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Design, Implementation, and Evaluation of a User Training Program for Integrating Health Information Technology into Clinical Processes

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University of Massachusetts - Amherst

DESIGN, IMPLEMENTATION, AND EVALUATION OF A USER TRAINING PROGRAM FOR INTEGRATING HEALTH INFORMATION TECHNOLOGY INTO CLINICAL PROCESSES

A Dissertation Presented

by

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DESIGN, IMPLEMENTATION, AND EVALUATION OF A USER TRAINING PROGRAM FOR INTEGRATING HEALTH INFORMATION TECHNOLOGY INTO CLINICAL PROCESSES

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DEDICATION

To my mother and father.

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ABSTRACT

DESIGN, IMPLEMENTATION, AND EVALUATION OF A USER TRAINING PROGRAM FOR INTEGRATING HEALTH INFORMATION TECHNOLOGY INTO CLINICAL PROCESSES

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Health information technology (IT) implementation can be costly, and remains a challenging problem with mixed outcomes on patient safety and quality of care. Systems engineering and IT management experts have advocated the use of sociotechnical models to understand the impact of health IT on user and organizational factors.

Sociotechnical models suggest the need for user-centered implementation approaches, such as user training and support, and focus on processes to mitigate the negative impact and facilitate optimal IT use during training. The training design and development should also follow systematic processes guided by instructional development models. It should take into account of users' characteristics of learning, and employ scientific training theories to adopt validated methods that facilitate learning and health IT integration.

My study aimed to develop and evaluate a scientific model-guided and systematically developed health IT user training program that explicitly mitigate IT negative impact and facilitate optimal use. I used an electronic health record (EHR) as the health IT, and used medication reconciliation as the clinical task. I developed a

sociotechnical model to guide analysis of users' clinical tasks and their IT interaction, and utilized this model to analyze technical aspects of an EHR, and explicitly integrate the EHR into the workflow of a medication reconciliation task. I designed and developed the training program following existing models, and designed cognitive mapping based interventions to facilitate learning and health IT integration.

I implemented and evaluated the training program using a controlled experiment with nursing senior baccalaureate students. Evaluation of participants' training performance showed that the developed training program was effective. The training program improved trainees' system use competency by comparing trainees' pre- and post- training performance, i.e., trainees were able to conduct clinical tasks using the EHR correctly and efficiently, and transfer the competency to use another EHR after training. The training also improved trainees' clinical outcomes by comparing clinical outcomes between the two training conditions, i.e., trainees who learned cognitive mapping were more competent to identify medication discrepancies. This result implied the proposed methodology could be used as an approach to health IT training, and may be generalizable to other clinical tasks, environments, or role-types.

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CHAPTER 1

HEALTH INFORMATION TECHNOLOGY TRAINING

1.1 Introduction

Health information technology (IT) has attracted wide attention over the last decade from government agencies, healthcare organizations, and academia, partly because a US national mandate requires that healthcare organizations implement electronic health records (EHRs) (Redhead, Library of Congress, & Congressional Research Service, 2009). This mandate originated in part due to expectations that health IT may streamline healthcare workflows, reduce medical errors, and improve patient safety and quality of care. In addition, health IT projects typically require significant investments from both public and private sectors. For example, Partners Healthcare in Boston spent 1.2 billion dollars on a new EHR system in 2015, making it the single biggest investment Partners has ever made (McCluskey, 2015).

Unfortunately, health IT implementation success rates remain relatively low (Kaplan & Harris-Salamone, 2009), and studies have reported mixed outcomes after the implementation of health IT. Some studies have shown reductions in medical errors, and improved communication and documentation patterns after health IT implementation (Poon et al., 2010). Conversely, other studies have reported instances where health IT may have contributed to increased medical errors or mortality rates (Han et al., 2005, Koppel, 2005).

These undesired outcomes are termed “unintended consequences” of IT in a healthcare system, and researchers have advocated the use of sociotechnical models to understand the mechanisms for these outcomes (Carayon et al., 2006). These sociotechnical models differ in their details, but most emphasize the interactive dynamics between varied components in a system, including technology, human, and organizational factors (Sittig & Singh, 2010). The unintended consequences of health IT are depicted as a product of health IT's impact on and interactions with other social factors. Some models particularly emphasize the IT's impact on clinicians' workflows; they conceptualize clinical outcomes, such as patient safety, as the product of how and how well clinicians perform work processes, and consider the processes as a mediator "between work system design on the one hand, and patient, employee, and organizational outcomes, on the other" (Holden, 2011).

