

PROMOTING COMMON GROUND IN A CLINICAL SETTING:
THE IMPACT OF DESIGNING FOR THE SECONDARY USER EXPERIENCE

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DEDICATION

Dedicated to Doc and Annie.

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Primary users can create a user experience (UX) for others—secondary users—when interacting with a system in public. Common ground occurs when people have certain knowledge in common and each knows that they have this shared understanding. This research investigates how designing for a secondary UX improves common ground during a patient-provider first encounter. During formative work, patients and providers participated in telephonic interviews and answered online questionnaires so that their respective information requirements for clinical encounters could be understood. The outcome of the formative work was a smartphone application prototype to be used as the treatment in an experimental study. In a mixed methods study, with a patient role-player using the prototype during a simulated clinical encounter with 12 providers, the impact of the prototype upon secondary user satisfaction and common ground was assessed. The main finding was that the prototype was capable of positively impacting secondary user satisfaction and facilitating common ground in certain instances. Combining the notions of human-computer interaction design, common ground, and smartphone technology improved the efficiency and effectiveness of providers during the simulated face-to-face first encounter with a patient. The investigation substantiated the notion that properly designed interactive systems have the potential to provide a satisfactory secondary UX and facilitate common ground.

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CHAPTER ONE: INTRODUCTION

Problem Statement

This research investigates patient-centered health information technology (HIT) in terms of the secondary user experience (UX). Specifically, it examines how personal mobile technology, under patient control, can be used to improve patient-provider communication about the patient's healthcare during a patient's first visit to a provider. In the human-computer interaction (HCI) discipline, secondary users are people who are affected by the main or primary user's operation of a technology (Abrams, Maloney-Krichmar, & Preece, 2004; Alsos & Svanæs, 2011; Eason, 1988). Primary users, on the other hand, are the dominant operators that control the system and the dissemination of its information (Eason, 1988). Alsos and Svanæs (2011, p. 85) remarked that the UX "is considered when designing for the primary user." However, they noted that "no equivalent concept [exists] in the HCI literature for the secondary user" (p. 85). Despite the history of discounting secondary users, some researchers believe that secondary UXs have the potential to improve collaboration and satisfaction in a variety of settings and, as such, advocate for its inclusion in interactive systems design (Gonzales & Riek, 2012; Inbar & Tractinsky, 2012; Montague & Xu, 2012).

A novel concept of this research is that it is one of the first empirical studies to explore the relative meaningfulness of a secondary UX for a specific task. Not all UXs are likely to have value during task-oriented communication. In healthcare, patient health often relies upon successful collaborations between patients and providers (Bardes, 2012). The concept of patient-centered care, which is a responsiveness to patient preferences, needs, and values, is increasingly seen as a way by which to improve

collaboration by increasing a patient's engagement with his provider and the ecosystem responsible for providing his healthcare services (Flatley Brennan et al., 2015).

The emphasis on patient-centered care requires patients to have digital tools to access and manage their own personal health data so that they will be more informed about their health statuses and be better able to participate in the healthcare decision-making process (Flatley Brennan et al., 2015). Secondary users have been identified in the medical informatics literature, but operationalized in terms of patients. This research introduces the opposite phenomenon and looks at secondary users as providers. The increasing reality of patient operated HIT means that providers will become secondary users of HIT more often. Due to this emerging trend, the author concurs with the assessment regarding the importance of a secondary UX for design. Identifying how patient managed HIT can improve collaboration between patients and providers during a first face-to-face encounter is important for advancing HCI in the healthcare domain.

In order to meaningfully improve HCI design for the secondary user, we must take into consideration the dynamic interplay between both types of users. As such, it is critical to identify the factors that impact the interaction between the secondary UX and system usability as well as the role that HCI design plays in the human intercommunication between the primary and secondary users as they mutually engage the technology. Once these factors are identified, the relationship of patients who use patient-centered technologies and the providers who treat them will be more clearly defined.

This research addresses the problem by investigating secondary UXs according to common ground, a communications theory about language use. The goal of this research

is to identify and describe key elements of the secondary UX that contribute to improved communication between the primary and secondary users. The quality of the primary UX is considered an important component of user satisfaction. However, such experiences potentially impact both users' satisfaction during face-to-face collaborations. Thus, secondary UXs can be germane for design and should be understood by HCI researchers. In light of these factors, the two assumptions underpinning this research are that (1) the creation of common ground is a key element of the secondary UX that contributes to improved communication and (2) that interfaces for interactive systems can be designed to facilitate the creation of this key element.

Recently, it has become common for more people to access the Internet through mobile devices than PCs (Sathiaseelan & Crowcroft, 2012). The advent of always-Internet-connected mobile technologies portends a wider set of UXs than previously envisioned. The lack of any practical geographic or temporal restrictions on the use of some types of patient-centered HIT, such as a smartphone personal health record (PHR)¹ application (app), is a recent phenomenon that impacts users and their experiences.

Anytime someone acts with an interactive system through an interface in public, he potentially creates a UX for others; this is the secondary UX. With more than 165 million smartphone users in the U.S. as of 2014, secondary UXs have the potential to become routine (Reisinger, 2014). Accordingly, it is necessary to improve our

¹ An Electronic Medical Record (EMR) or Electronic Health Record (EHR) is the provider equivalent of a PHR.

understanding of secondary users and how they experience technology. Alsos and Svanæs (2011) described the concept of the secondary user as follows:

Sometimes other people indirectly become users of the user interface without even interacting with it. One such situation is face-to-face interactions where one person, *the primary user*, is using an information system, while interacting with another person face-to-face (i.e., the *secondary user*) (p. 84).

In addition to the direct bearing upon face-to-face communication, other factors exist that make secondary users interesting. For example, secondary users who have influence over primary users (e.g., an expert or supervisor), play an important role in technology adoption by encouraging or discouraging people regarding the use of a system. In this way, secondary users act as opinion leaders and exercise an informal, but critical role in technology diffusion (Rogers, 2003). It can be important to gain the endorsement of secondary users as a part of a strategy to increase primary user technology adoption.

The Patient-Centered Emphasis in Healthcare

Healthcare, and the increasing emphasis on patient-centered technology, is an especially vital context in which to study the secondary UX. The PHR is an example of HIT where one person's use creates UXs for others. A PHR is a private, secure, electronic, web-based tool that people can use to communicate with their providers and access, manage, and share their health information (Jones, Shipman, Plaut, & Selden, 2010; Reti, Feldman, Ross, & Safran, 2010; Señor, Alemán, & Toval, 2012). PHRs are important tools for patient empowerment because they provide the lay person with access to relevant and adequate health information (Bos, Marsh, Carroll, Gupta, & Rees, 2008).

PHR apps are on desktop computers and mobile devices. Mobile PHR (mPHR) apps are interesting to investigate as part of the problem space because of the different types of UXs that are possible with them. They provide an example of a technology with

primary (i.e., the patient) and secondary (i.e., the provider) users, two stakeholders with different knowledge and priorities who need to collaborate to make treatment decisions. Encounters with clinical staff frequently occur in small spaces that impose limitations on the tools that can be used to enhance communication (Gonzales, O'Connor, & Riek, 2013). Consequently, PHRs within extremely compact devices, such as smartphones, have the potential to be operated within the close confines of a clinical space.

PHRs and other tools for patient empowerment are increasingly recognized as having the potential to improve healthcare delivery. Research has demonstrated that effective doctor-patient communication aids health outcomes (Ni, Karlson, & Wigdor, 2011). The ability to use patient-centered technologies to improve collaboration between patients and providers contributes to the attractiveness of PHRs and other patient-centered tools. There is also an increasing emphasis on PHRs from the government and industry because they are considered to be an important tool for reforming U.S. healthcare as they contribute to improved efficiency (Eung-Hun & Yongmin, 2010). A smartphone PHR app puts more responsibility in the hands of patients by providing them with a tool portable enough to ensure that their health data is always on their person and available to a provider during a face-to-face interaction.

Pew Research reported that, within a 1-year period, 62% of U.S. smartphone owners used their devices to look up health information (Smith & Page, 2015). In fact, health information was the highest frequency of use category out of several measured by Pew, such as banking, real estate, job information, and government services. This frequency indicates that smartphones, as a practical matter, are already a patient-centered technology that leads to patient empowerment. However, adoption of an *ad hoc* patient-

centered technology does not imply that deliberately designed tools (e.g., PHRs) will fare well among users.

PHR adoption, in contrast to the *ad hoc* adoption of smartphones, is poor—only a small percentage of Americans use them (Burnett, Whetstone, & Jaeger, 2013). The lack of adoption highlights the relevance of secondary users for design as providers have an important influence on their patients. Research has shown that, if providers are enthusiastic about PHRs and encourage their patients to use them, then patients are more likely to adopt and use them (Emani et al., 2012). Research also shows that aggressive marketing of PHRs by providers is the strongest predictor of adoption, so the importance of providers as opinion leaders cannot be overstated (Emani et al., 2012).

Users and Common Ground

Even with the recent interest in secondary users, the HCI literature about them remains sparse. The user type most often researched is the primary user and investigations about secondary users are limited (Ferneley & Light, 2006). Inbar and Tractinsky (2009) reported that secondary users are missing from both the theoretical and practical perspectives in HCI. Consequently, there is little research that exists to empirically demonstrate why secondary users should be included as a consideration in the design of a technology. The currently available research merely indicates that secondary UXs exist and that secondary users are a relevant stakeholder group (Abrams et al., 2004; Ferneley & Light, 2006; Sharp, Finkelstein, & Galal, 1999).

Another shortcoming in the HCI literature about secondary users is the lack of a theoretical basis to explain why secondary users are relevant and should be considered in technology design. Common ground can fill this void. It is an aspect of communication

between patients and providers. Common ground is established when people have certain knowledge in common and know that they have this knowledge in common (Kellogg et al., 2006). While improving patient access to health information leads to increased patient participation in health-related decision-making, it is not merely the access to data that creates this impact (Prey et al., 2014). It is also the improvement in *common ground* between the patients and their providers that makes superior patient engagement possible. The potential to improve how language is used during the patient-provider encounter and thus, increase the efficiency of communication between members of the dyad, makes the notion of common ground particularly salient when examining primary and secondary user collaborations.

The Need for Different Design Decisions

An example of medical technology with multiple interfaces is useful for demonstrating why different design decisions are appropriate because of secondary users. Patient controlled analgesia (PCA) pumps (Figure 1) are used in hospitals and other healthcare settings to administer morphine. The device incorporates a patient pendant that provides patients with a limited capability to operate the pump. The pump face contains one interface and the pendant is a second interface.

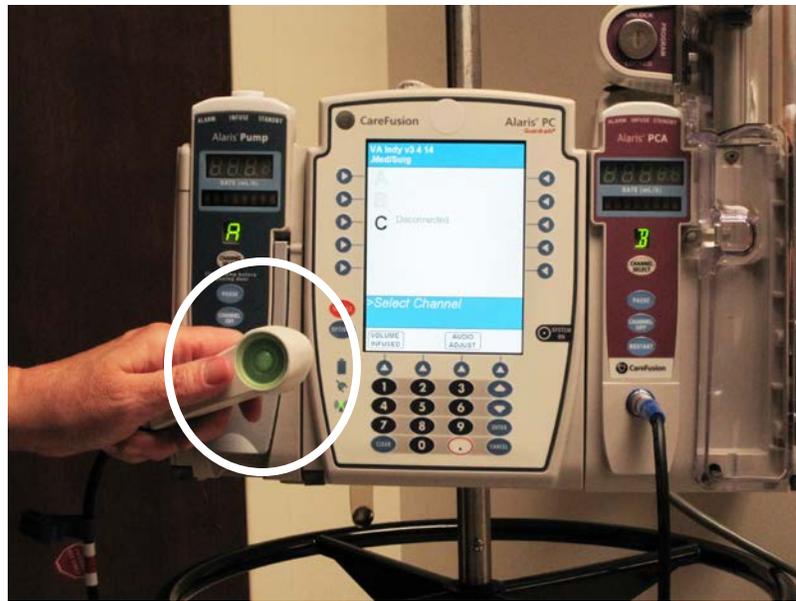


Figure 1: A patient controlled analgesia pump with the patient pendant circled.

The PCA pump screen is the main interface. It is designed for a primary user (i.e., the healthcare professional who sets up the pump and monitors its performance). The patient is a secondary user because he is affected by the primary user's ability to set the pump up correctly. There is also a patient pendant attached to the pump, which is a separate control that the patient uses to administer medication on demand. This pendant makes the patient an occasional user with a separate interface. As a safeguard, the pump is set with a limit on how much medication can be administered during a single period (e.g., one hour). This limitation prevents the patient from accidentally administering an overdose.

Patients who do not receive morphine when they activate the control (because of the safeguard) have two choices: (1) wait until the next period and administer the medication or (2) check with a nurse to see if an alternate pain medication has been prescribed. However, nothing on the secondary user's interface indicates whether the medication has been administered. This lack of feedback requires patients to attempt to

interpret the primary user's interface, which can be challenging because the patient is already cognitively impaired by medication and pain. Furthermore, patients are not trained to interpret the primary user's interface. The fact that the PCA provides a secondary UX, but does not have an interface that the patients can interpret in order to aid in their decision-making may negatively affect the patients' assessments of their care (Brickel, Montague, & Winchester, 2012). A more thoroughly considered secondary UX might encourage designs that support the ability of ill or cognitively impaired people to make reasonable pain management decisions.

Research Aims

Research suggests that well-designed collaborative technologies speed up the development of common ground by allowing teams to share knowledge, manage actions, and make decisions efficiently (Convertino & Carroll, 2011). This study builds upon this prior knowledge through the accomplishment of two aims. The aims are designed to create new knowledge regarding UXs and help establish the relevance of secondary users for HCI. The specific aims of this study are:

- **Aim 1:** To categorize the secondary UX in patient-provider encounters when the provider is the secondary user of a smartphone PHR app.
- **Aim 2:** To clarify the design space of the secondary UX in patient-provider encounters when the provider is the secondary user of a smartphone PHR app.

Contributions

Since this research emphasizes secondary users, it differs from earlier HCI research in which design from the primary user's perspective was the object. The emphasis on secondary users is important for several reasons. First, mobile devices have

saturated the market. In 2013, 91% of adult Americans owned cell phones and 61% of these cell phones were smartphones (Smith, 2013). Two years later, smartphone ownership had increased to almost $\frac{2}{3}$ of American adults (Smith & Page, 2015). This level of smartphone technology diffusion means that secondary UXs are common. This research examines interactions with secondary users in order to identify themes that describe what the experiences mean for people in healthcare contexts.

Second, usability for primary users is already a major focus of apps designed for operating systems produced by major corporations (e.g., Microsoft and Apple). The apps typically conform to a set of design guidelines that have undergone extensive HCI research. The guidelines are released to the public for use by independent developers who create apps for the corporation's platform (Wisniewski, 2011). Primary users are similarly considered in major open-source software frameworks, such as WordPress. Since primary user needs are already considered, an improved understanding of secondary users would help the research and design communities understand when it is important to move past considering only usability for primary users.

Third, it introduces the idea of determining the value of any efforts to obtain common ground with the implementation of technology. Sometimes, common ground is obtained in order to discover workarounds for the absence of important knowledge on the part of the participants. The problem that is the purpose of a communication cannot be resolved due to the continuing lack of knowledge, so participants agree upon a strategy to get the necessary information; this is the workaround. This plan to resolve the lack of information, which is a limited form of common ground, does not have the same value as achieving the type of common ground essential for competent healthcare decision-

making during a discussion. This type of common ground requires a level of shared understanding between patient and provider about the actual health problem.

The novel contribution of this research is that it empirically demonstrates that not all secondary UXs are meaningful for design. Common ground that is of limited value can occur during a face-to-face encounter regardless of the intervention of technology. When common ground is created because of the introduction of a technological solution in real time—this is of high value. This idea of assigning value to common ground and identifying any contribution of technology to its creation, has major implications for HCI in terms of making assessments to evaluate the value of any secondary UX by task. This type of assessment will permit sound decision-making about what investments are appropriate in regard to the secondary UX in a specific technology.

CHAPTER TWO: LITERATURE REVIEW

Framing the Secondary UX

This section describes the current conceptualization of the UX. It introduces recent concepts regarding the evolution of the UX and concludes with a preliminary description of the UX for secondary users. Even though the notion of human-centered design (HCD) incorporates usability concepts related to a range of stakeholders beyond primary users, HCD still falls short of recognizing secondary users (Earthy, Jones, & Bevan, 2012). The International Organization for Standardization (ISO) is the group responsible for publishing international standards and defines a UX as a “person’s perceptions and responses resulting from the use and/or anticipated use of a product, system, or service” (ISO, 2010, p. 3). This definition emphasizes the person using or intending to use the device—the *primary* user (Alsos & Svanæs, 2011). The definition is problematic because it ignores the increasing trend in which people have a form of experience with a device *through* the device’s primary user. (See Figure 2 for a descriptive model of face-to-face UXs.)

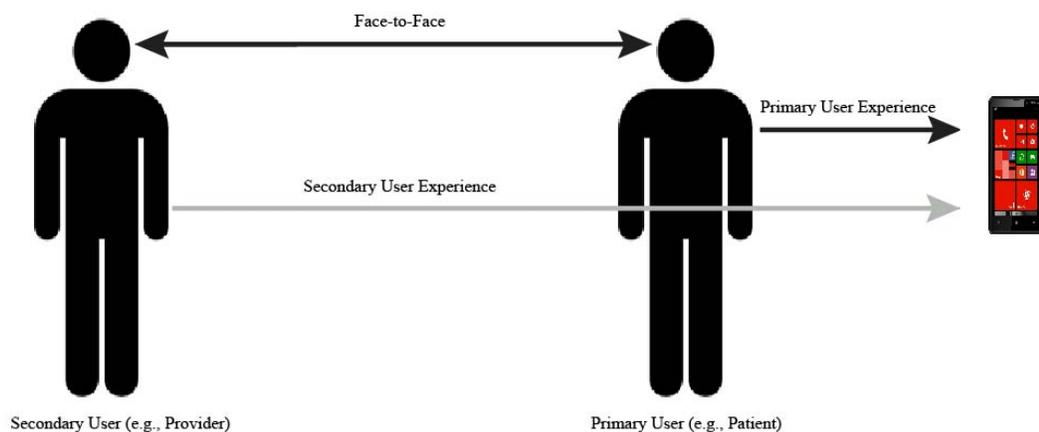


Figure 2: Descriptive model for a face-to-face interaction showing the location of primary and secondary users with respect to the technology being used.

Alsos, Dasb, and Svanæs (2012) showed that secondary UXs should become a testable usability requirement. Other researchers have advocated for the consideration of non-task related user needs in design (Montague, 2009). The ideas to accommodate secondary users, such as the addition of extra displays or providing them with more control over a system, are not trivial (Brickel et al., 2012; Inbar & Tractinsky, 2010, 2012). The notions regarding the creation of special interfaces highlights the importance of being able to discriminate between secondary UXs that have value for an interaction and those secondary UXs of marginal utility. If one cannot distinguish between them, then the default becomes to either design for them *all of the time* or continue to *ignore them*.

We know that secondary users have UXs with many types of technology (Montague, 2009). However, we do not understand when these experiences have meaningful impacts on user satisfaction, efficiency, and effectiveness, which is why the role of common ground is critical. It makes sense that secondary UXs would be important when common ground needs to be established between users.

UXs can occur during face-to-face interactions whenever a man-made interface is involved (Law, Roto, Hassenzahl, Vermeeren, & Kort, 2009). Mobile technologies allow people to carry with them the means to access, modify, and create information. Smartphones are so popular in the U.S. that they are increasingly used to access the Internet. In addition to smartphones, the advent of smaller, less obtrusive mobile technologies has created myriad opportunities for secondary UXs. As glasses, watches, and embedded systems join the computing landscape, their primary users create secondary UXs for others.

An early outcome of the literature review for this research was a working definition of the secondary UX. The working definition was refined and, eventually, finalized during subsequent stages of the investigation (see Chapter Three for the final version). Since secondary users may be occasional users of an information system (IS), the key concepts of actual and anticipated use were adopted from the international standard (ISO, 2010). The concept mapping methodology (Appendix A) was used to develop the remainder of the working definition, which is as follows:

The secondary UX is the secondary user's response to the primary user's display of a system, the collaborative nature of a system during its use in concert with a primary user, or the perceived competence of the primary user with a system. Secondary users who are occasional users of the system additionally have their UXs based upon direct or anticipated direct use of the system.

The purpose of the working definition was to frame the problem space during the early stages of this research.

Different User Types

Due to the changing nature of technology, a broader conceptualization of a user than the traditional "one-device-one-user" model is necessary. The idea of the secondary user dates to the 1980s. The early definitions for secondary user require modification because they do not address contexts made possible by mobile technology. In the 1980s, personal computers had yet to make an impact upon society. Computing was done in a work context. Today, computing devices are available to users regardless of location, time, or context (i.e., work or leisure). Now, people interact with computers even though they may not have control over the system. The idea of a user should be updated to include people who interact with a system through an intermediary.

In addition to primary users, secondary users are bracketed by tertiary users. The identification of primary, secondary, and tertiary users (see Table 1) is relevant because the expressions describe people who use an IS, are affected by its use, or play a critical role in its development or acquisition. These factors relate to usability in terms of actual use or requirements elicitation.

Table 1: Primary, Secondary, and Tertiary User Descriptions

Role	Type	Description
User	Primary	A frequent system user and may have a dedicated workstation (Eason, 1988). An example is a patient who manages his health information with a PHR.
	Secondary	An occasional system user and/or someone who may organize output from the system (Eason, 1988). This type of user also occurs when a primary user acts as an intermediary with a system (Abrams et al., 2004; Alsos & Svanæs, 2011). An example is a doctor who interacts with a patient who uses a PHR and the doctor provides the patient with lab results from an EHR.
Influential non-system user	Tertiary	This person does not interact with the system, but is affected by its operation (Eason, 1988). Senior executives and/or decision-makers who are responsible for the strategic direction of an organization and have a role in systems development or acquisition fall into this category (Abrams et al., 2004; McLeod & MacDonell, 2011). An example is a hospital CEO who makes decisions about releasing EHR information to patients in a format that is compatible with a PHR.

The use of primary, secondary, and tertiary user types has value as a descriptive tool within which to frame the role of a person regarding a system. The role may be intentional (primary user), unintentional (secondary user), or strategic (tertiary user). The different types of user descriptions and the relationships between them provide a method during the early stages of design to evaluate:

- Who actually has a UX and the relevance of that experience for design;

- How people have their experience—are they based upon their own, frequent use of the system; another person’s use of the system; or their own, occasional use of the system; and
- The leaders who make strategic decisions about a system’s design and acquisition.

Two more user types exist for those individuals who do not have hands-on use of the technology. A passive user does not have control over the technology used in a system (Montague & Xu, 2012; Xu & Montague, 2013), while an incidental user is involved in the exchange of information through a computerized system, but is not the principal user of the system (Inbar & Tractinsky, 2012). As the definitions of passive and incidental users conform to the idea of people interacting with an IS through an intermediary, they are considered secondary users for the purpose of the literature review.

The Importance of Usability for Secondary Users

Technologies are typically designed for primary users (Inbar & Tractinsky, 2009; Montague & Xu, 2012). As such, naturally, UXs are strongly associated with usability for primary users: Can they successfully perform desired tasks without frustration? Consequently, secondary UXs are currently overlooked, but are increasingly relevant as interactive systems become pervasive (Inbar & Tractinsky, 2010). Secondary users may also fail to accomplish their own goals relative to an information exchange if primary users cannot retrieve unique primary user controlled information that the secondary user requires for decision-making.

If a technology is used to improve face-to-face collaboration, then the secondary UX can be assumed to be important. However, if the secondary UX is fleeting due to the nature of the activity performed with the system, then a deliberate determination should

be made about the relevance of such an experience. This distinction is rarely made in the literature—in cases where the secondary user is considered directly, almost all secondary UXs are assumed to be important. The reality is that, while many of these experiences may be important enough to consider in the design process, many others are not worth the cost and effort necessary as they will not impact satisfaction, efficiency, or effectiveness for either user type or the attitude of the opinion leaders about the system.

Users for multi-user technologies (e.g. computer-supported cooperative work [CSCW]) are generally envisioned as “multiple primary users” and do not include a distinction between primary and other user types. However, today, it is useful to examine the satisfaction of the individuals who interact with a technology *through* a primary user. The advent of personal mobile technology makes this distinction between user types especially salient since the technology in question likely *belongs* to one of the people, probably the primary user. This new paradigm highlights a new design challenge to ensure that the primary UX is not degraded whenever secondary users merit consideration in the design process. The potential conflict of these different UXs with each other is why some researchers recommend that primary and secondary UXs be designed for together.

Recent research with HIT mobile systems highlights the need to improve the understanding of secondary UXs in the mobile space. An example is the development of a prototype mobile device app for children. Using the app, children draw their symptoms on a tablet computer during a consultation rather than using a pencil and paper, which is the traditional method of the Draw-and-Tell Conversation between children and providers (Hourcade, Driessnack, & Huebner, 2012). In the tablet system, the child is the secondary

user and the provider, who owns the system and must interpret the drawing, is the primary user. The app is an example of an instance in which the interface must be simple enough for an occasional (secondary) user to manage, yet comprehensive enough to provide an experienced (primary) user with relevant information.

Studies That Have Addressed the Problem

The lack of attention paid to secondary users in the literature is beginning to change. The change is especially apparent in literature from the medical informatics domain due to the increased interest in using mobile devices to improve communication between doctors and patients (Gonzales & Riek, 2012). Specific to PHR technology, Rodriguez, Casper, and Brennan (2007) have identified the need for PHR designs to incorporate the perspectives of secondary users, such as providers. Relevant secondary and passive user research is addressed in the following sections.

Secondary User Research

Alsos and Svanæs (2011) performed two usability studies with role-players in a hospital setting. In each study, doctors used handheld devices in various scenarios during their rounds performed on patient role-players. The authors retrospectively analyzed each study in the context of secondary UXs (as the studies were originally designed to gather data about the primary users). Three types of UXs emerged from the retrospective analysis: *UX*, which is the primary user's experience; *secondary UX*, which is the secondary user's experience; and *co-experience*, which is when both users have UXs with the same technology. Alsos and Svanæs (2011) defined a secondary UX as one that is attributed to the primary user's interaction with the system or the secondary user's interaction with the system using the primary user as an intermediary. The authors

concluded that primary users' interactions with the system affect secondary users and UXs for primary and secondary users should be designed for together rather than consecutively. As such, they recommended several design guidelines:

- The system should provide some form of feedback to the secondary user;
- The form factor should support non-verbal communication (some mobile devices can hinder face-to-face communication);
- Use language and representation familiar to secondary users in order to improve the secondary users' understanding of the communication; and
- As appropriate, provide an output device tailored for secondary users that removes irrelevant or overly complex information for secondary users.

Gonzales and Riek (2012) evaluated secondary users in the context of using a shared device to improve communication between doctors and cancer patients. Their research indicated that doctors and patients, in their first meeting after the diagnosis, disagreed about how well information was communicated during the meeting. Support documentation (e.g., generalized pamphlets) was usually provided to the patients during the encounter. Doctor and patient opinions diverged regarding the effectiveness of the materials. The authors believed that a shared mobile device that presented information tailored to the patient's treatment plan might improve the quality of communication. As such, the authors developed a concept for checklists that would be personalized to patients and relied upon a shared display that the doctor (primary user) and patient (secondary user) viewed simultaneously. Additional features would allow the doctor to highlight specific aspects relative to the patient's treatment. When the research article was published, Gonzales and Riek (2012) had not yet begun development of the system.

Alsos et al. (2012) conducted two experimental studies of doctors performing simulated rounds using patient records on paper, a PDA, and a laptop (on a wheeled cart). The focus of the study was how different mobile technologies helped or hindered communication between doctors (primary users) and patients (secondary users) during face-to-face communication. The authors recommended that secondary users' needs be represented using testable usability concepts. The research reported that three factors influenced the interactions between the doctors and patients: user interface, device form factor, and doctor communication practice. The authors concluded that:

- An interface should require minimum attention from users (allowing the primary users to pay more attention to the secondary users);
- The form factor should be small and mobile enough to not inhibit eye-to-eye contact; and
- The doctors should communicate what is happening, while they are interacting with the device—acting as proxy for device feedback to the secondary user.

Ni et al. (2011) created a prototype to help doctors communicate educational concepts to patients during an appointment. The authors relied upon a user-centered design, with doctors in mind as the primary users, to develop the prototype. They collected user data from doctors and physical therapists. However, a major part of the device's purpose was patient (secondary user) education and it included supporting features to project information onto a surface (e.g., wall), body (e.g., an image of a bone aligned to the patient's corresponding bone), or anthropomorphic model. A controlled experiment was conducted to understand patient responses to the projections. The body and model projections provided the best UXs for the patients.

Passive User Research

As mentioned earlier, passive users do not have control over the technology during an interaction. Someone else (an active user) uses the technology. This interaction style conforms to the idea of a secondary user who has a UX through an intermediary's use of an IS. For consistency, secondary user is used throughout this section to describe the user type. The original term used in the literature is referenced parenthetically.

Montague (2009) interviewed 25 new mothers about their experiences with medical technology while patients. The hypothesis was that the use of technologies created a unique form of secondary (passive) UXs for patients even though they are not the active users of the systems. The technology was not limited to HIT and included all types of devices used during treatment (e.g., clamps). The results demonstrated that patients do have UXs. Patients also formed positive and negative feelings regarding their interactions with the technology. Technologies that worked well had the potential to create positive experiences for the patient. Technologies that did not work well, or when the provider could not get the technology to work correctly, created negative experiences. This research confirmed that people do have secondary UXs that result in positive and negative feelings.

