GETTING EVERYONE ON THE "SAMEPAGE": CO-DESIGN FOR HEALTH INFORMATION EXCHANGE DURING CARE TRANSITIONS

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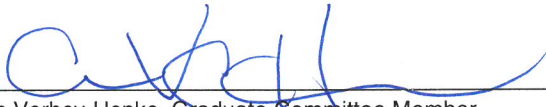
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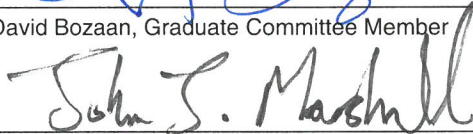Ann Arbor, Michigan

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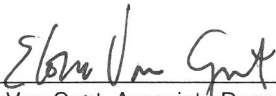
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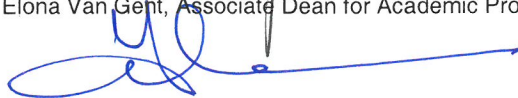Ann Verhey-Henke, Graduate Committee Member

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21ST CENTURY HEALTHCARE

Getting Everyone on the "SamePage":
Co-design for Health Information
Exchange During Care Transitions

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Acknowledgements

Contents

Abstract

Transition between different clinical settings is one of the most common activities in the U.S. healthcare system. During the care transition process, it is possible for clinicians and patients to encounter adverse events, medication errors, redundant diagnostic tests and have costly but avoidable readmissions. However, efficient Health Information Exchange (HIE) between clinicians, patients and families have seldom been explored. This study aims to investigate the factors which affect clinicians' and patients' HIE usage during care transitions. By collaborating with clinicians and patients, a co-design methodology was applied throughout the whole design process from data gathering and analysis to concept generation and realization. After a 7-month research process, a HIE tool called SamePage was delivered as the final output of this study.

SamePage can not only help clinicians better understand the health condition and history of new patients who are transferred from other clinical settings but can also help patients and families document their care journeys and navigate their care transition process in the complex healthcare system. By transferring health data into comprehensive, understandable and meaningful information, SamePage aims at getting all of the clinicians, patients, and families on the same page of patient care transition, but not pages.

Keywords

Care Transition, Health Information Exchange (HIE), Co-design, Electronic Health Records (EHR), Data Visualization & Analysis.

INTRODUCTION

Background

The transition from one kind of clinical setting, for example, an Emergency Room (ER), in-patient care unit or specialist clinic, to another, is one of the most common activities in the U.S. healthcare system. However, care transition is one of the most vulnerable periods of time for patients who have multiple chronic conditions because this group of people is more likely to transfer between various clinical settings, take many kinds of medications, and see lots of providers.

(Kessler, Williams, Moustoukas, & Pappas, 2013; The Joint Commission, 2012). Therefore, during the complicated care transition process, it is possible to encounter adverse events, medication errors, redundant diagnostic tests (Naylor & Keating, 2008), and costly but avoidable readmissions (Dartmouth Atlas Project & Lake Research Group, 2013).

Inefficient Health Information Exchange (HIE) between clinicians, patients and families has been recognized as one of the key reasons for unsuccessful care transition (Williams et al., 2012). HIE technology aims at helping clinicians, patients and families efficiently access and securely share patients' digital health information (HealthIT.gov, 2014 May). Appropriately and timely exchange of patient information can improve patients' safety, increase clinicians' efficiency, and reduce health-related costs. (HIMSS Guide to Participating in HIE, 2009 November). However, with increasing Electronic Health Record (EHR) and HIE adoption, there are three main problems which influence the quality of care transition. Firstly, according to IBM Watson, "each person generates one million gigabytes of health-related data across his or her lifetime, the equivalent of more than 300 million books." (Stankiewicz & Haswell, 2015). Therefore, helping clinicians get the most meaningful and actionable data out of the overwhelming data source is a serious problem that needs to be tackled. Secondly, it is tough for clinicians to understand new patients' health conditions and history accurately and holistically, this applies even more to patients (and their families) with comorbidities to follow up all the discharge instructions, and navigate themselves successfully in the complex healthcare system. Lastly, today, most existing EHRs are only designed to store clinician entered data, which is gathered during a patient's care journey. New technologies have enabled patients to generate self-reported health data outside of the clinical setting and share it with their care teams, to expand the continuity of health information accessibility. However, there are no widely established policies and regulation to define an appropriate use of self-reported health data (Deering et al., 2013)

To address these problems the present study explored the factors that affect clinicians' and patients' HIE usage during care transitions and applied a co-design methodology in the research process to generate the final design solution. The aim was to promote HIE development in the near future, when all of the health-relevant data is digitalized and shareable across different Health Information System (HIS).

Problem statement

The primary aim of this study is to use a co-design approach to developing a HIE tool which has the potential to help providers better understand the health condition and history of new patients who are transferred from the same or different HIS. This tool can also help patients and families to document their care journeys and navigate through the complex care transition process.

The context of this study is based in the University of Michigan Hospital System (UMHS) (Figure 1) and St. Joseph Mercy Hospital in Ann Arbor, Michigan (Figure 2) between January 2016 and March 2017. Thus all the data collected and the design outcomes delivered in this study were only situated within these two locations. Therefore this will be used as a case study to explore its universality and scalability.

Figure 1. UMHS

Figure 2. St. Joseph Mercy Hospital

Rationale

Health information today is fragmented into various care episodes, which makes it very difficult for clinicians from different care teams to share a holistic oversight of patient health conditions (Yamasaki, 2015). Lack of connection between clinicians is an essential reason for this problem. However, many existing HIE vendors are only focusing on essential features of HIE, such as the laboratory results delivery. The trend of offering provider-to-provider data exchange service is emerging, but still in an initial developing phase (Rudin et al., 2011). Therefore, it is necessary to create a shared platform which can not only connect the lab results but also connect clinicians, patients and families to better understand the shared information and generate insights to inform their decision making.

Next, in the context of health information sharing, information overload is becoming a huge issue which is negatively influencing the efficiency of providers' work. More health data is generated every year than a doctor can read in a lifetime (Halamka, 2014). As EHR adoption becomes more universal, clinicians could be increasingly overwhelmed by new patients' health data than they are today. Clinicians want to know what are the most actionable and meaningful information they can utilize rather than reviewing hundreds of medical data which is not practical (Furukawa et al., 2014). For patients and families, they are facing the same problem. Especially the patients who have multiple chronic conditions and may need to be transferred among various clinical settings, and generated many discharge documents. So adhering to these instructions and managing their care appropriately is a big challenge. Therefore, an effective way of filtering, organizing and displaying health information in an EHR is necessary for helping clinicians save their time, improve work efficiency, and assist patients to manage their care better and keep healthy at home.

The demand for HIE is growing along with nationwide efforts

to improve the quality, safety, and efficiency of the healthcare system. Both meaningful use (see more details in Contextual review) requirements and federal financial incentives drive the interest and demand for HIE. For example, the Office of the National Coordinator for Health Information Technology introduced the Health Information Exchange Challenge Grant Program. (HealthIT.gov, 2013 January; Mertz & Russell, 2013) This program was designed to foster innovative solutions to support nationwide health information exchange and interoperability, and the priority of this program is to improve the efficiency of HIE. The high returns on investment rate has demonstrated that HIE platforms have dramatically improved the quality of health care services nationwide (Khurshid, Diana, & Jain, 2015).

Lastly, interoperability has already been recognized as one of the critical barriers to making health data shareable across different HISs. According to the Office of the National Coordinator for Health Information Technology (ONC), interoperaterbility in health IT products and services will be avaiable for clinicians and patients by 2024 (The Office of the National Coordinator for Health Information Technology, 2015). In the past decades, the nation has made a dramatic improvement in digitizing the care delivery system. For example, over half of office-based professionals and more than 80% of hospitals are meaningfully using EHRs; half of the hospitals can search for patient information across various HISs; all 50 states have some form of HIE services available to support care (The Office of the National Coordinator for Health Information Technology, 2015). Therefore, in the near future, when all health data is digitized, and interoperability is no longer a hindrance for clinicians and patients to share health information across different HIS, how could we utilize this huge amount of data wisely and efficiently is worthwhile to be considered now.

Structure of the thesis

This thesis is organized as follows. The next section introduces the contextual background focusing on the relationship between HIE and care transition, meaningful use of EHR, transforming big data to a big impact, and co-design in healthcare innovation. The following section introduces the methodology applied in this study, which includes documentation of the partner and stakeholders involved, a co-design process map, data collection and analysis, concept generation and realization, as well as an identification of ethical risks during the user research process. The results of this study are then discussed relative to the development process, user feedback, limitation, and evaluation. The thesis concludes by highlighting project reflection and avenues for further plans.

CONTEXTUAL REVIEW

Health Information Exchange (HIE) is a key to a better care transition
What is care transition?

Care transition refers to "the movement patients make between healthcare settings as their condition and care needs change during the course of a chronic or acute illness" (Coleman, 2003). For example, when a patient is attacked by heart failure, he or she might receive

care from an ER or a cardiologist in an outpatient clinic, then transfer to a hospital inpatient unit. After being discharged from the hospital, the patient could be referred to a Skilled Nursing Facility (SNF) for rehabilitation, and/or return home, where he or she would receive care from a visiting nurse. Each of these shifts from a certain care provider and setting is defined as a care transition (as shown in Figure 3).

Poorly managed care transitions will not only decrease patient health, but could also result in huge unplanned readmission costs. According to the data from Center for Health Information and Analysis (CHIA), the estimated annual cost of this problem for Medicare is $26 billion, $17 billion of which is considered avoidable.

This study focused on the care transition process of patients with multiple chronic conditions. For this group of patients, the problems they encounter during their care transitions are typical and complex enough to come up with an inclusive design solution which could be applied to other patients without multiple conditions.

What is Health Information Exchange (HIE)

According to healthIT.gov "HIE allows doctors, nurses, pharmacists, other health care providers and patients to appropriately access and securely share a patient's vital medical information electronically—improving the speed, quality, safety and cost of patient care" (http://www.healthit.gov/providers-professionals/health-information-exchange/what-hie). There are three key forms of HIE. The first one is directed exchange, which means exchanging information electronically between clinicians. The second one is called query-based exchange, which helps clinicians to search patient's information from other providers. The last one is consumer mediated exchange, which is for patients to manage their own health information among clinicians (HealthIT.gov, 2014 May). In this study, all three key forms of HIE were taken into consideration.
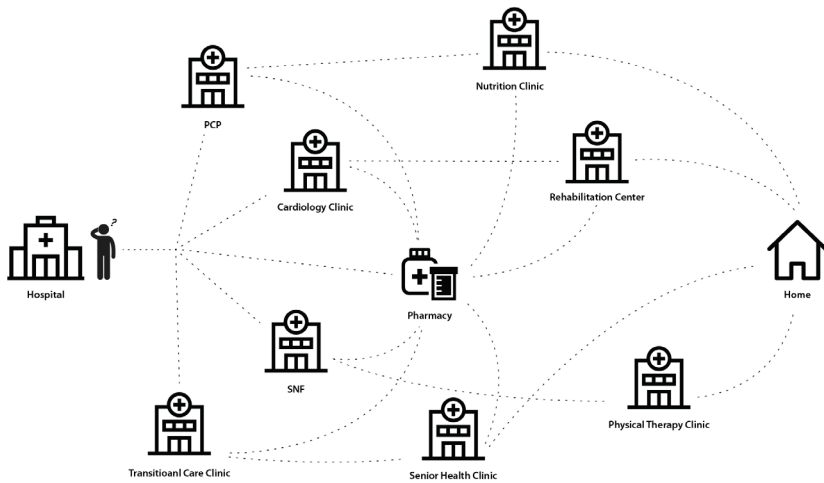
Figure 3. Example of Care Transitions

HIE can be an important component of existing EHR systems or developed as an independent application. No matter which kind of HIE, most of these vendors are mainly intended to share records between clinicians within a same native HIS, which means there is potential to have a cross-HIS HIE platform with the capability of integrating all the EHR data into the same place.

Why HIE is important to care transitions?

A core function of HIE is to facilitate data exchange among healthcare providers working in different locations (Rudin, 2011). Previous research suggested a significant need for this kind of data exchange. Pham et al. (2007) found that the typical Medicare beneficiary between 2000 and 2002 saw a median of seven different physicians in four different offices each year, and patients with chronic conditions saw an even greater numbers of physicians. But no matter where the patient has been referred to, and how many different places they have been, it is always helpful to have their medical records with them (Smith, 2012).

According to a U.S. Department of Health and Human Services (HHS) study reported in 2013 (Center for Medicare & Medicaid Service, 2013), HIE interventions have resulted in helping clinicians get away from dealing with paper documents, telephones and faxes, and have reduced hospital readmissions caused by medical errors, avoiding duplicative tests and procedures.

As HIE is becoming more integrated into the healthcare system and playing an important role in care transitions, this study explored the possibility of how communication issues in the care transition process could be diminished when patients' health information can be more easily and accurately tracked, reviewed and shared.

Design for Meaningful Use of Electronic Health Record (EHR)

What is meaningful use and why is it important?

Meaningful Use is using certified EHR technology to improve the quality, safety and efficiency of health care, while reducing health disparities. It engages patients and families in their health care and improves care coordination (Center for Medicare & Medicaid Service, 2017). In 2009, Congress authorized more than $30 billion in incentives to stimulate the adoption and meaningful use of EHR by eligible professionals and hospitals (Blumenthal, 2009). According to Centers for Medicare & Medicaid Services (CMS), meaningful use is implemented in a phased approach over a series of three stages. Stage one is designed to promote basic EHR adoption and data gathering. Stage two focuses on care coordination and exchange of patient information. Stage three aims at improving the overall healthcare outcomes (as shown in Figure 4).