One means to improve the health IT success rate therefore is to explicitly analyze and mitigate health IT negative impact in user-centered implementation tasks, such as training and user support, to ensure individuals in the healthcare system can use the technology successfully and effectively, and make optimal use of the capabilities and characteristics that the technology has to offer (Carayon, Alyousef, & Xie, 2012). The importance of examining and addressing health IT use is also emphasized in the sociotechnical model literature (Harrison, Koppel, & Bar-Lev, 2007).

Training as a user-centered implementation task, has been identified as one of the key success factors involved in technology implementation (Carayon et al., 2012), and it is the theme of this dissertation. The importance of training in health IT implementation also lies in the fact that health IT training is typically the first time clinicians get exposure to the technology, and the knowledge they gain from training will likely shape their long-term practice in the real clinical setting. Therefore, health IT training should help users mitigate the negative impact of health IT on their clinical tasks, and facilitate optimal IT use and acceptance. In particular, training should address the impact of health IT on care processes and workflows in order to improve clinical outcomes. Similar approaches have shown to effectively support health IT implementations (Novak, Anders, Gadd, & Lorenzi, 2012), but it remains to be studied how to systematically address and mitigate health IT negative impact on care processes and workflows in a training program.

Health IT training, similar to training in other domains, should also follow theoretical guidance from the science of training. However, healthcare organizations lack industry-wide best practices driven by scientific training theories. Though there are best practice principles of training in literature, healthcare organizations still often have to learn from their organization's own training experiences, which can be costly and inefficient (Laramee, Bosek, Kasprisin, & Powers-Phaneuf, 2011). Part of the reason is that translating principles to real training practices during training development is not a simple task, and the processes are often underreported and underemphasized in literature. The literature often includes lessons from costly "do-overs" after the training program go-lives (Leviss & Gugerty, 2010). Ideally, by following the science of training, those issues might be detected before the go-live, which could save money and time for clinicians and healthcare organizations. There are two main areas in the science of training directly instrumental to health IT training: a) instructional development models, i.e., the systematic process of developing a training program, and b) training methods that align with trainees' cognitive characteristics.

The need for model-guided health IT user training has been recognized. American Medical Informatics Association (AMIA) board members have called for "models of user training and support processes that can meet clinician needs" (Gardner et al., 2009).

Instructional development is a well-established domain focused on the training development processes, with over 100 validated instructional development models, such as the Instructional Systems Development (ISD) model (Chen, 2007), R2D2 model (Recursive, Reflective, Design and Development) (Willis & Wright, 2000), and rapid prototyping model (Tripp & Bichelmeyer, 1990). These models can help meet the call from AMIA, and improve user training and implementation process.

Determining appropriate training methods and techniques are also instrumental for an effective training program. Clinical educators have called for using foundational learning theory to guide the design and evaluation of training methods that account for learners' cognitive characteristics, and they identified significant gaps in current training design (Kaakinen & Arwood, 2009). These characteristics of learning can be structured in many ways, some of which may be particularly relevant for health IT training: knowledge types and acquisition.

Cognitive psychologists have distinguished between two knowledge types (i.e., procedural knowledge and declarative knowledge) (Anderson, 1983), and suggested using different training methods for different knowledge types (Koedinger, Corbett, & Perfetti, 2012). They have also studied the process of knowledge acquisition, and identified practice, feedback, and transfer as important factors of learning (Woolfolk, 2006).

There are many validated methods that facilitate knowledge acquisition from the training literature. By understanding how those methods align with users' cognitive characteristics, training developers and educators can make better-informed decisions on how to adopt appropriate methods in user training.