Asan and Montague (2012) examined how doctors interacted with EHRs during consultations with patients who were the secondary (passive) users. The objective was to evaluate patient-provider interactions in terms of the doctor's use of the technology and the patient's perception of the interaction measured in terms of trust and satisfaction. The authors analyzed 100 medical consultations. Prior research had shown that patient perceptions of HIT were based on the technology's characteristics, provider

characteristics, and provider's skill with the technology. The length of doctor's gaze at the EHR and typing during the consultation were the independent variables. The research resulted in the identification of three interaction patterns related to doctors.

- Technology-centered: Doctors displayed expert typing skills and multi-tasked by attempting to maintain eye contact with and talking to patients, while interacting with the technology (49.6% gaze at EHR, 21.6% typing);²
- Mixed: Doctors did not multi-task much, preferring instead short bursts of interacting with the technology and then focusing exclusively on the patient (34.8% gaze at EHR, 8.5% typing); and
- Human-centered: Doctors were not skilled with the technology (i.e., hunt and peck typing), did not multi-task, and used alternate methods (e.g., charts, nurse scribes, and voice dictation) to manage the data (24.9% gaze at EHR, 2.8% typing).

All of the doctors in the study received high ratings for trust and satisfaction from the patients. A common thread was the doctor's emphasis on the patient regardless of interaction style. Even in the mixed group, in which the doctors focused on the technology during their use of it, the interactions were characterized by short bursts of activity so that the doctors could turn their attention back to the patients as soon as possible. This research demonstrated that a variety of primary user interaction styles can be successfully applied to technology, while maintaining secondary user satisfaction.

² The percentages indicate the duration, as a percentage of the visit time that the doctor looked at the EHR (gaze) or spent typing during the consultation. They will not equal 100% because part of the time was spent doing other tasks, such as talking to or examining the patient.

Xu and Montague (2013) investigated secondary (passive) user perceptions during distance collaboration. This investigation explored how secondary users perceived primary users and their performances with technology over distance. The authors found that, in distance collaboration, how the secondary users perceived the technology contributed to their evaluation of the primary users. This result is contrasted with face-to-face encounters, in which the primary user's *performance* with the technology is more likely to influence the secondary user's perspective. This research indicated that secondary UXs are formed differently based upon the system, primary user's performance with the system, and proximity of the secondary user to the primary user.

Summary of Relevant User Research

The studies that have investigated elements of the secondary UX are important for several reasons: they demonstrate that secondary users have unique experiences; these experiences have an impact on secondary user satisfaction; and device usability impacts secondary UXs. See Table 2 for a summary of the research.

Table 2: Summary of Relevant User Research

Study	Study Purpose	Independent Variable	Dependent Variable	User	User Focus	Relevance
Alsos and Svanæs (2011)	Extend user focus beyond “first person user” to secondary users	Interaction techniques, media for medical records	Interaction with patients	Secondary user	Patient as secondary user	Primary user's use of the system impacted secondary user
Gonzales and Riek (2012)	Shared mobile device to improve patient-doctor communication	Delivery of information	Patient comprehension	Secondary user	Patient as secondary user	Shared mobile device with tailored information—contextual inquiry used

Study	Study Purpose	Independent Variable	Dependent Variable	User	User Focus	Relevance
Alsos et al. (2012)	To understand how mobile devices, help or hinder patient-doctor communication	Form of patient records	Interaction with patients	Secondary user	Patient as secondary user	User interface, device form factor, and doctor communication practice influenced the communication
Ni et al. (2011)	To understand patient responses to the technology	Presentation surface of the information	Retention of information and secondary users' satisfaction	Primary user	Doctor for design, but patient focus for experiment	Patients (secondary users) preferred the information in context (to the body)
Montague (2009)	Understand patient experiences	Medical technology	Patient feelings	Passive user	Patient as secondary user	Patients have UXs that manifest as positive or negative feelings
Asan and Montague (2012)	Examine how doctors interact with EHRs in primary care environments	Interaction style	Patient trust and satisfaction	Doctor	Doctor	Different interaction styles yielded equally high ratings in patient trust and satisfaction
Xu and Montague (2013)	Explore secondary users' perceptions of primary users in distance collaboration	Technological conditions and primary users' performances	Trust in technology and primary users	Secondary (Passive) users	Secondary (passive) users during distance collaboration	Primary users' performances observed by the secondary users affected the secondary users' trust in the technology

Limitations in Past Literature

There are instances that, on their faces, seem appropriate for addressing secondary user needs—the prototype developed by Ni et al. (2011) to help doctors educate patients is an example. However, the prototype does not fully address secondary user research because its design emphasizes insights from primary users, while the experimental study gathers usability feedback from secondary users. This type of disconnect is not uncommon for the cited studies, which do not stress designs of a single system for multiple user types. Furthermore, any research comparisons that have been made are most often between different systems (e.g., PDA and laptop) or contexts (e.g., presence or absence of secondary users).

The impact of the lack of attention to secondary UXs, particularly within the idea of patient-centered design, manifests when mapping the flow of communication. In the HIT domain, the information flow tends toward “provider → patient” rather than the desired “provider ↔ patient.” The “provider → patient” information flow is because patients rely almost exclusively on the providers for their health information during a consultation (Baird, North, & Raghu, 2011). Even though secondary users are increasingly incorporated into the literature, the vast majority of new HCI literature about users continues to emphasize primary users. To achieve the desired model of “provider ↔ patient,” both users should be designed for.

Design and Adoption

In order to be successful, a technology should have an adoption rate of between 10%-20%, at which point it reaches the critical mass necessary for self-sustaining adoption (Rogers, 2003). PHRs have yet to make the inroads necessary to become self-

sustaining. Even though 20% of *all* Americans have access to them, they are only used by 2%-7% of adults (Archer, Fevrier-Thomas, Lokker, McKibbin, & Straus, 2011; Burnett et al., 2013). This adoption paradigm is not unique. Many systems that are superior and technically sound still fail (De Marez, Evens, & Stragier, 2011). Part of the challenge for some interactive systems that fail may be that they are intended to be collaborative, but are designed from the perspective of one user type rather than both primary *and* secondary users.

Health Information Technology

Technology is often part of the communication process between patients and providers, much of it is not interactive. Using interactive technologies, such as PHRs, to improve the collaboration between patients and providers may require envisioning new user relationships in order to ensure that providers, as secondary users, develop favorable opinions about the technology. We know that team members working together on a project perform more effectively when some understanding exists of each other's roles (Convertino, Mentis, Ting, Rosson, & Carroll, 2007). Patients and providers are a team and could benefit from this level of understanding.

When considering the patient-provider relationship as a team, the integration of role-based information for team members (i.e., the patient and provider) into the system could be advantageous. The ability to share role-specific information (regarding a task) would increase opportunities for common ground (Convertino et al., 2007). These factors would also contribute to enriching UXs throughout the network of people touched by the primary user's utilization of the system. An enriched UX could influence adoption and help a technology advance toward the 10%-20% adoption rate.

Early research has indicated that the success of an interface should be determined by how well it supports common ground (Brennan, 1998). This notion is appropriate for patient-centered technologies because the current model of patient-provider interaction includes problems related to differences in domain expertise. An information exchange in the clinical environment often focuses on the needs of the provider who must seek information to establish a diagnosis and record information about the patient and treatment (Ni et al., 2011). The success of tools for patient-centeredness, in many instances, will depend upon how well the tools support information gathering by providers *as well as* improve the ability of patients to participate in their own healthcare—two distinctly different perspectives. Software that promotes a faster creation of common ground improves communication efficiency and, by necessity, should support multiple perspectives (Convertino, Mentis, Rosson, Slavkovic, & Carroll, 2009).

The Secondary UX and Usability

This section highlights literature pertaining to usability for the secondary UX that includes incidental and passive users, in addition to secondary users. When these user types are addressed, the term *secondary user* is used for clarity. The original language is shown parenthetically. The following studies demonstrate that, even though research about secondary UXs is still in its early stages, usability does play a role in secondary user satisfaction.

Ferneley and Light (2006) reported that mobility and the pervasive nature of computing increases the number of people who are exposed to a technology during its use. Using the case study method, they found that persistent access to information can adversely impact group dynamics. For example, among firefighters responding to a

service call, the improved location awareness afforded by Global Positioning Systems (GPS) resulted in information overload for the person relaying the directions (primary user) to the driver (secondary user). This example of information overload demonstrates the need to understand usability in terms of secondary users.

Inbar and Tractinsky (2010) examined service encounters in which technology provided an interface between the customer, a secondary (incidental) user, and the business. An example of such a service encounter is a customer working with a banker who is using an IS to access financial information. The design of the service environment determines if the customer can view the information. When he cannot, the main source of feedback is verbal from the company representative. Sharing information with customers and providing them with greater control can result in greater satisfaction (Inbar & Tractinsky, 2010, 2012). Unlike other researchers, Inbar and Tractinsky (2012) placed limitations on the implementation of designs for secondary users. They proposed that customers should have an interest in and familiarity with the information before designing features that grant them control in order to prevent the frustrations that occur when users lack the motivation or knowledge to complete transactions.

Montague and Xu (2012) learned that secondary (passive) users built trust in a technology based upon their interactions with the primary users and the primary users' interaction with the technology. Their research indicated that the performance of the primary user with the technology during a face-to-face encounter with a secondary user can affect the secondary user's satisfaction. This satisfaction frames the UX and demonstrates a straight line connection between the primary user's operation of a system and a secondary UX.

Extending the Notion of Usability to the Secondary UX

The relation of the UX to usability is important because each impacts the other. One perspective that clarifies the distinction between them is to remember that the UX is a person's emotional response to an interactive system, while usability is a technical aspect that emphasizes how well a person can use a system. (This is why it is said that one designs *for* a UX, because an emotional response to a technology cannot, in and of itself, be designed.) There is deep integration between the idea of the primary UX and usability because it is unlikely that a primary user can have a satisfactory UX if the system's usability is so poor that the user cannot accomplish anything productive with the system. However, the relationship between a UX and usability is unclear for secondary users and this idea deserves clarification due to the increased propensity for secondary users to have a UX. The following sections address concepts of usability that the literature has implied should influence both primary and secondary users.

Usability and HCD

Usability is the extent to which a system, product, or service can be used by specified users effectively, efficiently, and satisfactorily in a specified context of use to accomplish specified goals (ISO, 1998). It is in this regard that usability is a technical notion because it emphasizes actual use. HCD encompasses the idea of making systems more usable through the application of six principles (ISO, 2010):

- Designs are based on an explicit understanding of users, tasks, and environments;
- Involve users throughout the design and development processes;
- User-centered evaluation drives design;
- Iterative processes;

- Address the whole UX; and
- Multidisciplinary design teams.

The concept of usability is situated within HCD, an approach to interactive systems design, as is the notion of the UX. The clinical setting is attractive for this research because it provides a context for both primary and secondary users that is unambiguous and requires different conceptualizations of usability and UX for each user type.

Interactive systems are a combination of hardware, software, and/or services that take input from users and communicate output to them (ISO, 2010). Context of use frames the underlying effort to design usable systems. Context includes users, tasks, equipment, physical space, and social environment; it must be sufficiently described so that any aspects having significant impacts on usability are captured (ISO, 1998). Since the term *user* is closely associated with a primary user, current evaluations of context rarely provide insight into secondary UXs.

The Secondary User Context and Usability

This research acknowledges the continuing importance of the primary UX for most interactive systems. So much so that the incorporation of secondary user contexts should not degrade usability for primary users. As a result, it is important to understand how perceptions of usability for primary users have evolved and relate these perceptions to secondary users. This section examines changing notions of context for primary users and how they potentially impact secondary users.

Efforts are ongoing to expand the concept of *context of use* to address the social environment's impact on a technology. Some researchers propose to expand the conceptualization of users from role-based to persona-based, which is a significant

expansion of social context. Roles describe users by their functions within the system (e.g., a consumer or subscriber) and personas define users by imagining them as fictional characters (e.g., “Bill Jones”) with distinct experiences and behaviors in order to explore how these experiences and behaviors shape the characters’ interactions with the system (Hudson, 2013).

Integrating roles with personas has the potential to expand context to secondary users. When personas for fictional characters are developed, their roles can be defined as primary, secondary, or even tertiary users. This type of definition ensures that, when scenarios are developed for these users, the goals reflect their statuses as primary, secondary, or tertiary users. The status clarifies their access to the system as well as their interaction with it. Furthermore, their function within the system (e.g., consumer) can be incorporated into their personas to ensure a more thorough evaluation of who, what, and how the system is engaged by a particular user/user type.

Many developers of consumer-facing HIT take a technology-centric approach to design, rather than learning the health work context in which patients are supposed to use the systems (Marquard & Zayas-Cabán, 2012). This approach can result in poor usability for primary users (which will create friction with secondary users). Ethnographic research models are increasingly popular in HCI as a result because they provide rich insight into work settings and use contexts (Millen, 2000).

The sociotechnical systems theory has been successfully used to evaluate HIT, such as EHRs (Mohammed-Rajput, Smith, Mamlin, Biondich, & Doebbeling, 2011). Sociotechnical approaches stress work practices that frame how the technology will be used with a specific emphasis on cooperative work processes (Berg, 1999). The

sociotechnical systems theory views organizations as entities comprised of three highly interrelated subsystems: technological, social, and environmental (Flanagan et al., 2011). The theory has been successfully used to perform thematic analyses of interviews and observations of providers and staff in clinics (Flanagan et al., 2011).

Groups and Usability

Groupware offers insight into usability for secondary users and common ground because it is designed for multiple users. Groupware is a class of computer-based systems that provide interfaces to shared environments for groups of people performing common tasks or working toward common goals (Ellis, Gibbs, & Rein, 1991). The focus of usability in groupware is on interactions between people and how the interactions are mediated by an interface (Antunes, Borges, Pino, & Carriço, 2005).

The mechanics of collaboration (see Table 3) evolved from groupware research. The mechanics can be utilized to model aspects of collaboration with technology. Some groupware usability problems are caused by a lack of support for basic collaboration activities (Pinelle & Gutwin, 2001). Usability for groupware has an impact on team efficiency, effectiveness, and quality of work (Antunes et al., 2005). Development of the mechanics of collaboration was influenced, in part, by Clark (1996) and his work on common ground theory (Pinelle, Gutwin, & Greenberg, 2003).

Table 3: Mechanics of Collaboration

Category	Description (Mechanics)
Explicit communication	Planned and intentional communication (speaking, writing, gesturing, combining verbal and gestural, manifesting actions)
Information gathering	Gathering information in shared workspaces from others and their activities (basic group awareness, feedthrough, consequential communication, visual evidence, and overhearing explicit communications)

Category	Description (Mechanics)
Management of shared access	Managing group access to objects within the workspace (obtaining a resource, reserving a resource, protecting work)
Transfer	The movement of objects and tools between people (handoff and deposit)

Note. Adapted from “Task Analysis for Groupware Usability Evaluation: Modeling Shared-Workspace Tasks with the Mechanics of Collaboration” by D. Pinelle, C. Gutwin, and S. Greenberg, 2003, *ACM Transactions on Computer-Human Interaction*, 10(4), 281-311. Copyright 2003 by the Association of Computing Machinery.

The mechanics of collaboration were used during this research to establish a collaboration baseline for the analysis of content and functionality. A set of heuristics for the usability evaluation of groupware, based upon the mechanics of collaboration, has been developed (Baker, Greenberg, & Gutwin, 2001, 2002). The heuristics were applied during the usability evaluations of the prototype in order to ensure that it included features and functions that supported a satisfactory UX for both the primary and secondary users.

Mobility and Usability

Usability for mobile technologies is introduced because mobile devices are increasingly central to the idea of secondary users and their UXs. The explosive growth of apps designed for mobile devices has made myriad complex communication tasks possible (e.g., video teleconferences, presentations, and conference calls) on small, handheld and wearable devices. As such, mobile devices have become versatile on demand collaboration tools.

Mobile devices are rapidly shaping a large part of the ubiquitous computing environment. They provide almost uninterrupted Internet connections, even when the Internet is not being deliberately accessed through a browser. Live tiles on smartphones

are an example of such persistent Internet connectivity. A live tile is an icon on a smartphone home screen that updates programmatically, based upon preferences set by the user (Yan, Chu, Ganesan, Kansal, & Liu, 2012), such as a weather app icon that automatically updates the weather symbol (e.g., sunny changes to cloudy) and temperature as new weather reports are issued.

Usability for mobile devices is different from PCs and other systems because of the mobility, small screen size, and ergonomics of holding the device (Wisniewski, 2011). However, HCI research methods for these form factors are constrained because user-centered research often relies on direct observations (Hagen, Robertson, Kan, & Sadler, 2005). The lack of geographic restrictions for these systems makes observations difficult or impractical. Discount evaluation methods for mobile usability were created to counter these problems. Traditional discount tools, such as heuristic evaluation, were modified to incorporate mobile contexts and usability inspection checklists for mobile phone interfaces are available (Bertini, Gabrielli, & Kimani, 2006; Ji, Park, Lee, & Yun, 2006; Po, Howard, Vetere, & Skov, 2004). The modifications to low cost usability methods improve opportunities to conduct formative usability evaluations when designing for secondary UXs.

Kjeldskov and Graham (2003) performed a comprehensive review of mobile HCI research methods. They studied 102 conference and journal papers and described the research according to eight categories: case studies, field studies, action research, laboratory experiments, survey research, applied research, basic research, and normative writings. The authors found that laboratory experiments were appropriate when

evaluating user interactions with mobile devices. Of all of the papers that reported research requiring evaluation, 71% of them used laboratory experiments.

Hagen et al. (2005) identified several emerging methods in mobile HCI research. The authors found that simulations and enactments were effective when testing mobile prototypes as both provided methods to use scenarios with mobile devices in order to evaluate usability for them in a realistic context of use. Simulations were generally quantitative methods that evaluated the use of devices with predefined tasks in environments that mimicked real use situations (e.g., perform a task while walking). Enactments were usually qualitative approaches in which users acted out scenarios in contexts in which the device might be used.

Theoretical Model (Common Ground)

This section describes common ground, which provides the theoretical model for this research. Common ground is defined as “a proposition p is common ground if: all the people conversing know p and they all know they know p ” (Monk, 2003, p. 270). The theory was developed by Clark (1996) and explains how people achieve sufficient shared knowledge to successfully complete a communication. *Grounding* is the process to make communication effective and common ground is created as a result of the grounding process (Clark & Brennan, 1991).

During face-to-face meetings, the ability to share large amounts of content with someone can be limited by the lack of the interactivity of the physical tools (e.g., pen and paper) used by the team members (Convertino et al., 2009). One of the attractions of common ground for secondary UX research is the idea of external representation. External representation is a way to represent components of the communication in

physical form. Clark (1996) provided the example of a chess game with the board and pieces serving as external representations of the players. In HCI, a smartphone interface that displays objects of interest to primary and secondary users is an external representation. Direct manipulation interfaces (e.g., graphical user interfaces) have provided excellent support for grounding for many years (Brennan, 1998). Thus, the relation between computer interfaces and grounding has already established and does not require additional explication for this study.

Constraints on Grounding

Actions are important components of common ground. A joint action occurs when people intend to do their parts in the communication and believe that the joint action includes their parts and the other participants' parts (Monk, 2003). Common ground is incrementally built based upon the history of joint actions (Convertino et al., 2008). When joint actions are mediated by interactive systems, the technology places constraints on the establishment of common ground. Constraints are *positive* in grounding because they reduce ambiguity (Monk, 2003). The more constraints supported by a technology because of different combinations of devices and interfaces, the better (Convertino et al., 2008). There are eight constraints for grounding (see Table 4).

Table 4: Constraints on Grounding

Constraint	Description
Copresence	When A and B are co-located, such as in the same room
Visibility	When A and B can see each other
Audibility	When A and B talk to each other
Contemporality	When B receives messages at about the same time that A produces them
Simultaneity	When A and B can send and receive messages simultaneously

Constraint	Description
Sequentiality	When A's turn and B's turn cannot occur out of sequence
Reviewability	When B can review A's messages, as in written communication
Revisability	When A can revise messages for B before they are seen by others (outside of A and B)

Note. Adapted from "Grounding in Communication," by Herbert H. Clark & Susan Brennan, 1991, in L.

B. Resnick, J. Levine & S. D. Teasley (Eds.), *Perspectives on Socially Shared Cognition*, p. 229.

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Constraints can be used to predict the problems that people will have with an IS by evaluating which constraints are present or absent when using the system (Monk, 2003). The concept of constraints means that it is possible to anticipate what the UX will be with a product for a particular user type. Since the secondary UX can be anticipated through the evaluation of the constraints, it can be designed for during product development. The ability to predict the experience means that common ground theory can be used to explain problems that people have with an IS in certain contexts (Monk, 2009).

Constraints and Smartphones

Unlike most communication technologies, smartphones can support all constraints in a face-to-face setting. Table 5 shows comparisons of communication mediums and constraints ("X" is a supported constraint). The fact that smartphones allow users to switch back and forth between functionalities (e.g., email or text messaging) seamlessly and unobtrusively is an exciting prospect and important for grounding. Smartphone users do not have to access a fixed system or workstation to send and receive non-telephonic

messages because they have apps that perform several functions. An example of switching back and forth demonstrates the versatility of mobile technologies:

A patient and provider are interacting face-to-face [copresence, visibility, and audibility constraints]. As they discuss the patient’s medical history, the provider remarks, “So, you had your tonsils removed. When did that happen?” The patient responds, “I don’t know, but my mom remembers. I’ll text her [reviewability and revisability constraints] and have it for you in a minute.” The patient successfully gets the information via text.

In this instance, the dyad moved between constraints common to face-to-face communication and those common to written communication. Had the information remained unavailable, it might have negatively influenced the information exchange. Since it was easily obtainable, in a manner that did not appreciably slow down the conduct of the encounter, the UX for both users was positively impacted.

Table 5: Constraints on Communication Comparison Chart

Medium	Copre- -sence	Vis- -ibility	Aud- -ibility	Contemp- -orality	Simul- -taneity	Sequen- -tiality	Review- -ability	Revis- -ability
Face-to-Face	X	X	X	X	X	X		
Telephone			X	X	X	X		
Video Tele- -conference		X	X	X	X	X		
Letters							X	X
Email/Text							X	X
Smartphone	X	X	X	X	X	X	X	X

Note. Adapted from “Grounding in Communication,” by Herbert H. Clark & Susan Brennan, 1991, in L.

B. Resnick, J. Levine & S. D. Teasley (Eds.), *Perspectives on Socially Shared Cognition*, p. 230.

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The literature indicated that there is reason to believe that distinct secondary UXs occur. What the literature does not reveal is how to discriminate between the utility of the individual secondary UXs that manifest or map the intellectual activity of grounding to

digital systems. It is the author's contention that respective values for each secondary UX should be identified in order to understand the relative merit of each for resourcing and design. Concepts, such as constraints, provide a method to map the environment and context in which the communication will occur to a system's features and functions.

Common ground is important because it provides the vehicle by which to evaluate the quality and importance of a secondary UX. This is critically important within the context of a patient first time visit to a provider. There are many types of first time encounters (e.g., seeing a specialist). During these visits, healthcare professionals typically have less information about a new patient than they would have about a patient in a continuity visit. Therefore, establishing common ground during a first visit will contribute to an efficient and well-conducted encounter. A smartphone has the potential to improve common ground during a first visit if it contains relevant and properly organized health information. The research questions in the next section emphasize how common ground is used to demonstrate the relation of language to digital systems, in a manner that results in better communication in the envisioned healthcare setting.

Research Questions

Even though this research is about the secondary UX, operationalized in terms of common ground and satisfaction, key relations impact the potential for a satisfactory UX. Collaboration mechanics contribute to group usability and usability is important for common ground. Therefore, the relations among collaboration mechanics, common ground, and secondary user satisfaction are examined.

RQ₁: To what extent do smartphone apps designed using collaboration mechanics support grounding between primary and secondary users during face-to-face collaborations?

RQ₂: To what extent do smartphone apps designed to support grounding impact secondary users' satisfaction during face-to-face collaborations?

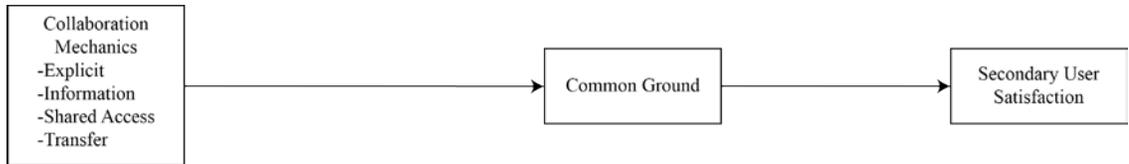


Figure 3: The conceptual model for the research questions.

CHAPTER THREE: FORMATIVE WORK

Introduction

The research culminated in an experimental study that required the conduct of a simulation using a custom designed tool. Before the experimental study could be conducted, extensive formative work was required to create the tool, which would be used as the treatment in the study. The tool that was eventually created was a custom designed smartphone PHR app prototype. Two assumptions informed the formative work and reflected what is already known about usability, collaboration mechanics, and common ground. The assumptions prevented the need to examine questions with answers that are already established knowledge or are obvious. These assumptions are as follows:

- Assumption #1 applies to technical frameworks (e.g., WordPress) used for prototyping and states that satisfactory usability for primary users is assumed because of the usability testing, design guidelines, and best practices common to organizations that produce such frameworks.
- Assumption #2 applies to relations leading up to common ground and states that collaboration mechanics influence usability and usability influences common ground. For example, if a calendar feature is added to support the *reserve a resource* collaboration mechanic, then device usability is impacted based upon how the calendar is implemented. If the calendar is sharable and implemented well, then this aspect of usability positively supports grounding.

The formative work occurred sequentially in four parts:

1. Phase 1: During this phase, a pilot study was conducted to test and validate the instruments that would be used for the data collection and prototyping processes.

2. Phase 2: During this phase, patients and providers were interviewed and the interviews were thematically analyzed according to common ground theory. The output was a finalized definition of the secondary UX, insight about the functionality desired in a smartphone PHR app, and feedback regarding health information desired by primary and secondary users during a patient-provider encounter. The output informed the design of the data collection instruments for Phase 3.
3. Phase 3: During this phase, online survey questionnaires were developed and distributed to primary and secondary users. The questionnaires were used to validate and extend what was learned during Phase 2. The outcome of Phase 3 was a set of design guidelines for creating the tool.
4. Phase 4: During this phase, the tool was created. The prototype was iteratively developed and usability evaluations were conducted throughout the process. The output from this phase was the smartphone PHR app prototype used during the experimental study.

Phase 1 (Pilot Study)

Introduction

This section provides an overview of the activities within Phase 1. The initial exploration for the pilot study consisted of interviews with a convenience sample of two doctors and two industry experts. A focus group to brainstorm ideas about smartphone PHR app functionality was also conducted. The interview participants were a convenience sample recruited based upon recommendations from the faculty of the Indiana University School of Informatics and Computing and a non-profit board member.

All of the participants were informally interviewed by phone or face-to-face. Open-ended questions about HIT were used to perform the interviews. The purpose of the interviews was to narrow the scope of the research and explore PHRs as a research topic.

The first doctor interview (emergency medicine specialty) was conducted telephonically on May 30, 2013, while the second (internal medicine specialty) was conducted face-to-face on March 4, 2014. Both interviewees had informatics backgrounds. The first industry expert, a PHR company president, was interviewed over the telephone on June 18, 2013. The second, a doctor and PHR company CEO, was interviewed face-to-face on September 2, 2014. All four interviews were informal and focused on the current information technology used in the medical domain and/or the future of the PHR industry. Brainstorming was conducted with a focus group in one 90-minute meeting on November 15, 2014. The focus group session was performed with 12 members of an Indiana inventors club (IIC). The purpose was to explore design ideas based upon the concept of collaboration mechanics. The IIC group members had a variety of backgrounds, including software engineering and medical education.

The following insights were gleaned from the initial exploration:

- The mobile space is a compelling research area for PHRs because not much has been done in this regard;
- Sharing must be simple between the patient and provider, while remaining within the constraints of privacy and security policies; and
- Consider wireless sharing with the provider's computing device.

Once the initial exploration was complete, a pilot study was conducted. The pilot study tested questionnaires and evaluated the efficacy of the planned prototyping methods. The goals of the pilot study were to:

- Assess and revise interview questions;
- Rehearse the interview process;
- Test the technology to be used when recording the interviews;
- Practice the design process for creating prototypes; and
- Gain insights from early iterations of the design.

Thematic Analysis

As an initial part of the pilot study, two semi-structured interviews were conducted with a convenience sample of one patient (a female university professor on November 26, 2014) and one provider (a male doctor on December 23, 2014), both of whom had informatics backgrounds. Participants with informatics backgrounds were selected because they were able to provide domain-specific feedback for the questionnaire development. The interviews were conducted over the telephone and audio recorded. The technology used to record the interviews was Calltrunk,³ a paid audio recording service that provided downloadable MP3 files. The participants received a \$10 Amazon.com gift card as an incentive.

The interviews were manually transcribed into a summary format and analyzed using NVivo 10, a computer assisted, qualitative data analysis software. NVivo 10 provides researchers with a set of tools to manage, query, and visualize data (Bazeley & Jackson, 2013). The interview analysis was complemented by a separate, thematic

³ The Calltrunk service is no longer available as BetterVoice acquired Calltrunk in 2015.

content analysis of seven common ground research papers. The purpose of this analysis was to ensure that there was adequate content by which to identify themes that could be operationalized in terms of a secondary UX. After the analysis, prototyping was conducted.

The thematic content analysis was performed in three rounds of coding. Early rounds were performed manually within the software. Subsequent coding was accomplished using the software's analytical tools. During each round of coding, notes were taken and included in the subsequent rounds of coding.

The first round of coding began with the manual coding of the common ground literature. This round resulted in the identification of several initial concepts that would be used to guide subsequent coding. The initial concepts were: *actions*, *common ground*, *constraints*, *costs*, *external representation*, *interface*, *grounding*, and *joint action*. Coding continued on the literature resulting in the revision of the initial concepts into five concepts: *actions*, *common ground*, *constraints*, *costs*, and *design*.