Meaningful use requirements have a fairly positive effect on both clinicians and patients during care transition. On one hand, meaningful use focuses on helping clinicians make more informed decisions by preventing duplicative lab testing, reducing adverse drug events, and enhancing collaboration. On the other hand, meaningful use requirements are supportive to patients, through providing them better access to their medical records, enhancing engagement and collaboration with their care teams, and allowing them to receive reminders about their follow-up appointments. Because of this, HIE allow patients to experience positive changes during care transitions (Center for Medicare & Medicaid Service, 2013).

Meaningful Use Stage	Stage 1: Data capture and sharing	Stage 2: Advanced clinical processes	Stage 3: Improved outcomes
Start date	Launched in **2011**	Began in **2014**	Providers have the option to begin in **2017**, but are not required until **2018**.
Discription	Meaningful Use Stage 1 emphasizes proper electronic data capture and data sharing using an EHR technology. Eligible providers can attest to Stage 1 and receive their incentive payment after meeting nine core objectives and one public health objective.	Introducing new objectives and measures, as well as higher thresholds, requiring providers to extend EHR capabilities to a larger portion of their patient populations. The recent changes to the Meaningful Use program have Stage 1 and 2 more closely aligned, with both requiring nine core objectives and one public health objective, for attestation.	Although details have not been finalized, Meaningful Use Stage 3 will aim to simplify the program, drive interoperability between electronic health records, and improve patient outcomes.

Figure 4. Three Stages of Meaningful Use

Problem list is the key to meaningful use

In the 1960s, Lawrence Weed created the problem list as a part of his recommendations for a problem-oriented medical record (Weed, 1968). The core feature of problem list is meant to convey the most important conditions about a patient so that clinicians to get a quick overview of the patient's condition and ensure that important information will not be neglected in the medical notes (Holmes, et al., 2012).

The problem list plays a significant role in EHRs since the meaningful use at stage one requires the creation and maintenance of an up-to-date problem list for 80 percent of patients. As a core of problem-centered EHR, the up-to-date problem list could deliver an integrated view of current patient conditions across different care settings, which is also the main goal of meaning use. In addition, an up-to-date problem list can also provide data for some performance and research plans which will finally help meet the criteria at Stage two and three of meaningful use (Bormel, 2011).

Clinicians' ability to quickly browse the most important health information about their patients is very critical for them to make high quality clinical decisions. The function and effectiveness of problem list will be decreased, when some key information is left out or hidden. Therefore, in order to improve patient care and reap further benefit from the problem list as a data resource, it is necessary for the medical community to have clear, consistent, complete, and accurate problem list.

From Big data to Big Impact in Healthcare

Big data in healthcare

Historically, the healthcare industry has generated large amounts of data, driven by record keeping, compliance and regulatory requirements, and patient care (Raghupathi W, 2010). According to reports, data from the U.S. healthcare system reached 150 exabytes in 2011. At this rate of growth, it is estimated that big data from U.S. healthcare system will reach the zettabyte soon (IHTT, 2013) (as shown in Figure 5)

The big data in the healthcare industry includes clinical data from CPOE (Computerized Physician Order Entry), physician's written note,

1 Megabyte (MB)	=	1024 Kilobyte (KB)
1 Gigabyte (GB)	=	1024 Megabyte (MB)
1 Terabyte (TB)	=	1024 Gigabyte (GB)
1 Exabyte (EB)	=	1024 Terabyte (TB)
1 Zettabyte (ZB)	=	1024 Exabyte (EB)
1 Yottabyte (YB)	=	1024 Zettabyte (ZB)

Figure 5. Big Data Scales

prescriptions, medical imaging, laboratory, insurance, patient data in electronic patient records (EPR), machine generated/sensor data, and social media platforms (Raghupathi & Raghupathi, 2014). All of these different types of health data comprise an enormous landscape of health database. (As shown in Figure 6).
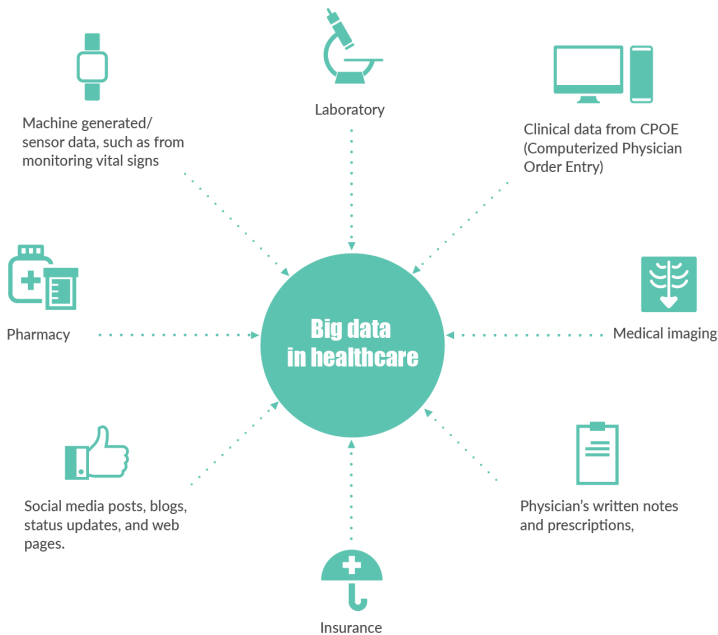

Figure 6. Health Data Source

Potential benefits of big data analytics in healthcare

By digitizing, combining and effectively using big data, healthcare organizations started to realize the significant benefits of applying big data into their medical practices (Burghard, 2012). The main advantages of utilizing big data in healthcare include detecting diseases at earlier stages, predicting the length of stay in the hospital, patients who could not benefit from surgery, and patients who could be risky for medical complications (Raghupathi, & Raghupathi, 2014). McKinsey estimates that every year, more than $300 billion will be saved in U.S. healthcare by big data analytics (Manyika, et al., 2011). Therefore, instead of only getting clinicians and patients' access to the EHR, organizing the existing health information in an understandable way is the primary goal of the present study. This study also tackled how to analyze the vast amount of data, and give a meaningful analytic outcome for clinicians and patients to make better medical decisions.

Co-design in healthcare innovation

Why should we conduct co-design in healthcare?

There are lots of different definitions of co-design. This study followed the one generated by Kleinsmann and Valkenburg (2008), co-design refers to "the process in which actors from different disciplines share their knowledge about both the design process and the design content in order to create shared understanding on both aspects, and to achieve the larger common objective: the new product to be designed."

Co-design methods have been widely used in the healthcare field,

from developing home-based prototype systems for monitoring and tracking health-related data for premature infants (Hayes, et al., 2011), to targeting older people with chronic dizziness and discussing challenges when performing co-design with sick users in private homes. (Grönvall & Kyng, 2013). Muller (2003) articulated a range of benefits of co-design, including improving mutual learning, understanding; integrating different people's ideas; and enhancing communication and cooperation between various people. For example, Kristensson, Magnusson, and Matthing (2010) invited "ordinary users" to ideate for innovative mobile ICT services in their experiments. Through these experiments, they found that the average users' ideas are more innovative and a better match with users' needs than the ideas generated by professional developers (Steen, 2011). Therefore, to collect more perspectives in this design process, various kinds of professionals should be invited to join the co-design team, such as a physician, nurse, pharmacist, social worker, patients and family caregivers. More detailed information about the co-design team formation will be discussed in the methodology section.

Challenges of conducting co-design in healthcare

Admittedly, implementing co-design in a healthcare design project is full of challenges. For example, since co-design in healthcare refers to the collaboration between healthcare professionals and patients working in partnership to improve certain products or services, it often requires the co-design participants to have plenty of time to join group work (Robert, et al., 2015). Because of time constraints, the coordination of different participants' schedules in the co-design project is a significant problem that needs to be solved. Also, how designers, as facilitators, could involve stakeholders in the co-design process, and help the co-design participants overcome the barriers

of mutual understanding to enhance their engagement and empathy. To improve the rigor and accountability of co-design in the healthcare innovation context (Frauenberger, Good, Fitzpatrick, & Iversen, 2015), this study aims to contribute a case study to the co-design community.

Research questions and scope

Based on the previous discussion, my research questions in this study include:

1.Can we design a HIE platform which can get clinicians access to patients' complete health records, and also provide a tool to organize, visualize and analyze health data in a meaningful way so that clinicians can understand patients' health conditions and history more accurately, holistically and efficiently?

2. Can we design a tool which can help the patient with comorbidities better adhere to discharge instructions, and navigate by themselves successfully in complex care transition process?

3. How to apply co-design methodologies to fully engage healthcare professionals, patients and caregivers to generate a collective design solution?

Due to the limited time and resource, some existing technical, economical and organizational problems, such as interoperability across different EHR systems, the return of investment rate, and scalability of this solution are out of the scope of this study.

METHODOLOGY

Clinicians need an efficient way to collect complete health information about their patients in order to understand their health conditions and history accurately & holistically.

Instead of being manipulated & got lost in the complex healthcare maze, patients and families should be able to understand and coordinate their care by themselves during the care transition process.

Building the stakeholder network

This study is a project of the Master of Design in Integrative Design (MDes) in the Stamps School of Art and Design at University of Michigan. Six MDes students worked collectively to tackle a wicked problem in communication among clinicians, patients, and caregivers during the care transition process, and identified their individual interests to deliver specific design interventions. A Blue Cross and Blue Shield of Michigan (BCBSM) learning collaborative called I- MPACT

(Integrated Michigan Patient-Centered Alliance on Care Transitions) is the major partner of the umbrella project. From the I-MPACT network, this study connected the University of Michigan Hospital (UMHS) and St. Joseph Mercy Hospital, two hospitals in Ann Arbor, Michigan. These connections provided the MDes students' access to the clinicians, patients, and families from these networks to conduct design research. The target users of this study are healthcare professionals who need to view and exchange patients' clinical data during their care transitions and patients with multiple chronic conditions and their families (as shown in Figure 7).

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With the guidance of I-MPACT and the collaborative hospital clusters, MDes went through a complete hospital volunteer application procedure which included immunization injection, volunteer training, examination and lots of paperwork to get permission to do research in these institutions. (Figure-8) As a group, MDes conducted two months of contextual observations of the discharge process at the
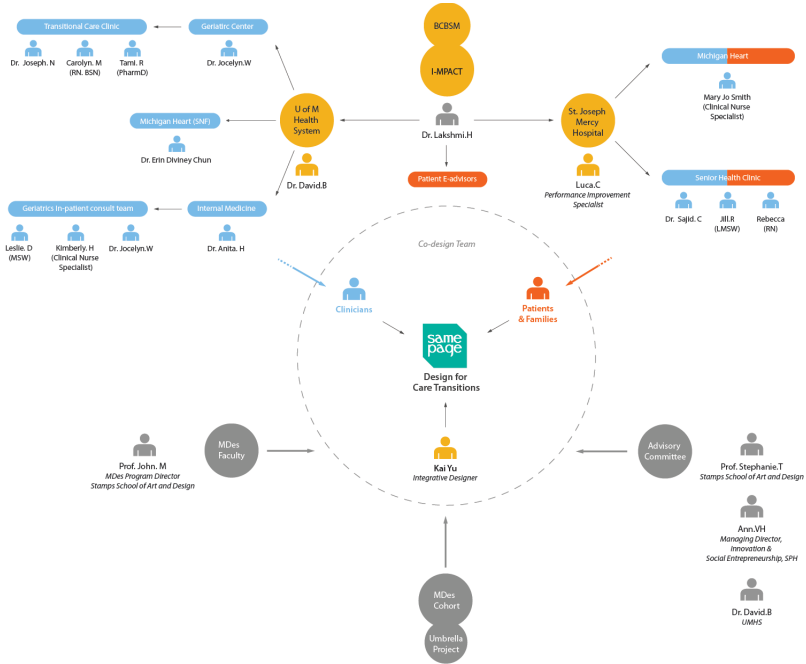
Figure 7. Stakeholder map

Figure 8. UMHS volunteer application

participating hospital clusters and interviewed more than 20 volunteer patients and families to gain insights of the care transition process. The insights from these field studies informed the planning and facilitation of a Quality Collaborative Kick-off workshop for I-MPACT (Figure-9). The workshop helped the participant hospital clusters better understand their patients, identify their problems and generate possible interventions for future implementation.

After the kick-off workshop, two hospital clusters, UMHS and St. Joseph Mercy Hospital became key partners of this study. They were able to be connected with their clinicians and patients and build a long-term collaborative relationship to conduct this study and generate a design-led intervention. There are three main reasons that contribute to the formation of this collaboration. Firstly, the key liaisons of these two hospitals are very supportive and open-minded to connect informants (clinicians, patients) which made the research process go very smoothly. Secondly, since these two hospitals use different EHR systems, and lots of patients are transferring between these two locations, it provides a perfect opportunity to study cross-platform health information exchange. Lastly, since these two hospitals are close in proximity, it saves travel time during the field study.

Based on the target population and the resources provided by these two hospitals, this study focused on some specific departments in the hospitals, including the general medicine department, in-patient geriatric consultant team, geriatric clinic, transitional care clinic (outpatient), senior healthcare clinic (outpatient) and SNF to collect relevant data of the target users. In summary, there were six physicians, four nurses, two social workers, one pharmacist, five patients, and families that got involved in this design process. These participants formed a co-design team which played a significant role in the problem clarification, concept generation, prototyping and validation phases.

Figure 9. Quality Collaborative Kick-off workshop for I-MPACT.