One training method that may be particularly useful for health IT training is called cognitive mapping, which represents and connects related concepts/knowledge (All & Havens, 1997). Because health IT training should help users mitigate the negative impact of health IT on clinical tasks, cognitive mapping can serve as a promising training technique to achieve this goal. First, this method can explicitly integrate health IT with clinical tasks into workflow by mapping health IT functions onto these existing clinical processes. Second, this method may also effectively aligns with learners' characteristics, because learning is more efficient if learners can acquire new skills with connections to previously learned skills (All & Havens, 1997). In addition, information retrieval and system navigation are a significant part of EHR use, and could impose more cognitive burden to clinicians. Cognitive mapping technique can also be used to represent and understand the structure of an EHR system, and therefore may facilitate EHR use. However, no studies have explicitly tested the effectiveness of this technique for health IT training.

1.2 Research Goals and Outlines

My dissertation aims to explore a systematic and generalizable way to develop health IT training and improve health IT implementation success. Specifically, the training program developed with this approach should explicitly mitigate health IT's negative impact on clinical processes and workflow to produce more ideal clinical outcomes, thus facilitating optimal use and higher technology acceptance.

I conducted my study with senior baccalaureate nursing students at a large public university. I used the EHR as the type of health IT. I used the clinical task of obtaining a medication history because it is an error-prone process involving comprehensive EHR-related competencies (e.g., information retrieval, documentation, decision-making). It has also been used in comprehensive practice sessions in previous EHR implementation training sessions in health organizations (Laramee et al., 2011).

This study is built on scientific models and theories from sociotechnical systems engineering, the science of training, and clinical practice. In this section, I will briefly outline the subsequent sections of my dissertation.

In Chapter 2, I review two areas of previous studies related to my work: a) sociotechnical models, and b) scientific training theories. First, the aim of user-centered implementation is to mitigate health IT's negative impact, and facilitate optimal use. Training should therefore utilize sociotechnical models to analyze IT's impact on users' clinical tasks, and identify strategies to integrate health IT into users' clinical processes and workflow. Second, current health IT training development processes are often empirically based and underemphasized. Scientific training theories, including instructional development models and training methods, can guide better training design. I describe the implications for my work.

In Chapter 3, I detail the methods of developing and implementing my training program. I first present a model developed to guide analysis of health IT's impact on clinical care at cognitive level. I utilize this model to analyze EHR impact on the medication reconciliation task, and identify mitigation strategies of integrating the EHR into the clinical workflow. I then detail the systematic process of training program development, the program details and implementation process, and my evaluation measures.

In Chapter 4, I evaluate the results of a study measuring the effectiveness of the training program.

In Chapter 5, I discuss findings, lessons, and experience learned from this project, and generalizable implications for health IT training.

CHAPTER 2

BACKGROUND

Effective user training has been recognized as an important factor to improve health information technology (IT) implementation success, but development of a successful training program remains a challenging task. Part of the reason is that healthcare organizations lack industry-wide best practices in electronic health record (EHR) training, so often have to learn from their organization's own training experiences, with can be costly and inefficient.

Developing an effective training program for health IT implementation is a systems engineering project. First, a training program should address not only technical issues with health IT, but other social factors as well. This will ideally mitigate unintended consequences and negative impact prior to or during training. It requires a comprehensive sociotechnical interactive analysis, and for user-centered implementation tasks, such as training, we need to focus on how to support optimal use. Second, we need a systematic and scientific way to guide the design and development process. Instructional development models should be used to systematically guide training design. In addition, understanding trainees' human factors, especially their cognitive characteristics, are particularly helpful for deciding appropriate training methods during the development phase.

In this chapter, I review two major areas related to health IT training: sociotechnical models and the science of training. I describe how previous work is related to my work.

2.1 Sociotechnical Models

In this section, I first introduce undesired outcomes of health IT, a key motivator for sociotechnical models to address health IT implementation problems. Then I review two types of sociotechnical models related to health IT. The first type of model focuses on the interactions between user and technology, while second type of model investigates user technology interaction in a broader social context. Finally I provide an in depth review of an important social factor related to my health IT training: the clinical task of medication reconciliation.