The second round of coding began with the manual coding of the pilot study interviews. The results highlighted tensions between the patients and providers about the quality of their communications. For example, the interviews indicated that patients might tend to believe they provided quality health information, when working from memory, to the providers.

When it's my own personal health, I don't really feel that I need, like in the context of an appointment, I don't think I need that information [medical history] on a[n] app, for example, I can just communicate and tell the doctor. Pilot Study Participant (Patient)

In contrast, it became apparent that providers might be likely to hold a much different perspective. The pilot study participant who was a provider remarked: "Most patients will

refer to the computer. So, if you said “What medications are you taking?” or “What medical problems do you have?”, they’ll basically say “It’s in the computer” or refer to an external resource.” This disparity of perspective between the patient and provider in the pilot study indicates an area of information that could adversely impact common ground during a patient-provider encounter.

The third round of coding began with the exploration of the literature and notes using a frequency word search. The following concepts emerged at this point: *ground* (e.g., grounding), *informed*, *community*, *groups*, *sharing*, *conversing*, *process*, *users*, *task*, *designs*, *interactivity*, and *collaborate*. Next, a text keyword search was performed based upon the concepts that emerged from the data.

The keyword search was insightful because it showed concepts that a keyword was related to. This information was then visualized in a word tree. It became easy to see that keywords with a high frequency of use may or may not relate to many concepts. For example, *ground* had a high frequency of word count (603) and was related to many concepts.

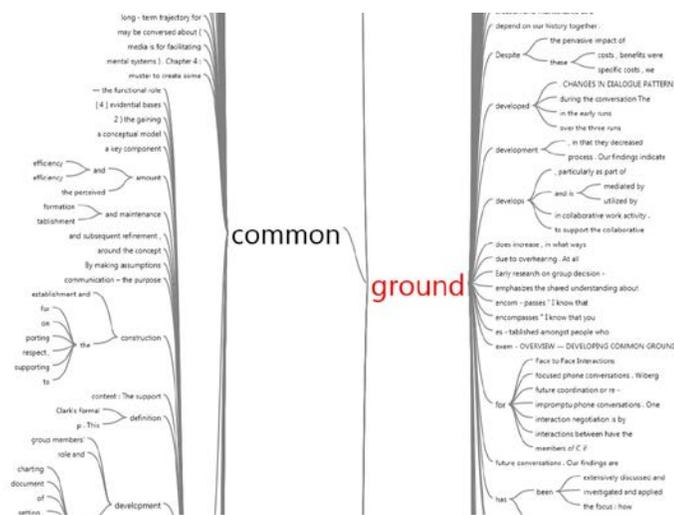


Figure 4: A section of the word tree for the ground keyword search.

In contrast to *ground*, *informed* had a high frequency word count (471), but was not related to many concepts. After the keyword search and word tree review, several themes emerged. The final themes were: *content and process knowledge, shared understanding, and collaboration is limited by a lack of interactivity.*

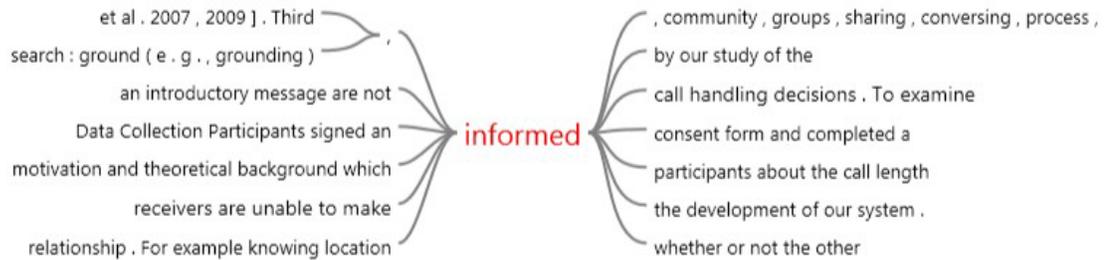


Figure 5: The complete word tree for the informed keyword search.

Prototyping

Once the thematic content analysis was complete, personas for one female patient and one male doctor were created. Use cases for primary and secondary users in a clinical setting were also prepared as well as storyboards for tasks. Sketching occurred early, following design best practices, with four iterations of interface sketches made. Three types of prototypes were subsequently produced in sequence: low-fidelity (paper-in-screen), medium-fidelity (PDF), and high-fidelity (HTML).

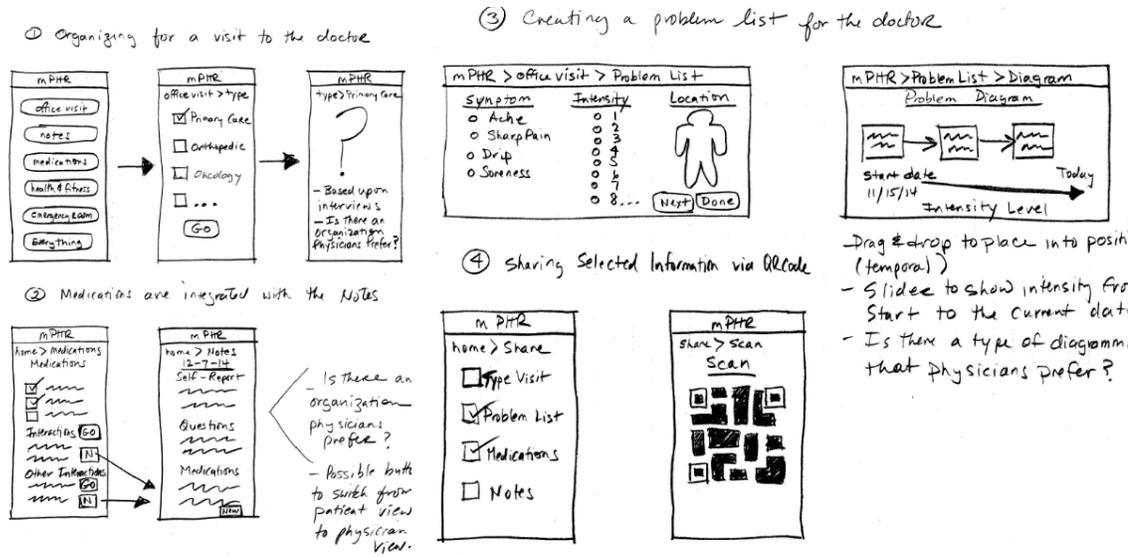


Figure 6: The final set of user interface sketches.

The sketches were followed by three iterations of paper-in-screen prototypes (see Figure 7), according to the method presented by Bolchini, Pulido, and Faiola (2009).

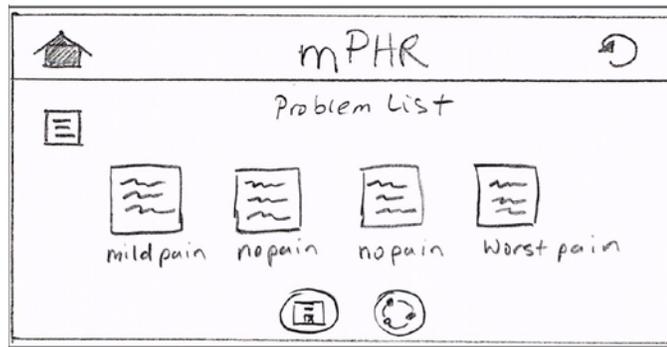


Figure 7: A paper-in-screen prototype example showing the problem list interface.

A usability evaluation of the paper-in-screen prototypes using the cognitive walkthrough technique, according to the process for groupware usability evaluation proposed by Pinelle and Gutwin (2002), occurred next. Two members of an IIC were the participants for this evaluation. Several usability problems were identified, such as confusion about screen labeling and purpose, a lack of warnings prior to sharing sensitive medical information electronically, and the need to define health problems as acute or

chronic. The usability problems were addressed and an interactive medium-fidelity prototype (wireframe) was created using Adobe Fireworks (see Figure 8).

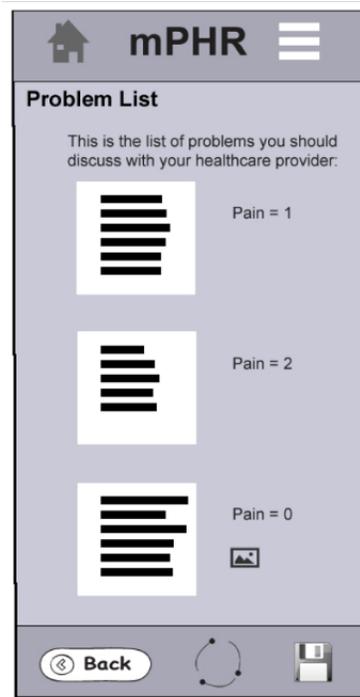


Figure 8: Wireframe of the problem list output screen.

An inspection of the wireframe revealed additional usability problems. Consequently, several redesign ideas were implemented, such as the consolidation of repetitive categories on the menu, additional warnings for sharing information electronically, and customized output screens for different user types. The final phase of the pilot study was the development of a high-fidelity prototype using Adobe Fireworks (see Figure 9).

Several design insights were learned during the pilot study. The problem list variations will serve as an example of the insights. The provider interview indicated that different views of information for primary and secondary users might be a technique to improve communication between patients and providers. The problem list was originally

organized with one output screen, primarily with textual information; it was revised to include multiple output screens. One screen contained less text and the addition of icons, while another screen contained output organized similar to an EHR or EMR.

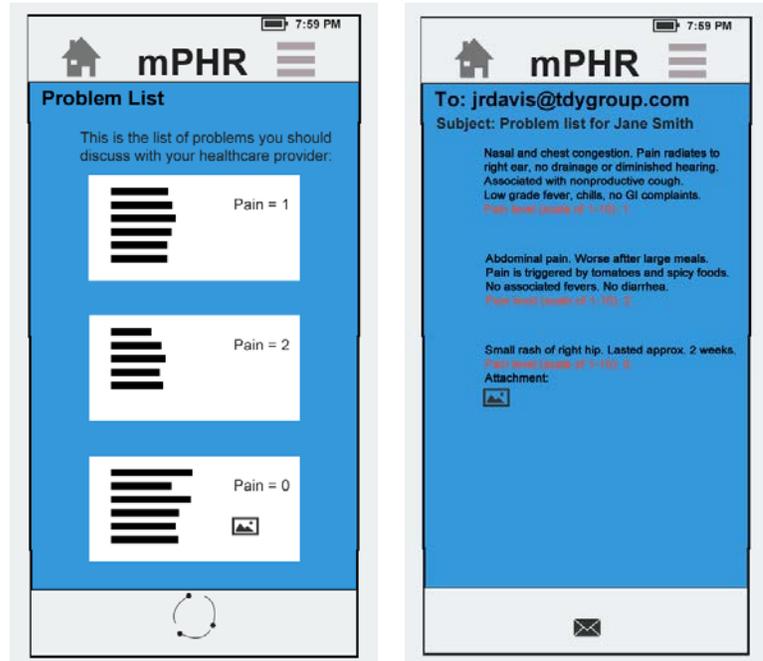


Figure 9: High-fidelity prototype example showing the problem list organized for face-to-face sharing (left) and for electronic sharing (right).

Phase 1 Conclusion

Phase 1 highlighted a possible disparity in perceptions between patients and providers. It revealed that patients believed that they had the correct health knowledge and providers did not believe that patients had the correct health knowledge. This disparity indicated the potential for a lack of common ground throughout an encounter. Most of the tools used to ensure that common ground is attained are manual and the responsibility of the provider. For example, providers ask questions to ensure that the patient understands his current health status. The pilot study demonstrated that

smartphones can contain the type of patient health information that providers consider important for a successful interaction.

Phase 2 (Patient and Provider Interviews)

Introduction

This section provides an overview of the activities conducted within Phase 2. Phase 2 began with a continuation of the pilot study thematic analysis using the theoretical sampling technique. Theoretical sampling is characterized by additional data collection based upon concepts that emerged from earlier coding (Corbin & Strauss, 2008). The additional data collection consisted of semi-structured interviews (Appendix B).

The theoretical sampling began by revising the Phase 1 semi-structured interview guides based upon what was learned during the pilot study. The revised guides were used for the interviews. The purpose of Phase 2 was twofold. First, to explore the intersection of collaboration mechanics and constraints on grounding in patient-provider communication. Second, to explore where collaboration mechanics and constraints on grounding diverge in patient-provider communication and whether there is something not yet identified that contributes to better communication.

Participants

There were 14 interview participants (seven patients and seven providers) and all of the interviews were conducted over the telephone between January 1, 2015 and April 22, 2015. The participants were recruited through a university listserv as well as Facebook and LinkedIn social media websites. A chance meeting with two providers also resulted in their recruitment for the study. As an incentive, the participants were offered

an opportunity to be entered in a drawing for a Toshiba Excite 7.0-Inch 8 GB Tablet Computer (value < \$100.00).

The seven patients were insured, with four having health insurance through work, two private pay, and one Medicaid. Each had seen a provider within 12 months of the interview. The seven providers practiced in the U.S. and each consulted with patients multiple times per week. While most of the providers provided face-to-face consultations, one provider provided telehealth consulting. Specialties included emergency medicine, mental health, oncology, surgery, internal medicine, gastroenterology, and palliative care. Experience varied for the providers (e.g., six months, six years, and 10 years for the three youngest providers and the four remaining providers had 22 to 31 years of experience).

Table 6: Interview Participant Demographics

Variable	Attributes	Patients	Providers
Gender	Male	3	4
	Female	4	3
Age	18–24	2	0
	25–34	4	2
	35–44	1	1
	45–54	0	1
	55–64	0	3
Job	Doctor	0	2
	Physician Assistant (PA)	0	2
	Nurse	0	3
Technology	Uses Feature Phone (i.e., “flip phone”)	1	0
	Uses Smartphone	6	7

Method

Calltrunk was used to record the interviews and its transcription service to transcribe them. The transcriptions were of good quality. When errors were discovered, they were reviewed, crosschecked, and corrected based upon the audio recordings. The transcribed interviews were analyzed using NVivo 10, according to established techniques for qualitative analysis using the software (Bazeley & Jackson, 2013).

First Round of Coding

The initial concepts used for the coding were collaboration mechanics (see Table 3) and constraints on grounding (see Table 4). These concepts were selected *a priori* (Bazeley & Jackson, 2013). The interviews were manually coded within the software. All of the providers used some form of electronic record in their practice. Regardless of their own perceived competence with computing devices, they felt that electronic records—including smartphone PHRs—were useful.

I would like to read it [patient health information contained within a smartphone PHR app] because I'm not computer savvy. I'm not really up on technology. I don't know if our systems are able to do that, those options [sharing with a smartphone PHR app via email, text, or QR Code]. I really don't know, but I can read a phone, so I would probably do that.
Participant 12 (Nurse)

The providers generally thought there was value for patients to have their health information organized electronically on a mobile device. Participant 12 (Nurse) had encountered a patient who used a smartphone: “I was impressed that they were organized. I wish more people would do that.” She was the only provider interviewed who had experienced a patient who retrieved personal health data from a smartphone.

Even though the providers reported positively about patient use of technology to manage and share personal health information, they expressed reservations about how it

could be shared. The providers described a current lack of capability for electronic data exchanges between patients and providers during a consultation.

Right now, we don't even have different medical softwares [sic] in hospitals and doctor's offices communicating. Once there's some uniformity and some connectivity, such that the smartphone can scan the stuff into my template, then that would be what we would do. Participant 14 (Doctor)

Even though the providers thought the idea of electronic information sharing with patients had potential, they were skeptical about its potential for implementation in the near-term.

In addition to factors such as interoperability and security, the lack of computer-to-computer capability limited how providers anticipated interacting with a patient's smartphone PHR app. The providers would prefer to look at the information on the smartphone, have the patient operate the device and verbalize pertinent information, or provide information from the app to administrative staff during the check-in process for inclusion into the electronic record that the provider reviews (before the patient is seen).

In terms of patients, most did not have their health information organized electronically. They all used computing devices in their daily lives; however, only a few used them for health information management and, of those who did, they interacted with their devices before or after an appointment, not during.

[Interaction with a device occurs] right after my appointment and I go out to the vehicle. I'll write them [notes about the appointment] down if I don't think I can remember [them]. Participant 5 (Patient)

Among the patients who did use a computing device to manage health information, the interviews indicated that any use of such a device was usually sporadic and an afterthought.

At the conclusion of the manual coding, the initial concepts were refined into the following areas of interest:

- Accuracy, security, and privacy;
- Desired application properties;
- Background information;
- The following collaboration mechanics:
 - Explicit communication consisting of combined speaking and gestures, gestures, speaking, and writing;
 - Information gathering consisting of basic group awareness, feedthrough, and overhearing others' explicit communications;
 - Management of shared access consisting of obtaining a resource; and
 - Transfer consisting of deposit and handoff;
- All eight constraints on grounding (see Table 4);
- Design ideas;
- Information and artifacts brought to an appointment;
- Organizing information for an appointment;
- Interaction with others;
- Information priorities;
- Tools; and
- Unknown or confusing information.

Second Round of Coding

This phase of coding used the analytical tools of NVivo 10 to evaluate concepts, consolidate data, and explore emerging themes. As a first step, the concepts were

reorganized into categories and explored with the software tools. The interviews were searched using the word frequency tool (including stemmed words). The three most frequently used words (*information*, *medications*, and *patient*) were studied using the text search tool (including stemmed words) to examine the context in which they were used. The same types of queries were run for each term for the patient interviews (grouped together) and provider interviews (grouped together).

The term *information*, and its variations, related more to questions asked rather than responses. As such, this term was deemed not useful for the analysis. However, both patients and providers used variations of the term *medications* meaningfully. Patients averaged three references per patient interview, generally focusing on bringing some reference tool to an appointment (e.g., medication bottles or medical records) or, in terms of software, easing information sharing before an appointment or storing and consolidating information. For example, Participant 3, who was a patient, remarked:

In multiple-choice questions, he can also inquire if I have started any self-medication. Am I on some drugs? I mean, there are various types of diagnosis that can happen before an appointment. A smartphone app would be helpful in that case.

Similarly, Participant 5, another patient, noted that information sharing might be made easier if a technology included:

Areas for quick questions or concerns to bring up with the doctor. An area that you can keep your personal medical history, like your medical background. You can bring it up to show the doctor if you're visiting a new doctor or something like that.

Both participant's comments highlight specific functionality that these patients believe an app can have for organizing health information to share with providers.

Providers, on the other hand, averaged 26 references to variations of *medications* per provider interview. Provider use covered a broad area. The use ranged from provider

decision-making about patient medications, to patient knowledge about medications, to concerns about accurately capturing patient medical history, to preventing patient abuse of medications.

If a patient doesn't have a doctor, so they keep going to clinics or whatever, and then, the next thing you know, they've got all these medications that should never be combined ... A way to put a stop to that through prescriptions is to find a way that all pharmacies can see what's going on here and they can also help control, so we don't get medications that should never be combined. Participant 11 (Nurse)

Medications were consistently a matter of concern for providers throughout the interview process. This is not surprising since correct knowledge of patient medications is important for properly treating an illness and to ensure that medications contraindicated for one another are not being taken by a patient.

Both patients and providers used the term *patient* meaningfully. However, only four patients used the term during their interviews (averaging 1.5 references for the four patients). Patients used the word mainly in the context of how software could be used to quickly improve provider knowledge about a patient's health status. As one would expect, *patient* was used by all of the providers (averaging 18 references per interview).

If there was a personal health record on the phone that they could more easily—people always have their phones on them. If they have a blood pressure, I think it would be good that it could just be uploaded. They could input it into their phone or stuff, such as activity tracking apps or stuff like that, if that could coordinate with the electronic health record app I think it could give you a better idea of your patient as a whole rather than just what they say they do. Participant 10 (PA)

Providers emphasized the potential for a smartphone PHR app to improve the quality of information shared with them by patients. Some providers cautioned about making the software too difficult for patients to use. The implied assumption from most providers

was that the patient would manipulate the device and hand it to the provider already properly configured.

The individual concepts discerned earlier were subsequently organized into four broad categories in order to identify emerging themes and explore increasingly homogeneous sets of data using the software tools. The categories were:

- *Appointment information needs, tools, and artifacts*, consisting of the background information, information and artifacts brought to an appointment, information priorities, interactions with others, organizing information for an appointment, tools, unknown or confusing information concepts;
- *Collaboration mechanics*, with subcategories consisting of explicit communication (combined verbal and gestures, gestures, speaking, and writing), information gathering (basic group awareness, feedthrough, overhearing others' explicit communications), management of shared access (obtaining a resource), and transfer (deposit and handoff);
- *Constraints on grounding*, with subcategories consisting of all constraints; and
- *Software*, consisting of accuracy, security and privacy, design ideas, and desired application properties concepts.

The same general procedure used to explore the interviews (i.e., word frequency first and then text search) was performed on the respective categories. An exception was made for terms showing up in the top three of the word frequency search that were previously evaluated during the interview exploration. These words were excluded from additional searching because the general context of use for them had already been established.

The top three terms (in order) in the *appointment information needs, tools, and artifacts* category were *medications*, *patient*, and *lists*. Since medications and patient had undergone prior evaluation, they were excluded and *lists* was selected for further evaluation. There were 110 instances of the use of the word and all of the instances were in the provider interviews. *Lists* was used to describe the tools that the patients used to manage medication information (e.g., medication list). The insight from the evaluation of lists was that there is interest from providers in patient tools to accurately manage and share medication information.

The top three terms (in order) in the *collaboration mechanics* category were *medications*, *patient*, and *information*. Since all of the terms had been searched for and evaluated previously, *understand* (the fifth most frequent word) was selected for further evaluation. (The fourth most frequent term was *like* and was eliminated as not useful for the evaluation.) The context for *understand* was a shared understanding between the patient and provider. Shared understanding is typically acknowledged during the consultation by the parties using speech and/or occasional gestures. An interesting comment in this category was about the availability of mobile phones.

A lot of people aren't prepared. I don't understand because they always have someone there to help them. I can understand if you don't have an advocate or a family member [with you], but they definitely come with a cell phone. They definitely have a cell phone. Participant 12 (Nurse)

The nurse's clear implication was that smartphones should be an aid that patients use to provide accurate medication information to providers.

The top three terms (in order) in the *constraints on grounding* category were *appointment*, *understand*, and *information*. *Appointment* and *understand* were selected for further evaluation (*information* was assessed earlier). There were no significant

insights from *appointment*. Insights regarding *understand* were similar to those insights found in the collaboration mechanics category described earlier.

The top three meaningful terms (in order) in the *software* category were *information*, *medications*, and *patient*. (*Like* was the fourth most frequent term, but not meaningful.) Since these terms had been searched for and evaluated previously, *app*, the fifth most popular term was selected for further evaluation. There were no unique insights from the term *app* in this category.

Several emerging themes were identified during the second round of coding. Based upon the analysis, *desired medication knowledge* and *relevant information sharing* were added as emerging themes. To be relevant, the provider must need the information to do his/her job and the information must be trustworthy. This requirement for relevance impacts the type of information managed by patients within an app and, subsequently, shared with a provider. It also has an impact upon how the app should be configured if/when the patient hands it off to the provider—the provider should immediately see it as useful.

The *appointment information needs, tools, and artifacts* category was retained and identified as an emerging theme. An emerging theme from collaboration mechanics was *building shared understanding with collaboration mechanics* and the category was changed to reflect this emerging theme. An emerging theme from *constraints on grounding* was *constraints on grounding that contribute to shared understanding* and the category was changed to reflect this emerging theme. The emerging theme for *software* was *what useful patient-managed health software should do* and the category was changed to reflect this emerging theme.

Third Round of Coding

The objectives of this round were to finalize the themes and explore the differences in data based upon attributes such as role, gender, and age. The first step was to perform a cluster analysis on the interviews based upon word similarity. Clustering of the provider interviews yielded four main clusters. In the first cluster, a doctor (Participant 14) was clustered with the second cluster consisting of a doctor (Participant 8) and nurse (Participant 12). In the third, two nurses (Participants 9 and 11) clustered together and, in the fourth, the two PAs (Participants 10 and 13) clustered together. This type of clustering means that participants who performed similar jobs used similar language to describe information sharing practices related to their jobs.

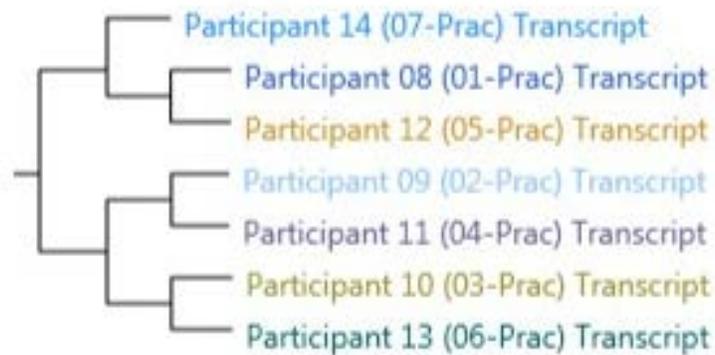


Figure 10: Clustering of participant interviews.

The clustering for patients was less clear and no single attribute was preeminent. Age was a common attribute for the four cases that clustered together in pairs (one pair was 18 to 24 years and the second was 25 to 34 years). The clustering of all 14 interviews together was not performed because the interview questions were different for patients and providers, which impacted word similarity.

After clustering the interviews by role, a cluster analysis of the emerging themes was performed to identify which themes clustered together based upon word similarity. Three main clusters emerged. The first cluster consisted of the *building shared understanding with collaboration mechanics* and *what useful patient-managed health software should do* emerging themes. The second cluster consisted of the *appointment information needs, tools, and artifacts* and *constraints on grounding that contribute to shared understanding* emerging themes. This clustering makes sense because collaboration mechanics is closely related to software and constraints on grounding is closely related to the type of artifact used to mediate communication within a dyad. The manner of clustering also indicated a similarity between these two clusters, which supports the relation between collaboration mechanics and common ground as shown in the conceptual model for secondary user satisfaction (Figure 3). This clustering also makes sense because the development of collaboration mechanics was influenced by common ground theory. The third main cluster consisted of *desired medication knowledge* and *information sharing*. This clustering seems appropriate since a constant theme of medication knowledge was to have patients share the correct knowledge with their providers.

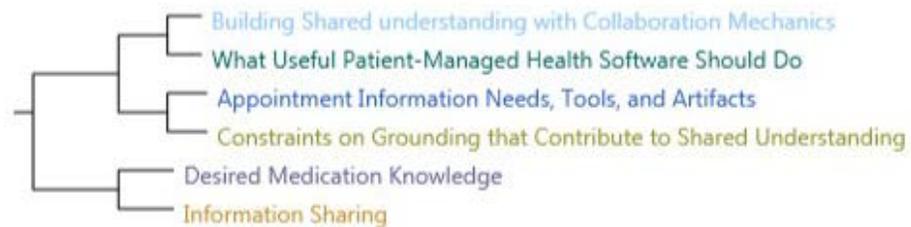


Figure 11: Clustering of emerging themes.

Word frequency searches were performed on each cluster. If terms were identified that might add additional insight, text searches were run on them. The word frequency search of the *building shared understanding with collaboration mechanics* and *what useful patient-managed health software should do* emerging themes showed interesting clustering as *accurate*, *medication*, and *list* clustered together.

Accurate was selected for further evaluation using the text search tool (the other terms had been previously searched). Four providers (at least one in each role) emphasized accuracy. This emphasis, combined with the clustering with *medication* and *list*, indicated that overt accuracy within any app is a potentially important concept for secondary user acceptance. Due to the prior close relation of accuracy to security and privacy, the *accuracy, security, and privacy concerns both patients and providers* theme was established. The *building shared understanding with collaboration mechanics* and *what useful patient-managed health software should do* emerging themes were retained and designated as themes.

The word frequency search of the *appointment information needs, tools, and artifacts* and *constraints on grounding that contribute to shared understanding* emerging themes did not reveal any new insights. Due to the prior established emphasis on the use of tools and artifacts during interactions, these emerging themes were designated as the *appointment information needs are supported by tools and artifacts* and *constraints on grounding contribute to improved communication using tools and artifacts* themes.

During this phase of the analysis, it also became clear that it would be useful to meaningfully differentiate between tools and artifacts in terms of their use to manage and

share information. Tools consist of computing devices (e.g., EHR or PHR) and artifacts are any non-computing device used to manage or share information (e.g., pen and paper).

The word frequency search of the *desired medication knowledge* and *relevant information sharing* emerging themes did not reveal any new insights. Due to the prior established emphasis on having trustworthy medication knowledge, these emerging themes were designated as *common desired medication knowledge necessary for a successful interaction* and *relevant information sharing to improve efficiency* themes.

As a final check, matrix queries that compared the coding for doctors, nurses, and PAs were performed. The intensity of engagement within the themes was similar for all of the roles, although there were differences in the tools and artifacts used on the job based upon role. For example, nurses have very formal shift transitions on the floor and use a variety of tools and artifacts during them as well as when they interact with patients (e.g., EHR and notes on a clipboard).

Results

Seven themes were identified during the analysis. The themes highlight factors to consider about patient-provider communication. They also provide insight regarding the potential for the communication to be mediated by smartphone technology and how it might be accomplished. The final themes were:

- Accuracy, security, and privacy concerns of both patients and providers;
- Building shared understanding with collaboration mechanics;
- What useful patient-managed health software should do;
- Appointment information needs are supported by tools and artifacts;

- Constraints on grounding contribute to improved communication using tools and artifacts;
- Common desired medication knowledge necessary for a successful interaction; and
- Relevant information sharing to improve efficiency.

Discussion

A key finding from the pilot study was confirmed: the disparity between patients and providers about patient concepts of personal health knowledge. Patients generally believed that they had adequately conveyed relevant health information to providers from memory.

To be honest, usually none [does not fall short of having information when seeing a provider]. I have all the important information with me and then I just hand over whatever they ask. I usually have everything. Participant 2 (Patient)

The only shortcomings that patients acknowledged were related to knowledge about administrative information, such as precise dates, understanding billing information, or other fine-grained information.

