>0.05$).*

Finally, for the participants' ability to predict the optimal day to contact their prescriber, it was found that participants with the Communication Summary were significantly more accurate in their predications compared to No-CS participants over time. Statistical significance was shown through Chi-Square test; X^2 = (1, N =20) = 5.41, $p < 0.05$).

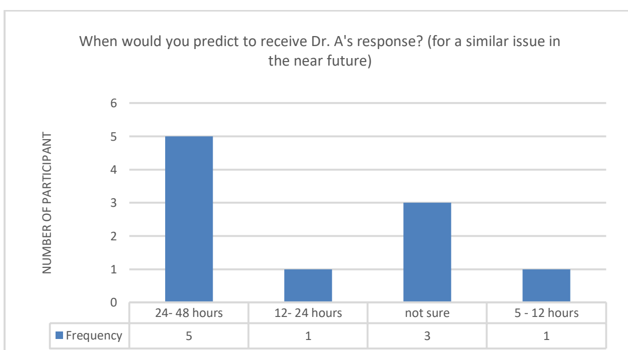

Figure 9 CS participants answers in Q1 (24- 48 hours is the correct answer)

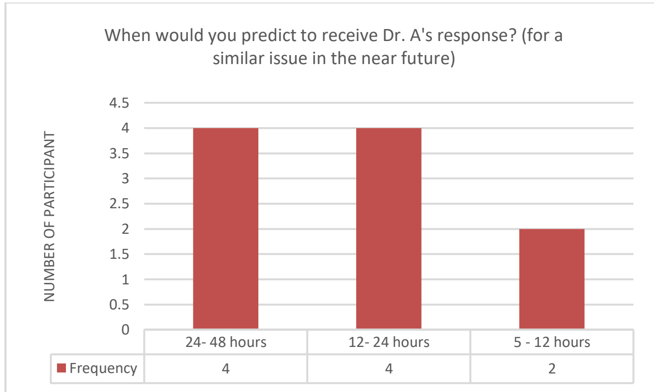

Figure 10 No-CS participants' answers in Q1

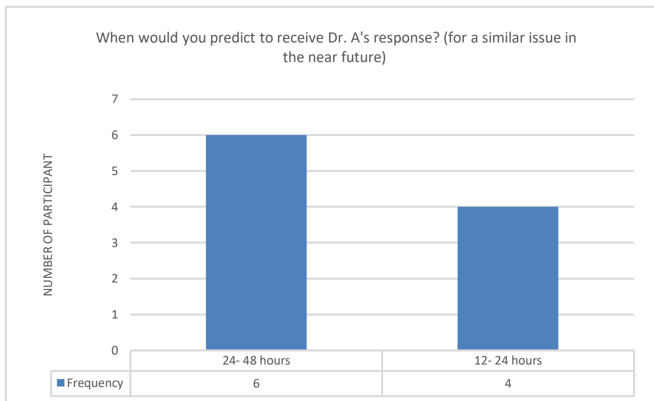

Figure 11 CS group answers in Q5 (24- 48 hours is the correct answer)

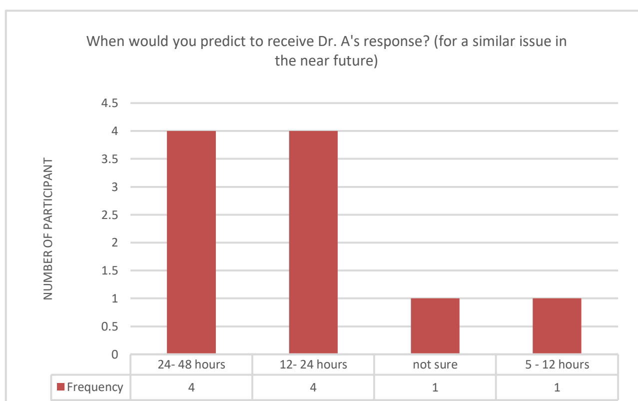

Figure 12 No-CS group answers in Q5

These results showed that the Communication Summary developed in this study seemed to help participants to more accurately assess and predict prescriber's behavior, especially the best day to contact them.

7.4.2 Ranking Assignment

At the beginning of the study participants were asked to prioritize and rank six items representing the features of the Communication Summary. The findings can be seen in Table 2.