2.1.1 Unintended consequences of health IT

Although health IT can produce benefits, such as improved quality of care (McCullough, Casey, Moscovice, & Prasad, 2010) and reductions of medical errors (Poon et al., 2010), health IT implementation projects are often not successful (Kaplan & Harris-Salamone, 2009). Health IT failure rates can be as high as 70%, and as few as one in eight implementations is considered truly successful (Kaplan & Harris-Salamone, 2009). DesRoches et al. (2010) also found limited successful EHR implementations, showing the relationship between EHR adoption in U.S. hospitals and quality and efficiency were “modest at best and generally lacked statistical or clinical significance”. In December 2008, the United States Joint Commission on Accreditation of Healthcare Organizations warned of technology-related adverse events in a Sentinel Alert, stating that “users must be mindful of the safety risks and preventable adverse events that these implementations can create or perpetuate” (Joint Commission, 2008). Other studies also report potential technology-related adverse outcomes, such as unexpected increases in mortality rate (Han et al., 2005), and prescribing errors (Koppel & Metlay, 2005). These undesired outcomes are termed “unintended consequences” of health IT.

Several review papers have attempted to define what factors influence the success and failure of health IT implementations (Brender, Ammenwerth, Nykänen, & Talmon, 2006, van der Meijden, Tange, Troost, & Hasman, 2003, United States Government Accountability Office, 2009). Many factors are non-technical, and AMIA has identified unintended consequences from four domains: technical, human/cognitive, organizational, and fiscal/policy and regulation (Bloomrosen et al., 2011).

Systems engineering experts have advocated the use of sociotechnical models to understand the mechanisms for these outcomes (Carayon et al., 2006). Though sociotechnical models differ in details, they characterized the unintended consequences a product of health IT’s impact on and interactions with other social factors.

2.1.2 User technology interaction model

Human and technology interaction is at the center of health IT implementation, and understanding and mitigating the impact of health IT on users can facilitate user-centered implementation plan, including training design and technical support. Scientific models at the cognitive level are often used to study the interactive mechanisms between users and technologies.

A well-known way of understanding cognition is through the concept of mental models. First introduced by (Johnson-Laird, 1983), mental models represent underlying knowledge structures that allow an individual to construct their perception of a system or content domain. Mental models can also be considered as an internalized, mental representation of a device or idea. Norman (1983) was one of the first to attempt to create a terminology for a human-computer interaction theory of mental models, where he introduced different models of a system based on role-types. He introduced a user model and a design model, which are both conceptual models, and a system image, which is implementation of the system (Norman, 2013). The designer creates a design model that is communicated through the system image and a user develops the user model through interactions with the system image. These two models ideally align but often do not, resulting in a disconnect between the way users and designers understand how a system works. This mismatch in designer and user mental models also occurs within the health IT domain. Zhang et al extended this terminology into the health IT domain for EHRs, and add an Activity Model, which is the user's mental model of how the functions of a system are used in practice (Zhang & Walji, 2011). As Zhang et al (2011) pointed out, "…for an ideal design with perfect functionality, these three models should be identical." (Zhang & Walji, 2011) An ideal product or training program should align these three mental models. Unfortunately, "discrepancies of functions across the three models are almost always present" (Zhang & Walji, 2011), and user training should address these discrepancies.

There are two basic mental models corresponding to two aspects of an interactive system, termed structural and functional models (Preece, 1994, Young, 1983). A structural model is used to describe the internal workings of a device, which is then used to make predictions about the operation of the device. Its basic advantage is that the knowledge of how a device or system works can predict the effect of any possible sequence of actions. The accuracy of a person's mental model will affect how the user interacts with the system. According to Zhang's model of designing and evaluating general information systems, an information system, (e.g., an EHR), consists of functions, meaning the technical capabilities of the system, and representations, meaning the way these functions are visually represented and structurally organized into hierarchies within the information system (Zhang & Butler, 2007). On the other hand, functional models, better known as task-action mapping models (Young, 1983), describe the procedural aspects of a system: the procedural knowledge about how to use system functions, where a procedural rule is described as "IF task + display state, THEN action"(Howes & Young, 1996). Mental model-based training research has shown that providing information about a system's structural model can help users build a correct mental model of the system, which may facilitate knowledge generalization and skill transfer (Santhanam & Sein, 1994).