Providers, on the other hand, felt that patients frequently came to clinical interactions without adequate personal health information. The main problem was knowledge about medications. Some patients poorly described medications from memory, while others maintained information on lists or brought bottles to an appointment. In some cases, family members were present to help the patient convey accurate information to the provider.

Most of them do not know the name of the medication that they're taking...like the main medications, the cancer medication that they're taking, many of them don't know that name or how to pronounce it. Participant 9 (Nurse)

Even though many patients use memory aids, six of the seven providers noted significant problems with patients' general abilities to share critical health information accurately.

Contrary to the pilot study, ideas regarding electronic data sharing between a patient's smartphone and provider's computing infrastructure were generally rejected by providers. The potential for computer-to-computer sharing in the future was acknowledged. However, providers did not feel that the current state of technology supported such data exchanges on a widespread, easy-to-use basis. Many of the providers' concerns about data sharing related to security, privacy, and other aspects of HIPAA.

Phase 2 Conclusion

The working definition of the secondary UX was revised to reflect what was learned during this and prior phases. The major insights that applied to the revision were that the information provided to the secondary user should be meaningful to them and that the secondary user must make a decision about how, or if, they will interact with the device if offered to them by the primary user. The revised definition of the secondary UX is: *The secondary UX is the secondary user's response to the primary user's ability to competently share relevant information from a product, system, or service with him, or the secondary user's direct or anticipated direct use of a product, system, or service.*

Phase 3 (Online Survey Questionnaires)

Introduction

The revised definition and results of the earlier work were used to inform the design of two online survey questionnaires. The purpose of the online survey questionnaires was to validate and extend what was learned in the prior qualitative

analysis, dive deeper into the specific idea of a smartphone PHR with patients and providers, and further explore the methods used by providers to organize data prior to seeing patients.

Participants

The 210 participants were recruited in the U.S. and were broken down into 132 patients and 78 providers. The providers were recruited from the healthcare and pharmaceuticals industry using the SurveyMonkey® Audience service. The provider attributes requested through the audience service were doctor, nurse, and other types of healthcare providers (e.g., dental assistant, phlebotomist). All of the providers indicated that they currently treated patients. Specific attributes (e.g., age or gender) were not requested through the audience service for patient participants. The 126 patient participants had seen a healthcare provider within 12 months. The incentives offered to the participants were a small contribution to a charity of the participant’s choice and an opportunity to enter contests for prizes.

Table 7: Online Survey Questionnaire Participant Demographics

Variable	Attributes	Patients ⁴	Providers
Gender	Male	38	11
	Female	79	54
Age	18–24	6	3
	25–34	17	9
	35–44	16	8
	45–54	23	13
	55–64	36	19

⁴ Most of the questions did not require a response; therefore, the number of answers will not equal 100% of the participants (for both the patients and providers).

Variable	Attributes	Patients ⁴	Providers
	65–74	15	13
	75 years or older	4	2

Method

The online survey questionnaire data collection occurred between October 24, 2015 and October 27, 2015. SurveyMonkey® was the technology used for the online questionnaire. The questionnaires were tailored for each type of participant (Appendix C). The questions were a combination of multiple choice, fill in the blank, and Likert scale format questions.

Patient Online Survey Questionnaire Results

A summary⁵ of the patient participant responses indicated that 40.63% of participants indicated that they did not organize anything prior to attending a doctor’s appointment. It also showed that 96.87% of participants owned a mobile phone with 76.04% of those owners having smartphones. Furthermore, 88.66% of respondents had 11 or more years of experience using computers. The high percentage of participants with smartphones indicates a likelihood that most patients will own the correct technology and have the right skills to use a smartphone PHR app.

The results indicated that the patients may not be inclined to maintain health information using a smartphone app or refer to an app containing it during an appointment. Even though there was a lack of enthusiasm for the idea of maintaining health information with an app, there were exceptions. In terms of medication

⁵ Percentages for patient and provider question summaries are for the specific *n* of respondents for a particular question.

knowledge, the respondents believed that they remembered the name and what the medication was for, but would like a smartphone PHR app to provide an indication about the purpose of a medication (e.g., a heart icon to indicate heart medication).

The patient respondents considered the security of health information important; however, they prioritized the security of financial data higher. Other types of information, such as emails, were prioritized lower than health information. This prioritization makes sense when one considers that the loss of financial information often results in the loss of financial resources through theft, but the loss of health information does not overtly or adversely impact a person's health.

Provider Online Survey Questionnaire Results

Providers indicated that they reviewed multiple sources of information before seeing patients. The question respondents reviewed a patient's EHR (54.55%), paper medical record (33.33%), and/or intake sheet (40.30%) prior to seeing the patient. The respondents believed that the most important features to include on a smartphone PHR app would be medical history, medication list, and complaints organized by review of systems (a technique for reviewing health information with a patient); however, they placed a different emphasis on information organization. Organizing medication information ranked above medical history and problem list in regard to importance.

Most provider respondents owned and operated the right technology to be able to use a smartphone PHR app offered by a primary user, with 100% owning a mobile phone, and 85.07% of them owning a smartphone. Among the respondents, 73.14% had 11 or more years of experience with computers. Technology use by patients would be accepted by the respondents, with 69.05% preferring that the patients referred to their

smartphone PHR app during an appointment. The respondents were split about how they would like patients to share information from a smartphone PHR app with them during an appointment: 25% preferred that the patient email a link, 25% preferred no electronic sharing, and 22.73% preferred that the patient hand them the device.

Regarding medications, 87.80% of the respondents liked the idea of having an external verification indicator of medication list accuracy, with 76.19% of them indicating a willingness to provide such verification for patients. Their willingness indicates that, not only do providers accept the idea of patient use of technology during an interaction, but they would also help patients with data management. The perspective of this group of providers, regarding patient medication knowledge, was consistent with prior research regarding the poor recall of medication names. The respondents indicated that patients typically remembered how often they took a medication (66.67%), what it was for (64.29%), and its color (64.29%).

A way to organize patient complaints for providers was to use the review of systems technique: 94.87% of respondents thought it was a good way to organize information within a smartphone PHR app. The idea of an image of a complaint was less popular. Providers did not believe that a picture would help them diagnose a patient's problem, which makes sense from the perspective that most medical conditions are impossible to photograph with a smartphone camera. However, easy-to-see conditions (e.g., skin rash) are often easy to photograph. These types of images may have some value for secondary users even if a diagnosis could not be reached.

Discussion

The results of the online questionnaire supported prior research that PHR adoption tends to be low among patients. This reluctance to adopt the technology is despite the fact that they have the technology and skills to successfully use a smartphone PHR app. The results indicate that any lack of adoption among patients is likely not related to any objections on the part of healthcare professionals as providers seem willing to allow their patients to introduce the technology into an encounter.

The perspective that patients are not adequately knowledgeable about their own healthcare, particularly regarding medications, was confirmed. The concept of wireless sharing between patient and provider devices—initially supported in the pilot study—was rejected during the interviews. Interestingly, it was embraced by 25% of the questionnaire respondents in the online questionnaire, which implies that no consensus exists on the matter and it is a topic for continued research. There were initially questions about the willingness of providers to become responsible for clinical data from non-clinical sources, but it seems that providers are willing to help patients manage their data. Finally, the appropriateness of the different interaction styles and views of data for patients and providers was supported by the participants.

Phase 3 Conclusion

The final step was to draft a preliminary set of guidelines to inform the final prototype design process. (The guidelines were finalized after the experimental study. See Table 16 for the final guidelines.) The guidelines supplemented the existing design concepts contained in the international standard. The development of supplemental guidelines was done because primary users are still the main operators of the technology

and their interests cannot be superseded by the interests of secondary users. Table 8 maps each guideline to the source(s) from which it was derived.

Table 8: Preliminary Secondary UX Design Guidelines

Guideline	Source
Identify primary and secondary user goals with the system.	Literature, pilot study, and interviews
Expect primary user interactions with the system to affect the secondary user.	Literature and pilot study
Assume that primary and secondary users will have different experiences; however, do not ignore the idea that some experiences will be similar or overlap.	Interviews and online questionnaires
Design for primary and secondary users simultaneously or, if modifying a design originally intended for primary users, ensure that an emphasis on secondary users does not diminish the primary UX.	Literature and pilot study
Understand the unique privacy and security expectations of secondary users (e.g., HIPAA).	Interviews
Primary and secondary users may each hold the device differently, as such, features and functions should anticipate how each receives and manipulates the device.	Literature
The system should provide feedback to secondary users tailored to remove irrelevant or overly complex information without degrading the experience for primary users.	Literature and interviews
Incorporate language and representation for secondary users without degrading the experience of the primary user.	Literature, pilot study, interviews, and online questionnaires
The interface should not impede common forms of communication (e.g., speaking) and should require minimum attention from users so that each user can communicate what is happening while they are interacting with the device.	Literature and interviews
Plan for and perform usability evaluations with secondary users.	Literature and pilot study

Phase 4 (Prototype Development)

Introduction

At the beginning of Phase 4, use cases (see Figure 12) and personas (Appendix D) were produced. A registered nurse (RN) was consulted about the patient intake process

and review of systems before finalizing the use cases. She was consulted as a check to refine concepts about the patient-provider consultation process and to explore ways to incorporate the review of systems into the prototype. The RN had more than 20 years of experience and worked in a skin cancer clinic.

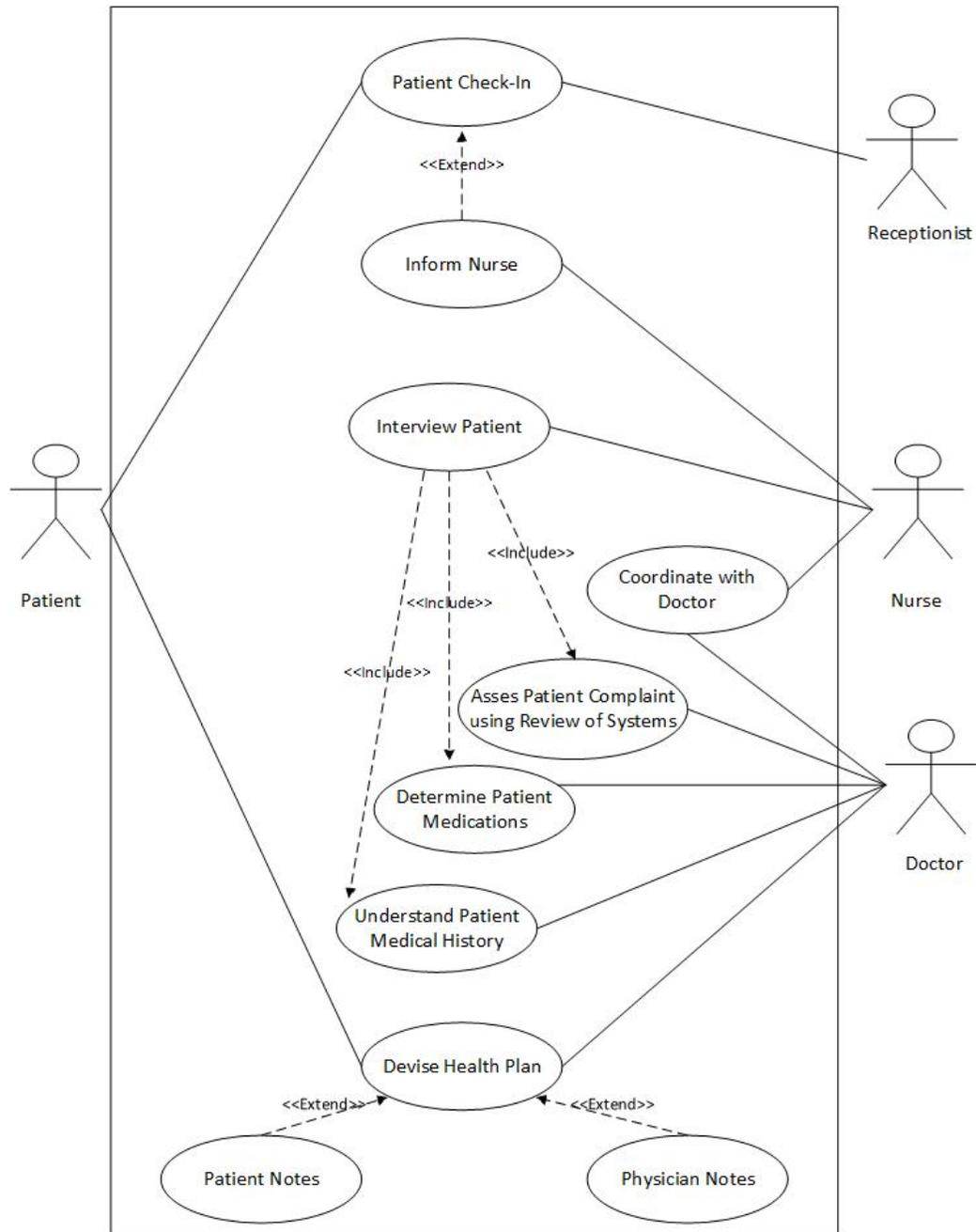


Figure 12: The use case diagram for the final prototype.

Focus Group Session

After the use case diagram was completed, several iterations of the patient and provider interfaces were sketched. Once a satisfactory series of sketches was produced, a focus group session was conducted with the IIC on November 12, 2015. The main purpose of the session was to explore ideas about methods to transition between patient and provider views of information within the prototype. Copies of the sketches (see Figure 13) were given to the eight session participants and the author served as the moderator. A sample of the design ideas from the session are as follows.

- On the start screen, show the icons for switching between the views and give a one-line explanation of each view.
- Use the patient's normal profile picture and the main color throughout the app to indicate the patient view.
- A caduceus was originally used as the icon to indicate the provider's view. It was recommended to use a different icon and different color (perhaps a grayed out main color) to indicate the provider view. Using the caduceus reminded some of the participants of a health insurance indicator.
- Patients and providers should each have unique navigation paths.

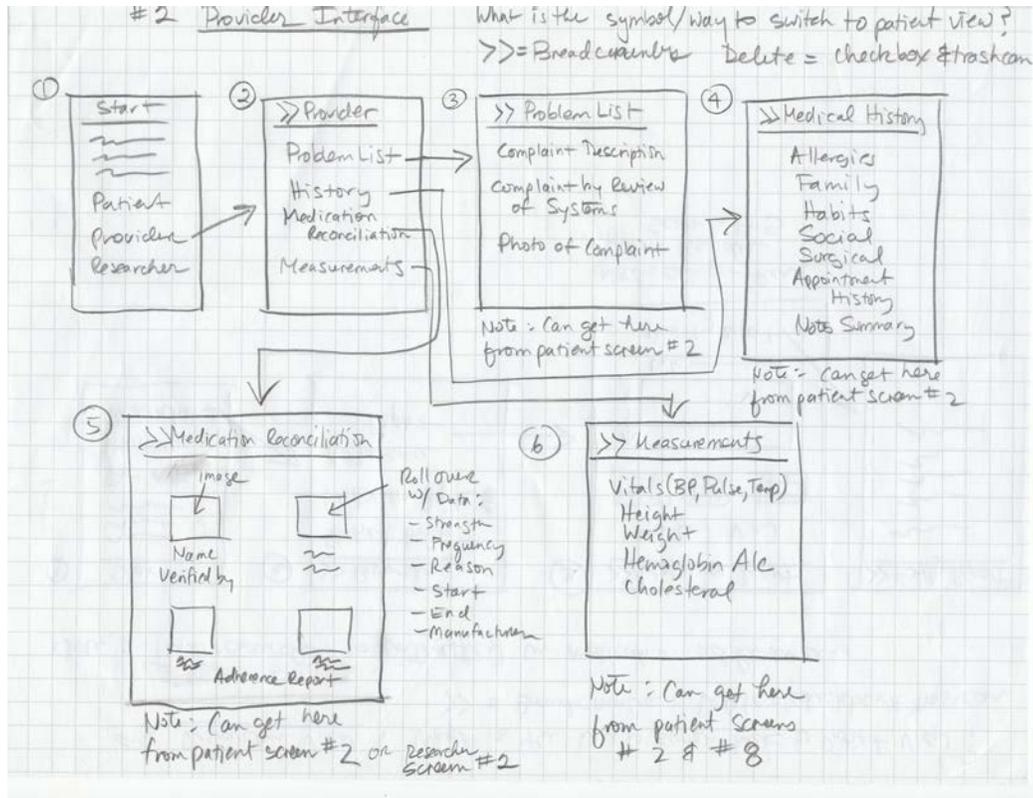
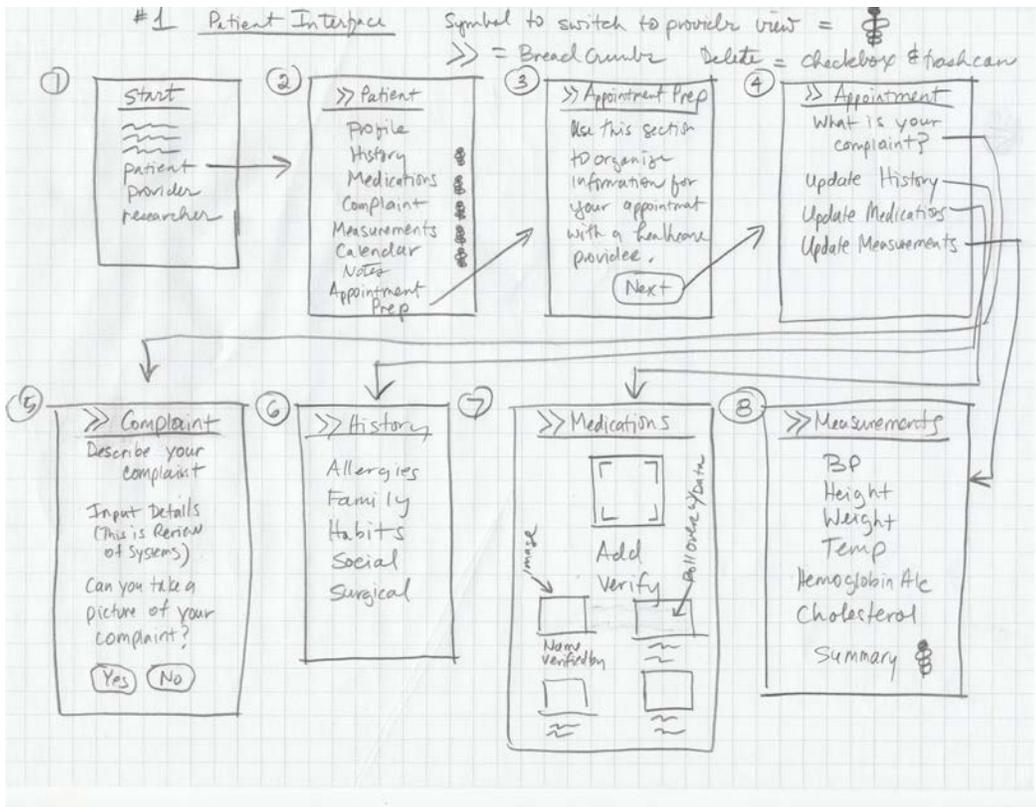


Figure 13: The set of sketches used for the focus group session.

Paper-in-Screen Prototype

After the focus group session, a paper-in-screen prototype was created by converting the sketches into a single PDF file. Interactivity was added to selected features so that a user could realistically transition between screens. The interface was composed of 13 screens broken into three sections: common screens, patient screens, and provider screens. The patient screen titles were color-coded with a blue background, while the provider screens were color-coded with a gray background so that the users would know where they were within the app at all times. There was no color-coding for the two common screens (i.e., the log in and start screens). The prototype was uploaded into Microsoft OneDrive and realistically manipulated by users on a smartphone during subsequent usability evaluations.

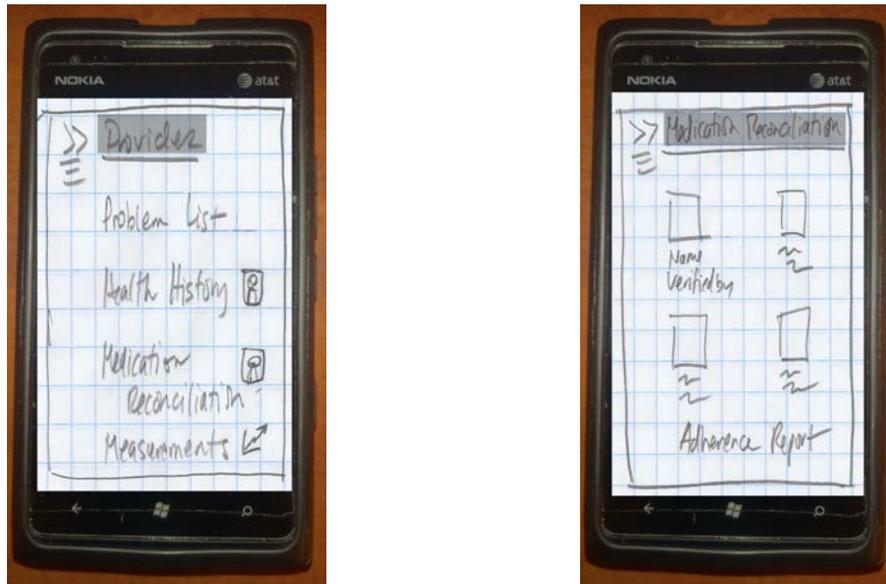


Figure 14: Example of the paper-in-screen prototype showing the provider start screen (left) and medication reconciliation screen (right).

The completed paper-in-screen prototype underwent a heuristic evaluation by the author and a usability evaluation with two participants using the cognitive walkthrough

technique. One participant had more than 20 years of experience in software development and the second was a Ph.D. candidate in HCI. The key insights from the heuristic evaluation and cognitive walkthroughs were as follows.

- Keep in mind the patient workflow and provide the ability for the patient to move to a related provider section regardless of where the patient is within the app.
- The provider will likely not move to a patient section; however, when the smartphone is returned to the patient, he will want to return to the patient section quickly.
- The start screen is unnecessary, place icons to switch to the different views at the bottom of each page. This placement will ensure that, if a user selects the wrong role (e.g., provider instead of patient), he has an escape mechanism to return to the correct role and location within that particular role.
- Add *about* and *help* pages to explain the unique elements of the app, such as the meaning of the different icons for patient and provider.
- Add a notice about security and privacy.
- When the patient is preparing information for an appointment, have a feature that provides a reminder of best practices for using the app during the appointment. The reminder might be linked to the calendar.
- Check to see if there are common colors/icons that providers associate with their roles and with the patient role.
- Consider incorporating the term *symptoms* in the patient section so that they identify the term *problem* with a medical problem.

- In the patient medication section, incorporate a patient notes area for medications so that the patient can add details about the prescription, such as changes to the doses over time.

Final Prototype

Upon completion of the cognitive walkthrough evaluations, the final prototype (<http://mphrtest.org>) was developed in WordPress using a responsive design theme. The prototype underwent multiple usability evaluations before it was finalized. A summary of the usability evaluation results can be found below.

- Review by a likely user (30-year-old female). She noted that a new page (organized as a new top level tab) opened whenever she clicked a link. New top level tabs are a common feature of desktop applications, but provide an annoying experience for users on smartphones. The use of top level tabs was discarded.
- Three Peek (<http://peek.usertesting.com/>) usability tests. Peek provides a short video (approximately 5 minutes) of someone using a website or app on the correct device and commenting using the think aloud protocol. The first evaluation resulted in changes to the icons at the bottom of each page for consistency and attractiveness (e.g., the doctor icon was specifically identified as unattractive). The second and third evaluations resulted in content revisions for clarity and brevity.
- Two cognitive walkthroughs by participants with clinical backgrounds. One participant was a female RN with 13 years of experience who was working as a clinical supervisor in homecare for a major regional hospital. The second participant was a female licensed practical nurse (LPN) with four years of

experience who was working as a telehealth clinical technician in a Veterans Administration (VA) hospital.

- The RN noted that how primary users interact with secondary users can be based upon the primary user's personality. A "chatty" person will want detailed information within the app (e.g., when does a typical seasonal allergy manifest and what are the symptoms), so that he can talk through the details with the provider. A stoic person, in contrast, may prefer to hand off the device, so the information needs to be succinctly organized for the provider. Other comments included breaking out certain information categories separately and adding alternate names to the patient interface for medications (i.e., generic and brand names) because patients often get confused if they are prescribed the same medication by a different name.
- The LPN noted that the VA uses a Computerized Patient Record System (CPRS) that includes a series of templates for consults by clinic. She recommended using a similar system of templates (reverse engineered for patients) for problem lists and health histories. Templates make input easier for the primary user and the secondary user view more relevant because they are reverse engineered from templates based upon clinical information. When images are included, the provider should be able to adjust them (e.g., zoom into a particular spot or lighten them). She noted that skin problems might be easier to discern if the provider could

manipulate the image. Finally, the addition of side effect information to the patient view of medications was recommended.

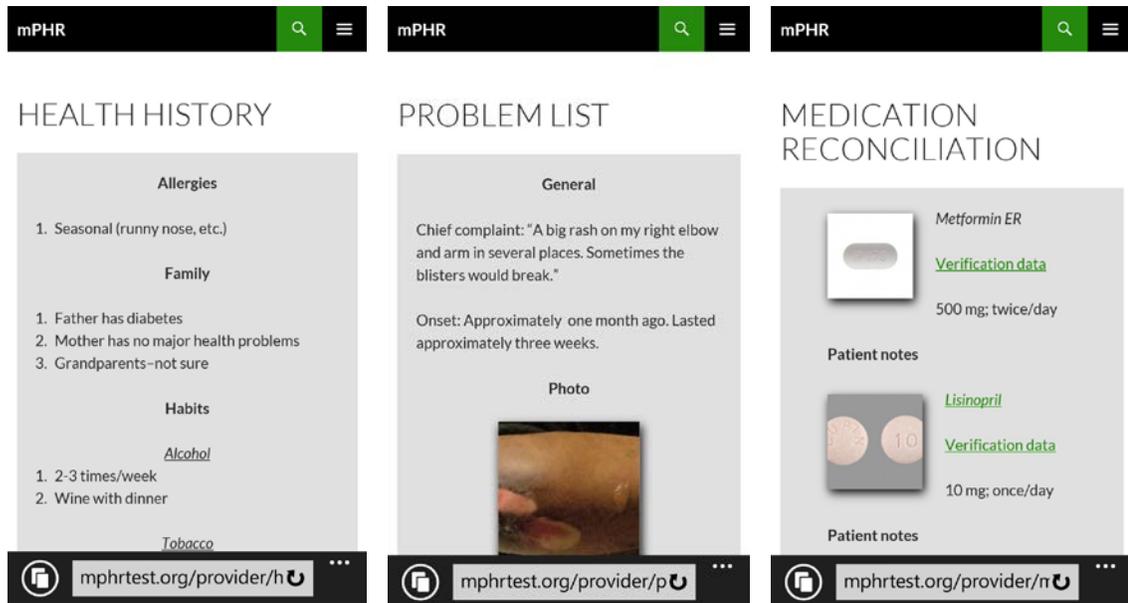


Figure 15: Sample screen captures of the final prototype: history (left), problem (center), and medications (right).

Phase 4 Conclusion

Patient workflow was considered in the design in order to ensure that the manipulation and use of the prototype would be as realistic as possible during the simulation (Ozkaynak et al., 2013). Regarding the secondary user's workflow, as the user's interest and familiarity with the information within the device increased, his need for control might also increase. This factor was addressed during the usability evaluations. Both the primary and secondary user tasks were incorporated into the evaluations in order to explore how transitions are made by each type of user and how secondary users might attempt to go deeper into the information.

The usability evaluations were important because, as Wisniewski (2011) has noted, a major difference between using a smartphone for a computing task and other

devices is the ergonomics of holding a smartphone. Furthermore, people hold smartphones differently based upon the types of tasks they are performing (Hooper, 2015). As such, users have multiple choices about how they interact with mobile devices. Something as simple as handing the device back and forth between different users, with the device oriented in portrait or landscape view potentially impacts the UX if the design does not ensure that the view of the information responds properly to changes in the device orientation.

CHAPTER FOUR: METHOD

Experiment Design Overview

Once the treatment tool was finished, an experimental study was conducted. The study consisted of simulated face-to-face clinical encounters in which an actor role-played a patient and experienced clinicians were the study participants. The experimental design was a post-test-only control group, with randomization and matching to ensure a similar number of doctors were assigned to the control and treatment groups (Babbie, 2011). The presence of the prototype was used as the treatment. The study was designed to answer the two research questions:

RQ₁: To what extent do smartphone apps designed using collaboration mechanics support grounding between primary and secondary users during face-to-face collaborations?

RQ₂: To what extent do smartphone apps designed to support grounding impact secondary users' satisfaction during face-to-face collaborations?

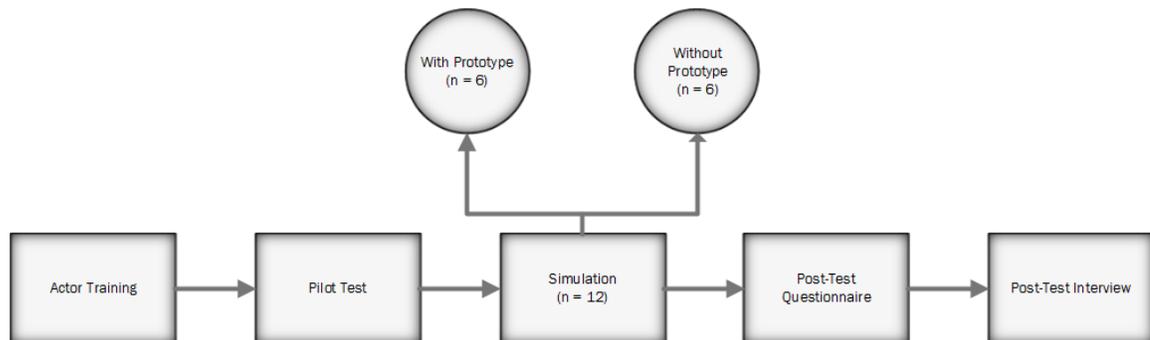


Figure 16: Model of the experimental design.