Table 2 Ranking Assignment Results

Priority	Item	Ranked As	Number of Voters
1	Keeping track of prescription	Important (2 out of 6)	11
2	Prescriber's information	Very important (1 out of 6)	7
3	Keeping track of previous conversation	Very important (1 out of 6)	5
4	Knowing whether the issue with prescription is resolved or not	Very important (1 out of 6)	5
5	Predictions about prescriber response day	Not Important (5 out of 6)	9
6	Predictions about prescriber response time	Not Important (5 out of 6)	9

These prioritization of the above information is important to consider while organizing and designing the user interface of PMSs.

7.4.3 End of the Study Questionnaire

At the end of the study, participants were asked to complete a ten-minute questionnaire with three parts: (1) Trust and Collaboration, (2) USE Questionnaire (only for experiment group), (3) Feedback on the Communication Summary Display

7.4.4 Trust and Collaboration (both groups): There were no significant differences between No-CS vs. CS for trust and motivation. Although the Communication Summary did not have a significant effect on trust and collaboration, it was found that the response time of prescribers was rated important to pharmacists.

When queried at the conclusion of the study, both groups prefered to work with Dr. A. Nineteen out of twenty participants agreed that Dr. A is a more trustworthy prescriber to work with due to his faster response time and added that the best way to reach Dr. A is *fax*.

On the other hand, eleven participants responded that best way to reach Dr. B is *phone*. The reasoning was that Dr. B has a longer response time and the participants felt that "*it is more likely that Dr. B might ignore their fax*".

These findings indicated that the response time of the prescribers (fast vs. slow) has a strong impact on a pharmacist's trust and motivation to collaborate with prescribers. Furthermore, the response time also affected the preferred method of contact that the pharmacists chose.

7.4.5 USE Questionnaire (experiment group only): USE Questionnaire is designed to measure usability of interfaces and is based on Lund (2001). CS was asked to self-assess their agreement with statements such as *"Communication Summary Display helps me be more effective in a pharmacy"*. Five participants agreed that the Communication Summary helped them be more productive in a pharmacy, and six participants felt that the Communication Summary would save them time when they use it. Furthermore, six out of ten participants strongly agreed that the Communication Summary was easy and simple to use as well as user-friendly. Finally, six participants mentioned they would recommend the Communication Summary system to other pharmacists.

7.4.6 Feedback (both groups): At the end of the study all participants were asked to provide feedback on the interface. Although the control group did not use the communication summary, they were still shown a screen shot of CS to assess their ability to grasp the interface without training. All participants in No-CS were able to understand and explain each feature without any external assistance.

Next, both groups were asked "*what information on the Communication Summary did they find most useful* and *which information was not important to them"* (Figure 15 & 16). Both groups found *Communication History, Doctor Call Box, Prescribers' Response Time* and *Doctor's Information* very useful. On the other hand, both groups found the *Graph* in the Predictions section redundant.

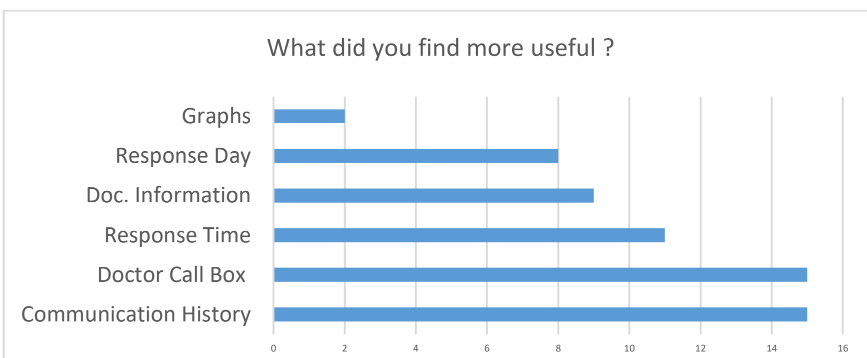

Figure 13 Participants' answers for what did you find more useful on the Communication Summary Display? (n = 20)