2.1.3 Sociotechnical system models for technology evaluation

Sociotechnical models investigate human and technology interactions in a social context. Depending on the purpose of a model, they may adopt different scopes, structures and granularities to represent the interactions between different domains and factors. For example, some models may treat technology as one whole element, while others break it down into its individual components (Sittig & Singh, 2010). In this section, I present sociotechnical models that have been particularly influential in providing the foundation of my proposed model. For each model, I first review the model structure and elements, and then describe implications relevant to my work.

2.1.3.1 Interactive Sociotechnical Analysis (Harrison et al., 2007)

The Interactive Sociotechnical Analysis model was developed to mitigate unintended consequences of IT in healthcare. The model contains four components and five interaction relationships.

The four components with definitions or example of each are:

a) New health information technology (IT to be implemented in the healthcare organization)
b) Social system (e.g., people, tasks, relationships)
c) Health information technology in use (IT currently used in the healthcare organization)
d) Technical and physical infrastructure (e.g., computer networks, physical environment)

The five interactions are:

a) New health IT changes the organization's social system
b) Technical & physical infrastructure mediates health IT use
c) The organization's social system mediates health IT use
d) Health IT use changes the organization's social system
e) Health IT-social system interactions engender health IT redesign

This model explicitly depicts unintended consequences as a product from interactive processes between health IT and the healthcare organization's sociotechnical system, including its workflows, culture, social interactions, and technologies. This implies that in order to address unintended consequences, implementation should explicitly address health IT interaction with and impact on social factors. This model also emphasizes health IT use in four of its identified interactions, as well as the change to social systems. User-centered implementation tasks, such as training and technical support, therefore are important to mitigate these impacts and facilitate optimal use. However, the Interactive Sociotechnical Analysis model does not have details about the social system, and how those interactions affect clinical outcomes, which have been addressed by models such as the systems engineering initiative for patient safety model (SEIPS) (Carayon et al., 2006).

2.1.3.2 Systems Engineering Initiative for Patient Safety (SEIPS) Model (Carayon et al., 2006)

The SEIPS model adopts a work system-process-outcome structure, and conceptualizes healthcare structures as five-element work systems, including:

- *Person(s)*, such as care providers, other employees of a healthcare institution such as a biomedical engineer, or patients
- *Tasks*, such as a clinical task, or informatics related tasks, e.g., documentation
- *Tools and technologies*, such as an EHR
- *Physical environment*, such as physical locations of rooms
- *Organizational conditions*, such as hospital culture or policy

The five elements of the work system interact with each other, and the element of *person* (also referred to as *individual*) is at the center of the work system. The model particularly emphasizes the need to "enhance and facilitate performance by the individual and to reduce and minimize the negative consequences on the individual and therefore the organization" (Carayon et al., 2006); the aim for user-centered implementation is consistent with this view.

According to the authors, a care process can be considered as “a series of steps or *tasks* performed by an *individual* or a team of *individuals* using various *technologies and* tools” (Carayon et al., 2006). For example, a medication administration process can be divided to four steps or subtasks, typically ordered by: a) retrieving medications from an electronic medication dispenser, b) verifying a patient’s identity, c) giving medications to a patient, and d) documenting the task. A nurse can use a Workstation on Wheels or a tablet to perform the process (He, Marquard, & Henneman, 2014). For the same task and technology, processes may vary between clinicians (Doberne et al., 2015).

The structure of the SEIPS model is similar to that of human factors paradigm for patient safety (Karsh, Holden, Alper, & Or, 2006), which suggests *processes* serve as the mediator between a *work system* and clinical *outcomes*: the *work system* affects *processes*, and *processes* influence the patient, employee, and organizational *outcomes* of care. This view is consistent with evidence from previous studies. For example, in a study of medication administration, researchers were able to explicitly link nurses’ visual scanning patterns (processes) to their abilities of identifying medication errors (outcomes) (Marquard et al., 2011).

In summary, the implication of this model is, in order to mitigate negative impact of health IT and reduce unintended consequences, health IT training should adopt a user-centered view, and focus on the users’ clinical processes and workflow.