Co-design process map

This map (Figure 10) illustrates the key phases throughtout the entire co-design process; and integrates the information of who were the participants, what were the outputs or activities, and what kinds of methods were applied in each phase.

The process started with a design intent which was improving the quality and experience of care transition by increasing the efficiency and accuracy of HIE. The first step was inquiry. The main components in this section were interviews, observation and a design workshop. These methods were critical to gather and examine information, challenge assumptions and build contextual research. The output of the inquiry were research findings, such as field notes, audio,

and video recordings. Based on these results of the research, a systematic analysis phase was initiated. The goal of this phase was to categorize and interpret this raw information from verbal or behavioral phenomena to cause profound insights which could be applied as design principles for the further design work. The methods used for the analysis phase include data coding, affinity wall, and trend mapping.

Then, according to the insights and design principles, the co-design team started to ideate and create the personas, user stories, and multiple potential design solutions. During the solution generation phase, as many new concepts were created as possible - regardless of how feasible they were. Through group discussion, the team decided which idea to pursue further. When all the ideas had been narrowed down to a particular design concept, we initiated the prototype phase, which concentrated on creating user scenario, product features, information architecture, wireframes, building user interface mockups, and lo-fi and hi-fi prototypes.

From the insight generation to prototype phase, validation was a critical part to test whether the prototypes were making any sense from other members' perspectives in the co-design team. This method could examine whether the design solutions would reflect the real experience of clinicians and patients, instead of only designer's assumptions. When the design features were developed, all the team members reviewed them collectively to discuss whether these features could resolve the problems in the real healthcare context. In the prototype phase, testing the low-fi or high-fi prototypes with team members and modifying based on their feedback was an efficient way to iterate the design solutions. Compared with the traditional linear design process, which puts validation at the end of prototype phase, this strategy saved lots of time and energy for the co-design team to make valid decisions and iterate simultaneously.
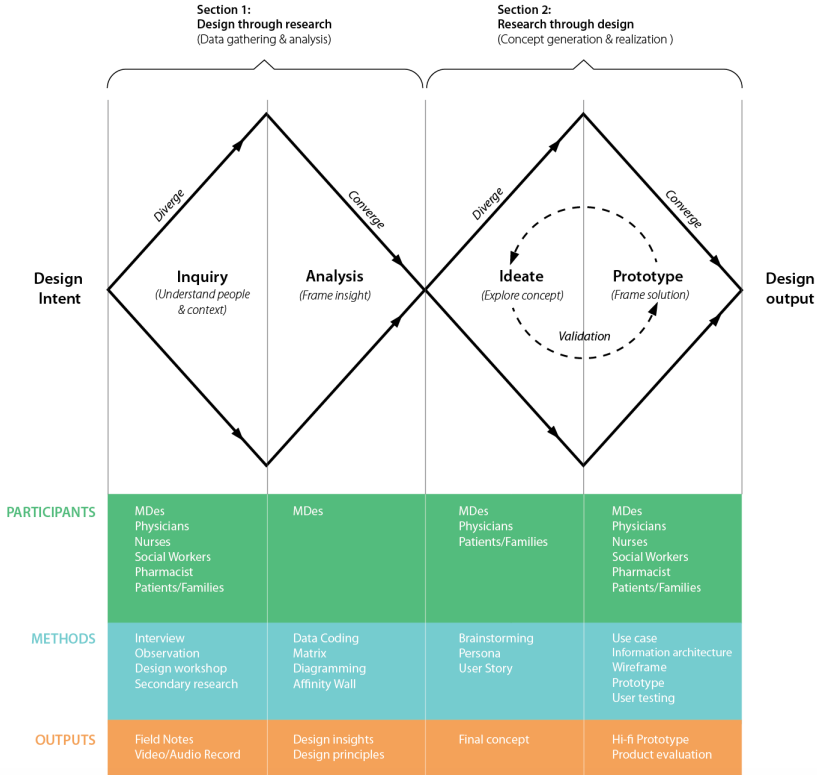
Figure 10. Co-design process map.

Design through research - Data collection and analysis

The first part of the design-through-research phase is an inquiry, the main components of inquiry are observations in hospital settings, a co-design workshop, and interviews with clinicians, patients, and caregivers. The inquiry is essential to gather and examine information, challenge assumptions and seek shared goals among various stakeholders. After inquiry, all the research findings gathered from previous observation, workshop and interviews were analyzed and

synthesized into qualitative insights and design principles, which provided the co-design team a guideline for developing concepts in the next phases.

Observation

There are two rounds of observations in this study, the first round was from January 2016 to March 2016, and three 4-hour long passive participatory observation were conducted in the short-stay inpatient unit at UMHS. Since the quality of the discharge education will significantly influence patients' care transition experience, in the first round observations, several physicians and nurses were shadowed to monitor how they discharge patients and educate them before they were discharged. (Figure 11-16: 1st round observation)

The second round of observation was between October 2016 and January 2017, eight moderate participatory observations with various length of time were conducted in the general medicine department, geriatric clinic, transitional care clinic (outpatient) at UMHS, and senior healthcare clinic (outpatient) and SNF at St. Joseph Mercy Hospital. This round of observations focused more on the new patient assessment process, clinicians' interaction with EHR, and the interaction between clinicians and patients in the patient room. (Figure 17-20: 2nd round observation)

Key Findings:

During the observation, I used a notebook to document what I saw and heard in the form of POEMS (People, Object, Environment, Message, and Service) (Kumar, 2012) (Figure 21). This framework helped me look beyond human interaction to services, messages, product and environment in the clinical setting. From applying the POEMS framework in the observation, some key findings are as follows: (Figure-21: observation notes)

Figure 11

Figure 12

Figure 13

Figure 14

Figure 15

Figure 16

1. Lots of patients are eager to be discharged soon, but they are not mentally and physically prepared to go home. One nurse told me after seeing a patient, "he wants to eat at home, he feels like tired of being here, but I think he will fail at home by himself, he will come back…"

2. Some patients cannot give very explicit answers to their doctors/nurses' questions; they don't know themselves very well. Particularly for the patients, I observed in the geriatric department, poor communication between patients and clinicians makes it tough for clinicians to get the information they want. If the patients have dementia symptoms, the situation could be even worse.

3. Most of the physicians' time is spent on reading information from the EHR and importing data into it, but not with patients. Understanding patients' conditions by reading the previous notes and lab results took physicians a considerable amount of time. Moreover, documenting what they gathered from patients into the EHR for other clinicians to read costs them, even more, time and energy.

4. For the patients who are transferred from St. Joseph Mercy to UMHS, physicians need to call each other to fax all the medical records over, and it is also the physicians' job to scan all of these documents into the EHR, which is a very tedious and inefficient procedure.

5. When patients are discharged from St. Joseph Mercy, they will be given two different sorts of discharge document. One is for clinicians to read, patients can take this document when they next visit any hospital or clinic, just in case the clinicians cannot get access to their digital medical records. The other document is for patients themselves; it includes some vital health information such as diagnosis, medications, instructions and follow-up appointments.

6. Patients often complain that clinicians keep asking them some similar questions over and over again, and every time they have to give same answers to different people in their care teams. This is very annoying, and influences the experience during their hospital stay.

Figure 17

Figure 18
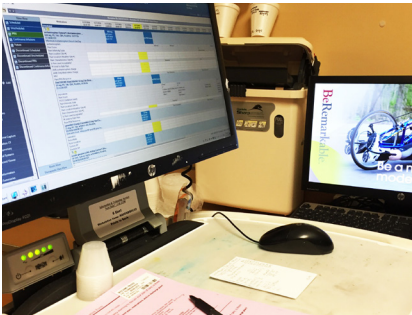
Figure 19

Figure 20
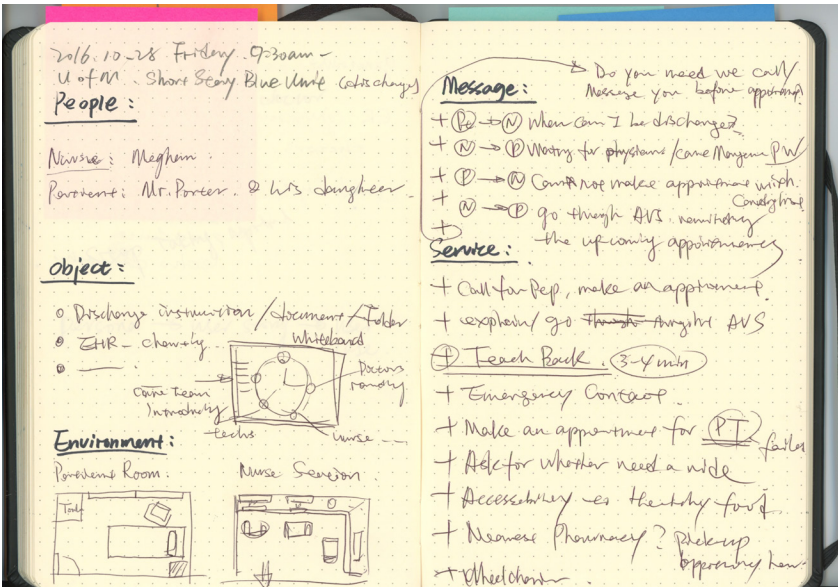
Figure 21. Observation notes.

Design workshop

With the theme of improving the care transition experience by redesigning the interaction between clinicians, patients, and caregivers, a co-design workshop was collectively organized and facilitated by the MDes students. There were more than 40 participants in this workshop which includes healthcare professionals, patients, caregivers, and designers (Figure-22). At the beginning of the workshop, we used the data collected from the previous observation to create personas and user stories, which were used to trigger a series of collaborative brainstorming activities within the co-design team to stimulate mutual learning and cross-disciplinary collaborations. Also, game-storming, another effective tool to facilitate the conversations between the team members with various backgrounds, was used during the design workshop. We created a collaborative (role-play) card game, which simulated a medical team working together to discharge patients. (Figure 23) The game mechanic was abstracted from our previous observation in the healthcare settings, and it made the players (co-design team members) resonate their experience and provoked informative discussions during the workshop.

After the brainstorming session, our co-design team focused on developing a concept to tackle two initial problems. One of the problems is how might we help clinicians conduct better discharge education for patients and families, allowing them to adhere to the discharge instructions and stay healthy at home. The other is how might we improve the communication among clinicians during care transitions to foster a better health information exchange system for clinicians to understand patients' conditions more comprehensively? The design workshop ended up with a potential design solution, which was a mobile app which can improve the communication between clinicians, patients, and family caregivers. Through new channels of communication, simple tracking of patient progress, and automated triaging with predictive analytics, this solution aims at

Figure 22. Design workshop.

Figure 23. Game-storming

helping clinicians provide continuous care to their patients after being discharged.

Although the design concept generated from the workshop was not continued in the study, it was a great experience and opportunity to work with the stakeholders from various backgrounds, listen to their stories, ideas, and concerns about care transitions. Compared with interview and observation, design workshop can inspire participants and resonate them with each other to trigger more profound and interesting conversations, in this study, the design workshop was a more engaged, and inclusive method to gather more useful information from the target users.

Key Findings:

The whole process of the design workshop was video and audio recorded. All of the post-it notes, sketches, whiteboarding were synthesized into some key findings as follows (Figure-24):

1. The existing healthcare system lacks efficient information exchange mechanism between individual clinicians.

2. Misalignments of incentives result in a lack of accountability across care teams and locations of care (e.g., primary care, acute care)

3. The healthcare system usually does not foster patients' involvement in healthcare decision-making process

4. New patient assessment, as a significant part during the hospitalization, is often overlooked.

5. Current communication processes are designed to meet facility-specific needs, and does not look across the continuum.

PROBLEM STATEMENT: How do we improve patient navigation through Health care system?

Theme	Theme	Theme	Theme
Communi...	Patient Educ...	Coordination	Discha...

\# We exist in a care system that lacks information & inter - personal exchange.

\# A misalignment of incentives results in a lack of accountability across care teams & locations of care (PC, acute, PAC)

\# The health care system currently does not foster patient involvement in health care decisions.

Figure 24. Synthesize the ideas from design workshop

Interviews

Besides observation and the design workshop, six physicians, four nurses, two social workers, one pharmacist, five patients, and families were interviewed. In the interviews with healthcare professionals, my goal was to understand what the current way for them to understand the patients' condition and history when they were admitted to clinical settings was? And what kinds of obstacles would prevent them from getting enough information in the existing EHR system? When I interviewed patients and families, I focused on exploring how they managed their care after being discharged from hospitals? And what were the most challenging tasks during care transitions?

Key Findings:

The interview was conducted face to face or by telephone depending on the availabilities of the interviewees. All of the interviews were semi-structured in nature and partly audio recorded with permission (Figure 25). Based on the interview notes and transcripts, I generated key findings from clinician interviews and patient interviews separately as follows.

From clinicians' interview:

1. Before physicians see new patients in the clinic/hospital, they need to spend lots of time on their medical records to understand patients' health condition and history. According to one physician, "every five mins talk with one patient, I need to prepare relevant information for about 25 minutes."