Participants

Fifteen nurses and doctors participated in the experimental study, with 12 included in the final analysis. The first two participants (February 10, 2016 and March 5, 2016) were not included in the final results because they were used as a pilot test for the

scenario, questionnaires, video recording simulations, and audio recording interviews. The pilot test participants consisted of a doctor in the control group and an advanced practice registered nurse (APRN) in the treatment group. After the pilot test, additional participants were recruited using snowball sampling and email solicitations. As an incentive, the participants were rewarded with a \$15 Amazon.com gift card. An adult male with physical characteristics closely matching the scenario, with more than a decade of professional and community theater acting experience, was hired at a rate of \$20/hour to role-play the patient. The same actor was used to role-play the patient for all simulations.

During a later iteration of the study, one participant became frustrated during the simulation and requested that the video recording cease. The subsequent interview revealed that she normally used an EMR and followed a standardized routine when interviewing patients (an EMR was not provided as part of the scenario). The lack of an electronic tool made her feel as if she was not providing quality service to the patient (role-player), which caused her to become frustrated and culminated in her request to cease the video recording. These results were excluded from the final analysis.

The backgrounds of the final 12 participants, by assignment to control group and treatment group, are shown in Table 9. Two of the participants were educators and no longer interacted with patients. One (APRN) had transitioned to teaching within the past six months and the other (RN) had 19 years of prior nursing experience. A third provider (RN) had recently shifted to case management. The RN working in case management had transitioned to the new job within the past six months. Unlike the educators, she did interact with patients routinely; however, her current interactions were telephonic. She

also had more than 25 years of experience in nursing. The three participants had the necessary skills to perform the scenario tasks and were qualified for the study.

Table 9: Participants' Backgrounds (12 Participants)

Control Group	Practice/Specialty	Treatment Group	Practice/Specialty
APRN	Geriatric	Doctor	Pulmonary Medicine
APRN	Geriatric	RN	Case Management
Doctor	Internal Medicine	RN	Clinical Education
Certified Nurse Midwife	Midwifery	APRN	Internal Medicine
RN	Intensive Care/IV Team	RN	Perioperative Nursing
Doctor	Internal Medicine	Doctor	General Surgery

The professional experience of the participants varied from less than one year to more than 25 years. All of the participants owned smartphones and had 11 or more years of experience using computers. Nine of the participants reported owning tablet computers. The participants who currently or recently (within the past six months) worked with patients had experience with electronic charting.

Table 10: Participant Demographics (12 Participants)

Variable	Attribute	Control Group	Treatment Group
Gender	Male	2	1
	Female	4	5
Age	25–34	1	0
	35–44	3	3
	45–54	2	3
Years of Experience	< 1	1	0
	1–5	3	0

Variable	Attribute	Control Group	Treatment Group
	6–10	2	1
	11–15	0	0
	16–20	0	1
	21–25 years	0	2
	More than 25 years	0	2

Materials and Procedure

The experimental study was conducted between February 10, 2016 and May 17, 2016 in two large Midwestern cities. The prototype was developed as a WordPress website so that it could be accessed regardless of smartphone manufacturer and operating system (OS). The actor’s personal smartphone, a Samsung Galaxy Prevail LTE Android Version 4.4.4, was used to access the prototype during all simulations. Patients can be expected to become familiar and confident with their personal technology because of its daily use by them. The concept of patient familiarity and confidence was operationalized by allowing the actor to use his personal device.

The providers received minimal information during the scenario briefing (Appendix E). The scenario required the provider to see a patient for the first time in a simulated encounter. The reason for the patient’s visit was that he had suffered a rash, which had healed and was no longer visible. For the control group, the patient mimicked patient behavior of a typical encounter by relying on memory to share information with the study participant about the problem that had sparked the visit (rash), health history, and current medications. The treatment group, on the other hand, was shown an image of the rash (see Figure 17) by the actor in addition to receiving a verbal description of the

ailment. The image used for the rash was of a patient with bullosis diabeticorum, a blistering condition that heals in a few weeks.



Figure 17: Image used in the prototype to show the patient's past ailment.

Note. Image adapted from “Bullosis diabeticorum: Rare presentation in a common disease,” by V. Gupta, N. Gulati, J. Bahl, J. Bajwa., and N. Dhawan, 2014, *Case Reports in Endocrinology*, p. 2.

Other ailments for the patient included Type 2 diabetes, obesity, hypertension, and high cholesterol. Four medications (see Table 11) were part of the patient profile. Details about the medications were shared with the treatment group from the prototype (see Figure 18) by the actor. The prototype was not offered to members of the treatment group for the medical history task unless they specifically made a request to look at the information on the device (there were no provider requests to review medical history on the prototype).

Table 11: Scenario Patient Medication Profile

Medication	Dose	Frequency	Reason
Metformin ER	500mg	Twice/day	Diabetes

Medication	Dose	Frequency	Reason
Lisinopril	10mg	Once/day	Blood pressure
Atorvastatin	80mg	Once/day (night)	Cholesterol
Glipizide	2.5mg	Three/day w/meals	Diabetes

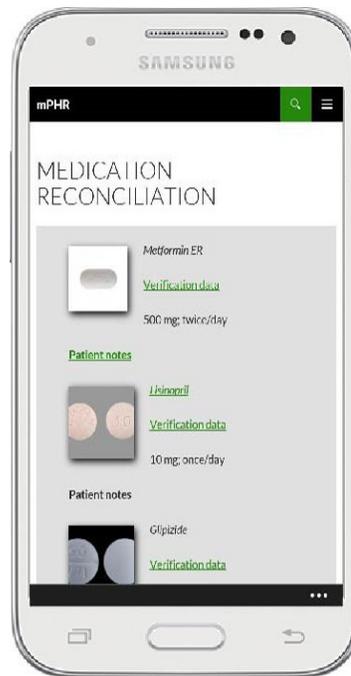


Figure 18: Example Samsung Galaxy Prevail LTE with medications.

Variables

The independent variable was the presence or absence of the prototype smartphone PHR app. The dependent variables were common ground and secondary user satisfaction. The participant's perception of performance was also measured because of its likely impact upon satisfaction. Common ground and the remaining variables were measured by analyzing the simulation videos, Likert scale responses, and interview

transcripts. The details of the three measures to evaluate the presence or absence of the treatment are:

1. Video recordings. The simulation was video recorded for later analysis with NVivo 11.
2. A 7-point Likert scale questionnaire (Appendix F). Upon the conclusion of the scenario, the participants completed the questionnaire, which was composed of demographic questions and a set of 15 psychometric scales measuring satisfaction, common ground, and performance.
3. A semi-structured interview (Appendix G). The interview was conducted with the participants after the simulation. The results were transcribed using the *TranscribeMe!* service provided through NVivo 11. The transcriptions were *clean verbatim* in which filler words (e.g., umm, ah, and you know) were removed. Irrelevant concluding remarks were deleted (e.g., closing courtesies). The transcriptions were of good quality. When errors were discovered, they were reviewed, crosschecked, and corrected based upon the audio recordings.

Even though the study was conducted using mixed methods, the emphasis was on rich qualitative data, which is gained when saturation is reached. The sample size was deemed adequate because saturation had been reached during earlier phases of this project using qualitative data collection with similar sized groups. Saturation was, in fact, achieved during the experimental study. The statistical power analysis indicated that the sample size was too small for hypothesis testing (Cohen, 1992). In lieu of this type of testing, descriptive statistics were used to compare interactions with and without the

presence of the prototype. These factors ensured adequate investigation of the dependent variables.

Validation

Thematic analysis, the most common approach used in healthcare research, was used to analyze the transcripts and videos (Pope, Ziebland, & Mays, 2006). The 7-point Likert scale post-test questionnaire was based upon work done in prior studies (Convertino et al., 2008; Convertino et al., 2007; Convertino, Neale, Hobby, Carroll, & Rosson, 2004).

The orientation and training of the role-player was extensive. The actor reviewed online videos of simulated clinical encounters that included the tasks required for role-play. After reviewing the videos, a rehearsal training session (February 3, 2016) with an experienced RN (13 years), who has a Ph.D. (Nursing Science) and is an assistant professor of nursing at a large Midwestern university, was conducted. After the session, the simulation documentation was revised and a checklist to assess treatment fidelity (Appendix H) was created. The checklist enhanced the internal and external validity by ensuring that the role-player addressed standardized areas with providers and ensured that the study could be replicated (Borrelli, 2011). A second rehearsal using the treatment fidelity checklist as a guide was telephonically conducted with the actor on February 9, 2016. A pilot test (described earlier) and review of the pilot test simulation videos with the actor was completed before beginning the study.

Procedure

The study was performed at a location selected by the providers. Hospital treatment rooms and administrative or public spaces in medical facilities and academic

buildings were typical. At the beginning of each iteration, the provider was asked to review the study information sheet. The scenario was reviewed with the provider, who was then provided with a pen, clipboard, and paper for taking notes during the simulation. Next, the simulation began and was video recorded.

Due to the different specialties and practices encountered during the study, it was impossible to anticipate the flow of the conversation during each simulation. The actor was authorized to incorporate real life experiences as necessary to maintain realism during the simulation. For example, discussions about diet and exercise mimicked the role-player's real life experiences.

After each simulation, the role-player's performance was reviewed and behaviors corrected as necessary. The potential effect of actor learning was controlled through training, the use of checklists for treatment fidelity, and counterbalancing between the control and treatment groups (Borrelli, 2011; MacKenzie, 2013). Consistency was maintained as much as possible. Minor errors completed by the actor did not disrupt the study as long as the actor was consistent throughout the duration of the simulation.

CHAPTER FIVE: RESULTS

Thematic Analysis

A thematic analysis of the videos and semi-structured interview transcripts was performed using NVivo 11. The videos were coded by importing them into NVivo 11, reviewing each video within the software, selecting parts along the range of the media using the software tools, and assigning the range to an appropriate coding container. Summary transcriptions of the videos were also created within NVivo 11, showing general topics of conversation at selected points in the video (e.g., medication reconciliation or problem identification). The audio recorded semi-structured interviews were transcribed, as described earlier, and coded within NVivo 11.

There were three rounds of coding with the first round being done manually within the software. The second round relied upon the analytical software tools of NVivo 11. The third round scrutinized the data based upon membership in the control or treatment group and evaluated how the content diverged thematically between the groups. Since both groups accomplished a substantial level of grounding for the medical history task, it was not coded in detail because the analysis of the task, in and of itself, would not contribute to answering the research questions.

Prior to starting the first round of coding, several concepts were selected *a priori* to initially organize the data. The selection of the concepts was derived from how the data might relate to common ground and secondary user satisfaction. The initial organizing concepts were *common ground established*, *grounding not occurring*, *grounding occurring*, *provider not satisfied*, and *provider satisfied*.

The purpose of the first round of coding was to refine the five initial organizing concepts into broad areas of interest for further analysis. The transcripts and videos were reviewed and statements were coded into the concepts. As the coding continued, the concepts were reorganized based upon the trends identified during the coding. Several insights led to the identification of a final group of concepts for the first round.

There were several insights from the first round of coding for the control group. Providers in the control group listened to information about the rash and informed the patient that, if it came back, he should contact them immediately.

The rash, that was difficult because once he described the rash, I thought of probably three things it could have been. So, maybe that was probably about an eight [out of 10] difficulty just because it's not there anymore. So, I can't treat something or even tell him what it is without having seen it. I can't treat something I can't see. Participant 3-C (APRN)

Little grounding occurred in this instance because the rash was gone and the role-player's verbal description was of limited utility to the providers.

Grounding was also poor during the medication reconciliation task. None of the providers felt that they had a complete enough medication list to act upon.

What I didn't know were his medications, and I didn't want to guess. I needed that information, but I just have to find it from another source or ask him next time to bring his medications. Participant 2-C (APRN)

The participants indicated that this situation—patient lack of knowledge about their medication details—was typical of encounters with new patients.

The insights from the first round of coding for the treatment group indicate that communication between members of the dyad was enhanced by the technology. In the treatment group, much like the control group, no diagnosis was offered about the origin of the rash. Providers universally liked being able to see the rash image, but its true impact on grounding was difficult to determine. For example, Participant 3-T (RN)

commented “that [the rash] was something I didn't feel we were able to resolve.” This statement clearly indicates a lack of grounding. However, during the same interview, she found the picture helpful because “in this particular case, ... it could rule out some things.” This statement indicates that some grounding occurred.

Common ground was established during the medication reconciliation with the treatment group. An additional benefit of this task was that the technology allowed some of the providers to seek granular information. For example, Participant 2-T (Doctor) asked: “That says it’s an extended release, do you take that once a day or twice a day?” The task was concluded with the question: “Are those the pictures of your actual medicines?” (The role-player answered both questions affirmatively.) The prototype tended to allow deeper engagement with the patient by the provider. Grounding during medication reconciliation occurred quickly and the ease of the task performance was enhanced by the use of the prototype.

Oftentimes, patients don’t know what medications they're taking, they don't know why they're taking them. The fact that he had that on his smartphone made it very easy. It was accessible and he was just open and friendly and so that made it just that much more pleasant. Participant 3-T (RN)

In general, providers in the treatment group felt very satisfied with the quality of the interaction and believed that it was enhanced by the introduction of the prototype.

There were several conclusions from the first round of coding. During the first round of coding, concepts were merged, revised, and discarded as patterns became more obvious. The concepts that ultimately resulted from this coding are listed alphabetically below.

- *Ambiguous grounding*. This concept means that some grounding is probably occurring, but its effectiveness cannot be determined.

- *Common ground established.* This concept means that the grounding is complete, the patient and provider have certain knowledge in common, and each knows that they have this level of shared knowledge.
- *Good grounding occurring.* This concept means that grounding is occurring and it supports the creation of common ground for a scenario task.
- *Grounding not occurring.* This concept means that there is a series of joint actions, but they are not sufficient to positively move toward the creation of common ground for a scenario task.
- *Grounding to resolve a lack of information.* This concept means that grounding is occurring to develop a workaround to counter the inability of the patient and provider to reach common ground.
- *Improving the potential for grounding.* This concept means that the provider has described ideas about how to create common ground between patients and providers during the type of encounter simulated in the experimental study.
- *Information gathering.* This concept means that the provider is conducting some form of information gathering related to the scenario tasks that has a minor impact upon grounding or is neutral as far as impact upon the scenario tasks.
- *Information quality (-).* This concept means that the quality of information was considered to be poor.
- *Information quality (+).* This concept means that the quality of information was considered to be good.
- *Patient education.* This concept means that patient education related to the scenario tasks was performed.

- *Provider not satisfied.* This concept means that the provider was not satisfied with some aspect of the communication.
- *Provider personal confidence.* This concept means that the patient provided information that did not necessarily contribute to grounding, but did impact provider confidence. (The impact was generally positive.)
- *Provider satisfied.* This concept means that the provider was satisfied with some aspect of the communication.

The second round of coding began with the creation of a basic concept map (see Figure 19). The map was built in order to sort the concepts that resulted from the first round of coding and aid in reorganizing them into a hierarchical system for analysis. The purpose of this round of coding was to identify related concepts, reorganize them structurally, and continue coding using analytical software tools. The concept map depicts three broad classes of data as described below.

- *Indicators of task relevant joint actions.* These indicators are signs that the necessary joint actions for grounding are occurring and the joint actions will build common ground related to the scenario tasks.
- *Indicators of non-task productive joint actions.* These indicators are signs that joint actions for grounding are occurring, but the joint actions are unlikely to contribute to common ground related to the scenario tasks.
- *Unknown contribution to meaningful grounding.* These indicators are signs that joint actions are not occurring or they are failing. Ideas to improve grounding in the future for similar encounters are also included in this class.

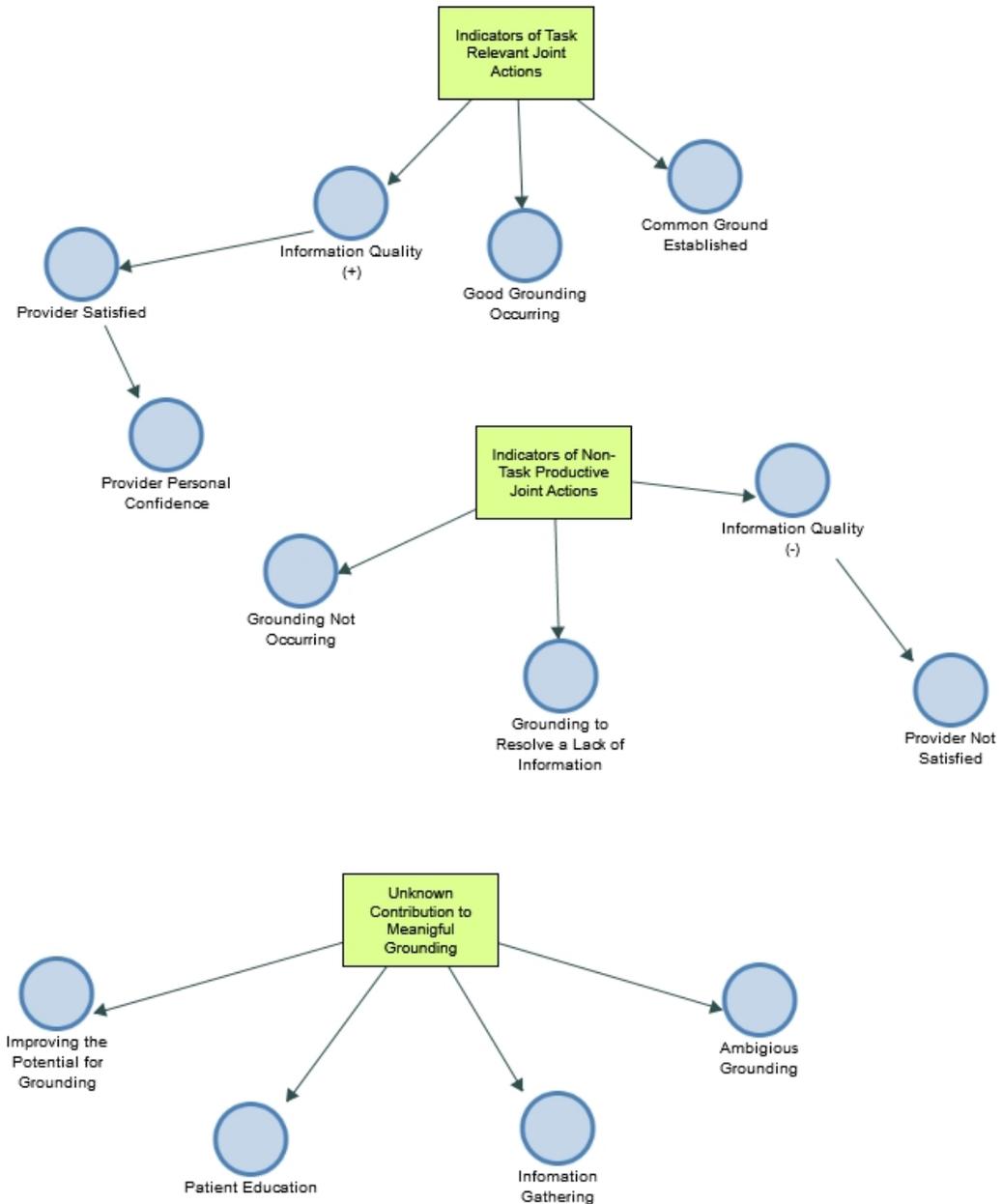


Figure 19: The concept map showing the hierarchical relations between the concepts.

Both categories of indicators of joint actions had value in regard to answering the research questions and were selected for additional analysis. The category *unknown contribution to meaningful grounding* presented low utility for answering the research questions and was excluded from further analysis. Next, visualization tools were used to assess the efficacy of the coding previously performed and show the relations among the

concepts so that they could, eventually, be organized into themes. Visualizations were also useful when exploring the strengths and weakness of common ground within the control and treatment groups.

As a check on the efficacy of how the simulation videos and interview transcripts were coded, a cluster analysis on the coding similarity was performed. The videos and transcripts for the respective groups clustered generally together by type (i.e., video or transcript) and group (i.e., control or treatment). The exception was found in the clustering of the transcripts for participants 3-T (RN) and 4-C (Doctor), which clustered together. The general agreement in coding similarity shows a high level of consistency and is a good check on reliability.

As a check on the efficacy of how related concepts were coded and subsequently organized, a cluster analysis on the coding similarity of the concepts was performed. The subordinate concepts for the *indicators of non-task productive joint actions* clustered together and the subordinate concepts for the *indicators of task relevant joint actions* clustered together. The cluster analysis is a good check that demonstrated the appropriateness of the broad categories identified during the concept mapping.



Figure 20: The clustering of concepts to show similarities by coding.

A comparison of the diagram of the coding between the *indicators of task relevant joint actions* and *indicators of non-task productive joint actions* was created using the software analytical tools. The diagram showed that audio files for three members of the control group (2-C, 5-C, and 6-C) and three control group video files (3-C, 6-C, and 8-C) were coded exclusively in the non-task productive group. Audio files for three members of the treatment group (2-T, 4-T, and 7-T) were coded exclusively in the relevant joint actions group as was one treatment group video file (7-T). This categorization indicates that (1) common ground was a challenge to obtain throughout the control group and (2) grounding was strongest in the treatment group. The diagram further indicated that grounding occurred most strongly during the encounter with Participant 7-T (Doctor) and was weakest with Participant 6-C (RN).

Next, a query was run to see how participants 7-T and 6-C were coded. Since these participants demonstrated the strongest examples of grounding and not grounding, the query was used to highlight agreement and divergence. There was some agreement regarding provider satisfaction with the information obtained, which was not surprising. Throughout this research, the providers indicated that patients often lacked knowledge about their own health statuses. Thus, it is not surprising that Participant 6-C would be satisfied with the amount of information provided by the role-player, since providers indicated his acting was consistent with the realities most of them had encountered in their respective practices.

Participants 7-T and 6-C differed in terms of grounding. Participant 7-T obtained information that led to good grounding and resulted in the achievement of common ground. Participant 6-C had difficulty obtaining the right information for grounding.

There were instances when grounding for this participant happened to resolve a lack of information and instances when it did not occur at all. The evaluation of the differences in grounding between participants 7-T and 6-C concluded the second round of coding. The second round of coding was useful for evaluating the reliability of the coding, exploring the data, and showing the strength of the relations between the concepts.

The third round of coding was used to break out details of the data to satisfy the research questions by identifying the themes for the control and treatment groups. A matrix query (see Table 12) by assignment to experimental group was run to display the frequency of the coding in each major category of joint action. The query results highlighted a higher rate of grounding coding among members of the treatment group. The analytical tools of the software were used to perform word frequency and text searches of the transcripts. Coded portions of the video files were also reviewed.

Table 12: Matrix Query Results

Indicators	Examples	Control Group	Treatment Group
Indicators of Non-Task Productive Joint Actions	<p>“I would have loved to have seen the rash when it was there.” Participant 2-C (APRN).</p> <p>“We can always either call his pharmacy to verify medication, or call his other physician.” Participant 6-C (RN).</p>	48	10
Indicators of Task Relevant Joint Actions	<p>“It’s like as if he brought his bottles of medications with him, without actually having them there.” Participant 4-T (RN).</p> <p>“The medications that he showed me on his phone looked like medications that yes, that he should have.” Participant 3-T (RN).</p>	9	48

The four most frequent terms discovered during the word frequency search of the *indicators of non-task productive joint actions* were *information, just, rash, and medications* (in order). The terms were used for a subsequent text search (with

synonyms) in order to explore their context of use. There was a 17% higher usage of the terms among members of the control group than the treatment group. After reviewing the context for the terms and selected video content, two themes emerged, which are discussed below.

- *A lack of common ground leads to near term planning uncertainty*, which means that not enough information exists to formulate a specific plan of action. Workarounds had to be devised to determine how to collect the information necessary to enable better treatment.
- *External measures are required to support grounding*, which means that interactions with external resources, such as the patient's pharmacy or another provider, were necessary to get precise medication information and necessary for the interaction to productively continue.

The four most frequent terms discovered during the word frequency search of the *indicators of task relevant joint actions* were *like*, *think*, *information*, and *medications* (in order). The terms were used for a subsequent text search (with synonyms) in order to explore their context of use. There was a 41% higher use of the terms among members of the treatment group than the control group. After reviewing the context for the terms and selected video content, three themes emerged, which are discussed below.

- *The patient is engaged in his own healthcare*. If a patient is willing to take the time to manage his health information electronically, then it is an indication that he is engaged in his own healthcare.
- *The information is trustworthy*. The use of sophisticated technology implies a higher trustworthiness of information or, at least, the same level of

trustworthiness as other traditionally accepted (but low use) methods, such as bringing medication bottles to an appointment.

- *Enough information at an acceptable level of quality for some level of decision-making is obtained.* This amount of information and its quality does not mean that there is a diagnosis. It means that better planning is performed with the patient, even if that plan is to do nothing.

Quantitative Analysis

The quantitative analysis of the time on task provided insight about efficiency and effectiveness. Each video was studied to assess the amount of time spent on the three scenario tasks (i.e., problem identification, medical history, and medication reconciliation) and the percentage of time the tasks consumed of the entire encounter. In addition to the basic scenario tasks, patient education was a discussion topic in the post-test interviews for most participants. Since patient education was a topic of broad concern to the providers, patient education discussions about the rash, medical history, and medications were identified and coded for the time analysis. Time spent on general nutrition, health and fitness, and similar counseling was not evaluated. Means, standard deviations, maximums, and minimums were calculated using SPSS 23 (see Table 13).

The descriptive statistics for the task times (see Table 13) were useful for inferring evidence of communication efficiency for the providers. In general, the role-player's use of the smartphone seemed to improve provider efficiency during the encounter. Overall encounter and task times averaged slightly faster in almost every instance for the treatment group than the control group. Task times were faster in the control group for the medical history task, which can be explained by the fact that not all

providers completed the task. As such, the overall mean is artificially reduced for the control group. Finally, standard deviations generally clustered more closely around the mean for tasks in the treatment group than the control group.

A benefit of the quicker times seems to be that providers had more time to conduct patient education discussions. The mean for every education task is higher for the treatment group than the control group. This difference likely contributed to the higher percentage of the encounter time overall spent on the three tasks by the treatment group. The emphasis on performing task relevant patient education is another indicator of a more efficient use of time and implies a more *effective* use of time since the providers considered patient education important.

Table 13: Descriptive Statistics for Encounter and Task Times

Group		Encounter	Rash	Ed	Med Rec	Ed	History	Ed	Tasks	% Tasks
Control	Mean	0:12:45	0:02:52	0:00:18	0:03:03	0:00:17	0:01:25†	0:00:00†	0:07:57	67%
	Median	0:11:09	0:02:08	0:00:00	0:02:37	0:00:00	0:00:57†	0:00:00†	0:07:40	N/A
	SD	0:06:19	0:02:33	0:00:44	0:00:58	0:00:29	0:01:43†	0:00:00†	0:02:39	N/A
	Min	0:06:35	0:01:12	0:00:00	0:02:33	0:00:00	0:00:00†	0:00:00†	0:04:41	N/A
	Max	0:25:05	0:08:02	0:01:50	0:05:02	0:01:13	0:04:10†	0:00:00†	0:11:25	N/A
Treatment	Mean	0:12:22	0:02:40*	0:00:19*	0:02:24†	0:00:36†	0:02:46†	0:00:23†	0:09:11	76%
	Median	0:12:30	0:02:02*	0:00:00*	0:02:11†	0:00:00†	0:02:23†	0:00:00†	0:09:12	N/A
	SD	0:02:38	0:01:36*	0:00:31*	0:01:05†	0:00:58†	0:01:38†	0:00:57†	0:01:49	N/A
	Min	0:08:47	0:01:44*	0:00:00*	0:01:09†	0:00:00†	0:00:54†	0:00:00†	0:06:45	N/A
	Max	0:15:40	0:05:53*	0:01:13*	0:04:14†	0:02:14†	0:05:04†	0:02:21†	0:11:16	N/A

Note. Rash = Time discussing rash, Med Rec = Time discussing medications, History = Time discussing history. Ed = Patient education time for a task (to the left of the Ed). % Tasks = Percentage of encounter time spent on the three tasks. The * = partial common ground achieved. The † = common ground achieved.

The quantitative analysis of the post-test questionnaire examined secondary user perceptions of satisfaction, common ground, and performance. For the post-test questionnaire, a Cronbach's α reliability analysis (see Table 14) was performed on all of the subscales using SPSS 23. In order to improve the reliability of the satisfaction subscale, two items were removed. This removal increased the reliability to $\geq .80$, which is good reliability (Gliem & Gliem, 2003). Reliability for the common ground and performance subscales were $\geq .80$ and $.90$, respectively, which are good and excellent reliabilities, respectively (Gliem & Gliem, 2003).

Table 14: Subscale Reliability Analysis

Characteristics	Cronbach's α	No. Items
Satisfaction	.824	3
Common Ground	.892	6
Performance	.981	4

The descriptive statistics for each subscale (see Table 15) show higher means for the control group than the treatment group, indicating that members of the control group perceived that they had a higher level of satisfaction, common ground, and performance than members of the treatment group. Standard deviations show better clustering around the mean for the treatment group on each subscale, which could indicate a better consensus among the treatment group members, reflecting a more accurate evaluation of satisfaction, common ground, and performance than in the control group.