2.1.3.3 Extended Technology Acceptance Model (Venkatesh & Davis, 2000)

The extended technology acceptance model is an extension of a classic Technology Acceptance Model (TAM) that addresses the impact of individuals’ cognitive factors and social influences on technology adoption and use, an important predictor of technology (and therefore health IT) success. The original TAM theorized that an individual's behavioral intention to use a system is determined by two beliefs: 1) the perceived usefulness of the system, defined as the extent to which a person believes that using the system will enhance his or her job performance, and 2) the perceived ease of use of the system, defined as the extent to which a person believes that using the system will be free of effort (Venkatesh & Davis, 2000). In the extended model, the researchers include a variety of sociotechnical factors that significantly influence user acceptance of a system, including social influence processes and cognitive instrumental processes, such as job relevance.

This model offers insights about what kind of support can be provided to users to increase the likelihood of technology acceptance. From a training or support perspective, adult learning theory confirms that in order to be used, a system should be relevant to the user's needs (job relevance) (Knowles, Holton, & Swanson, 2011), implying that training should incorporate job-specific materials. This model also implies that user-centered implementation should adopt strategies of mitigating the technology impact on users' cognitive processes, increasing their perceived ease of use of the technology.

2.1.4 Introduction to medication reconciliation

Clinical tasks are one key sociotechnical factor. In my developed training program, I used the clinical task of obtaining a medication history. This task is designed specifically to reduce medication errors. Errors can serve as both feedback mechanisms in training and a clinical outcome measure (King, Holder, & Ahmed, 2013, Holden, 2011). Therefore I can use errors an indicator to evaluate whether explicitly teaching clinical processes using health IT can produce better clinical outcomes. Medication reconciliation has also been used in comprehensive practice sessions in previous EHR implementation training in other health organizations (Laramee et al., 2011).

Medication errors in medication records are prevalent (Caglar, Henneman, Blank, Smithline, & Henneman, 2011). The most common medication discrepancies include the following:

a) Omissions: an medication was on the home medication list but not on the medication list obtained during the admission process (Caglar, Henneman, Blank, Smithline, & Henneman, 2011)
b) Commissions: medications are in the medical record that are no longer being taken by the patient (Kaboli, McClimon, Hoth, & Barnett, 2004)
c) Unspecified medication: the use of a medication at home without a corresponding disease or condition in the patient's records (Gizzi et al., 2010)
d) Duplication: the same medication is listed twice using a different name (e.g., lasix and furosemide) (Caglar et al., 2011)
e) Dosing error: an incorrect dose or frequency of a medication (Caglar et al., 2011)

In order to address the above error-types, systematic medication reconciliation tools and procedures have been proposed and tested in many studies. The tools or procedures support the medication reconciliation process by building relationships between symptoms and therapies (Truitt, Longe, & Taylor, 1982), reviewing a patient's medication history based on medication categories (Hocking, Kalyanaraman, & deMello, 1998), or by combining the two approaches (Tessier, Henneman, Nathanson, Plotkin, & Heelon, 2010). There are many benefits to these methods as they are systematically organized based on pharmaceutical knowledge, and may relieve some cognitive load for health professionals.

In my study, I adopted the Six Step Medication Reconciliation Tool (Henneman, Tessier, Nathanson, & Plotkin, 2014). This method adopted structures and processes by building relationships between symptoms and therapies, and by reviewing a patient's medication history based on medication categories, with a focus on high risk factors. The step details are summarized as follows:

- Step 1: Assemble demographic information, and inquiry any allergies, other adverse drug events, and the nature of these events.
- Step 2A: Review the existing medication list. A nurse must obtain the current medication list (or medications themselves) from the patient or family, and assess the reliability of the information, the nature of the list or prescription bottles, how current the information is, and whether there are other sources of medication information available.
- Step 2B: Conduct a systems review. This step maps problems of each body system to medications.
- Step 3: Conduct a "what's missing" check. This step identifies frequently missing medications.
- Step 4: Probe for more. This step intends to obtain details about drugs, doses, dosage forms, adherence, and any problems with therapy.
- Step 5: Conduct a final check. The final check investigates issues not previously addressed during the interview.

- Step 6: Reconcile certain issues immediately. This step prompts nurse to prioritize which medications need immediate reconciliation.

A diagram that illustrates the six steps is shown in Figure 1.