2. All the clinicians pointed out that the information overload in EHR is an overwhelming problem they have to face every day. There are tons of notes, lab results they need to browse on EHR, however, only a small portion of information is actionable and meaningful for them, so they really need an efficient mechanism to filter out irrelevant information.
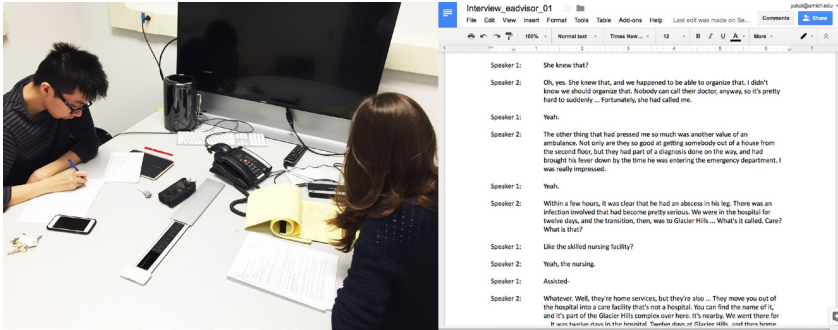
Figure 25. Phone interview & Transcription

3. The problem list is an essential feature on most EHR systems, but now this feature is much abused. According to one physician, "There are lots of problems on the problem list." Because patients' health conditions are not updated timely and categorized appropriately, it is very confusing and risky for clinicians to use the existing problem lists to understand a patient health status.

4. Since the health information cannot be shared across different EHR systems, clinicians usually have to spend a considerable amount of time and energy in gathering patients' health information from other healthcare locations by telephone or fax, which is a very inefficient way to use their work time.

5. Clinicians have subjective routines of using EHR to find the information they need. However, there is some vital health information that could be hidden deeply or distributed extensively in individual sections, which can hardly get clinicians' attention.

6. Clinicians want to know patient health conditions outside the hospital by gathering patient self-reported data (ex. heart rate, blood pressure, body weight) at home. This will be very helpful for clinicians to view the full landscape of patient care.

From patients' interview:

1. Most of the patients I interviewed have suffered a lot during care transition process, but they have no way to call attention from the healthcare system. One patient said, "The transitions out of the hospital are highly flawed or can be, and that's why I'm excited that this study is happening, and hopefully somebody's going to pay attention to it."

2. One patient mentioned it was very challenging for him to remember every detail that their clinicians told them in the hospital, this makes them feel so unprepared to be discharged. He said, "I was so overwhelmed with what happened, and I can't really absorb anything. When somebody just told you, 'You have cancer.' Once you hear that word, you just kind of are ... All you hear is, "Wah. Wah. Wah." That's why they always tell you to take somebody with you to listen and write down.''

3. Patients often think that their physicians do not take their care seriously and are not well prepared to talk with them. Because the meeting time was so short and it took much longer to make an appointment to see them again.

4. For the patients with multiple chronic conditions, their problems after discharge were more severe. They need to coordinate all the follow-up appointments, which means the patients need to figure out whether there is any time conflict between each date, who can send them to the appointment, and how to manage the complicated medication lists.

5. The current patients' portal of EHR was rarely used by all the patients I interviewed. The most common reasons they gave me were they did not know it existed, the information on the patient portal was the same as the paper documents they already had, and the patient portal was not easily accessible.

Framing insights

Synthesizing the key findings collected in previous research sections played a critical role in generating insights. The process started from transferring all the key findings I gathered from the observations, design workshop and interviews with post-it notes. (Figure-25) Then I used an affinity diagramming method to identify the patterns and categorize them into clusters. In each cluster, one insight was generated by summarizing all the notes and presented in a succinct way which is of great help in the later phases, when the co-design team is looking for guidelines to develop concepts.

Figure 26. Insights generation

Insights:

1. The overwhelming amount of data in EHR has become a hindrance which prevents clinicians from getting the most actionable and meaningful health information efficiently.

2. Clinicians need a tool to collect complete health information of their patients to understand their health condition and history accurately and holistically.

3. Care transitions should be a continuous process not only for patients but also for the healthcare system to extend the care service from clinical setting to home.

4. Instead of getting lost in the complex healthcare maze, patients and families should be able to understand and coordinate their care by themselves during the care transition process.

5. EHR system should not only work for clinicians, patients and families, but it also needs to document their care journey and analyze their health condition(s).

Framing insights

The design principles were established from the research insights generated in the previous stage. These transform insights from research into actionable, forward-looking statements to guide the ideation phase (Kumar, 2012). Design principles were also the first priorities which were considered in the next conceptualization and prototyping phases. (Figure 27)

Principle 1: The solution should not aim to replace the existing EHR, but add more value to it by providing complementary features.

Principle 2: There should be a brief overview of patients' health condition for clinicians to browse quickly before they dive into the detail information.

Principle 3: Information should be appropriately categorized to be filtered effectively according to clinicians' needs.
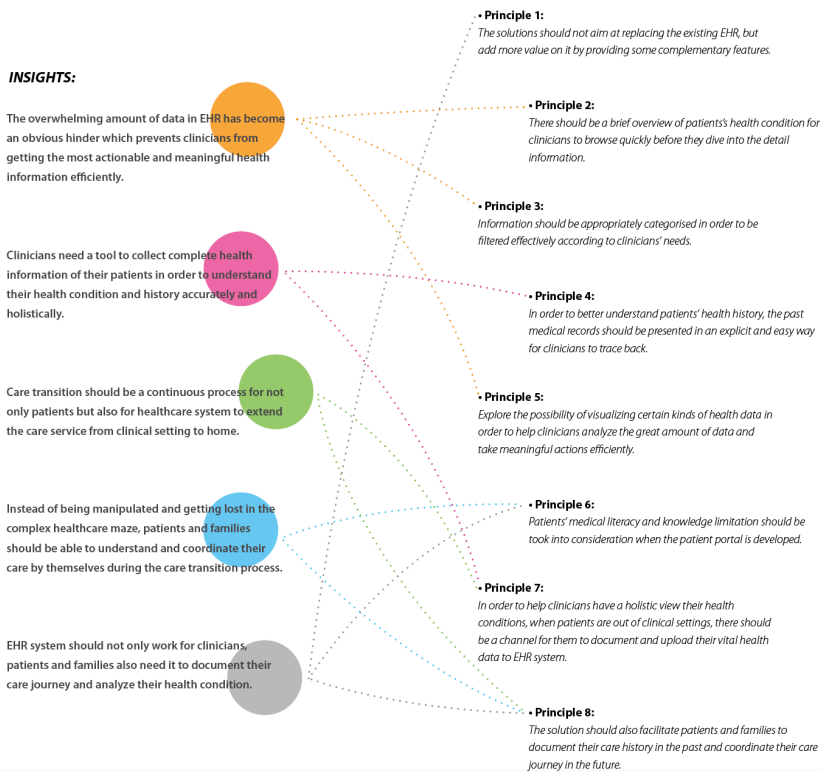
Figure 27. From insights to design principles

Principle 4: To better understand patients' health history, the past medical records should be presented in an explicit and easy way for clinicians to trace back.

Principle 5: Explore the possibility of visualizing certain kinds of health data to help clinicians analyze a great amount of data and take meaningful actions.

Principle 6: Patients' medical literacy and knowledge limitation should be taken into consideration when the patient portal is developed.

Principle 7: To help clinicians have an extensive view of their health conditions when patients are out of clinical settings, there should be a

channel for them to document and upload their vital health data to an EHR system.

Principle 8: The solution should also enable patients and families to document their past care history and coordinate their care journey in the future.

Research through design - Concept generation and realization

Cross (1982) defined research through design: "designers' mode of problem-solving is solution-focused; their mode of thinking is constructive; they use codes that translate abstract requirements into concrete objects; they use these codes to both 'read' and 'write' in object languages." In this study, the codes equal to the insights and design principles we generated previously, and objects are like personas, and prototypes. By interpreting codes into objects, the co-design team got an explicit way to set problems and solve them in the real world (Donald, 1983).

The two main components in research through design phase are ideate and prototype. The ideate section started with building two personas and user stories of a clinician and a patient based on the previous research findings and insights. Then, according to the design principles, the co- design team started to generate and finalize concepts. When the team confirmed the final concept, we moved to the prototype section, in which two sets of user scenarios were created to illustrate why and how will the target people use the solution to solve their problems. After that, I started to focus on building a wireframe, low-fi and hi-fi prototype, and demonstrated these prototypes to different target users, and iterated the prototypes according to their feedback.

Persona and user story

Based on the research findings in the previous sections, a persona and user story were created for the two target groups respectively. These tools supported the co-design team to focus on target people's specific needs to create some concepts which can fit with their contexts.

Persona & User story for Hospitalist (Figure 28)

Persona

"…Identifying the information I need from tons of irrelevant notes and charts in the EHR is the most tedious and inefficient thing I have to do everyday…"

Angie Miller

Age: 44
Occupation: Hospitalist
Education: Doctoral degree
Location: Ann Arbor, MI

Bio:
Dr. Miller is a physician in St. Paul hospital. She has been working as a hospitalist in the internal medicine department for more than 10 years. Since her department has built a great reputation in this area, besides seeing the patients who are referred internally from the other departments, Dr. Miller has lots of appointments to see the patients from other hospitals or regions as well.

Goals:
• Understanding health condition and history of her new patients accurately and holistically.
• Saving time of reading vital health information on the EHR in order to take care of more patients.
• Preventing redundant diagnostic tests.
• Making right decision of diagnosis, interventions and medication in order to get rid of unplanned hospital readmission.

Frustrations:
• Making lots of effort to get the medical records of patients who are transferred from other health information systems.
• The information on EHR is overwhelming. She needs to spend lots of time to identify the most useful information she needs from tons of irrelevant notes and charts.
• She got very limited time to have big pictures of new patients' condition and history.
• Information on EHR is not organized clearly and effectively for her to read.
• Having no idea what happened to the patients outside hospital.

Needs:
• Complete medical records for every new patient she is go to see.
• New patients' latest vitals and reasons for admission.
• An overview of patients' problems.
• Filtering the most actionable and meaningful information she needs from a large data base.
• Displaying the selected information in an easy way to read and analyze.
• Patient self-report data from home.

User Story:

As a hospitalist who sees lots of new patients everyday, I want to have an efficient way to understand my patients' health condition and history accurately and holistically, so that I can make right decisions of diagnosis and keep them healthy at home.

Figure 28. Persona & User story for Hospitalist

51

Persona & User story for Patient (Figure 29)

Persona

Sam Hardy

Age: 77

Occupation: Retired Engineer

Education: Bachelor's degree

Location: Ann Arbor, MI

Bio:

Sam is a 77 years old retired engineer with multiple chronic conditions, such as heart failure, diabetes and newly diagnosed dementia. His wife Amy is taking care of him. Three weeks ago, Sam was readmitted to the hospital after a fall at home. It is the 3rd hospitalisation of him within 90 days. Healthcare system for this old couple is like a maze, they have no idea where they came from, and how can they find the way out.

"…I can't remember what they told me to do when I was discharged, because I got too many things from different places. My wife and I often feel overwhelmed and lost by all of these discharge documents and follow-up appointments, which make us more miserable than we're in the hospital…"

Goals:
• Fully understand his care condition and history in order to manage his care by himself.
• Better communicate with clinicians, let them know vital health information which is gathered outside hospitals.
• Improving the experience of care transition and keep healthy at home.

Frustrations:
• He has collected lots of discharge documents over the time, he has no idea which information is most important to him, and what the relationship between the documents, and does he need to keep all of them.
• When there are many follow-up appointments in the future, it is very hard for him to keep all of those in mind.
• His medication list is modified frequently after every encounter, it is very hard for Sam and his wife to identify the nuanced difference, and adhere to the updated ones correctly
• Clinicians often ask them some questions which they can hardly recall the details to give definite answers.

Needs:
• A platform for him to document all the previous encounters in the healthcare system, and extract the key information he needs to know.
• Convenient access to healthcare professionals who can explain his problems during the care transition process.
• A reliable way to remind him about follow-up appointments.
• An effective way for him to document important health information at home, help him articulate his health condition efficiently when he meets the clinicians.

User Story:

As a patient who has multiple chronic conditions, I want to have a tool to help me document my care journey and navigate the encounters during my care transition process in the future, so that I can manage my care after being discharged from hospital and keep healthy at home.

Figure 29. Persona & User story for Patient

Concept ideation and selection

According to the previous research insights, design principle, persona and user story, some concepts were created in the ideation section. The first concept is "USBe with You" (Figure 30). "USBe with You" is

a platform which enables patients to download their most complete
and meaningful health information into a USB from every EHR system
which has their health records. Patients can take this USB to different
locations with them, and share the information with any clinician who
needs to get involved in their care transition process.

Figure 30. Concept-1: "USBe with You"

The second one is called "EHR+me" (Figure 31). "EHR+me" allows
physicians to create a personalized template which can help them to
reorganize patients' health information on the EHR in an efficient way
to read. This template will save clinicians lots of time to find particular
information they need in a huge database by automatically fill in the
right information according to the given format. Also, patients can also
upload their self-report data onto the EHR system, and these data will
be reflected on clinicians' report to help them make decisions.

Figure 31. Concept-2: "EHR+me"

The last one is "SamePage" (Figure 32). "SamePage" is a plug-in for an existing EHR system. It can help clinicians and patients to better understand a complete landscape of patient health conditions and history by integrating all the health records into a timeline. Moreover, patients' self- reported health data could be easily documented, analyzed and reported to their clinicians to help them get a more extensive understanding of their patients' health conditions in a timely manner. (Figure 32: Concept-3: "SamePage")

After a group discussion and vote, the co-design team found the third concept, SamePage, had the best alignment with previous research insights and design principles. Therefore, we decided to move forward with this concept and specify more detailed user scenario, information architecture, wireframe, and user interface of it.