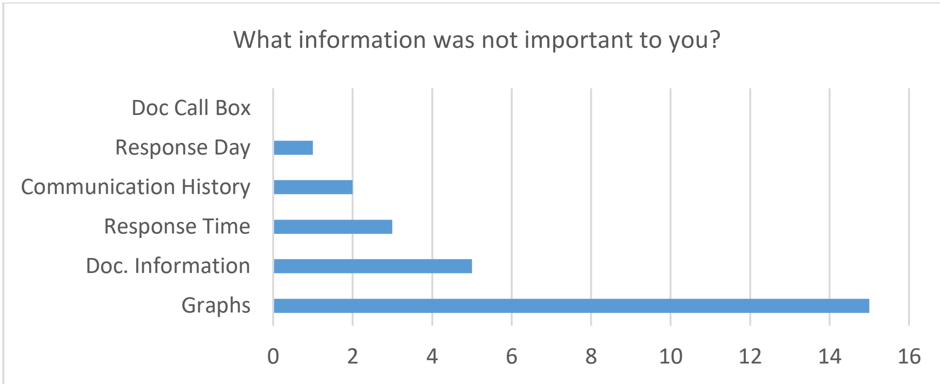

Figure 14 Participants' answers for what was not important on the Display? (n = 20)

Next, participants were asked for final feedback on the Communication Summary. Over all, the feedback for the display from both groups was very positive. Participants commented: "The best thing about this system is knowing whether or not a fax is resolved or pending. Often faxes get misplaced or it is not clear to other staff if it was resolved. This is the best feature of the communication summary, knowing if we are still waiting to hear back or if it was resolved"

"I like the idea. Great practicality for community pharmacy! I love the idea of tracking the doctors' response times as well as which days they usually respond, this gives us an idea of what to tell patients on when we will hear back from the doctor and thus then when they would hear from the pharmacy."

"Prediction times - initially before using it, I did not think it would be very helpful but as it went on I actually quite liked it –it helps if a patient asks you how long it typically takes for a response, as with so many doctors it may be hard to keep track of who has the quickest response time"

We also received constructive feedback on the limitations of the Communication Summary and possible improvements:

- The Communication History was found redundant since it overlaps with the Doctor Call Box. It was recommended to combine these elements.
- Finding the Communication Summary under a prescriber's profile was foreign and unusual to pharmacy students. It was recommended to represent the Communication Summary under a patient's profile.
- The graph predicting prescribers' most responsive day was found unnecessary.
- Doctor's Information box was missing the licensing number of physician.
- Some participants noted that some physicians have multiple practice sites with different address / phone /fax numbers. It is imporant to incorporate this in CS.
- Finally, it was participants would have liked to record phone conversations between pharmacists and prescribers on a PMS.

7.5 Conclusion

This study was an initial attempt to explore design of pharmacy management systems to better support communication between pharmacists and prescribers.

The results showed that CS helped participants to better predict and understand prescribers' behavior including the best day to contact prescribers.

Interestingly, there was a correlation between how fast a prescriber responds to an inquiry and pharmacist's motivation to collaborate with the prescriber. Additionally, prescribers' response time also impacted pharmacists' preferred method of communication.

Overall, the Communication Summary mock-up was seemed to aid pharmacy students to be more effective and productive in the pharmacy while CS was found to be being user-friendly.

There were some limitations for the present study as well, for instance the uneven gender ratio, which may have resulted in an unbalanced representation of pharmacists in Canada. Next, only static mock ups were used throughout the study and it is recommended to implement these interfaces in a dynamic prototype to test pharmacists' responses in a future study. Lastly, as an exploratory study the sample size was quite small (only 10 participants each groups) which might have caused us to miss out on otherwise statistically significant effects. As a future follow up study, it is recommended to test the Communication Summary developed here with larger samples of pharmacists in real work settings, in which CS is implemented in an actual PMS, to find stronger statistical relations.

Chapter 8 Updated Communication Summary UI & Discussion

The previous chapter showed that the newly designed communication aid tool: Communication Summary helped participants to better predict and understand the prescribers' behavior and response time as well as it was rated by pharmacy students as a useful tool for pharmacists to be efficient and productive in pharmacy. Furthermore, the Communication Summary was found to be useful, user-friendly and also easy to use and learn. Also, it was found to save time to pharmacists when it was used.

While the mock up was rated very positively by the participants, the Communication Summary still has some limitations and there is space for improvement. This chapter is designated to improve the Communication Summary based on the user feedback and needs discovered in the previously explained study in Chapter 8.