This clinical task developed to improve medication history accuracy is not simple, and becomes even more complicated when we introduce health IT as part of the workflow, because sociotechnical models and previous literatures suggest health IT may introduce or facilitate more errors (Koppel & Metlay, 2005). Health IT training is therefore important to mitigate this impact and explicitly address potential errors by focusing on process change.

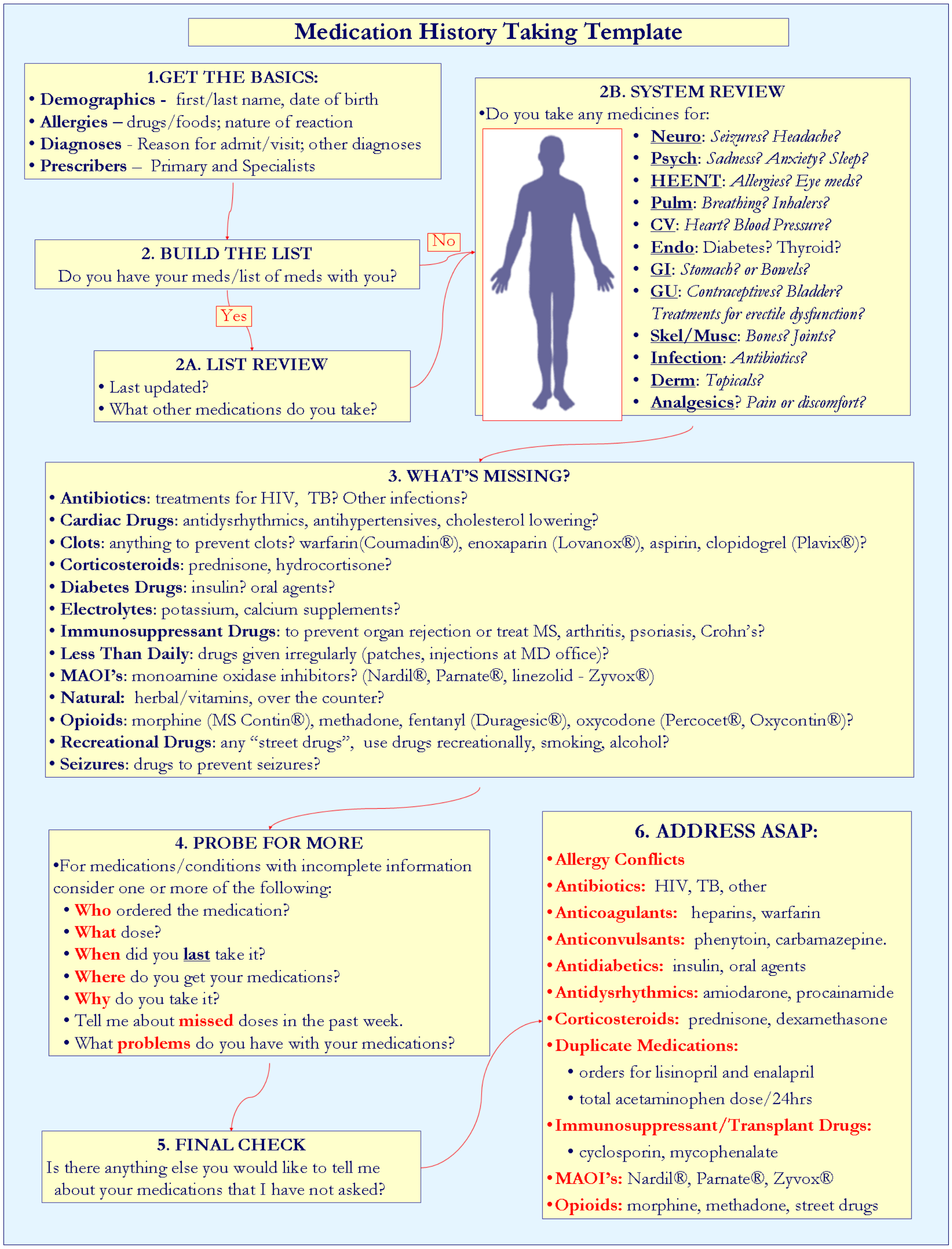


Figure 1. Six Step Medication Reconciliation Tool (Henneman et al., 2014)

2.2 Science of Training

Training and learning is one of the key user-focused components of technology implementation (Carayon et al., 2012). The current accounts of successes or failures in EHR training often focus on the final format of training, and it is rare to see detailed descriptions of the training development processes. In addition, very few studies address training methods by explicitly accounting for learners' cognitive characteristics (Kaakinen & Arwood, 2009, Leviss & Gugerty, 2010, Kushinka, 2011).