User scenario

Based on the previous personas, user stories and selected concept, two user scenarios were developed to help the co-design team understand
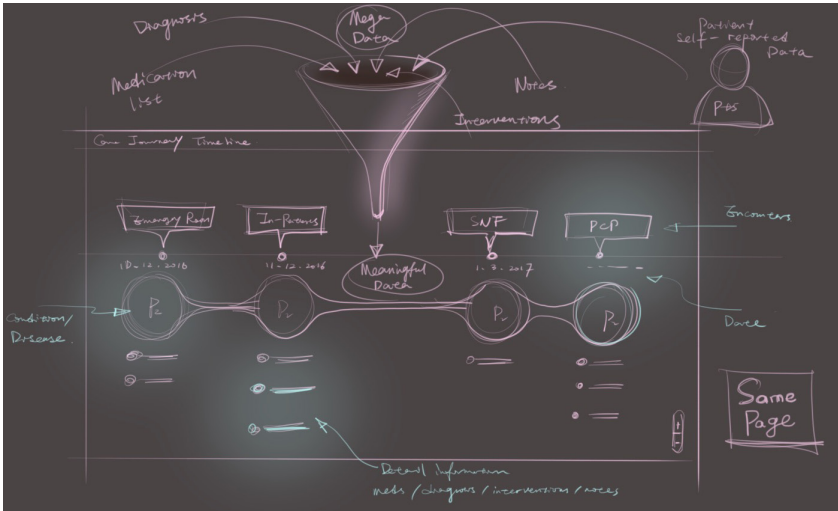
Figure 32. Concept-3: "SamePage"

the target people better, such as why they need this solution, and what exactly they are looking for when they use this solution. These user scenarios could also support the team to grasp people's goals and hence make the final design output correctly match their expectations. The two user scenarios were developed for clinicians and patients, respectively. To some extent, the previous personas were instilled into these user scenarios, which made them more accurate.

User scenario - Clinician:

Dr. Miller is a hospitalist in St. Paul hospital. She has been working in the internal medicine department for more than five years. Since her department has an excellent reputation in this area, besides seeing the patients who are referred internally from the other departments, Dr. Miller has lots of appointments to see the patients from other hospitals and regions ("outsider patients") as well.

Compared with patients from the same healthcare system, Dr. Miller needs to make extra effort to understand the cases of "outsider patients" by contacting their providers from various systems, asking

them to fax the patients' medical records, scan them into the EHR system, and read through the documents to find useful information. This process is extremely time-consuming and inefficient. In addition, sometimes, Dr. Miller often asks her patients and families to describe their health conditions, and although some patients and families can give specific answers, these are not reliable for Dr. Miller to make accurate and responsible clinical decisions. Even for the patients whose EHRs are accessible, the information in EHR is overloaded with information. Dr. Miller needs to identify the most meaningful and actionable information from tons of useless notes, charts and lab results.

<u>User scenario - Patient:</u>

Sam is 77 years old; he is a retired engineer with multiple chronic conditions, including heart failure, diabetes, and newly diagnosed dementia. His wife Amy is taking care of him. Three weeks ago, Sam was readmitted to the hospital after a fall at home. It is his 3rd hospitalization within 90 days. Healthcare system for this elderly couple is like a maze, they have no idea where they came from, and how can they find the way out.

During the recent three months, Sam had been referred to lots of places like transitional care clinic, senior health clinic, heart failure clinic and SNF. Whenever he visited these places, his medication could be changed, which made it even harder for Sam to keep adhering to the updated medications correctly. Also, when he was transferred among different health systems where the EHR cannot be shared, Sam may need to explain his conditions to his clinicians by himself, and sometimes, receive same exam/treatment repeatedly. Now, Amy uses a paper calendar and notebook to coordinate all the appointments and document important medical information for her husband. Most of the time, she felt extremely overwhelmed and lost.

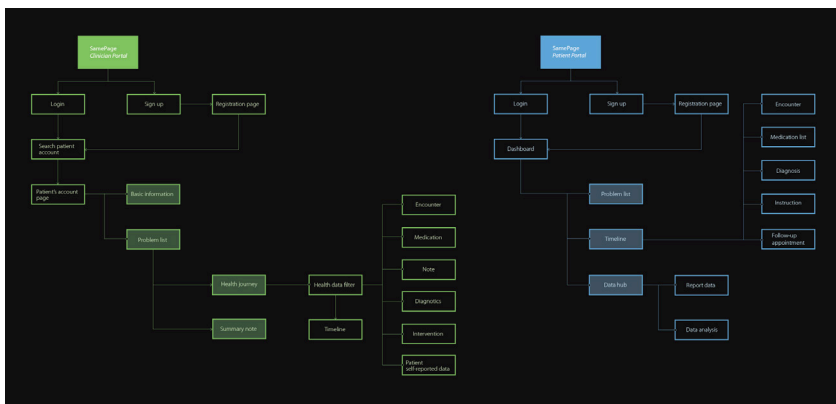# Information architecture & wireframe
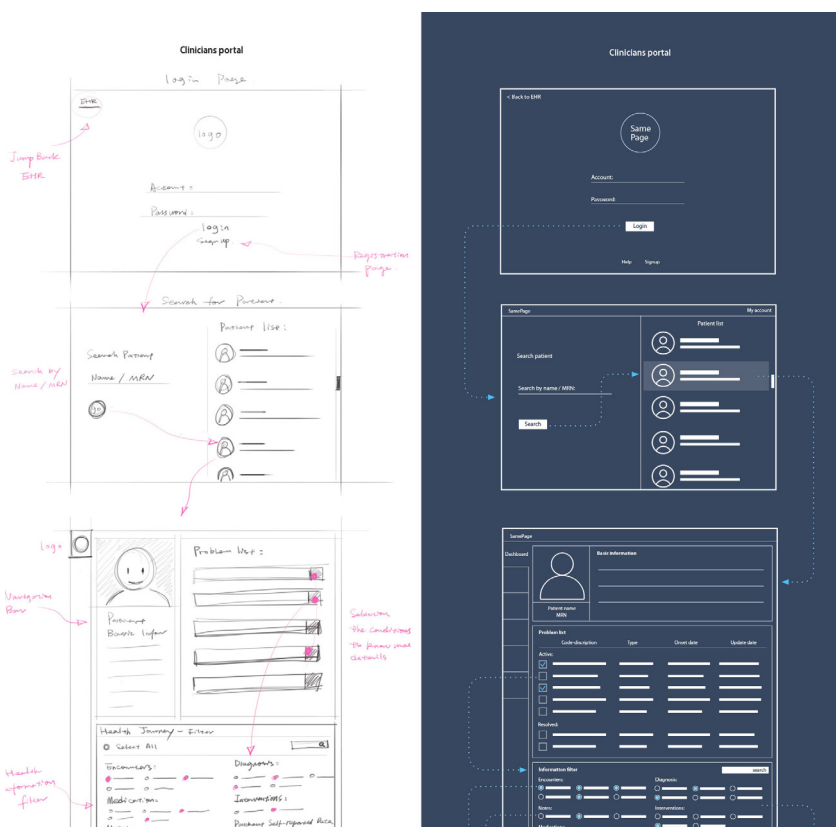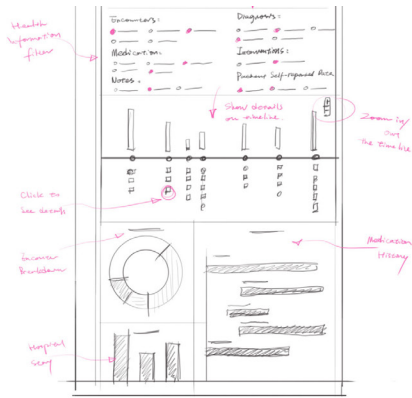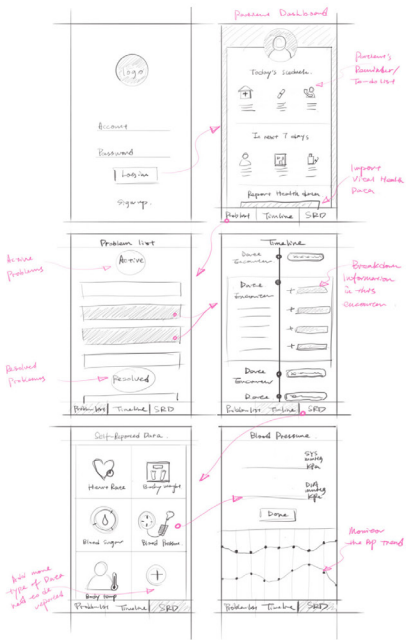

Figure 33. Information architecture

Figure 34(a). Wireframe.

Figure 34(b). Wireframe.

Prototype

Starting from a wireframe of the concept, the co-design team developed the first prototype and evaluated it through a series of user testing interviews to collect non-biased feedbacks. The information from the interviews was synthesized and incorporated into the next iterations of the prototype. When the final prototype was delivered, we had conducted three rounds of iterations until users' concerns had been reduced to an acceptable level. The following images illustrated the evolution of the prototype, with the detailed user testing reflections being discussed in the evaluation section. (Figure 35)
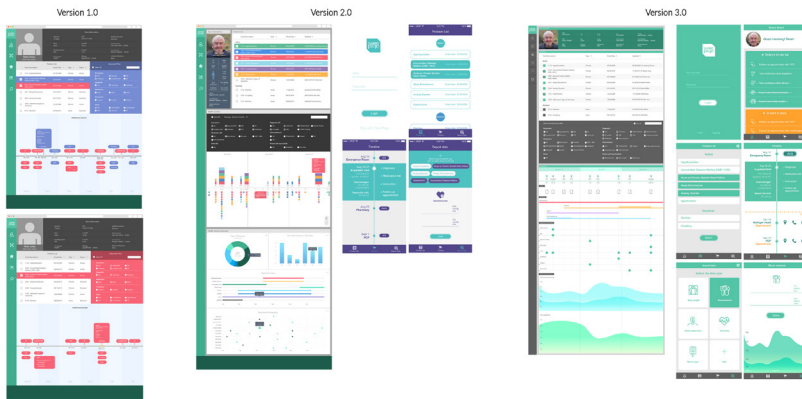
Figure 35. Prototype iterations

Ethical issues

As for the ethical issues, one of the most critical consideration is how to conduct user research with patients in appropriate manners, especially in a healthcare context, where patients' health information and personal privacy should be highly confidential and protected by researchers. (Figure 36). When I conducted observation and interview with clinicians and patients in any context, not intruding people's private areas, keeping secrets of any personal information, and being respectful with the interviewees were the necessary requirements I set for myself.

Another ethical concern came from executing the co-design practice. "When people engage in a co-design process, they also engage in ethics—in a process with ethical qualities." (Steen, 2013). According to Steen, when co-design participants share their experiences, discuss problematic situations, envision possible or desirable situations, develop and evaluate alternatives, and make final decisions, the ethical issues become manifest. If the first ethical consideration was about the ethical responsibility of researchers to patients, this one referred to the mutual respect among the participants inside the co-design team. As a designer and facilitator in the co-design team, besides valuing the opinions from other team members by myself, I also encouraged the other co-design participants to do the same thing with me, work collaboratively with a team rather than isolated individuals. This was a fundamental ethical point for a co-design team, but it was often overlooked by lots of the co-design practitioners.
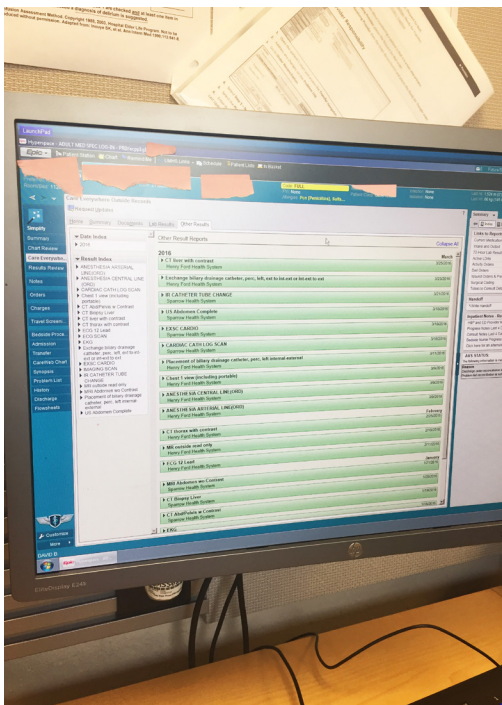
Figure 36. Protect patients privacy when I researched on their EHR.

RESULT AND DISCUSSION

Introducing SamePage

SamePage (Figure 37), as the final deliverable of this study, is a HIE tool which can help clinicians better understand the health conditions and history of new patients who have transferred from other clinical settings. This tool can also help patients and families document their care journeys and navigate their care transition process in the complex healthcare system. By turning all of the health data into comprehensive, understandable and meaningful information,

SamePage aims at getting all of the clinicians, patients, and families on the same page regarding patient care transitions..