Based on the study findings, Communication Summary is redesigned as follows:

1) In the updated version, pharmacists access the Communication Summary under the patients' profile (Figure 17). The profile of the patient is divided in three parts. In the first part, the pharmacist can access the basic information about the patients such as their names, address, birthdays, insurance plans and phone numbers. In the second section, the pharmacist can see the past prescriptions of the patient. Finally, the last part is the Communication Summary feature, where the pharmacist can access the prescriber's basic information, doctor call box and predictions.

2) In the updated version, under the information section on the prescriber, the pharmacist can find information about not just one but multiple clinics at which a prescriber works. If there is more than one clinic the physician works at, it is indicated with "[…]" icon. Upon clicking on the "[…]" icon, pharmacist can see *fax number 2, address number 3* etc. to contact the prescriber (Figure 19).

3) Another update was removing the graph from the Predictions. In this version, pharmacists will see the written information to predict physicians' most responsive days. (Figure 17)

4) Finally, based on the feedback received by participants in the lab study, Communication History and Doctor Call Box are combined: In the new version, if a pharmacist would like to see their interaction with the prescriber, they can click on the prescription number listed in Doctor Call Box and see the detailed documentation of their interaction between pharmacist and prescriber. This was redesigned to reduce the crowded interface and eliminate redundant information on the display (Figure 18).