Table 15: Descriptive Statistics for the Post-Test Questionnaire Subscales

Group		Satisfaction	Common Ground	Performance
Control	Mean	5.83	5.94	5.83
	SD	1.44	1.25	1.54
	Min	3.00	3.83	3.00
	Max	7.00	7.00	7.00
Treatment	Mean	5.67	5.75	5.25
	SD	1.01	0.43	0.98
	Min	4.33	5.17	4.00
	Max	6.67	6.17	6.00

Final Design Guidelines

Another end result of the experimental study was to validate the preliminary design guidelines. Many features and functions implemented in the technology were useful for establishing common ground during the simulations. Others less so, and still others provided no obvious value for common ground during the experimental study. After the experimental study data was evaluated, the guidelines were revised into a final set of secondary UX design guidelines. The guidelines are included in this section. Examples from the prototype for each guideline are provided to highlight how a respective guideline was implemented. One guideline was of little or no value and it is lined through. Two new guidelines, identified as the result of the experimental study, are italicized.

Table 16: Final Secondary UX Design Guidelines with Examples

No.	Guideline	Source	Example
1	Identify primary and secondary user goals with the system.	Literature, pilot study, and interviews	The primary user manages information with the language of a lay person while the secondary user consumes it from a clinical context. Example: the patient enters his problem using lay language and it is presented to the provider using review of systems.
2	Expect primary user interactions with the system to affect the secondary user.	Literature and pilot study	The primary user initially retrieves information and configures the device for the secondary user. Example: the patient and provider buttons at the bottom of each screen allow the primary user to switch back and forth between the respective views of information.
3	Assume that primary and secondary users will have different experiences; however, do not ignore the idea that some experiences will be similar or overlap.	Interviews and online questionnaires	Some information is not complex or difficult to recall. Example: the patient health history was easy for the patient to verbalize and was not difficult for the provider to interpret.
4	Design for primary and secondary users simultaneously or, if modifying a design originally intended for primary users, ensure that an emphasis on secondary users does not diminish the primary UX.	Literature and pilot study	Different views of the same information specifically organized for each user (primary and secondary). Example: patient and provider screens each have unique identifying attributes (different background colors) so the primary user can easily differentiate between primary and secondary user views of the information.
5	Understand the unique privacy and security expectations of secondary users (e.g., HIPAA).	Interviews	Patients have personal concerns about privacy and security due to theft and other consequences regarding the loss of personal information. Providers have professional concerns regarding health information and how electronic sharing might compromise their office healthcare systems. Example: electronic sharing of information between provider and patient was not implemented.
6	Primary and secondary users may each hold the device differently, as such, features and functions should anticipate how each receives and manipulates the device.	Literature	Providers may want to manipulate the information to glean more refined information. Example: a provider expands the view of the rash to see more detail.

No.	Guideline	Source	Example
7	The system should provide feedback to secondary users tailored to remove irrelevant or overly complex information without degrading the experience for primary users.	Literature and interviews	Secondary users do not need full access to data that primary users may require. Example: primary users need forms to enter and update health data while secondary users do not.
8	Incorporate language and representation for secondary users without degrading the experience of the primary user.	Literature, pilot study, interviews, and online questionnaires	The different decisions required from primary and secondary users require different information. Example: the primary user can easily configure relevant information for the secondary user through the use of unique buttons on each page that switch between different views of the same information.
NA	The interface should not impede common forms of communication (e.g., speaking) and should require minimum attention from users so that each user can communicate what is happening while they are interacting with the device.	Literature and interviews	This guideline was unnecessary and was not implemented because the form factor and size of smartphones typically does not block the view of speakers from one another and inhibit their personal face-to-face communication.
9	Plan for and perform usability evaluations with secondary users.	Literature and pilot study	Recruit from different populations. Example: patients and providers both participated in usability evaluations.
10	<i>Consider how to incorporate design elements that can be perceived from a distance to improve secondary user interaction with the smartphone.</i>	<i>Experimental study</i>	<i>This guideline was not implemented in the prototype, but should be in future iterations. Example: Secondary user screens can use a different font color and/or size to enhance visibility from a distance.</i>
11	<i>Some information incorporated for the secondary user will be irrelevant for the primary user, but the primary user will still have to know how to configure it for the secondary user.</i>	<i>Experimental study</i>	<i>Clinicians may have a protocol that they prefer to use to evaluate information provided by patients. Example: using review of systems to organize the problem list screen in the provider view—the patient had to know how to reach this screen before sharing the device with the provider even though the patient did not need to understand review of systems.</i>

Findings

The experimental study provided substantial insight about grounding in the context of a face-to-face clinical interaction. The research questions were comprehensively addressed during the study. Grounding was better in the treatment group, indicating that the idea of integrating collaboration mechanics into designs with the intent to improve grounding has merit. The specific findings for each research question follow.

RQ₁: To what extent do smartphone apps designed using collaboration mechanics support grounding between primary and secondary users during face-to-face collaboration?

Findings for RQ₁: The experimental study results indicated that such apps support grounding and are capable of facilitating complete common ground. The success of grounding with them is task dependent.

RQ₂: To what extent do smartphone apps designed to support grounding impact secondary users' satisfaction during face-to-face collaboration?

Findings for RQ₂: The experimental study results indicated that such apps have the potential to positively impact secondary user satisfaction, performance, and perspective about the primary user's commitment to the collaboration.

CHAPTER SIX: DISCUSSION

Explanation of Outcomes

Grounding occurred in both groups regarding the medical history task. However, the time analysis shows that the minimum time on task for the control group was 0 seconds while the treatment group's minimum time was 54 seconds. Furthermore, none of the providers in the control group conducted patient education related to the medical history task, which was contrasted with a mean time in the treatment group of 23 seconds. Thus, even though grounding for this task occurred in both groups, it occurred throughout the treatment group with some patient education. This aspect of the time analysis indicates that the encounters in the treatment group were more effective than those in the control group, because all treatment group members accomplished the required task (and some made time for education), while those in the control group did not.

In the control group, grounding did not occur for problem identification or medication reconciliation. The providers were not able to confidently identify any aspect of the rash other than it had occurred and had healed. The providers were able to exclude some environmental causes during their discussions with the patient (e.g., no recent changes to medications). The grounding that did occur involved future patient action if the rash recurred (i.e., contact the office immediately). Regarding medication reconciliation, there was no indication that the providers were able to glean enough information to be confident that they had correctly identified the patient's medication regime. On one hand, medication reconciliation was the most challenging task for the providers in the scenario. On the other hand, they were so used to dealing with a lack of

medication information that they already knew what questions to ask in order to devise workarounds.

He didn't know his medication doses and timing, so I was worried that there was a high risk for error in assuming [that] what he was telling me was right. It was difficult to make recommendations or a plan without knowing what those medications were. Participant 3-C (APRN)

Regardless of the fact that providers had a substantial amount of experience with patients who lacked detailed knowledge about their own medications, the lack of patient medication knowledge did inhibit decision-making about the patient's healthcare.

In summary, it was apparent that grounding did not occur in the control group for the medication reconciliation task except with regard to planning workarounds. The providers developed plans with the patient for obtaining the information (e.g., bring medications to the next appointment). Even though there were successful joint actions during the course of the control group encounters, they typically culminated in planning activities focused on getting the correct information. The lack of common ground made the encounters distinctly inefficient in the control group.



Figure 21: The patient is unable to recall the details of specific medications making the attainment of common ground during medication reconciliation impossible.

In the treatment group, grounding occurred for the problem identification and medication reconciliation tasks. Even though the providers could not determine the cause of the rash or swab it for testing, the picture sparked deeper engagement with the patient about the ailment and allowed the providers to exclude some diagnoses. It also seemed to improve the general confidence among the providers about their interactions with the patient.

I like that he took pictures of his wound. It would have been, like I told him, helpful in the future to actually be seen when the situation is acute versus resolved, but taking that photo when it was an active rash was helpful—at least would be helpful—to the physician. Participant 6-T (RN)

Even though grounding was not complete for this task, the providers in the treatment group were typically more willing to share detailed information about this type of wound with the patient. This is noteworthy because rashes are often a difficult clinical issue, so any improvement to communication about such a problem is important.

Use of the prototype resulted in common ground being obtained during the medication reconciliation task. The providers were confident at the end of the interaction that critical and accurate information about the medications had been relayed to them, which allowed them to probe deeper with specific questions or spend more time on patient education. Treatment group members trusted the information provided from the prototype. For example, Participant 5-T (APRN) remarked that “my gut reaction is that it's accurate and it's a tool that can be shared between the patient and the provider.” The information obtained during the medication reconciliation task was of good enough quality to support medical decision-making. For example, Participant 6-T (RN) felt that the hospital could dispense medications to a patient admitted for an overnight stay with the level of detail provided by the role-player.



Figure 22: The patient provides accurate medication information by using the prototype to augment his memory, making the attainment of common ground possible. The interaction style shown here reflects the descriptive model shown in Figure 2.

Successful joint actions leading to common ground occurred during all tasks for the treatment group. However, the completeness of common ground and relevance of the prototype did vary by task. The prototype supported successful joint action and partial common ground for the problem identification task and complete common ground for the medication reconciliation task. The prototype was unnecessary for accomplishing common ground during the health history task. Joint actions in the treatment group were comprehensive enough that providers could make future plans for treatment based upon the details obtained during the interview. For example, at the end of the encounter, the providers knew enough about the patient's medications to maintain what had been previously prescribed because the patient was being treated with the correct medicine at the proper dosage for his ailment. The combination of the medication information and the

image of the rash allowed some providers to more confidently exclude certain things as possible causes of the rash.

Even though the post-test questionnaire implies less satisfaction among members of the treatment group, the richness and depth of the findings of the qualitative analysis indicate the opposite and provide a more comprehensive view of the data. The qualitative analysis indicated that providers in the treatment group were more satisfied than their peers in the control group. The completeness of information and its contribution to a more successful encounter becomes obvious as a result of the qualitative analysis.

That information that you have to have to make decisions, we didn't have to spend a lot of time figuring that out [because of the prototype]. We were able to quickly get all of that and then move onto here's what we're going to do about the problems that you have, the issues that you have, and go from there. So, we had more time for that, rather than just trying to figure out the historical data. Participant 2-T (Doctor)

For the treatment group, the analysis of satisfaction expressed by the providers combined with the descriptive statistics for the performance of the tasks, indicate that treatment group encounters were more efficient and effective than those encounters in the control group.

The qualitative analysis was a rich source of data and provided detailed insight in regard to answering the research questions. The quantitative analysis of the task performance supported the conclusions of the qualitative analysis. According to these measures, the use of the smartphone optimized common ground for members of the treatment group. In contrast, the results from the post-test questionnaire were a bit perplexing. For example, research about the impact of introducing examination room computers to the patient-provider encounter showed a higher degree of satisfaction among patients after the introduction of computers (Hsu et al., 2005). One would expect a

similar outcome for clinicians in this research. It is unclear why the *perspectives* of the providers in each group, as assessed using the post-test questionnaire, were reversed.

Even though the post-test questionnaire implied that the control group's perceptions were more favorable than the treatment group, this analysis was clearly not accurate based upon the strong positive responses of the treatment group members during the simulations and semi-structured interviews. Furthermore, poor clustering around the mean for satisfaction, common ground, and performance for the control group on the post-test questionnaire indicated less consensus among them about these variables than in the treatment group. Other factors, such as the distinction between the UX and usability, may help explain how and why the differences in perception occurred. As described earlier, a UX is an emotional outcome and usability is a technical component of a system. The placement of a patient-managed technology between the clinician and patient may have subtly and negatively transformed provider perceptions in the treatment group.

Even though providers in the treatment group liked the usability of the system and found it helpful, they might have perceived it as creating a barrier between themselves and the patients in some way. This idea of a barrier makes sense when considered in light of the emotional nature of the UX and the technical nature of usability. Moreover, the control group was largely made up of primary care professionals who look at patients holistically and longitudinally. The treatment group was largely made up of specialists, who may emphasize a procedural perspective because they look at patients for specific ailments and patient relationships tend to be much shorter than the relationships cultivated by their primary care peers. Although interesting, within the context of the experimental study, this distinction is a minor point because the simulation descriptive

statistics and post-test interviews clearly indicate that the performance was better and the UX was more satisfactory for the treatment group.

Three general patterns of personal interaction within the dyad, as they related to communication and grounding, were observed during the experimental study. The first pattern was associated with an interaction without the treatment. The second and third patterns were observed in the treatment group and supported insights gleaned during the formative work.

In the control group joint actions did occur as participants attempted to create common ground. However, grounding, as related to the specific task goal, was typically broken (see Figure 22) because of the lack of patient knowledge. Workarounds for this lack of knowledge were eventually devised.

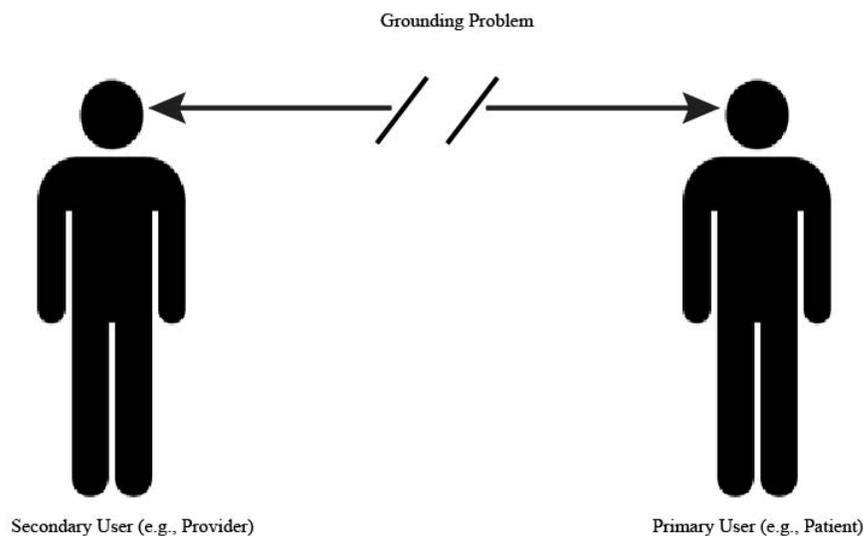


Figure 23: The pattern of interaction without technology when common ground cannot be reached.

The second and third patterns were observed in the treatment group when patient memory was supplemented by the use of the prototype. The preferred pattern occurred when the actor offered the prototype to the participant in the treatment group and the providers interacted directly with the device (see Figure 23). This is the *offer-accept*

pattern in which the primary user offers the technology and the secondary user accepts the offer. In this pattern, providers looked at the device while the patient held it; interacted with it via swipe, pinch, or scroll as he held it; or took the device from him and operated it themselves. The secondary UX for offer-accept is formed through multiple channels. The provider interacted directly with the device and their personal interactions as an *occasional user* are supplemented by the verbal conversations within the dyad (e.g., “Are those the pictures of your actual medicines?” with a response of “They are spot on.”). The device is physically between the primary and secondary user in a way that both users have direct access to it. It is important to note that by offering the prototype to the secondary user, the primary user is making a decision about how the secondary user can interact with the technology, it is in this respect that the primary user continues to act as an intermediary.

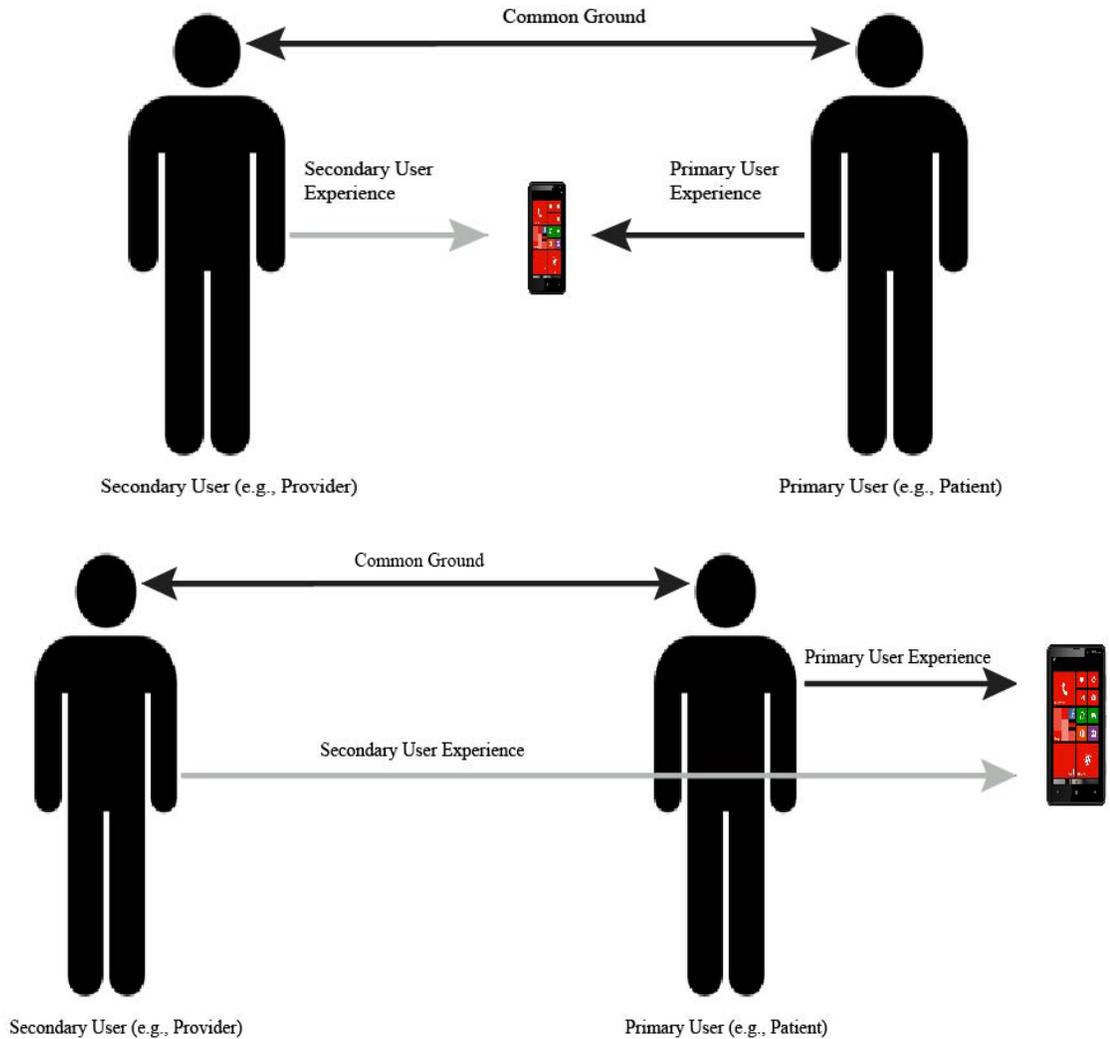


Figure 24: The offer-accept (top) and offer-reject (bottom) patterns of interaction.

In one instance (i.e., medication reconciliation), the pattern was that the provider strongly rejected the offer to directly interact with the device. She asked the patient to read the information to her, which allowed her to take notes and record the information as medication details were being recited to her by the patient. This is the *offer-refuse* pattern. The behavior of offer-refuse reflected the originally proposed model of a person having their secondary UX through the primary user (as depicted in Figure 2). In this model, common ground occurs, but the secondary user forms their UX based upon how well the primary user, as an intermediary with the system, relays the information to them.

It was the least popular model in the treatment group, with most preferring to have their experience by interacting directly with the device visually by observing its contents, or physically by touching the device and manipulating it in some way to obtain the information.

A few unanticipated outcomes of insight were gleaned. The first was about the possible impact of the technology upon the perspectives of the provider. This insight was an interesting observation. The semi-structured interviews revealed that the providers in the treatment group were happy with the outcome of the encounter and felt that the information exchange was better than usual. However, they did not record a level of satisfaction higher than their peers in the control group on the post-test questionnaire. The disparity indicates that the potential impact of patient-centered technology on perceptions deserves a closer look.

Another insight was concerning the willingness of providers to become responsible for clinical data from non-clinical sources. An early assumption during the requirements gathering process was that providers might not be willing to help manage this type of data. Nothing in the following stages of formative work or the experimental study suggested any reluctance on the part of providers to interact with this type of data. Rather, the providers considered the data trustworthy or, at least, as trustworthy as other types of patient provided information that they hold in high regard.

Implications of Results

The medication reconciliation task produced the strongest example of grounding in the research, which should not be surprising as the experimental study participants indicated that 50% to 90% of their patients did not have accurate medication information

with them during an encounter. This lack of accurate information suggests a gap in knowledge and in patient-centered tools to aid patient recall. As the experimental study demonstrated, a tool that provides relevant medication information to providers has the opportunity to facilitate common ground. The prototype's interface used external representations of medications that were clear objects of interest to secondary users. The representations allowed providers in the treatment group to quickly collaborate with the actor about his medications, regardless of the secondary user's interaction style.

The strength of grounding during the medication reconciliation supports the notion that the secondary user design guidelines described herein have utility as a tool to create positive secondary UXs. The encouraging responses of the treatment group members support the idea that a specially-designed system contributes to the attainment of a satisfactory secondary UX *and* improves efficiency and effectiveness. As a result of this research, we now understand that secondary users not only have distinct experiences, but that these experiences can be influenced by HCI design and are significant enough to impact task performance.

Limitations

The scope of the research was restricted to the relation between usability and common ground within an HIT setting. The research initially relied on a thematic analysis according to common ground theory. The research culminated in a small sample experimental study using a simulation. Consequently, there are limitations for generalizability. Form factor and device functionality were relevant to the experimental study in regard to the simulated patient-provider interactions. Additionally, the sample size was too small for hypothesis testing. Therefore, the results may not be generalizable

to devices that do not have the capability to meet all of the constraints for grounding or to collaborations outside the scope of short-duration, face-to-face clinical encounters.

Nonetheless, even though sample size was small, there is still a groundbreaking nature to the study because it emphasizes the patient being more knowledgeable about their health (through the introduction of the technology) and sharing their personal health information in a manner that improves the overall efficiency and effectiveness of providers during an encounter.

Future Research and Recommendations

This study is one of the first to conduct extensive requirements gathering to support the simultaneous design of a single system for both primary and secondary UXs and to conduct an experimental study with secondary users using the custom system. The study results are encouraging. In order to improve the generalizability of this type of user research, the study should be replicated with a larger sample and providers who work in the same hospital or practice. It would be best to limit the study participants to one skill or specialty (e.g., RNs who do the preliminary interview before the doctor sees the patient).

Limiting participants has several advantages for ecological validity. Dummy patient electronic records and intake sheets can be created using systems common to the organization. With the standardized procedures, training, and tools common to a single organization and specialty, confounding variables can be limited and simulation realism improved.

Finally, the prototype used for the simulation should be a smartphone app running on the device rather than a responsive design website. There was some latency accessing

the website based upon location and network quality, which caused small delays. An app running on a smartphone mitigates the impact of a slow running website and will more accurately capture any shorter encounter times due to the use of the prototype.

CHAPTER SEVEN: CONCLUSION

Combining the notions of common ground, HCI design, and mobile technology resulted in a prototype that improved the efficiency and effectiveness of face-to-face collaboration for secondary users with the system's primary user. During the formative work, the priorities that emerged for providers in the type of encounter simulated were to conduct medication reconciliation, problem identification, and then health history. The priorities, with regard to the technology and its efficacy as a tool to facilitate communication, were supported during the experimental study. For example, peak usefulness of the prototype was demonstrated whenever providers attempted to glean highly clinical data (i.e., detailed medication information) from the primary user, who is typically a non-clinical source for such information. Additionally, providers in the treatment group had improved confidence because the rash image was available. Finally, while technology did not improve or detract from grounding for members of the treatment group during the medical history task when compared to the control group, it seemed to create efficiencies for the overall encounter that allowed all members of the treatment group to complete the task (while all members of the control group did not).

The alignment of the perceptions of the relative importance of the respective tasks from providers to the actual creation of common ground during the experimental study, should be interpreted as providing a level of awareness for design decisions regarding the allocation of time and design resources. If tasks are difficult to accomplish (i.e., medication reconciliation), then attempts to promote grounding using technology may be a good use of resources, while it may be a poor use of resources for easy tasks (i.e.,

medical history). This identification of importance and the relation to common ground is an important insight for the overall body of secondary user research.

Regarding outcomes in the different experimental groups, it is not that grounding did not occur in the control group—it did. Rather, it is the value of the common ground achieved that is at issue. The participants noted that the attainment of common ground during a first encounter with a new patient was frequently rare in real life. They also indicated that they would support patients' uses of smartphones as a tool by which to improve face-to-face communications during encounters.

The easiest thing about sharing information with this patient was his ability to use technology to show me, so that we were both on the same page. As opposed to [a verbal] description, [where] I paint my own. Then, we're both on apples to apples, instead of me trying to paint in my head what he's describing. Participant 4-T (RN)

This study indicated that well-designed systems that deepen the engagement of patients in their own healthcare, while improving near-term communication with providers, has a place in HIT.

The provider responses in the treatment group reinforced design decisions about the information that should be made available to secondary users. Overall, the utility of patient-controlled devices during a first encounter with a new patient depends as much upon the difficulty for the provider of normally obtaining the information intended to be shared, and its impact upon immediate decision-making, as on the HCI design decisions. Medication reconciliation is a difficult task that is necessary for successful treatment decisions. In real life, inconclusive reconciliation is so routine that it is expected among providers. The introduction of patient operated technology to mitigate a patient's personal lack of knowledge has the potential to create fast, efficient, and effective common ground

within the dyad for this type of complex and difficult healthcare task. This observation is another critical insight for the overall body of secondary user research.

The experimental study is one of the first studies to directly demonstrate that not all secondary UXs are meaningful for design. For example, grounding occurred during the medical history task in the control and treatment groups. Any marginal improvement due to implementation of technology, in cases where grounding occurs regardless of technology, is probably not worth the effort. The fact that common ground was only completed during medication reconciliation in the treatment group, which was an essential enabler for healthcare decision-making, indicates that an investment in the secondary UX for this task is worthwhile.

Combining the notions of common ground, HCI design, and smartphone technology resulted in a prototype that improved the efficiency and effectiveness of face-to-face collaboration for secondary users with the primary user. The prototype clearly facilitated a higher quality of information exchange than normal. Thus, the investigation substantiated the notion that properly designed interactive systems have the potential to facilitate common ground while providing a satisfactory secondary UX.

APPENDICES

Appendix A: Concept Map

Concept Mapping the Secondary User Experience

Concept mapping with computer software is an innovation that provides a diagrammatic tool for knowledge representation (Moon, Hoffman, Novak, & Alberto J, 2011). Concept maps offer a methodology for discovering and visualizing relations that exist between the primary user's operation of a device and the secondary user's experience. The map displays knowledge by showing concepts and the relations among them (Cañas et al., 2005).

The first step when creating a concept map is to develop a focus question that the concept map is intended to answer. The focus question used to build this concept map was "What is the role of usability in the secondary UX during collaboration with a primary user?" The concept map revealed three main insights:

- Usability influences the collaboration mechanics and individual use that leads to success or failure of task performance;
- Successful task performance between two or more users performing a collaborative task creates common ground (e.g., shared understanding); and
- Secondary users have a response based upon the display of the technology, collaborative nature of the technology, and success or failure of the task performance.

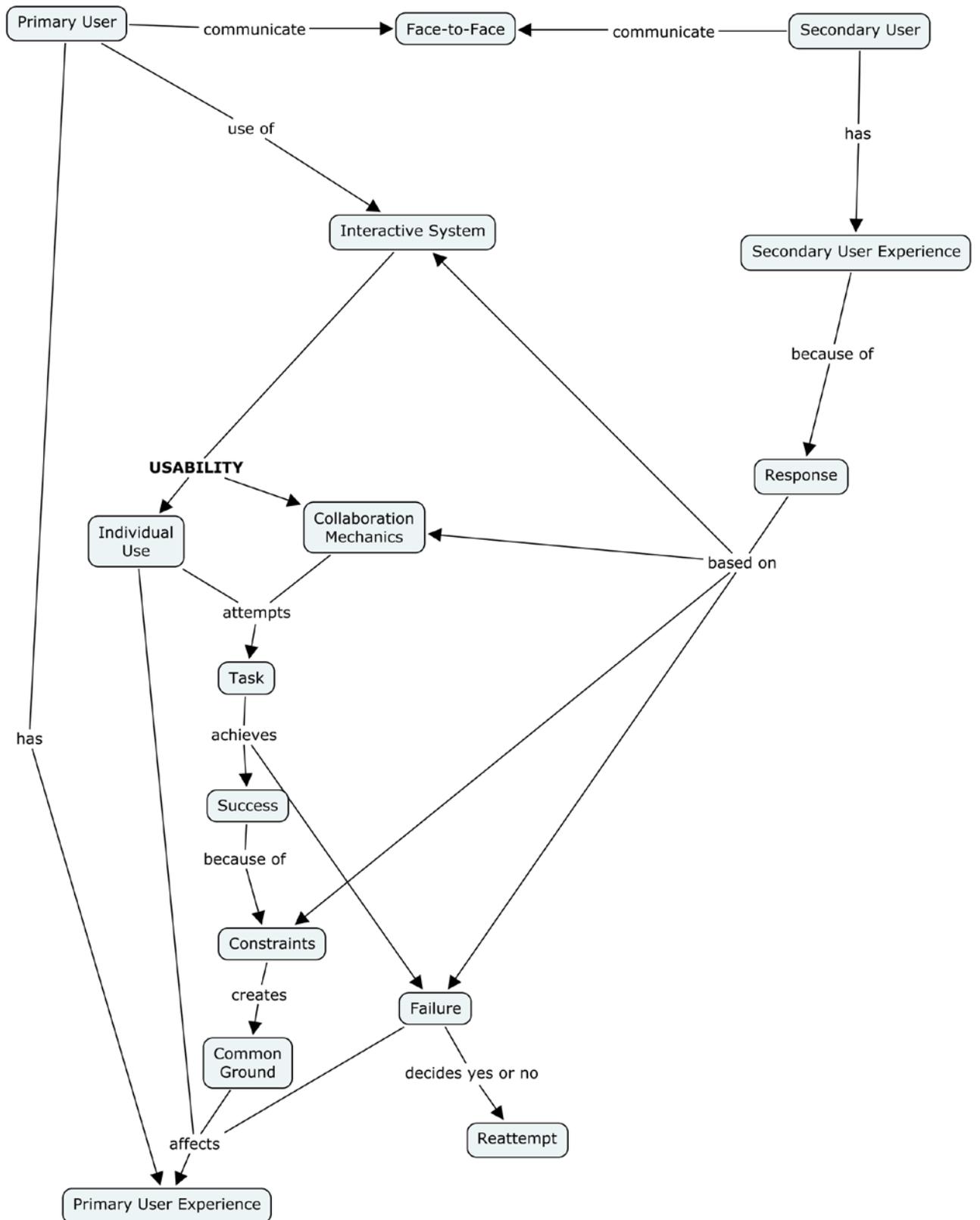


Figure 25: Concept map of the secondary UX.