Figure 37. SamePage logo

SamePage clinician portal & use case

Based on the research questions, insights and design principles generated from the previous research process, several key features were developed for clinicians to improve their work efficiency and get the most meaningful and actionable information from data-overloaded EHR. (Figure 38)

Firstly, The SamePage clinician portal does not aim at replacing the existing EHR. However, it is separated from the EHR system as an independent information sharing platform which provides some complementary features to help clinicians better understand new patients, with accessibility across various HISs. Clinicians can switch between SamePage and EHR anytime according to their particular needs. (Figure 39)

Secondly, for clinicians, being able to quickly browse the most valuable and updated patient health information before diving into detailed information on their condidtion is critical in making high-quality clinical decisions. Because of this, the basic patient information and problem list sections were redesigned. In the new problem list, instead of being updated separately by clinicians, patients' conditions will be
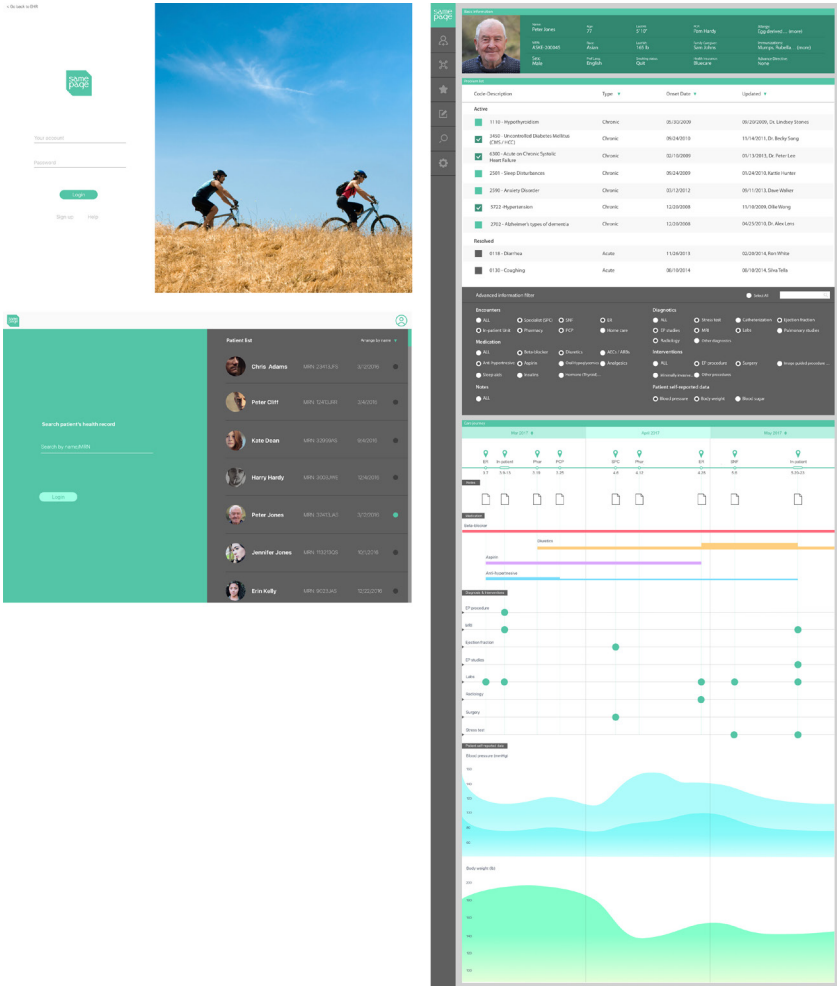
Figure 38. SamePage clinician portal user interface

automatically synchronized with new diagnoses that clinicians have imported into the her. This mechanism is positive for setting a unified standard and format across different HISs to get the most accurate and succinct health condition summary for clinicians. Also, all the conditions on the problem list are categorized according to the status (active or resolved), type (chronic or acute), and onset data and update time to help clinicians have a clearer picture of patient health history. (Figure 40)

Figure 39. Clinician portal login page & patient search page

Code-Description	Type ▼	Onset Date ▼	Updated ▼
Active			
1110 - Hypothyroidism	Chronic	05/30/2009	09/20/2009, Dr. Lindsey Stones
3450 - Uncontrolled Diabetes Mellitus (CMS / HCC)	Chronic	09/24/2010	11/14/2011, Dr. Becky Song
6300 - Acute on Chronic Systolic Heart Failure	Chronic	02/10/2009	01/13/2013, Dr. Peter Lee
2501 - Sleep Disturbances	Chronic	09/24/2009	01/24/2010, Kattie Hunter
2590 - Anxiety Disorder	Chronic	03/12/2012	09/11/2013, Dave Walker
5722 -Hypertension	Chronic	12/20/2008	11/10/2009, Ollie Wong
2702 - Alzheimer's types of dementia	Chronic	12/20/2008	04/25/2010, Dr. Alex Lens
Resolved			
0118 - Diarrhea	Acute	11/26/2013	02/20/2014, Ron White
0130 - Coughing	Acute	08/10/2014	08/10/2014, Silva Tella

Figure 40. SamePage clinician portal problem list

Thirdly, after clinicians selected the conditions they want to know further, all the breakdown information about these selected conditions will be displayed in the filter system. The detailed information elements were organized with regards to encounter, medication, notes, diagnosis, intervention and patient self-reported data. The clinician can choose the particular information they need and sort this efficiently from the database. From another point of view, since all the previous health information is displayed in the filter section, clinicians can have a better overview of patient care history and be effectively aware of the complete landscape of patient care. For example, they will know where their patients have visited, which kinds of medications, interventions, and procedures they had taken before, and what sorts of lab results are available to view. (Figure 41)

Moreover, to help clinicians better understand patients' health history holistically, an interactive timeline which integrates key health history information, such as medication list, clinical visit and lab results was created. On this timeline, all of the past medical records were presented in an explicit and interactive way to enable clinicians to trace their patients' health histories. For example, besides identifying where
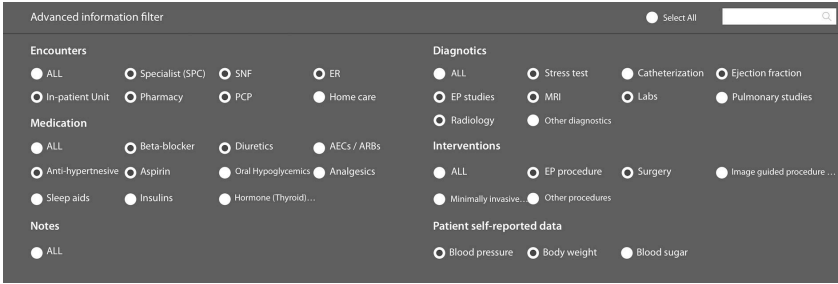
Figure 41. Clinician portal information filter

and when patients have encountered the healthcare system, clinicians can also check the relevant notes generated from each encounter, what kinds of medications/doses they had taken, why they stopped taking the medications, and what kinds of interventions or procedures they already had. By visualizing all of these components in the form of a timeline, clinicians can capture all the vital health information in each patient care journey chronologically, and make logical connections between various kinds of information to enable them to make better clinical decisions. (Figure 42)

Lastly, as we discussed above, care transition should be a continuous process not only for patients but also for the healthcare system, which extends the care service from clinical setting into the home. Clinicians need a channel to monitor patient health condition after they were discharged from the hospital. Thus, to achieve this goal, in the clinician portal, there is a patient self-reported data section to visualize some health data such as blood pressure, blood sugar level, and heart rate, which were collected by patients themselves. These self-reported data could support clinicians to extend their scope of understanding patients' complete care transition process from hospital to home. (Figure 43)
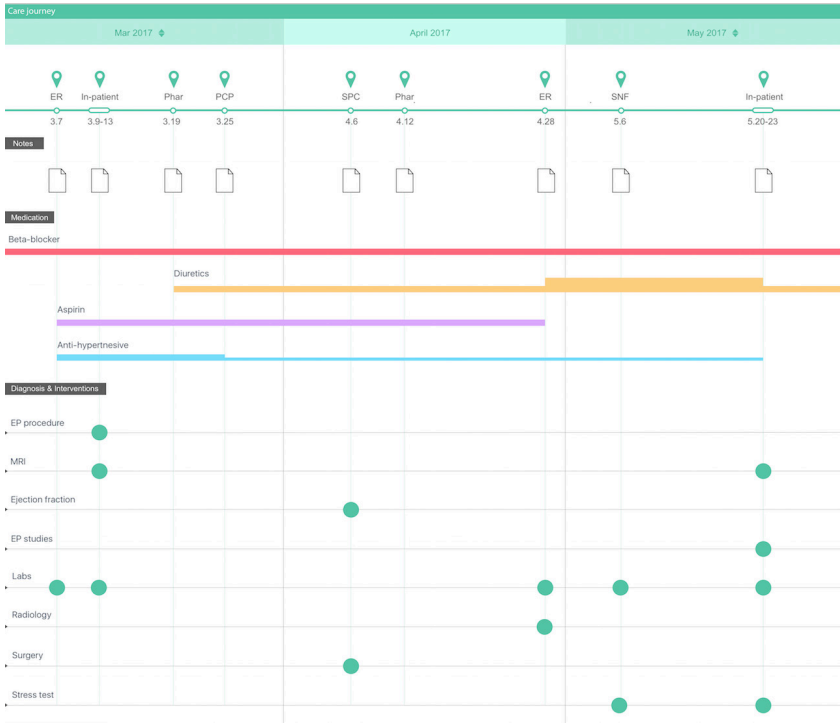
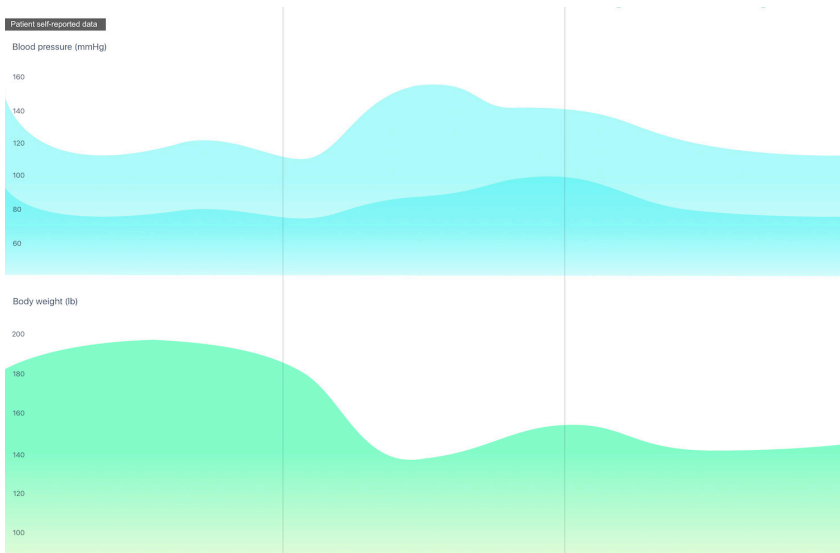*Figure 42. Clinician portal timeline*

Figure 43. Clinician portal patient self-reported data

To articulate how these key features in the SamePage clinician portal could help clinicians tackle their challenges and achieve their goals during care transitions, the following use cases was created to demonstrate how clinicians would utilize SamePage to improve their efficiency for solving real problems in the clinical settings.

Use case:

User: Dr. Miller (Hospitalist)

Goal: Better understand Sam's (new patient) health condition and history in an efficient and accurate way.

Steps without SamePage:

1. Dr. Miller received a notice of newly admitted patient, Sam. She logs in EHR system, and searches Mr. Hardy's medical records by his name/MRN. Dr. Miller views the latest vitals of Sam to see whether his current condition is stable, and understand his reason for admission.

2. Except the current admission reasons, Dr. Miller does not have a clear overview of what other conditions that Sam had developed before, and are there any other problems should be concerned during this hospitalization as well. Because the current problem list on EHR is very out of date, it is difficult to figure out which conditions are still active and which ones have already been resolved.

3. Dr. Miller starts to browse all the notes, lab results, medication lists on the EHR. Since there are lots of medical records were generated previously, it is very possible for her to overlook some critical information during this tedious process.

4. Another situation when some key information could be neglected is, if Sam had ever been admitted to some clinical settings which are using different HIS with Dr. Miller's hospital, these medical records will not be available for Dr. Miller.

5. Because of the overwhelmed information display in the EHR, and

the interoperability issues across different HISs, it is very possible for Dr. Miller to give redundant diagnostic tests or medication which could incur medical errors. To prevent this kind of concerns coming true, Mr. Miller spends lots of time to check Sam's previous health records carefully, and this process decreases her efficiency significantly.

6. In addition, since all the medical records are only created in clinical settings, Dr. Miller has no idea what happened to Sam at home. For example, how were his heart rate, blood pressure, and body weight look like during the recent time, if there is any significant fluctuation happened, Dr. Miller needs to find out the reasons and connect these evidence with this hospitalization.

7. Even though Dr. Miller has seen lots of information on the EHR in a very short time, she still has many things need to be clarified. Dr. Miller is not sure whether she can get clearer answers from Sam when she meet him, or she needs to spend more time on the EHR system later.

Steps with SamePage:

1. Dr. Miller received a notice of a newly admitted patient, Sam. She logs into the SamePage system and searches Sam's medical records by his name/MRN. She views Sam's latest vitals such as blood pressure, heart rate, oxygen level and body weight to see whether his current condition is stable.

2. Dr. Miller browses the problem list, in which all the problems are categorized by status (active/resolved), type (chronic/acute), onset date and update information, to have an overview of Sam's health condition. And then she selects Acute on Chronic Systolic Heart Failure and Uncontrolled Diabetes Mellitus in the active problems to explore more details about them.

3. Dr. Miller selects specific encounters, medications, interventions, diagnostics and patient self-reported data that she wants to know in the information filter system, and then all the selected detail

information is integrated into a timeline chronologically. Therefore, Dr. Miller does not need to read all the information in one document and spend lots of time to filter the useful parts.

4. Dr. Miller checks the most recent notes and lab results generated from the latest encounters in ER and PCP, because these could be helpful for her to understand Sam's current situation.

5. In the integrated timeline, Dr. Miller identifies the dose of Aspirin was changed since April 4th and suspended one month later, she can simply check the relevant notes on the timeline and found out bleeding is the main reason why this medication is modified. After this, she can figure out whether it is safe for Sam to take it again.