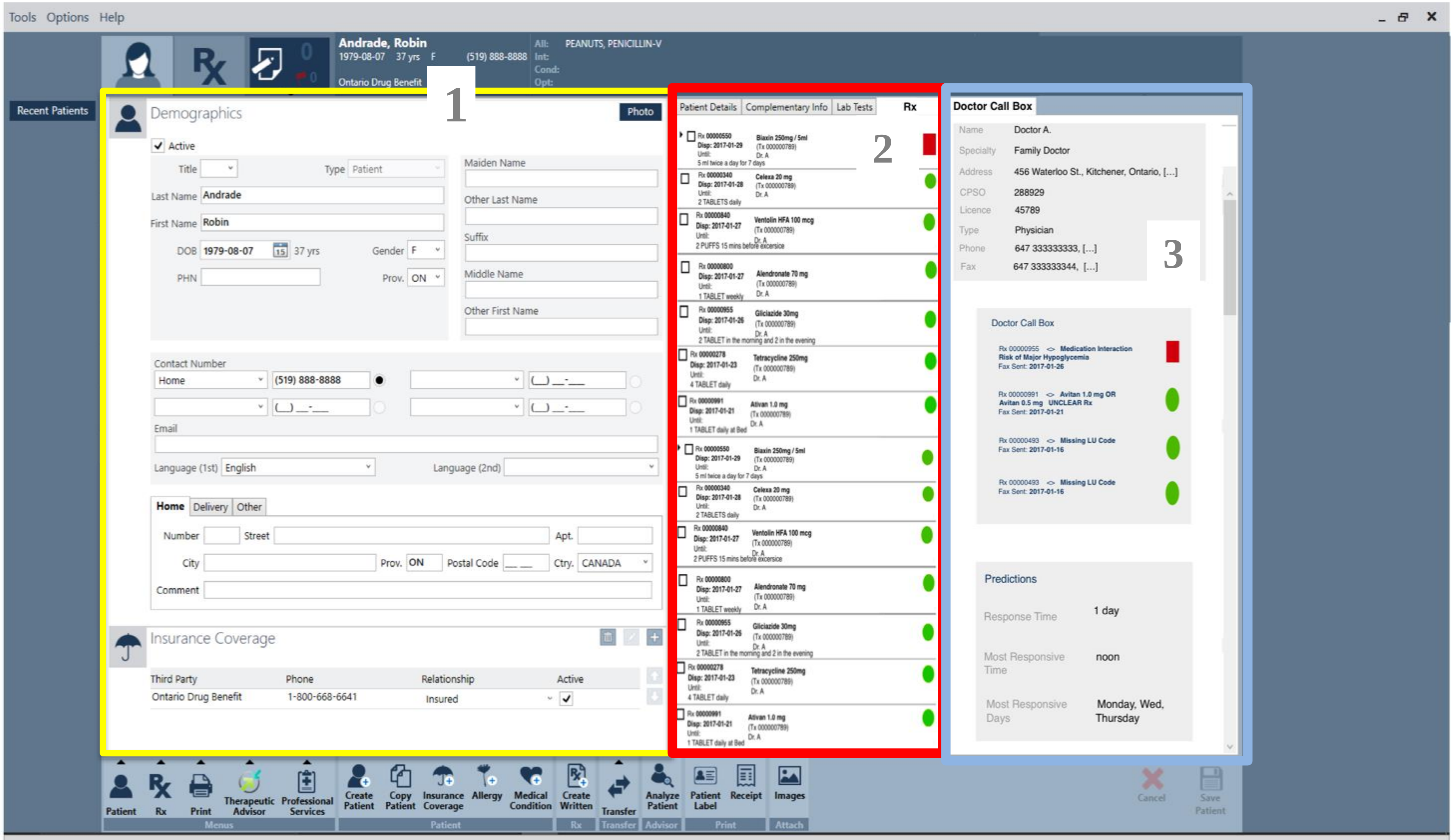

Figure 17 Updated UI for Communication Summary. Communication Summary is moved under the patients' profile. Patient's profile is divided in three parts: (1) basic information about the patients (2) patient's past prescriptions (3) Communication Summary feature