Appendix B: Semi-Structured Interview Questionnaires

Preliminary Contact

Hello, my name is Harry Tunnell and I will be conducting the interview.

Thank you for agreeing to participant in the interview. Before we get started, there are a couple of preliminary things I would like to go over with you.

First, would you like to be entered in the drawing for the tablet computer? Y/N (If the response is yes, take down the address information.)

Name: _____

Email: _____

Street: _____

City: _____

State: _____

ZIP: _____

Have you had a chance to read the study information sheet yet? (If not, provide the link to them.)

The way this will work is that, after we finish this preliminary talk, I will hang up and call you back. When you pick up, the interview will be recorded and the recording will start automatically. I'm going to assign you a code for the interview, which is _____. When I call you back, I will refer to the code. This code keeps your personal information from being disclosed on the recording.

Do you have any questions about the study?

Thanks again for doing this study. I'm going to hang up and call you right back.

Patient Questionnaire

1. ID: This is Harry Tunnell interviewing participant _____ and this call is being recorded.
2. Date/Time:
3. Have you read the study information sheet: Y/N?
4. When is the last time you went to the doctor?
 - a. 1–3 months
 - b. 4–6 months
 - c. 7–9 months
 - d. 10–12 months
5. Age Range:
 - a. 18–24
 - b. 25–34
 - c. 35–44
 - d. 45–54
 - e. 55–64
 - f. 65–74
6. What is your gender:
7. Insurance:
 - a. I don't have insurance.
 - b. I have private pay insurance.
 - c. I have insurance through work.
 - d. I have Medicare insurance.

- e. I have Medicaid insurance.
8. Do you review or organize anything before you go to the doctor?
- a. No, nothing
 - b. Insurance card
 - c. Written notes
 - d. Internet medical sites
 - e. I rehearse what I'm going to tell the doctor.
 - f. Is there anything else you would like to add?
9. Do you take anything with you to see the doctor?
- a. No
 - b. Wallet or purse
 - c. Insurance card
 - d. Driver's license or other ID card
 - e. Mobile phone
 - f. Tablet computer
 - g. Written notes
 - h. Is there anything else you would like to add?
10. When talking to the receptionist, nurse, or doctor, what information do you typically fall a little short on having?
11. During an appointment, how do you share information with the nurse and doctor about your health status?
- a. Talk
 - b. Written notes

- c. Electronic notes
 - d. Is there anything else you would like to add?
12. During an appointment, how do you know when you have shared understanding with the nurse and doctor about your current health status?
- a. I tell them I understand.
 - b. They ask me if I understand.
 - c. I nod.
 - d. Facial expression
 - e. Is there anything else you would like to add?
13. During an appointment, how do you know when you have shared understanding with the nurse and doctor about what you should do in the future regarding your health?
- a. I tell them I understand.
 - b. They ask me if I understand.
 - c. I nod.
 - d. Facial expression
 - e. Is there anything else you would like to add?
14. During an appointment, do you use any tools to help you retain the information that you learn during the appointment?
- a. No
 - b. Yes, I write notes.
 - c. Yes, I send myself an email.
 - d. Yes, I use a mobile phone.
 - e. Yes, I use a tablet computer.

- f. Is there anything else you would like to add?
- 15. Would you use a smartphone app to help you share information with a nurse and doctor during an appointment?
- 16. What would you like to see in the design of a smartphone app for managing personal health information to help you out at an appointment?
- 17. Is there anything else you would like to add?
- 18. Do you own a mobile phone and/or tablet (If so, what type?)

Provider Questionnaire

- 1. ID: This is Harry Tunnell interviewing participant ____ and this call is being recorded.
- 2. Date/Time:
- 3. Have you read the study information sheet: Y/N?
- 4. What is your role: Physician, Nurse, or Other?
- 5. Age Range:
 - a. 18–24
 - b. 25–34
 - c. 35–44
 - d. 45–54
 - e. 55–64
 - f. 65–74
- 6. What is your gender?
- 7. What type of practice are you in and what is your specialty?
- 8. How long have you been a practicing clinician?

9. How often do you see patients?
10. What do you review before you see a patient?
11. What do you organize and take in with you to see a patient?
12. What information do you want patients to have available when you see them?
13. During an appointment, what information do patients typically have with them and in what format (e.g., notes)?
14. During an appointment, how do patients share information with you about their health status (e.g., do they tell you or hand you notes)?
15. When you talk to a patient, what information do they typically not have available or not know?
16. Is there a specific sequence that you prefer to follow with a patient during an appointment when discussing the following topics:
 - a. Medication list
 - b. Problem list
 - c. Self-report
17. What do patients have difficulty remembering when discussing their medications with you (e.g., type of medication, dosage, frequency)?
18. Do patients bring a list of their medications or the actual medications to an appointment with you?
19. What do you want to know about patient medications during an interaction with a patient (e.g., any drug interactions)?
20. What kind of information is discussed when going over a self-report with a patient?
21. What kind of information is discussed when going over a problem list with a patient?

22. During an appointment, how do you know when the patient has acknowledged that you and they have shared understanding about their health status?
23. During an appointment, how do you know when the patient has acknowledged that you and they have shared understanding about what they should do in the future regarding their health?
24. For this next question, let's assume that the technology meets all of the privacy and security rules for HIPAA. If a patient brings a smartphone personal health record into an appointment, how would you like them to share information maintained on the smartphone with you:
- a. Let me review it on the smartphone.
 - b. Email a link to me during the appointment so that I can open it on my computer.
 - c. Text a link to me during the appointment so that I can open it on my smartphone.
 - d. Let me scan a QR code with my smartphone.
 - e. Other
 - f. I do not want them to share information from their smartphone. (Please explain why.)
25. How could a patient-managed smartphone personal health record help you do your job?
26. If a patient could use a smartphone app to share information with you during an appointment, what would you like the app to do?

27. What attributes would you like to see in the design of a smartphone app for managing personal health information in order for you to recommend to your patients that they use one?
28. Is there anything else you would like to add?
29. Do you own a mobile phone and/or tablet? (If so, what type?)
30. Do you use a computer when you are talking to patients? If so, how/what do you use it for?
31. Do you have a recommendation about how I can get other participants for this questionnaire (where I should advertise, etc.)?

Appendix C: Online Survey Questionnaires

Patient Online Questionnaire

1. By selecting yes, you are consenting to participate in the study.
 - a. Yes
 - b. No
2. When is the last time you went to the doctor?
 - a. 1–3 months
 - b. 4–6 months
 - c. 7–9 months
 - d. 10–12 months
 - e. Longer than 12 months
3. What is your age?
 - a. 18–24
 - b. 25–34
 - c. 35–44
 - d. 45–54
 - e. 55–64
 - f. 65–74
 - g. 75 or older
4. What is your gender?
 - a. Female
 - b. Male
5. Please tell us about your medical insurance.

- a. I don't have insurance.
 - b. I have private pay insurance.
 - c. I have insurance through work.
 - d. I have Medicare insurance.
 - e. I have Medicaid insurance.
 - f. Other (please specify)
6. Do you review or organize anything before you go to the doctor? (Check all that apply.)
- a. No, nothing
 - b. Insurance card
 - c. Written notes
 - d. Internet medical sites
 - e. I rehearse what I'm going to tell the doctor.
 - f. Other (please specify)
7. Do you take anything with you to see the doctor? (Check all that apply.)
- a. No
 - b. Wallet or purse
 - c. Insurance card
 - d. Driver's license or other ID card
 - e. Mobile phone
 - f. Tablet computer
 - g. Written notes
 - h. Other (please specify)

8. Do you have a mobile phone?
- a. Yes, I have a smartphone.
 - b. Yes, I have a “flip phone.”
 - c. No
9. Do you have a tablet computer?
- a. Yes
 - b. No
10. How many years have you been using computers?
- a. < 1 year
 - b. 1–5 years
 - c. 6–10 years
 - d. 11–20 years
 - e. 21+ years
11. How many hours a day do you spend on the Internet?
- a. <1 hour
 - b. 1–2 hours
 - c. 3–5 hours
 - d. 6–8 hours
 - e. 9+ hours

The next series of questions are about using a smartphone app to organize information before a medical appointment.

12. I would use a smartphone app to maintain information about my personal health situation. (7-point Likert scale from Extremely Disagree to Extremely Agree.)

13. If I had my medical information stored on a smartphone, I would refer to it during an appointment with a doctor. (7-point Likert scale from Extremely Disagree to Extremely Agree.)
14. If I had my medical information stored on a smartphone, I would hand it to the doctor during an appointment so the doctor could review the information and talk to me about it while I am in the room. (7-point Likert scale from Extremely Disagree to Extremely Agree.)
15. If I had my medical information stored on a smartphone, I would send it to the doctor electronically (e.g., email or text) DURING an appointment so the doctor can review the information and talk to me about it while I am in the room. (7-point Likert scale from Extremely Disagree to Extremely Agree.)
16. If I had my medical information stored on a smartphone, I would send it to the doctor electronically (e.g., email or text) BEFORE an appointment so the doctor can review the information before he/she sees me and then talk to me about it while I am in the room. (7-point Likert scale from Extremely Disagree to Extremely Agree.)
17. I think using a smartphone camera is a good way for me to record information about a medical problem (e.g., take a picture of a rash) before my appointment to share with my doctor during the appointment. (7-point Likert scale from Extremely Disagree to Extremely Agree.)
18. I think using a smartphone app is a good way to keep accurate information about the medications I take, and to share this information with my doctor during an appointment. (7-point Likert scale from Extremely Disagree to Extremely Agree.)

19. I think using a smartphone app is a good way to keep information about my medical history, and to share this information with my doctor during an appointment. (7-point Likert scale from Extremely Disagree to Extremely Agree.)
20. There should be signs in the waiting room at the doctor's office explaining how to search the Internet for medical information related to my appointment. (7-point Likert scale from Extremely Disagree to Extremely Agree.)
21. There should be signs in the waiting room explaining how to go to a video channel like YouTube or Vimeo to find medical information related to my appointment. (7-point Likert scale from Extremely Disagree to Extremely Agree.)
22. There should be signs in the waiting room explaining where to find podcasts on the Internet about medical information related to my appointment. (7-point Likert scale from Extremely Disagree to Extremely Agree.)
23. If I used a smartphone app to maintain a list of my medications, I would like a way to verify that I have the information right. (7-point Likert scale from Extremely Disagree to Extremely Agree.)
24. If I used a smartphone app to maintain a list of my medications, I would like an indicator of what a medication is for (e.g., a heart icon for heart medication). (7-point Likert scale from Extremely Disagree to Extremely Agree.)
25. Please place in order (with 1 being best), how you would like to input information into a smartphone PHR app during an appointment with a doctor.
 - a. Swipe and touch
 - b. Type (virtual keypad)
 - c. Talk

- d. Stylus (pen-like device)
- e. Other (please specify)

26. Please place in order (with 1 being most important), what information needs the most protection within and smartphone that you would use.

- a. My emails
- b. My text messages
- c. My personal health information
- d. My personal financial information
- e. My record of phone calls
- f. My pictures and videos

27. The security and privacy of any personal health information contained within a smartphone app concerns me. (7-point Likert scale from Extremely Disagree to Extremely Agree.)

28. When you talk to a doctor or nurse about your medications, what information do you typically remember? (Check all that apply.)

- a. Name (e.g., Losartan)
- b. Color (e.g., light green)
- c. Shape (e.g., oblong tablet)
- d. What the medication is for (e.g., high blood pressure)
- e. Dose (e.g., 50 mg)
- f. Frequency (e.g., once daily)
- g. Other (please specify)

Provider Online Questionnaire

1. What is your job?
 - a. Physician
 - b. RN
 - c. Nurse Practitioner
 - d. Physician Assistant
 - e. LPN
 - f. Other (please specify)

2. What is your age?
 - a. 18–24
 - b. 25–34
 - c. 35–44
 - d. 45–54
 - e. 55–64
 - f. 65–74
 - g. 75 or older

3. What is your gender?
 - a. Female
 - b. Male

4. How long have you been a practicing clinician?
 - a. < 1
 - b. 1–5 years
 - c. 6–10 years

- d. 11–15 years
 - e. 16–20 years
 - f. 21–25 years
 - g. More than 25 years
5. What type of practice are you in?
6. How often do you see patients?
- a. 1–3 days per week
 - b. More than 3 days per week
 - c. A few days per month
 - d. I do not treat patients.
 - e. Other (please specify)
7. What do you review before you see a patient? (Check all that apply.)
- a. The patient’s intake sheet that they filled out before the visit or when they arrived at the office.
 - b. The patient’s electronic health/medical record.
 - c. The patient’s paper medical record. Other (please specify)
8. What is your specialty?
9. Do you have a mobile phone?
- a. Yes, I have a smartphone.
 - b. Yes, I have a “flip phone.”
 - c. No
10. Do you have a tablet computer?
- a. Yes

b. No

11. How many hours a day do you spend on the Internet?

a. < 1 hour

b. 1–2 hours

c. 3–5 hours

d. 6–8 hours

e. 9+ hours

12. How many years have you been using computers?

a. < 1 year

b. 1–5 years

c. 6–10 years

d. 11–20 years

e. 20+ years

The general scenario for this questionnaire is that you are seeing a new patient for the first time. The patient is a 55-year-old male that is in average health. The patient is taking numerous medications. He has completed all of the forms and questionnaires that your office requires for new patients. This patient also maintains his personal health information on his smartphone in a Personal Health Record (PHR) app. The app is HIPAA compliant and incorporates numerous security and privacy features. The information within the app is organized into three main areas:

- Medication(s)
- Medical History, and
- Problem List/Complaint(s).

13. If a patient organizes their health information within a smartphone PHR app BEFORE an appointment with me, this the order that I think they should prioritize the information (1 is best):
- a. Medications
 - b. Medical History
 - c. Problem List/Complaint
14. If a patient brings a smartphone PHR app into an appointment, I would want them to share information from the smartphone PHR app with me by:
- a. Letting me review it on the smartphone.
 - b. Emailing a link to me during the appointment so I can open it on my computer
 - c. Texting a link to me during the appointment so I can open it on my smartphone
 - d. Letting me scan a QR code with my own smartphone
 - e. I do not want them to share information from their smartphone with me.
 - f. Other (please specify)
15. Please prioritize the features below (1 is best), that you would like to see in a patient's smartphone PHR app:
- a. Camera to take pictures of complaint before the appointment
 - b. Ability for patient to record (audio) notes during the appointment
 - c. Ability for patient to write notes during the appointment
 - d. Written medication list
 - e. Pictures of medications currently taking
 - f. Medical history

- g. Patient complaint organized by review of systems
- h. Patient complaint organized by personal notes taken by the patient
- i. Ability to share information from the smartphone PHR with me electronically
- j. Ability to share information from the smartphone PHR app with my administrative staff electronically

16. Is there a structured tool or form that you use to gather information before a patient visit:

- a. No
- b. Yes, I use _____. (Please specify)

17. If a patient had their personal health information stored on a smartphone, I would like them to refer to it DURING an appointment with me.

- a. Yes
- b. No

18. Please place in order (with 1 being best), how you would like a patient to input information into a smartphone PHR app during an office visit with you.

- a. Swipe and touch
- b. Type (virtual keyboard)
- c. Voice
- d. Stylus (pen-like device)

19. Please place in order (with 1 being best), how you would like to interact with a smartphone PHR app, if the patient hands it to you, so that you can review the information within it.

- a. Swipe and touch

- b. Type (virtual keyboard)
- c. Voice
- d. Stylus (pen-like device)

In addition to the information from the general scenario, please consider the following as you answer the next few questions. The patient has information about several of his medications stored within the smartphone PHR app. The information includes the name of the medication, strength, dose, frequency taken, and date started.

20. Do you think a smartphone PHR app is a good way for patients to manage medication information and to share this information with you DURING an appointment?

- a. I think it's a good way for them to manage information, but not a good way for them to share it with me.
- b. I think it's a good way for them to manage information and I would like for them to hand the phone to me during the appointment so I can review their medication list.
- c. I think it's a good way for them to manage information and I would like for them to email the medication list to my office before I see them.

21. I am confident that the medication list stored within a patient's smartphone app would be accurate and up-to-date.

- a. Yes
- b. No
- c. It's probably close, but might be missing some key information.
- d. I wouldn't trust it unless there is some way I could verify the information.

22. The best way to verify the accuracy of the patient's medication list is to just ask the patient about their medications.
- a. Yes
 - b. No
 - c. Yes, but patients still get a lot of information about medications wrong. I would still have to ask a lot of follow-up questions.
 - d. No, patients have problems remembering their medications. I like reviewing the electronic health/medical record first., then I will follow up with the patient and ask them questions about their medications.
23. A good way to verify the accuracy of patient medication on a smartphone PHR app is to have some icon or other indicator next to each medication indicating that it has been verified by a pharmacist, nurse, or physician.
- a. Yes
 - b. No
24. At the end of the appointment with the patient, I would be willing to provide the necessary verification to show that medications within the patient's smartphone PHR app have been verified.
- a. Yes
 - b. No
25. When going over medications with a patient, what information do they typically remember? (Check all that apply.)
- a. Name (e.g., Losartan)
 - b. Color (e.g., light green)

- c. Shape (e.g., oblong tablet)
- d. What the medication is for (e.g., high blood pressure)
- e. Dose (e.g., 50 mg)
- f. Frequency (e.g., once daily) Other (please specify)

In addition to the information from the general scenario, please consider the following as you answer the next few questions. The patient has three years of medical history stored within a smartphone PHR app.

26. This is a good way to share medical history with me DURING an appointment. (7-point Likert scale from Extremely Disagree to Extremely Agree.)

27. I think three years of medical history stored within a smartphone app is adequate for an appointment with me:

- a. Yes
- b. No, this is too much.
- c. No, it is not enough.
- d. It should include as much medical history as the patient has available.
- e. Other (please specify)

In addition to the information from the general scenario, please consider the following as you answer the next few questions. The patient's chief complaint is a rash, which has already cleared up. The patient's basic complaint within the smartphone app is organized by review of systems. In addition to the review of systems information, the patient took a picture of the rash with the smartphone camera and it is stored within the smartphone PHR app. The picture includes a time-date stamp of when it was taken and rulers showing the approximate size of the rash.

28. I think the review of systems is a good way to organize the information.
- a. Yes
 - b. No, I think this way would be better _____ (Please specify).
29. I think the picture will help me diagnose the patient's problem. (7-point Likert scale from Extremely Disagree to Extremely Agree.)
30. In addition to the picture and problem list on the smartphone PHR app, I will refer to the medical history in the smartphone PHR app to diagnose the problem.
- a. Yes
 - b. No
31. In addition to the picture and problem list on the smartphone PHR app, I will refer to the medication information in the smartphone PHR app to diagnose the problem.
- a. Yes
 - b. No

Appendix D: Personas

Patient Personas

Patient (Good Health)



Susan Wilson,
Primary User

40 y/o working mom. She has seen a doctor w/in 3 mos.

Efficiency is her motivation—she is extremely busy.

"I usually take handwritten notes, so... Yes, of course I carry my phone all the time, but I could use it to take notes."

- She does not do any specific preparation for appointments and she has insurance through work. She takes her purse, insurance card, ID, and mobile phone with her to an appointment.
- She has been using computers for 11 or more years and she spends 3-5 hours per day on the Internet.

- She is not inclined to store her medical information in an app. However, if her medical information was stored within an app she might refer to it or hand it to the healthcare provider during an appointment.
- She is in good health.

Patient (Good Health)



Susan Wilson,
Primary User

40 y/o working mom. She has seen a doctor w/in 3 mos.

Efficiency is her motivation—she is extremely busy.

Tasks & Key Activities

- Self-report medical history (allergies, past procedures, etc.).
- Discuss current medications.
- Describe current medical problems.
- Ask questions about health status and treatment plan.
- Understand instructions, treatment plan, and follow-up.

Product Value

- Helps patients document health status & changes.
- Helps patient record, maintain, and share health history.
- Helps patient record, maintain, and share medication list.
- Provides both user types with a tool they can use to explore patient problem lists.
- Gives provider access to clinical-info from a non-clinical source.
- Provides a tool providers can use to engage patients.

Figure 26: Female patient persona.

Patient (Chronic Illness)



Photo/Wikimedia

Stan Smith, Primary User

48 y/o married father. He has seen a doctor w/in 3 mos.

Wants to feel better but has a chronic illness and lacks discipline.

"I have all the important information with me and then I just hand over whatever they ask. I usually have everything."

- He does not do any specific preparation for appointments and he has insurance through work. He takes his wallet, insurance card, ID, and mobile phone with him to an appointment.
- He has been using computers for 11 or more years and he spends 1-2 hours per day on the Internet.

- He is not inclined to manage or store his health information in a smartphone app.
- He suffers from Type 2 diabetes, obesity, hypertension, and high cholesterol.
- His diabetes is well-controlled with medication and his Hemoglobin A1C is 6.6.

Patient (Chronic Illness)



Photo/Wikimedia

Stan Smith, Primary User

48 y/o married father. He has seen a doctor w/in 3 mos.

Wants to feel better but has a chronic illness and lacks discipline.

Tasks & Key Activities

- Self-report medical history (allergies, past procedures, etc.).
- Discuss current medications.
- Describe current medical problems.
- Ask questions about health status and treatment plan.
- Understand instructions, treatment plan, and follow-up.

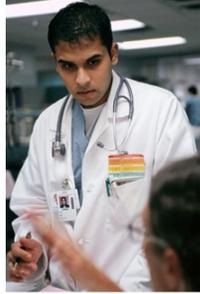
Product Value

- Helps patients document health status & changes.
- Helps patient record, maintain, and share health history.
- Helps patient record, maintain, and share medication list.
- Provides both user types with a tool they can use to explore patient problem lists.
- Gives provider access to clinical-info from a non-clinical source.
- Provides a tool providers can use to engage patients.

Figure 27: Male patient persona.

Provider Personas

Physician



Steve Davidson,
Physician, Secondary
User

49 y/o, sees patients 3 or more times/week. Practicing 20+ years.

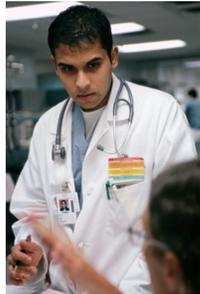
Understanding medications and history in addition to complaint.

"Patients that might have a whole detailed summary of what they've been through, that might be 25-percent."

- Patients should know history, medications, and allergies.
- Patients don't bring memory aides or fully know health info.
- To ensure shared understanding, providers will repeat back the patient's health story.
- To ensure shared understanding when closing, providers explain tests, their medical conclusions, instructions, and ask for questions.

- Owns a smartphone and is comfortable with patient use of a smartphone to recall health information during an appointment.
- Accurate medication list and allergy list is key.
- Knowing how long on each medication helps ID problems.
- Share data with provider via link during appointment.

Physician



Steve Davidson,
Physician, Secondary
User

49 y/o, sees patients 3 or more times/week. Practicing 20+ years.

Understanding medications and history in addition to complaint.

Tasks & Key Activities

- Review patient's EHR and intake sheet.
- Communicate effectively with patient.
- Ask details about medications.
- Understand patient health story.
- Diagnose problem.
- Explain treatment plan.
- Implement treatment plan.
- Explain patient responsibilities regarding treatment plan (e.g., instructions, follow-up).

Product Value

- Helps patients organize medication list, medical history, and problem list.
- Helps patient share relevant health information with the provider.
- Gives provider access to clinical-info from a non-clinical source.
- Organizes information for providers by review of systems.
- Provides a tool providers can use to engage patients.

Figure 28: Male provider persona.

Nurse



Photo/Wikimedia

Dana Troy, Nurse,
Secondary User

55 y/o, sees patients 3 or more times/week. Practicing 25+ years.

Quickly capturing the patient's health story for the physician.

"A lot of people aren't prepared. I don't understand.... they definitely come with a cell phone."

- Patients should know history, medications, and allergies.
- Patients don't bring memory aides or fully know health info.
- To ensure shared understanding, providers will repeat back the patient's health story.
- To ensure shared understanding when closing, providers explain tests, their medical conclusions, instructions, and ask for questions.

- Owns a smartphone and is an experienced computer user.
- Performs patient intake and reports status to physician.
- Does not want patient to share electronic information—prefers that they verbalize smartphone contents or hand over the smartphone.
- Patient use of a smartphone PHR app would be a benefit to patients and providers.

Nurse



Photo/Wikimedia

Dana Troy, Nurse,
Secondary User

55 y/o, sees patients 3 or more times/week. Practicing 25+ years.

Quickly capturing the patient's health story for the physician.

Tasks & Key Activities

- Review patient's intake sheet.
- Perform intake evaluation of patient.
- Communicate effectively with patient.
- Review EHR first then ask details about medications.
- Understand patient health story.
- Explain to patient what happens next and any responsibilities regarding treatment plan (e.g., instructions, follow-up).
- Communicate patient health status to the physician.

Product Value

- Helps patients organize medication list, medical history, and problem list.
- Helps patient share relevant health information with the provider.
- Gives provider access to clinical-info from a non-clinical source.
- Organizes information for providers by review of systems.
- Provides a tool providers can use to engage patients.

Figure 29: Female provider persona.

Appendix E: Experimental Study Scenario

This is meant to represent a routine scheduled visit as in your normal practice. You have another patient scheduled after you finish with the one you are about to see.

You are seeing a patient for the first time who switched to you from another provider.

The patient has Type 2 diabetes. The patient also suffers from obesity, hypertension, and high cholesterol. The patient reports recently having a rash. The rash healed before the appointment, so it is no longer visible.

You are seeing a **56**-year-old male named **Dennis**.

The patient's height is **5'11"** and weight is **263** lbs.

The patient's diabetes (**Hemoglobin A1C: 6.6**) appears to be under control with medication. The patient's cholesterol is available (**LDL: 150, HDL: 60**). Today, the patient's temperature (**98.6**), heart rate (**83**), respiration rate (**16**), and blood pressure (**120/80**) have been taken by the Medical Assistant. However, medication reconciliation has not been performed.

You have three tasks to perform with this new patient (do them in the order you think appropriate):

- Go over the patient's problem,
- Update what you know about the patient's medical history, and
- Conduct medication reconciliation.

Appendix F: Post-Test Questionnaire

Demographics

1. Did the patient use a smartphone during the interaction?
 - a. Yes
 - b. No

2. What is your job?
 - a. Physician
 - b. RN
 - c. Nurse Practitioner
 - d. Physician Assistant
 - e. LPN
 - f. Other (please specify)

3. What is your age?
 - a. 18–24
 - b. 25–34
 - c. 35–44
 - d. 45–54
 - e. 55–64
 - f. 65–74
 - g. 75 or older

4. What is your gender?
 - a. Female
 - b. Male

5. How long have you been a practicing clinician?
 - a. < 1
 - b. 1–5 years
 - c. 6–10 years
 - d. 11–15 years
 - e. 16–20 years
 - f. 21–25 years
 - g. More than 25 years
6. What type of practice are you in?
7. How often do you see patients?
 - a. 1–3 days per week
 - b. More than 3 days per week
 - c. A few days per month
 - d. I do not treat patients.
 - e. Other (please specify)
8. What do you review before you see a patient? (Check all that apply.)
 - a. The patient's intake sheet that they filled out before the visit or when they arrived at the office.
 - b. The patient's electronic health/medical record.
 - c. The patient's paper medical record.
 - d. Other (please specify)
9. What is your specialty?
10. Do you have a mobile phone?

- a. Yes, I have a smartphone.
- b. Yes, I have a “flip phone.”
- c. No

11. Do you have a tablet computer?

- a. Yes
- b. No

12. How many hours a day do you spend on the Internet?

- a. <1 hour
- b. 1–2 hours
- c. 3–5 hours
- d. 6–8 hours
- e. 9+ hours

13. How many years have you been using computers?

- a. < 1 year
- b. 1–5 years
- c. 6–10 years
- d. 11–20 years
- e. 20 + years

Satisfaction (7-Point Scale)

14. I enjoyed communicating and sharing ideas using the available tools with my patient.

15. I enjoyed planning with my patient.

16. I would enjoy working with my patient and building a health plan using the available tool(s).

17. I am satisfied with the plan we just completed.

18. I wish we could change the plan we just completed.

Common Ground (7-Point Scale)

19. I found it difficult to keep track of the conversation.

20. During the conversation, I was able to focus on the task at hand.

21. My patient and I communicated well with each other.

22. Over time, I got to know my patient better.

23. Over time, my patient and I came to share more and more ideas about the project.

24. Over time, my patient and I shared more ideas about the available tools.

Performance (7-Point Scale)

25. Our teamwork was effective.

26. Our teamwork was time-efficient.

27. My patient and I produced a good amount of work together.

28. My patient and I produced a good quality of work together.

Appendix G: Post-Simulation, Semi-Structured Interview Guide

1. How do you think the interaction with the patient went? (Be prepared to probe more fully. If their comment focuses on the negative, ask for positive points and vice versa.)
2. How confident were you in the quality of information provided by the patient?
3. What are your other thoughts about the quality of information shared during this interaction?
4. What was the easiest thing about ...? (The thing selected will be based upon the prior answers. Ask them to rate it on a scale of 1–10 with 1 being very easy)
5. What was the hardest thing about ...? (The thing selected will be based upon the prior answers. Ask them to rate it on a scale of 1–10 with 1 being very easy)
6. Do you think a patient having their health information on a smartphone is useful in an interaction like this?
7. What do you think the impact of a patient referring to their health information on a smartphone during an interaction with you would be on time management?
8. Would you recommend to a patient that they store relevant health information on a smartphone and refer to it, or let you review it, during an appointment with you?
Why/why not?
9. Overall, how satisfied were you with the interaction?