6. Dr. Miller selects patient self-report data (weight and blood pressure), to visualize the trend in the recent two years. She finds that there is an obvious weight drop recently, and such kind of problem happened one year ago as well. Therefore, Dr. Miller opens the notes generated during that period to take as an important reference.

7. After reviewing all these key information, Dr. Miller got a clear overview of Sam's condition and history, and she is ready to see Sam in person, and discuss Sam's case with her care team.

SamePage patient portal & use case

Besides clinician portal, SamePage also introduced a patient portal which did not only simplified some key features from clinician portal, but also added some new ones for patients to document their care journey and coordinate their care transitions efficiently. (Figure 44)

To start with, after a patient logs into the SamePage interface, today's to-do list will be automatically generated, reminding patients to achieve their goals, such as scheduling a follow-up PCP appointment, taking medications after a meal, and importing their blood sugar levels. Also, patients see reminders for the next three days so they
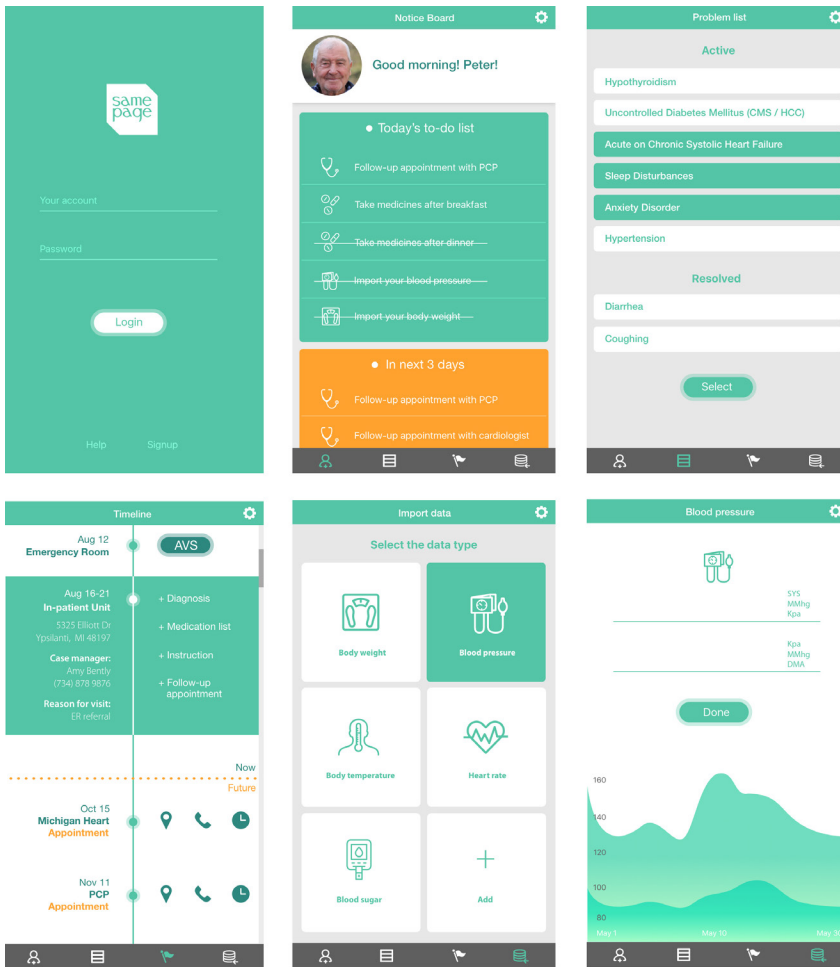
Figure 44. SamePage patient portal user interface

can prepare in advance. This feature could help patients interpret their discharge instructions into understandable, bite-sized pieces of information, and set up multiple achievable goals to enable them to stay healthy at home. (Figure 45)

Next, instead of applying the exact same problem list from the clinician portal, a simplified problem list was created for patients, particularly for the patients with comorbidities, to understand their current health condition clearly. Patients can choose specific problems on the list to

explore more details. (Figure 46)

Figure 45. Patient portal dashboard   Figure 46. Patient portal problem list
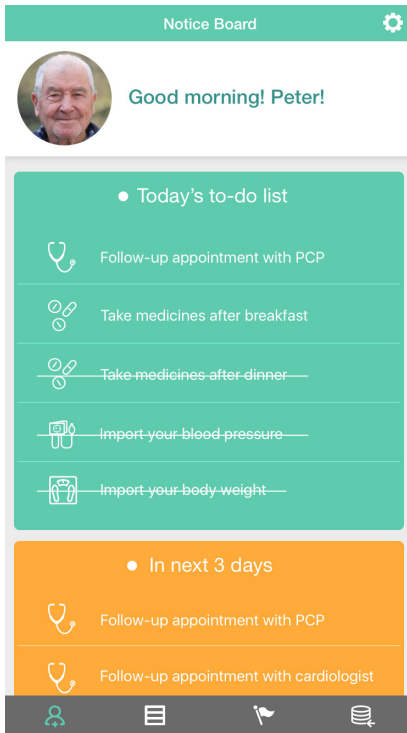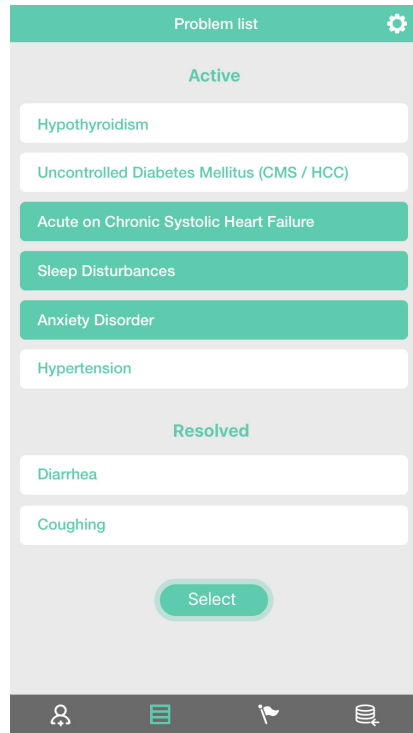
Moreover, after patients chose particular problems, a timeline which includes all the relevant health information about these selected problems will show up. This timeline could help patients document their past care history, for example, the previous clinical encounters, their locations, contacts, the reason for visiting, and After Visit Summary (AVS). It can also facilitate patients to better coordinate any future follow-up appointments. (Figure 47)

Last but not least, to help clinicians have an extensive view of patient health conditions, a self-reported data channel was introduced in the patient portal. Patients can upload their vital health data, such as heart rate, blood pressure, blood sugar level, and body weight
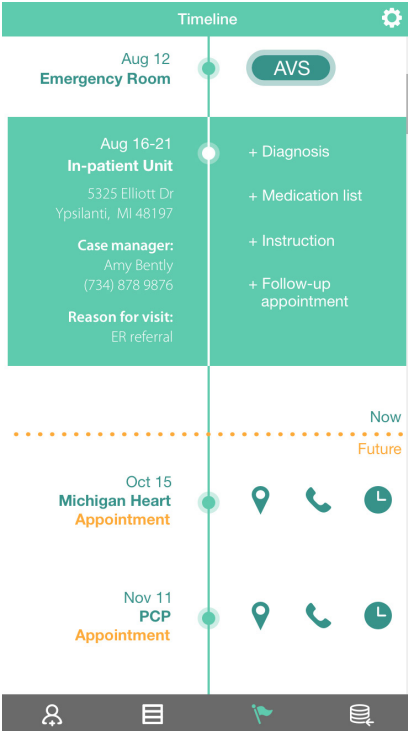
Figure 47. Patient portal timeline

according to their clinicians' requirements. By contributing these
self-reported data to SamePage, the patient health database will be
extended from clinical setting to home. This data resource will provide
clinicians excellent references beyond the existing clinical data to
understand patient complete health condition outside hospitals and
make better clinical decisions. (Figure 48)
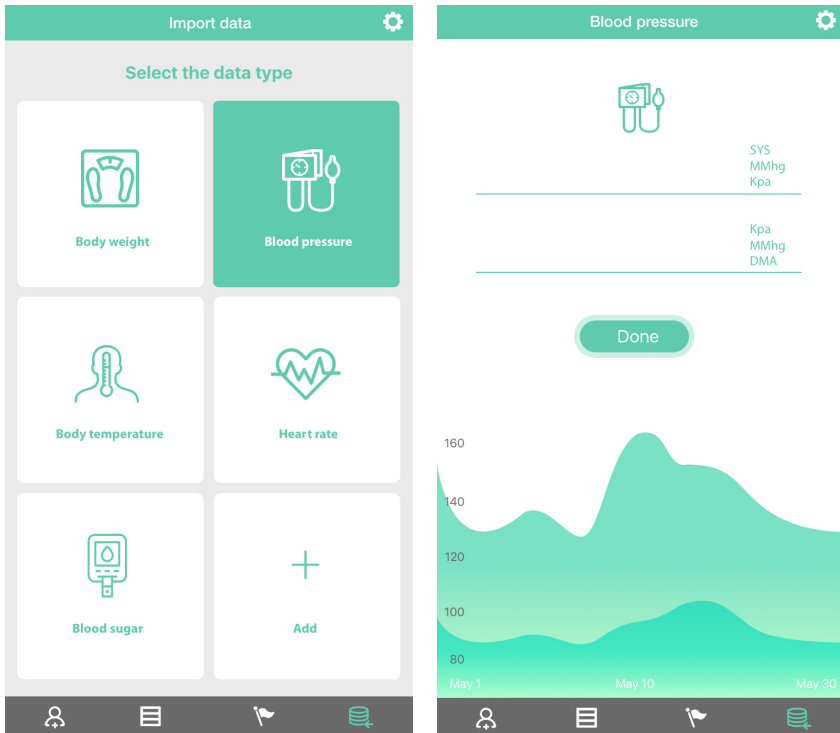
Figure 48. Patient portal self-reported data

The following use case conveys how patients could use the key features in the patient portal to help them manage and coordinate their care journeys by themselves and improve their care transition experience significantly.

Use case:

User: Sam (Patient)

Goal: Understand his care history and plan, adherent to all the discharge instructions, and keep healthy at home.

Steps without SamePage:

1. Before Sam is ready to be discharged from hospital. The nurse went through the discharge instruction with Sam and his wife Amy. Sam's

medication is modified a little bit, because of a bleeding problem, he does not need to take Aspirin any more. In addition, there will be three follow-up appointments in the next a couple of weeks.

2. Sam has already got used to this kind of situation, he has been transferred to more than 7 places in the last three month. During this time, he has collected lots of medical documents. Fortunately, although all of these documents are very overwhelming, Amy is helping Sam to document all the important health information and schedule follow-up appointments accordingly.

3. As the medical documents keep accumulating, it is very challenging for Sam and Amy to remember every single detail what clinicians asked them to do or avoid. And sometimes, it is also confused for them to understand the reasons of visiting, and connect all of these follow-up appointments together.

4. Sam keeps measuring his blood pressure and body weight at home as his doctor asked him to do. But there is no media to document these data and share them with his doctor digitally.

5. Sometimes, Sam may login to the EHR patient portal to see his health records. But he thinks the patient portal cannot help a lot, it is basically just reappearing all the paper version health documents in a digital format, nothing new could be found there.

6. Sam and Amy are still struggling in the complex care transition process. Healthcare system for this old couple is like a maze, they have no idea where they came from, and how can they find the way out.

Steps with SamePage:

1. After a 4-day stay in the hospital, Sam's condition is stable now; he is ready to be discharged today. The nurse went through the discharge instruction with Sam and his wife, Amy. Sam's medication was modified a little bit, because of a bleeding problem, he will not need to take Aspirin anymore. Also, there are several follow-up appointments

which Sam needs to go in the next couple of weeks.

2. When Sam is at home, to better understand his health condition and coordinate his care journey, Sam logs into SamePage where he can see all his current health problems and complete care journey clearly.

3. On the dashboard page, Sam can see his to-do list for today and the next three days, such as clinician appointments, medication reminders, and self-reported data entries. The items on the to-do lists are generated from his previous discharge instructions. Sam can cross out the tasks he already finished, and keep in mind what kinds of things he may need to do in the future.

4. Sam goes to his problem list, selects heart failure in the problem list and then review all the relevant health information about this disease. Besides all the previous encounters, the follow-up appointments scheduled in the future were also integrated into the timeline for reminding.

5. When Sam clicks a specific encounter on the timeline, detailed information, such as diagnosis, medication, instruction and follow-up appointments will show up. Besides, Sam can also see the encounter location, the reason for visiting, and who should be contacted if needed.

6. Instead of only viewing health information generated from clinical settings, Sam could also upload his self-reported data, such as body temperature, weight, blood pressure and heart rate, to the SamePage platform through this patient portal. These self-reported data will be analyzed, and the results will be shared with his doctors to inform them to make better clinical decisions .

7. By using the SamePage patient portal, Sam and Amy are enabled to more engage into their care journey and coordinate their care easily by themselves. With better understanding of his health condition and adherence to all details of the discharge instructions, the risk of

readmission for Sam will be reduced significantly.