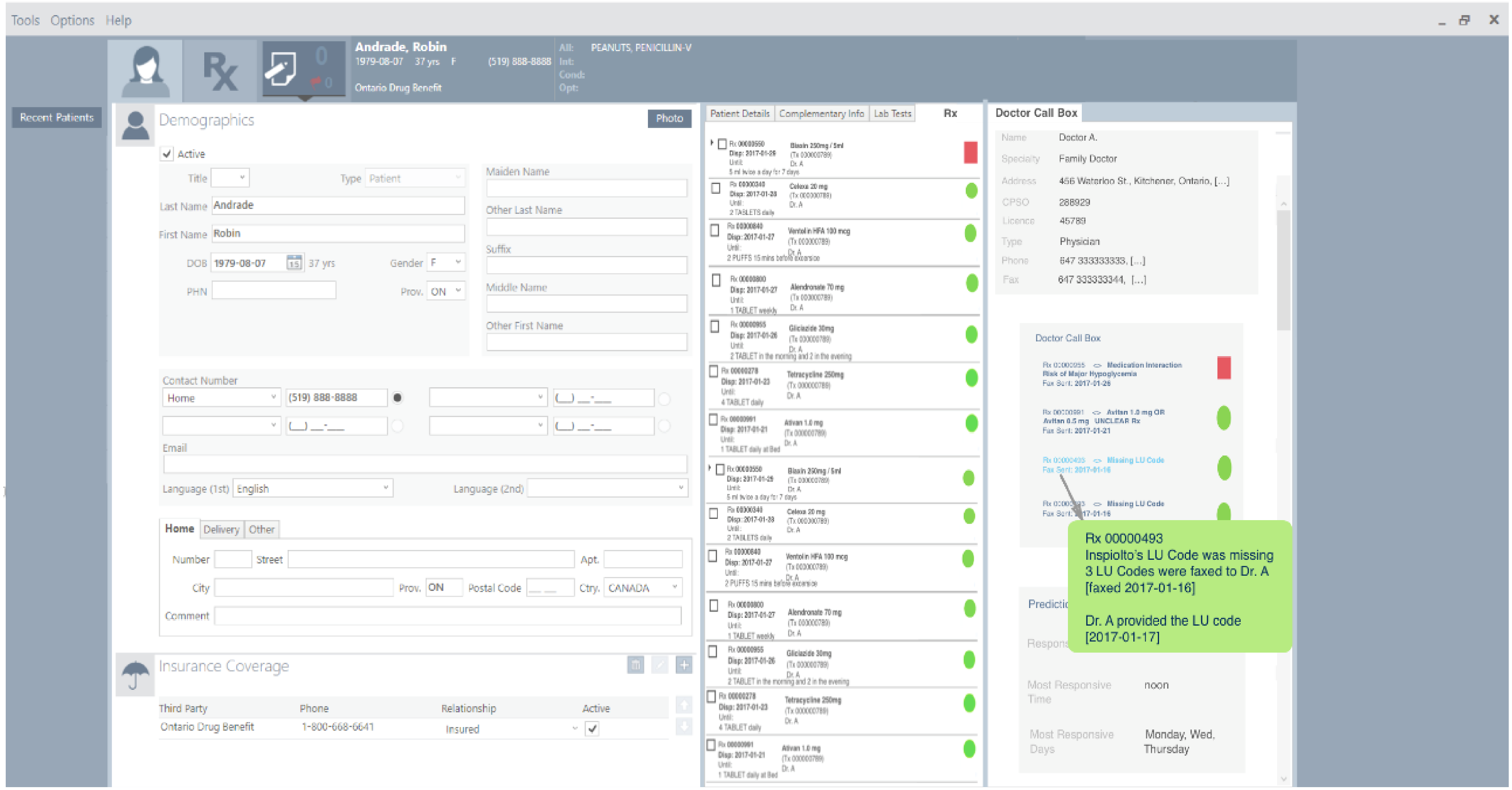

Figure 18 Communication History and Doctor Call Box are combined: If a pharmacist would like to see their interaction with the prescriber, s/he can click on the prescription number listed in Doctor Call Box and see the detailed documentation of their interaction