Appendix H: Checklist for Treatment Fidelity

Without the Smartphone

When describing the rash, make the following statements:

- *When discussing the location of the rash:* “It was a big rash on my right elbow and arm.”
- *When describing the rash:* “They were like blisters.” And “Some would break and some were filled with fluid stuff. It was clear, I think.”
- *When discussing how long the rash lasted:* “It lasted about three weeks and then went away by itself. It’s been gone a week or so.”
- *When asked about the cause of the rash:* “I don’t know. I use a lot of chemicals, cleaning solvents and stuff, at work. It could be anything, I guess.”

When describing past medical history, make the following statements:

- *When asked about blood pressure history:* “I started my job about six years ago and I started having blood pressure problems the next year, so about five years.”
- *When asked about diabetes:* “I started taking diabetes medication about two years ago.”
- *When asked about cholesterol:* “The cholesterol thing started about 2–3 years ago.”

When describing medications, make the following statements:

- *When discussing the total number of medications:* “I know I take four medicines. Two for my diabetes, one for my cholesterol, and one for my blood pressure.”
- *When discussing Lisinopril:* “I take Lisinopril, once a day, 10 milligrams for my blood pressure.”

- *When discussing Metformin ER:* “One of the ones for my diabetes is Met, Met, Met something. It’s oval shaped and I take it twice a day. It’s 500 milligrams. I remember that because that’s the biggest number.”
- *If they follow-up by asking if its Metformin:* “That sounds right.”
- *If they follow-up by asking if it’s something else:* “That doesn’t sound familiar.”
- *When discussing Atorvastatin:* “It’s Ater-Vas-A-Tin or something like that. I take it at night. I think that’s my cholesterol pill.
- *When discussing Glipizide:* “The other one for my diabetes begins with a G. It’s a white round pill. It’s a real small dose and I take it with meals. That’s about all I remember.”
- *If they follow-up by asking if its Glipizide:* “That sounds right.”
- *If they follow-up by asking if it’s something else:* “That doesn’t sound familiar.”
- *When asked where you get your medications:* “CVS.”

With the Smartphone

When describing the rash, make the following statements:

- *When describing the rash:* “It was on my right arm and elbow. I took a picture of it. Would you like to see it?”
- *When discussing how long the rash lasted:* “It lasted about three weeks and then went away by itself. It’s been gone a week or so.”
- *When asked about the cause of the rash:* “I don’t know. I use a lot of chemicals, cleaning solvents and stuff, at work. It could be anything, I guess.”

When describing past medical history, do the following:

- Refer to the information in the smartphone, but only give it to the provider if they ask to see it.
- *When asked about blood pressure history:* “It’s in my phone. Let me check.”
- *When asked about diabetes:* “It’s in my phone.”
- *When asked about cholesterol:* “Let me check my phone.”

When describing medications, make the following statements:

- *When discussing the total number of medications:* “I know I take four medicines. Two for my diabetes, one for my cholesterol, and one for my blood pressure.”
- *When asked for more detail about medications:* “I don’t remember all of their names, but I have a list in my phone. Would you like to see it?” (If they do not want to see the smartphone, then refer to the information in the smartphone as you tell them the medications.)
- *When asked where you get your medications:* “CVS.”

Appendix I: Commented Views of the Prototype

This appendix provides additional details about the prototype. A few more examples of the prototype are shown here. Comments about key aspects of the screens, as they relate to the final design guidelines or other outcomes of the experimental study, are also provided.

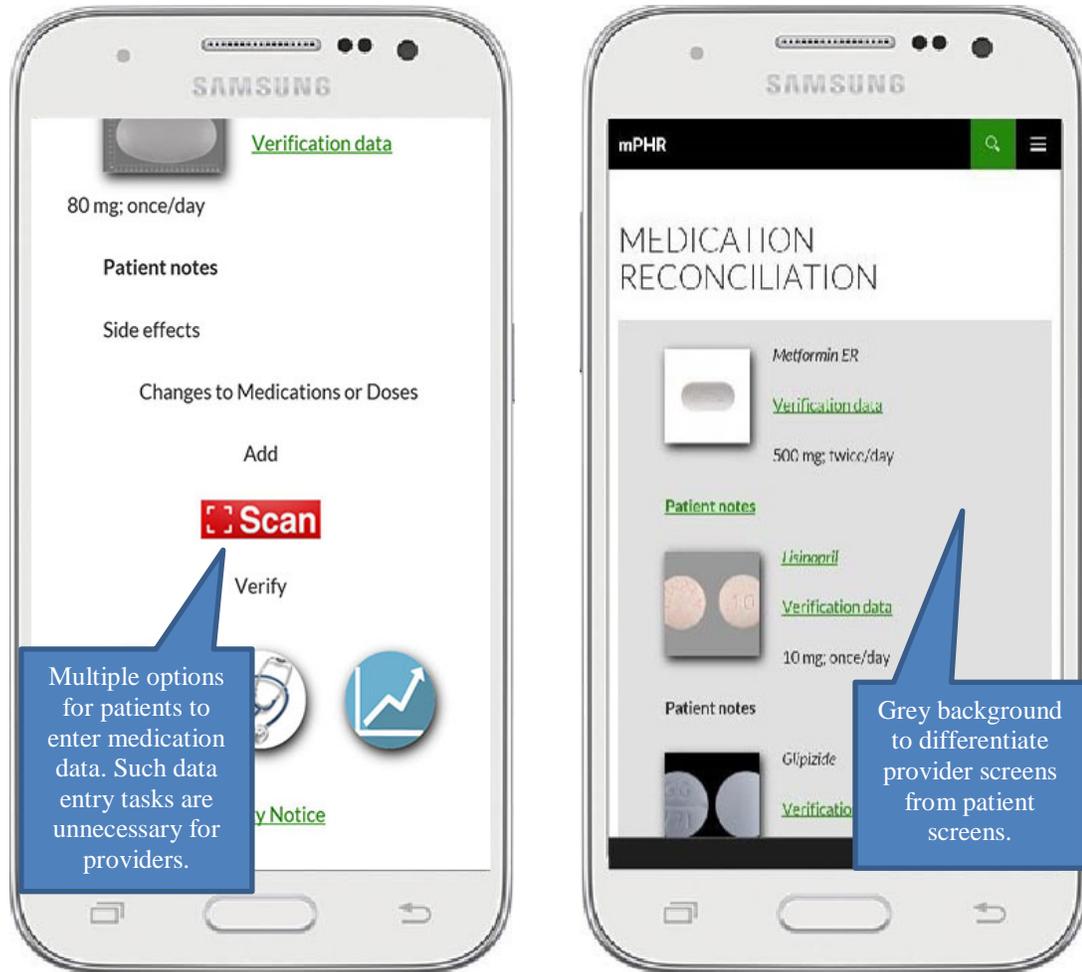


Figure 30: Commented medication screens for the patient (left) and provider (right).

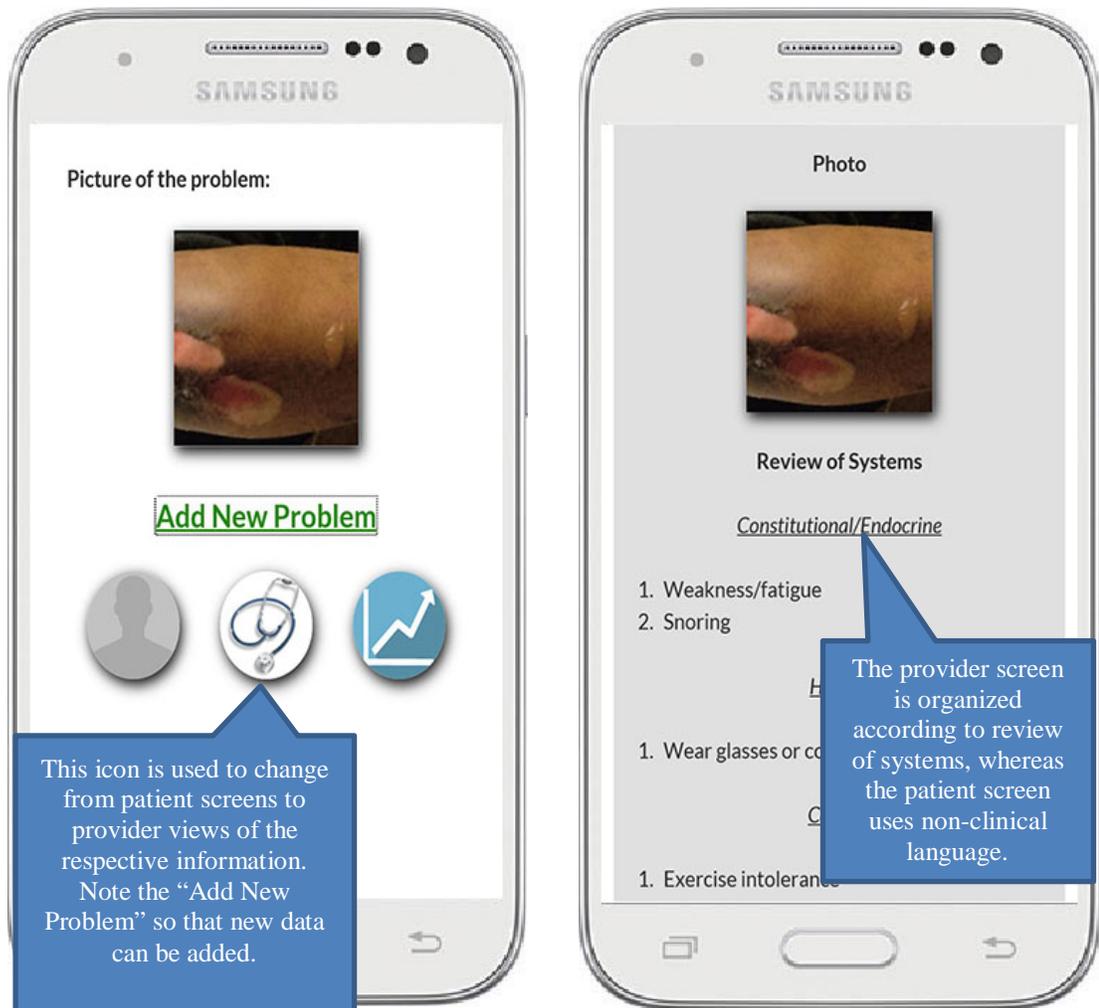


Figure 31: Commented problem screens for the patient (left) and provider (right).

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- Inbar, O., & Tractinsky, N. (2012). Lowering the line of visibility: Incidental users in service encounters. *Behaviour & Information Technology*, 31(3), 245-260.
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- Pinelle, D., & Gutwin, C. (2002). *Groupware walkthrough: Adding context to groupware usability evaluation*. Paper presented at the SIGCHI Conference on Human Factors in Computing Systems: Changing our World, Changing Ourselves.
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- Xu, J., & Montague, E. (2013). Working with an invisible active user: Understanding trust in technology and co-user from the perspective of a passive user. *Interacting with computers*, 25(5), 375-385.
- Yan, T., Chu, D., Ganesan, D., Kansal, A., & Liu, J. (2012). *Fast app launching for mobile devices using predictive user context*. Paper presented at the Proceedings of the 10th International Conference on Mobile Systems, Applications, and Services, Low Wood Bay, Lake District, UK.

CURRICULUM VITAE

Harry D. Tunnell IV

Research Interests

I conduct user research with a focus on secondary users. Primary users are the main operator of a product, system, or service and may interact with it in a way that impacts others, who are secondary users. The ubiquity of mobile and wearable computers means that computing has few geographic constraints and is no longer a solitary activity, which increases the pool of secondary users. My research examines secondary user experiences to determine if, when, and how they should be represented in technology design. Understanding secondary users is particularly important when organizations want to extend the reach of a product, system, or service beyond the direct user to people who are in the immediate vicinity of the primary user.

Education

Ph.D.	Indiana University – Purdue University Indianapolis <i>Human-Computer Interaction</i>	(2016)
MS	University of Maryland, Baltimore County, Baltimore, MD <i>Information Systems</i>	(2013)
MS	National War College, Washington, DC <i>National Security Strategy (Information Strategies)</i>	(2005)
MMAS	Command and General Staff College, Ft. Leavenworth, KS <i>Military History</i>	(1998)
MA	Purdue University, Fort Wayne, IN <i>Professional Communication Studies</i>	(1997)
BS	U.S. Military Academy, West Point, NY <i>No Major</i>	(1984)

Technical

Languages	HTML 5, CSS, SQL
Software	Adobe Dreamweaver, WordPress, Mapititude Geographic Information System (GIS), SPSS, WEKA Data Mining Workbench, Microsoft Project, Microsoft Office (Visio, PowerPoint, Word, and Excel)
Certifications	Project Management Professional (PMP), CompTIA Project+, CompTIA Network+ ce, CompTIA A+ ce (Computer Technician), Microsoft Office Specialist (PowerPoint, Word, and Excel)

Instruction Military Historian (5X), CompTIA CTT+ (Certified Technical Trainer)

Skills

Web Design Indiana University – Purdue University Fort Wayne Cert. (2014)

GIS IS-00922 Applications of GIS for Emergency Management (2012)

UX Design Human-Computer Interaction, Indiana University Cert. (2011)

Innovation MIT Sloan School of Management Executive Cert. (2009)

Negotiation The Program on Negotiation at Harvard Law School (2008, 2009)

Security Clearance Top Secret (2007)

Current Position

2016 – Present **Adjunct Faculty**
IU School of Informatics & Computing, Indianapolis, IN
Teaching responsibilities as a member of the Department of Human-Centered Computing.

Employment History

2008 – 2016 **Principal**
InRef, LLC, Fort Wayne, IN
Promoted rewarding user experiences through the design of better equipment, processes, and procedures.

2011 – 2012 **Director, Market Research & Analytics Directorate (Formerly the Center for Accessions Research)**
Army Marketing and Research Group, Fort Knox, KY
Director of the 40-person R&D organization that planned, coordinated, integrated, and executed the U.S. Army's research for markets, marketing, and accessions.

2010 – 2011 **Executive Officer to the Commanding General**
U.S. Army Accessions Command, Fort Knox, KY
Directly managed the commanding general's personal staff and the Commander's Initiatives Group.

2007 – 2010 **Stryker Brigade Commander**
Fort Lewis, WA and Afghanistan
Commanded a 5,000-person (at its peak) Infantry brigade task force. The brigade was the world's most technologically advanced ground combat formation at the time.

- 2006 – 2007 **Chief, Commander’s Planning Group**
U.S. Army Training and Doctrine Command, Fort Monroe, VA
 Led the team responsible for senior official speech preparation. The team also conducted directed and independent research about defense-related strategic initiatives.
- 2005 – 2006 **Strategic Author and Researcher**
Center for Strategic Communications, Washington, DC
 Conducted directed research for the President, National Defense University (NDU) and independent research on national security; authored strategic papers and evaluated the curricula of NDU’s five colleges and several research entities.
- 2003 – 2005 **Patient, WRAMC and Student, National War College**
Walter Reed Army Medical Center & Ft. McNair, Washington, DC
 Recovered from combat wounds sustained in Iraq. Attended the National War College.
- 2002 – 2003 **Parachute Infantry Battalion Commander**
Vicenza, Italy and Iraq
 Commanded a 500 + person Infantry battalion and led the battalion in a combat parachute jump during the assault phase of the invasion of Iraq. Led numerous combat missions until wounded in action and evacuated from the theater of war.
- 2000 – 2002 **Speech Writer and Previously Special Plans Officer**
U.S. Special Operations Command, MacDill Air Force Base, FL
 Performed speech preparation for the commanding general. Developed operational-level Special Operations Forces plans for counterterrorism, consequence management, counter proliferation, and information operations.
- 1984 – 2000 **Company and Field Grade Infantry Officer**
Various locations in Europe, Central America, and the US
 Leadership duties in tactical Infantry assignments during peacetime, war, and contingency operations. Positions included assignments as a commander and staff officer in General Purpose Force and Special Operations Force units.

Projects

Patient medication adherence (08/22/2016 – Present). Problems with patient medication adherence is a major healthcare challenge. Some estimates indicate that up to 50% of patients do not take their prescribed medications properly. The failure of patients to adhere to a medication regimen adds an estimated \$100-200 billion to healthcare costs. I am working as a member of a multidisciplinary team that researches patient medication

taking behavior. We also design and prototype technologies to improve medication taking behavior among patients.

Smartphone personal health records (04/24/14 – Present). The effort to give patients access to their personal health information electronically, and the ubiquity of mobile and wearable technologies, potentially impacts patient-provider communication. My research identifies and describes elements of the secondary user experience that contribute to improved communication between patients and providers. Early research results are reported in the paper “Clinicians as secondary users of patient-centered mobile technology in complex healthcare settings.”

Network-Centric Warfare (02/19/2014 – Present). Network-centric warfare (NCW) theory, provides a framework to ensure that new possibilities for decision-making, command and control, and action, made possible by cloud and other information technology innovations, is not constrained by outmoded industrial age ideas. My research extends the theory and examines U.S Army resistance to NCW. The research is reported in the papers “The U.S. Army and network-centric warfare: A thematic analysis of the literature” and “Network-centric warfare and the data-information-knowledge-wisdom hierarchy” and the presentations: “Network-centric warfare theory: Prospects for operations after Iraq and Afghanistan” and “Network-centric warfare: Why it matters.”

MedInfo 2015 Editorial Committee (04/16/15 – 07/18/15). Performed duties as an assistant editor for the MedInfo 2015 Conference (<http://www.medinfo2015.org/>). MedInfo is the premier international meeting on biomedical informatics. Editorial responsibilities included reviewing English and layout format of accepted conference papers and posters, fixing layout issues using a Microsoft Word template, and correcting grammatical errors.

Military informatics (10/03/12 – 10/08/14). Military informatics is the “Art and science of designing information systems for military users, who perform tasks with them in a military work context. The task performance supports military-related goals.” My research focuses on military users and their roles with technology. The research is reported in the papers: “A pilot study about military users and information systems: Exploring military user attitudes about technology”; “Combining technology acceptance and culture in one tool: Implications for information sharing within coalitions”; and “Technology diffusion and military users: Perceptions that predict adoption.”

Patents

Tunnell, H.D., IV. (2014). *U.S. Patent No. 8,643,670 B2*. Washington, DC: U.S. Patent and Trademark Office.

Tunnell, H.D., IV. (1998). *U.S. Patent No. 5,732,978*. Washington, DC: U.S. Patent and Trademark Office.

Books

Tunnell, H.D., IV. (2006). *Red Devils: Tactical perspectives from Iraq*. Fort Leavenworth, KS: Combat Studies Institute.

Tunnell, H.D., IV. (2000). *To compel with armed force: A staff ride handbook for the battle of Tippecanoe*. Fort Leavenworth, KS: Combat Studies Institute.

Book Chapter

Tunnell, H.D., IV. (2015). Crisis Management and Combat Operations in Afghanistan. In J. D. VanVactor (Ed.), *Crisis Management: A Leadership Perspective* (pp. 195-209). New York: Nova.

Peer-Reviewed Journal Articles

Tunnell, H.D., IV. (2014). Network-centric warfare and the data-information-knowledge-wisdom hierarchy. *Military Review*, (92)3, 43-50.

Tunnell, H.D., IV. (2013). Homeland security information representation: A case for standardization. *Journal of Homeland Security Education*, 2, 36-43.

Peer-Reviewed Conference Papers

Tunnell, H.D., IV, Pfaff, M., Faiola, A. (In Press). Secondary users and the Personal mHealth Record: Designing tools to improve collaboration between patients and providers.

Tunnell, H.D., IV. (2015). *The U.S. Army and network-centric warfare: A thematic analysis of the literature*. Paper presented at the 2015 IEEE Military Communication Conference, Tampa, FL.

Tunnell, H.D., IV, Faiola, A.J., Haggstrom, D.A., & Srinivas, P. (2015). *Clinicians as secondary users of patient-centered mobile technology in complex healthcare settings*. Paper presented at the 2015 IEEE International Conference on E-Health Networking, Application, and Services, Boston, MA.

Tunnell, H.D., IV. (2014). Technology diffusion and military users: Perceptions that predict adoption. Paper presented at the 2014 IEEE Military Communications Conference, Baltimore, MD.

Tunnell, H.D., IV. (2013). Combining technology acceptance and culture in one tool: Implications for information sharing within coalitions. Paper presented at the 2013 IEEE Military Communications Conference, San Diego, CA.

Tunnell, H.D., IV. (2013). A pilot study about military users and information systems: Exploring military user attitudes about technology. ASE/IEEE International Conference on Social Computing, Washington, DC.

Tunnell, H.D., IV & Verma, Aeshvarya. (2013). Supporting the continuum of care for combat wounded patients: Adaptive interfaces for personal health records. In C. Stephanidis & M. Antona (Eds.), *Universal Access in Human-Computer Interaction. Applications and Services for Quality of Life* (Vol. 8011, pp. 544-552). New York: Springer.

Professional Publications

Tunnell, H.D., IV. (2011). Task Force Stryker network-centric operations in Afghanistan. *Defense & Technology Papers* (No. 84). Washington, DC: Center for Technology and National Security Policy.

Tunnell, H.D., IV. (2009). A short summary of information operations terms. *IO Sphere, Spring*, 10-17.

Tunnell, H.D., IV, Shields, B., Schroeder, G., & Molino, C. (2009). Manning, training, and equipping a company battle staff. *Infantry Magazine*, (98)1, 8-12.

Tunnell, H.D., IV. (2008). Developing a unit language capability for war. *Joint Forces Quarterly*, 51(4th Qtr), 114-116.

Streusand, D. & **Tunnell, H.D., IV**. (2006). Choosing words carefully: Language to help fight Islamic terrorism. *NDU Release No. 06-008*. Washington, DC: National Defense University.

Posters

Tunnell, H.D., IV. (2013, September 10). A pilot study about military users and information systems: Exploring military user attitudes about technology. Poster session presented at the ASE/IEEE International Conference on Social Computing, Washington, DC.

Tunnell, H.D., IV. (2013, May 7-8). *Understanding 19th century combat decisions with GIS*. Poster session presented at the Indiana GIS Conference, Muncie, IN. [Awarded 3rd place.]

Presentations and Videos

Tunnell, H. D., IV (2015, November 8). Creating the Battle of Tippecanoe staff ride. Presentation at the Tippecanoe County Historical Association, Battle Ground, IN.

Tunnell, H.D., IV. (2015, April 29). *Network-centric warfare: Why it matters*. Presentation at InfowarCon, Nashville, TN.

Tunnell, H.D., IV. (2014, February 19). Panel member: Prospects for counterinsurgency, stability operations, and peacekeeping after Iraq and Afghanistan. University of South Florida: Modern Warfare's Complexity and the Human Dimension conference. [Presentation "Network-centric warfare theory: Prospects for operations after Iraq and Afghanistan."]

- Tunnell, H.D., IV. (2013, November 4). *Fighting it out along the Wabash: Harrison, Tecumseh, and the Shawnee Prophet*. The George R. Mather Lecture Series, Allen County – Fort Wayne Historical Society.
- Tunnell, H.D., IV. (2012, April 11). *Battle wisdom: How IT contributes to developing wisdom for battle*. Presentation to the Louisville Chapter of the MOAA, Louisville, KY.
- Tunnell, H.D., IV. (2011, November 9). *Experiences of a Purple Heart recipient*. Speech to the Louisville Chapter of the MOAA, Louisville, KY.
- Tunnell, H.D., IV. (2011, January 25). *Military informatics*. Presentation to the Mounted Combat Data Working Group, National Ground Intelligence Center, Charlottesville, VA.
- Battle Command Training Center. (2011). *Operation Blowfish: Decision making exercise* [DVD]. Joint Base Lewis-McChord, WA: Joint Base Lewis-McChord Battle Command Training Center, Leader Development Team [5/2 ID (SBCT) subordinate unit operations in Afghanistan].
- Battle Command Training Center. (2010). *Operation Opportunity Hold 5/2 SBCT Operation Enduring Freedom* [DVD]. Joint Base Lewis-McChord, WA: Joint Base Lewis-McChord Battle Command Training Center [5/2 ID (SBCT) unit operations in Afghanistan].
- Tunnell, H.D., IV. (2010, September 15). Panel Member: Stryker Brigade Combat Team combat operations. Infantry Warfighting Conference, Columbus, GA. September 13-15, 2010.
- Tunnell, H.D., IV. (ca. 2009). Panel Member: ARFORGEN discussion. Command and General Staff College. Fort Leavenworth, KS.
- Tunnell, H.D., IV. (2008, September 15-17). *Stryker Brigade Training*. Presentation to the Infantry Warfighting Conference, Fort Benning, GA.
- Tunnell, H.D., IV. (ca. 2008). *ARFORGEN brief to Command and General Staff College students* [Video]. Presentation to the Command and General Staff College. Fort Leavenworth, KS.
- Tunnell, H.D., IV**, Neumann, J., Shields, B., Smith, D., & Allen, S. (2008). *5/2 ID (SBCT) discussion of a commander's role in exercising command and control* [DVD]. BG S.L.A. Marshall Combat Leader Interview Series. Fort Lewis Battle Command Training Center, Fort Lewis, WA.

Workshop

Tunnell, H. D., IV (2015, November 8). Staff ride workshop. Presentation at the Tippecanoe County Historical Association, Battle Ground, IN.

Interviews

Tunnell, H.D., IV. (2011, February 11; 2010, December 1). *Interview with Colonel Harry D. Tunnell IV (2 Parts)/Interviewer: Steven Clay*. Contemporary Operations Study Team, Combat Studies Institute, Fort Leavenworth, KS.

Tunnell, H.D., IV. (2010, July 19). *COL Harry Tunnell Brigade Commander 5/2 SBCT/Interviewer: William Reeder* [Video]. S.L.A. Marshall Combat Leader Interview Series. Joint Base Lewis-McChord Battle Command Training Center, Joint Base Lewis-McChord, WA.

Tunnell, H.D., IV. (2008, May 12). *COL Harry Tunnell 5/2 ID (SBCT) /Interviewer: William Reeder* [Video]. PRIDE Individual Interview Series. Fort Lewis Battle Command Training Center, Fort Lewis, WA.

Tunnell, H.D., IV. (2006, January 23). *Interview with Lieutenant Colonel Harry D. Tunnell IV/Interviewer: Terry Beckenbaugh*. Contemporary Operations Studies Team. Combat Studies Institute, Fort Leavenworth, KS.

Blogs

Tunnell, H.D., IV. (2014, December 26 – Present). Fort Wayne Inventors Club, multiple entries [Blog]. Retrieved from <http://fortwayneinventorsclub.org/blog/>

Tunnell, H.D., IV. (2014, November 4). How to use free software to enhance your history projects [Blog]. Retrieved from <http://historycenterfw.blogspot.com/2014/11/how-to-use-free-software-to-enhance.html>

Tunnell, H.D., IV. (2014, August 30). The Negro Motorist Green Book (1936-1964) [Blog]. Retrieved from <http://www.blackpast.org/aah/negro-motorist-green-book-1936-1964>

Tunnell, H.D., IV. (2014, January 28). Fighting it out along the Wabash: Part two [Blog]. Retrieved from <http://historycenterfw.blogspot.com/2014/01/fighting-it-out-along-wabash-part-two.html>

Tunnell, H.D., IV. (2014, January 27). Fighting it out along the Wabash: Part one [Blog]. Retrieved from <http://historycenterfw.blogspot.com/2014/01/fighting-it-out-along-wabash-part-one.html>

Grants

2015	MilCom Travel Grant (\$750.00)
2014	MilCom Travel Grant (\$750.00)
2013	MilCom Travel Grant (\$750.00)

Honors and Awards

2016	Award of Distinction for Website Design
2015	Silver Davey Award for Website Design
2015	W ³ Silver Award for Website Design
2015	Award of Distinction for Website Design
2015	Ideas Solving Social and Economic Challenges (Finalist)
2014	Tapia Scholarship
2013	IndianaMap (GIS) Poster Competition (3 rd Place)
2012	Legion of Merit, 2 nd Award (1 st Award 2010)
2003	Purple Heart Medal
2003	Combat Infantryman Badge, 2 nd Award (1 st Award 1989)
2003	Master Parachutist Badge with Combat Jump Device
2002	The Order of Saint Maurice (Centurion)

Teaching

2016	Instructor, I275, Introduction to Human-Computer Interaction Theory
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Service

2014 – Present	Webmaster and Meetup Organizer, Fort Wayne Inventors Club
2014 – 2016	Chair, Marketing Committee, History Center, Allen County – Fort Wayne Historical Society
2012 – 2016	Member, Board of Directors, History Center, Allen County – Fort Wayne Historical Society

Associations

2015 – Present	American Medical Informatics Association
2014 – Present	Indiana Geographic Information Council
2013 – Present	Fort Wayne Inventors Club
2013 – Present	Omicron Delta Kappa (National Leadership Honor Society)
2013 – Present	Phi Kappa Phi (Academic Honor Society)
2012 – Present	Allen County – Fort Wayne Historical Society
2012 – Present	Upsilon Pi Epsilon (Honor Society for Computing Sciences)
2011 – Present	Golden Key International Honour Society (Academic Honor Society)
2011 – Present	Institute of Electrical and Electronics Engineers
2011 – Present	Association for Computing Machinery
2010 – Present	Armed Forces Communications and Electronics Association
2009 – Present	United Inventors Association
2004 – Present	Military Order of the Purple Heart (Combat Wounded Veterans)
2001 – Present	American Legion (Veterans Organization)
1995 – Present	Veterans of Foreign Wars (Combat Veterans Organization)