Evaluation

User testing

During the prototype iteration process, several user tests (Figure 49) were organized to collect people's feedback, which was reflected in the next versions of prototypes. Here are some examples of the user testing results and how we solved the problems.
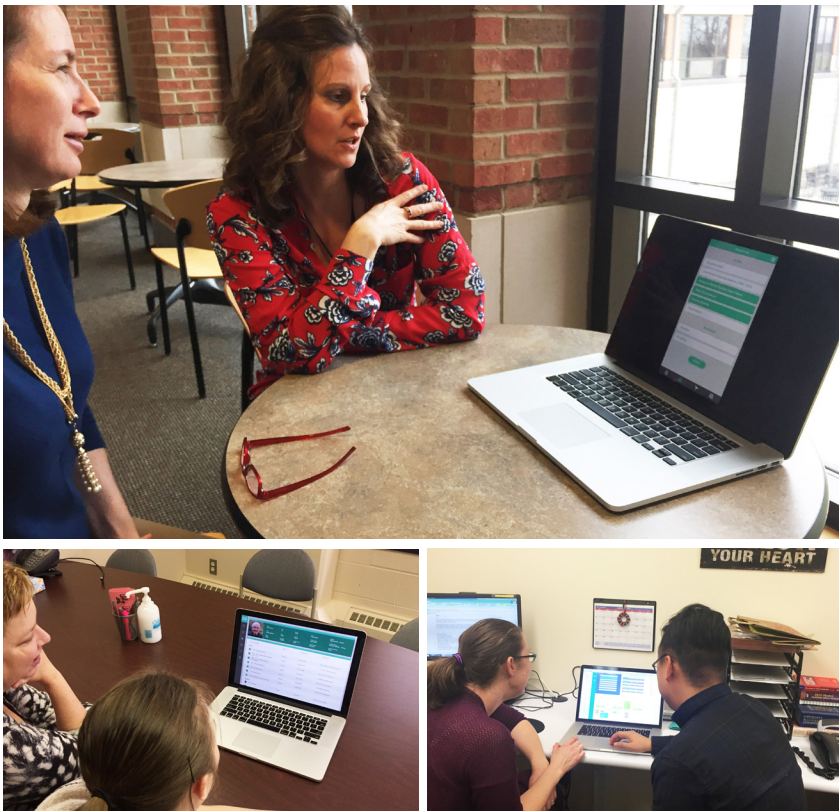

Figure 49. User testings

To begin with, in the clinician portal prototype v.2 (version 2), all the selected diseases in the problem list were marked with different colors to synchronize with the information displayed on the timeline below. However, according to some clinicians' suggestions, logically, it is not necessary and feasible to distinguish medical information by different diseases. Visually, this kind of design will give a huge burden to the users who are not very sensitive to colors, or color blind. Thus, in the new problem list design this color-coded feature was eliminated. Instead, a very simple color combination and icon system were applied here to indicate which diseases had been selected to display more detailed information on the timeline. (Figure 50)

Secondly, some clinicians mentioned that the square buttons under each encounter on the timeline were very tiny to see and manipulate. Also, this design was not intuitive enough for clinicians to understand what these small square buttons were used for. For example, the square buttons with "M" on the top means medication list; clinicians cannot know anything by just seeing these square buttons distributed along the timeline. In light of this, the original square button design was replaced by a new layout, which visualized all the medical information into four sections, such as a note, medication, intervention & procedure, and self-reported data. In each section, clinicians can clearly identify the information they need and make any connections between various types of medical data. (Figure 51)

Moreover, lots of clinicians I interviewed agreed that the statistics of encounter types and visit frequency at the bottom of clinician portal prototype v.2 would be helpful to have, but not necessary in terms of understanding new patients. Therefore, in the next version of the prototype, these features were deleted.

Lastly, for the patient portal, since this study focused on the patients with multiple conditions, which requires them to visit various clinicians regularly, these patients often had lots of discharge instructions to follow during their care transitions. In light of this, patients had a very

Figure 50. Problem list design iteration

Figure 51. Patient care journey design iteration

hard time to manage and coordinate their care based on all of these separated documents. Thus, in the patient portal, a unified to-do list which combined all the discharge information, helped patients understand what exactly they need to do every day to adhere to all their discharge instructions correctly.

Besides the problems which were identified in the early rounds of user testing and were already solved during the iteration process, there were also some recently found issues which need to be tackled in the future. One of the problems was patient literacy and this was considered when we designed the simplified version of the problem list in the patients portal. To give an example, "Uncontrolled Diabetes Mellitus (CMS / HCC)", as an item in the problem list for clinicians, was appropriate, but should not be reused in the problem list for patients, because most patients cannot understand what this means. Another problem is, besides some vital health information like blood pressure and body weight, patients also need to document and report important symptoms to their clinicians. However, some clinicians argued that for the sake of the clarity and effectiveness of information, clinicians only intend to see the data which they required patients to report, otherwise the overloaded data will be fairly difficult to manage. Last but not least, in order to motivate patients to adhere to the to-do list in the long term, an incentive mechanism was missing from the current patient portal design. Thus, realizing an incentive mechanism in the new patient portal is another essential point to consider in the future.

Review on the co-design practice

Apart from discussing the final design outcomes, it is also worth reflecting on the co-design process. The value that the co-design team brought to this study was remarkable, especially for the clinicians, patients, and family caregivers, who were proactively engaged in the design process by contributing their knowledge, experience, and

passion. Whereas, like one of the co-design team member said to me, "Clinicians know where the problems exist during care transitions and are willing to do something to change this situation, but the thing is they cannot stop their work to figure out how to solve these problems."

Therefore, as the only designer and facilitator in the co-design team, how to balance and coordinate the busy schedules of all the co-design team members was one of my critical tasks. In this study, besides the design workshop when all the co-design team members could work together physically, most of the time, I need to talk with them separately in different locations due to individuals' full-time job commitments. The benefits of doing this was that team members could have plenty of time to express their opinions and focus on this project without being influenced by their jobs. But the compromise of this collaboration style was that we lost some opportunities for the team members to work closely and inspire each other. The other main task for me was how to maintain an active long-term relationship with the co-design team members and retain their sense of belonging to this study. An essential point to achieve these goals was meeting with the co-design team members frequently, showing respect for their opinions, and indicating how their thoughts had influenced the final decision making and iterations of the design. A successful long-term relationship with co-design team members was positive and involved them in this study and added more accountability of co-design project in a healthcare innovation context (Frauenberger, et al., 2015).

Limitation of the study

Although this study was carefully prepared and has generated some preliminary findings, some caveats need to be noted as follows.

First, as we discussed above, this study focused on tackling the HIE challenges during care transitions in the near future, when all

the health records are digitized and shareable across different HIS nationally. So the final design solution was based on a precondition that the current HIT promotion, and government incentive policies, such as meaningful use, were successfully implemented as expected. Therefore, it would be less appropriate to evaluate the effectiveness and feasibility of this study within the present situation than in the near future.

Second, the co-design team lacked involvement from a health data scientist. Without expertise in data science, most of our findings in this study were limited to the medical and behavioral level. Thus, the co-design team failed to fully explore the possibility and feasibility of how we might further manipulate the existing database from a technical perspective, and how might data science influence the way that clinicians and patients import and export the data from the EHR system.

Third, this study explored how to improve the quality and experience of care transition by increasing the effectiveness of HIE among clinicians and patients. However, HIE is only one part of the complete care transition landscape, and there are other aspects to consider, including (although not limited to) health insurance, government policies and incentive mechanisms. These could be considered as key components to affect the final results of care transition as well.

Last but not least, who will be the potential buyer of this final product? And how to convince the decision makers or funders to invest in this HIE tool were out of consideration in this study, but should be worthwhile research problems to explore in the future.
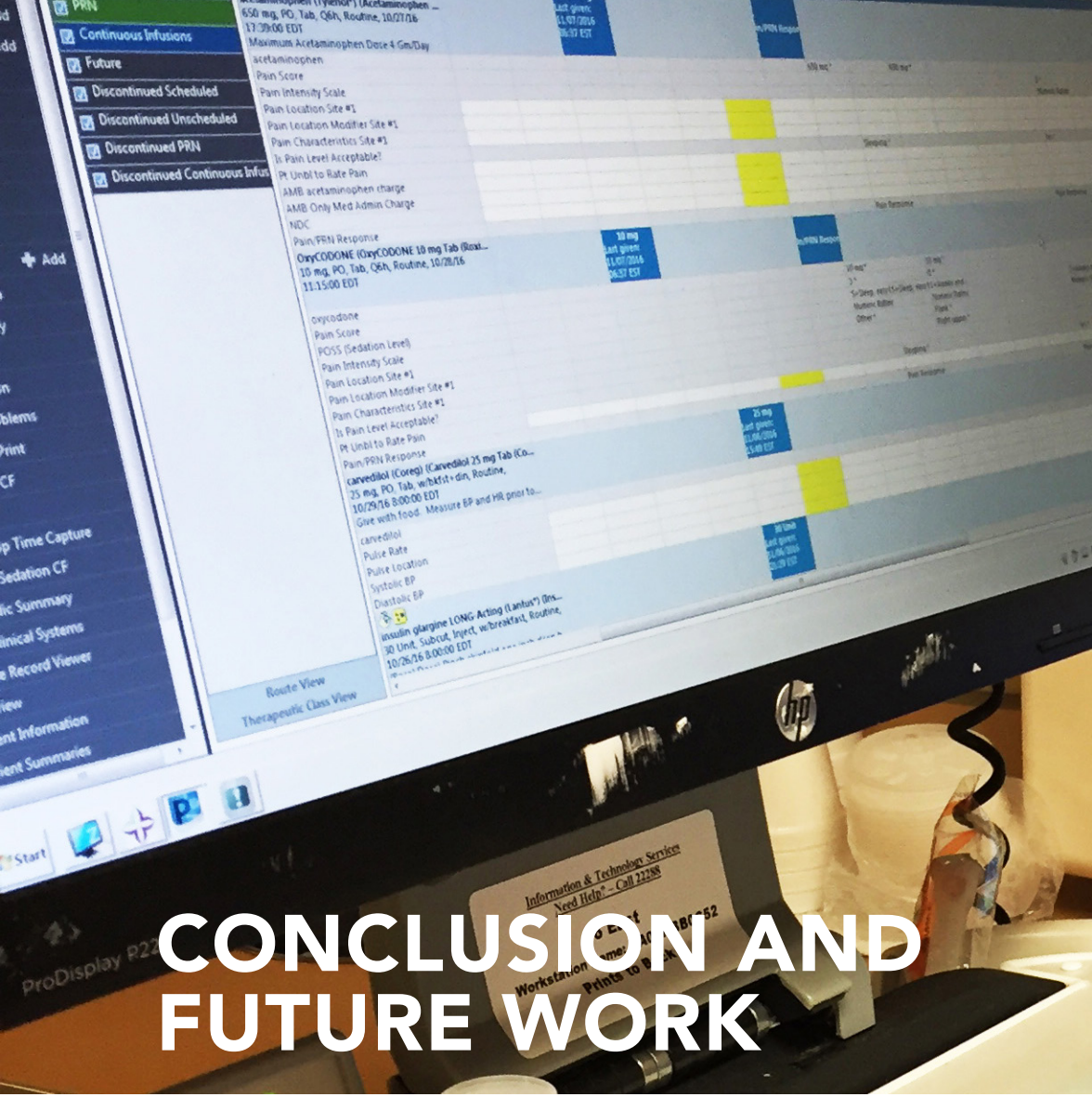
CONCLUSION AND FUTURE WORK

The ultimate goal of this study was to use co-design methodology to develop a tool which can facilitate clinicians and patients to exchange vital health information more effectively during care transitions. Through the research, some critical barriers were found for clinicians and patients which prevent the HIE process going smoothly and efficiently during care transitions. For clinicians, firstly, it is very difficult for them to acquire the most actionable and meaningful health information they need from the overwhelming amount of data from current EHRs. Secondly, clinicians can hardly collect complete patient

health information across various clinical settings to understand the patient condition and history accurately and holistically. Last but not least, although care transition is considered as a continuous process of care, the healthcare system failed to extend the care service from clinical setting to home. For patients, on the one hand, understanding and coordinating their care during care transitions are always difficult, and getting lost in the complex healthcare maze happened frequently. On the other hand, the current EHR systems are only designed for clinicians. Patients and families cannot use EHR to document their care journey or analyze their health condition.

The final design deliverable provided two separated portals to tackle clinicians and patients problems, respectively. For clinicians, an updated problem list was created to deliver a unified view of current patient health conditions across disparate care settings. This was done to build a solid foundation for a coordinated care system since a Health data filtering system can increase the efficiency and accuracy for clinicians to get the health information they need and display an entire landscape of patient health information by visualizing the medications, diagnostics and intervention information on an integrated care journey timeline. This timeline can also help clinicians holistically understand patient health condition and history to make better clinical decisions. For patients, in addition to a problem list, and a care journey timeline, a self-reported data entry was created for patients to record, monitor and report their vital health data out of clinical setting conveniently and timely.

The self-reported data platform also provided an extensive way for clinicians to understand patients' complete health condition by capturing some critical health information at home. And currently, these self-reported data are often absent in the existing EHR systems.

Although further iterations on the design would be required to address all of the clinicians and patients' needs, this study demonstrated how designers could tackle the HIE issues during care transition by

collaborating with healthcare professionals and patient partners, and fully engage them in co-creating/co-designing a collective outcome. Beyond generating a suggestion to tackle the HIE-focused problem, this study could also be a good example for other healthcare innovation projects in terms of applying a co-design approach within a multidisciplinary team to achieve their goals.

While the key features in the final design output have proven to resonate with clinicians and patients' needs in this study, there are many things to be developed in the future. For example, how could SamePage better synchronize with EHR to generate the most comprehensive health information for clinicians? How could the health data be appropriately tagged when they are generated so that clinicians can smoothly search the most accurate information they need? And how could patients be motivated to capture their vital health data constantly at home to help clinicians have a complete overview of their health condition during care transitions? By answering these questions profoundly, this HIE tool will be implemented successfully to help clinicians and patients have better care transitions in the future.

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