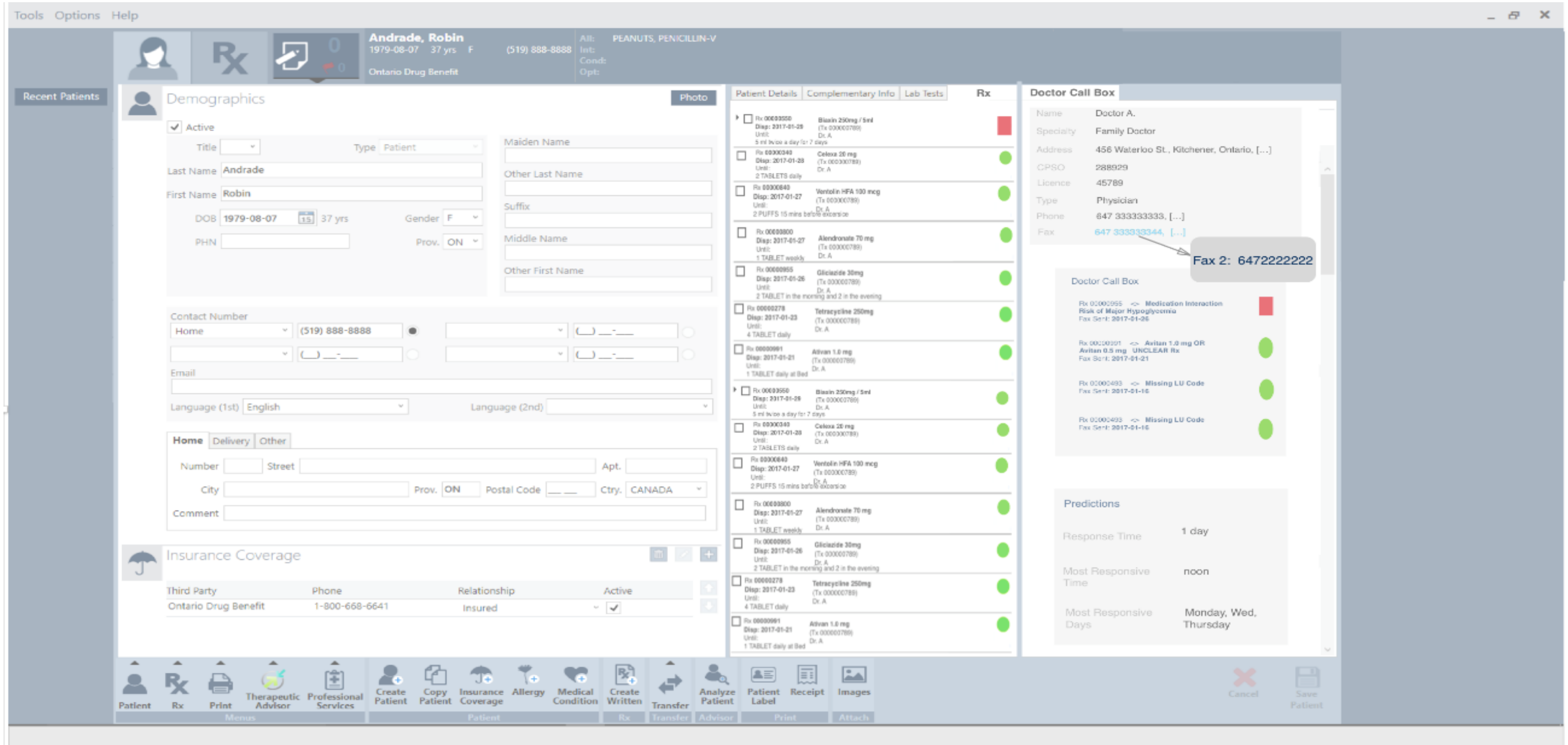

Figure 19 Information about multiple clinics prescribers works at. Upon clicking on the "[…]" icon, pharmacist can see fax number 2, address number 3 etc. to contact the prescriber

Chapter 9 Conclusion & Future Research

This research was an initial attempt to understand why miscommunication occurs between pharmacists and physicians and how technology used in their work environments contributes to miscommunication. I conducted an exploratory study to investigate design requirements for a communication-aid tool that can be used as a part of a PMS.

Data gathered through field study including observation, talk aloud protocol and interviews indicated that the technology used (PMSs) in pharmacies have an important role in pharmacy-physician communication. It was found that the current PMSs used in Ontario do not support the physician-pharmacist relationship as well as they do not predict prescribers' behavior, keep track of any interaction between pharmacist-prescriber and do not indicate whether or not an outstanding issue with prescriptions has been resolved.

Based on the field study results, a mock-up was designed to observe whether a communication aid tool (Communication Summary) could help pharmacists to work more efficiently and support their communication with prescribers. Although the lab study showed that the features in Communication Summary do not impact the trust of pharmacists or their motivation to work with physicians, physician's response time affects pharmacists' trust and it is important to have a prediction feature to predict the most responsive times to interact with physicians.

An updated user interface was designed to give an idea how the Communication Summary could look like to better support pharmacist-physician relations in Ontario based on the participants' feedback. It is recommended to run a similar study with the updated version of Communication Summary to evaluate its usability and its effect on the pharmacist-physician relationship. As a follow up study, it is recommended to implement updated Communication Summary in PMSs used in Ontario and evaluate with a larger sample size of pharmacists to gather further detailed feedback on the system.

A similar study should be replicated with physicians. It would be useful to see whether similar results would be acquired. More field and experimental studies across Canada will be needed to redesign the whole PMS considering the law and regulation changes across provinces.

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Appendix A

Recruitment E-mail – Field Study

To whom it may concern,

My name is Damla Kerestecioglu and I am a Master's of Applied Science Candidate in the Systems Design Engineering Department at the University of Waterloo. I am currently working under the supervision of Dr. Catherine Burns in the engineering faculty and we collaborate with Dr. Kelly Grindrod and the University Waterloo, School of Pharmacy on a research project entitled "Playing Telephone: Medication management and integrated electronic health records". The reason we are reaching out to you today is to invite you to participate in this innovative Canada-wide project involving primary health care practitioners, patients, and technology.

We are looking for healthcare professionals who will help us understand how electronic medical records can be better designed for medication management. We are hoping to do this in several provinces, mainly Ontario, Alberta, Quebec, and Nova Scotia. The goal of this project is to improve the management of medications in order to save lives and reduce the overwhelming financial burden of medication errors and side effects.

In order to accomplish this, we would like to visit your workplace and observe how medications are being managed. This would include observing processes such as medication reviews, how medications are recommended, and how patients make decisions. We would also conduct a semi structured interview to identify how each participant manages and solves medication problems. The entire interaction would take no more than 2 hours of your time and would be at your convenience. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee and the Research Ethics Board at Wilfrid Laurier University.

If you are interested in participating, or would simply like more information, please do not hesitate to contact either Jilan Yang, Kelly Grindrod, Catherine Burns or myself:

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Appendix B

Field Study Pharmacists Interview Questions

Record an OTC consult and the checking of a prescription.

Think Aloud

1. Imagine you have a student standing next to you. Can you talk through this as if you were teaching the student what you are doing?
2. That's how we want you do the think-aloud when checking a prescription.
3. Afterward the talk aloud, ask: How did you know this was indicated? Effective? Safe? That the patient is going to take it?

We're going to start by talking about how you work with patients and physicians.

Context setting & Care:

1. Tell me what it's like in your pharmacy.
2. Think back to the last time you helped a patient choose an OTC, can you tell me about that?
3. Think back to the last time you identified a side effect or drug interaction, can you tell me about that?
4. Think back to the last time a patient asked you to help them make a choice about a medication, can you tell me about that?
5. I've given you some examples. Where are other places you work with patients to make choices?
6. We're going to ask you questions about physicians. When I say physician, who comes to mind for you? What physicians do you work with?
7. Describe to me what you do when you need to get in touch with a physician? (*Probing options: What have you found to be the best, or easiest way? How often do you talk to a physician on the phone? Through fax? When do you call them? When do you fax them? How do you know when a physician got the information you wanted to share? Do you think there's a way to make it easier?)*
8. Describe to me how you present a physician with different treatment options?
9. Describe to me how you present a patient with different treatment options?
10. When was the last time you disagreed with a physician about a suggested treatment? How was it resolved? *(Probing: What were the steps involved?)*
11. Tell me how you find out the indication for a patient's medication?
12. How do you follow medication adherence in your patients? How do you find out a patient decided to stop taking medication? Or that they changed how they take a medication? How do you know when patients got/filled their medication?
13. When talking to a patient, how do you decide what information to tell them?
14. What else did you want to add?

Now we're going to switch over to a discussion of your computer systems.

Context setting & Care:

1. When you start your day/shift, what information do you look at first?

2. When you open a patient's record/medication order what do you look at first?

3. Problem identification: Over the last week, can you think of an example of a medication problem that you identified, such as a drug interaction, side effect, a problem with a dose or a problem with adherence?

4. If you had a question about the prescription, what would you do first? Why?

5. What computer system do you use? *(Probing options: How long have you had it in place? Why did you choose this system? Who purchased it? Have you worked between different systems? What system do you prefer and why?)*

6. Think back to the last patient you saw. Talk me through how you used your [ ] system. *(Probing options: What information did you look at first? Where did you spend most of your time? Would you say this is the standard use of the system?)*

7. Describe how <u>easy or difficult</u> it is to use your [ ] system to review a patient's medications? What about the medical history?

8. Describe how <u>useful or not useful</u> your [ ] system is for reviewing a patient's medications. What about medical history?

9. What do you like most about your [ ] system? What do you like least?

10. Describe how you document the care you provide during dispensing. What about medication reviews?
11. When you prescribe a medication in the pharmacy, tell me to whom the prescription goes to and how?
12. In Ontario and Quebec, prescribing includes smoking cessation, renewals and adaptations
    a. AB: includes all medications
    b. NS: includes minor ailments

13. In addition to the [ ] system, describe how you access <u>other</u> patient records like lab values, x-rays or hospital discharge summaries? What do you look for the most? (AB: Netcare; SW Ontario: Clinical Connect; NS: SHARE; QC: DSQ) Why do you generally need to access them?
14. Describe how you've seen your role change over the last 5 years. What further changes do you expect to see, or would like to see?

15. Describe an ideal pharmacy computer system? *(Probing: Do you foresee any barriers to using even an ideal system – even in an ideal world? How would you fix those barriers?)*

16. Now that we've talked about your practice and your computer systems, what is your take home message for us?

Appendix C – HFES Healthcare Symposium Poster, 2016

Appendix D – Lab Study – Example Pharmaceutical Scenarios

A) *Prescriptions Without Issues*

Monday 2017.01.16

A male, 65-year old, patient comes to your pharmacy with a prescription.

Doctor A. prescribed Inspiolto for the patient two puffs daily. You skim the prescription to enter the information in the system and realize that the LU code is missing.

What would you do?

A) Contact the prescriber for further clarification

B) No need to contact the prescriber

B) *Prescriptions with Issue*

Saturday 2017.01.21

A female, 60-year old patient comes to your pharmacy with a prescription. Her GP is Dr. A.

You went to her profile and saw that she used to take Ativan 0.5 mg for 2 years, three times a day.

In the new prescription she handed to you just now, Dr. A prescribed Ativan 1.0 mg once a day at bed time, 20 pills and 6 refills.

When you asked to the patient whether she is aware of the change in the treatment, the patient told that she has been taking it three times a day over two years and Dr. A has not mentioned any changes in the treatment.

What would you do?

A) Contact the prescriber for further clarification

B) No need to contact the prescriber