While current literature does introduce some training design principles (McAlearney, Robbins, Kowalczyk, Chisolm, & Song, 2012), there is still a gap in guidance on how to translate those principles into varied clinical practices or settings. For example, EHR Communication guidelines provided by healthIT.gov, which aims to aid providers and health IT implementers with the implementation of an EHR system, recommends implementation strategies developed by Kushinka (2011) as part of the California Networks for Electronic Health Record Adoption (CNEA) initiative. Those strategies include super users, process-based training, role-based training, and mock-clinic training (Kushinka, 2011). While these strategies as training methods are useful, they are only one facet of training. An effective training program also requires knowledge of sociotechnical interactive analysis to mitigate health IT negative impact, systematic training development process, as well as training methods that align with learners' characteristics. Training outcomes may still be undesirable without explicitly addressing these factors appropriately.

A case study from the book "H.I.T. or Miss: Lessons Learned from Health Information Technology Implementations" (Leviss & Gugerty, 2010), demonstrates that using super users training methods would still fail if training implementation and evaluation are not appropriately planned. In another study, a large medical center had to learn from their unsuccessful training outcomes to redesign their training processes (Laramee et al., 2011). They provided comprehensive training on the technical features of a new EHR during the first round of training, but ignored other social factors that influence health IT use and training, such as job relevance, trainees' abilities to learn, and integration with current workflows. Had they followed systematic processes to guide their training design, these issues would have been addressed before the training go-live.

In this section, I review two main areas in the science of training directly instrumental to health IT training: a) instructional development models, i.e., the systematic process of developing a training program, and b) training methods that align with trainees' cognitive characteristics of learning. I also describe how these studies influence my work.

2.2.1 Generalized training design process

American Medical Informatics Association (AMIA) board members published a white paper entitled "Core Content for the Subspecialty of Clinical Informatics", which identifies core educational content for clinical informatics. Among the numerous knowledge and skill content areas addressed by the AMIA board members, knowledge under "clinical information system implementation" includes "models of user training and support processes that can meet clinician needs" as one of three sub-topics (Gardner et al., 2009). Instructional development is a well-established domain, with over 100 validated instructional development models, such as the Instructional Systems Development (ISD) model (Chen, 2007), R2D2 model (Recursive, Reflective, Design and Development) (Willis & Wright, 2000), and rapid prototyping model (Tripp & Bichelmeyer, 1990).

The Instructional Systems Development (ISD) model is one of the most widely used (Chen, 2007). The ISD model is a generic model developed in the 1950s to meet military and commercial aviation training needs (Chen, 2007). In this model, training consists of five basic stages: analysis (A), design (D), development (D), implementation (I), and evaluation (E), so also referred to as ADDIE model. The details of each stage are presented in the following:

- Analysis: assessing training needs, specifying objectives, guiding training design and delivery, and developing success criterion.
- Design: developing learning objectives, performance measures, and the progression of the training program.
- Development: revising the training plan formulated in the design phase, and removing weaknesses.
- Implementation: final preparation and actual training.
- Evaluation: assessing the effectiveness of the training.

The ISD model is comprehensive in content and systematic in procedures, and covers almost all necessary components needed to carry out an effective training program.

To meet a variety of specific training needs, other models build on the ISD model stages. For example, the development stage may take a long period of time, so may fail to meet the pace of technology updates. The rapid prototyping model tries to facilitate training development by performing several stages simultaneously, condensing the generic ADDIE model into a four-level process, including: a) performing a needs analysis, b) constructing a prototype, c) utilizing the prototype to perform research, and d) implementing the final system (Tripp & Bichelmeyer, 1990).

The ISD model also does not embrace the fact that reality can be different from what was planned, and may change over time. Therefore, the R2D2 model (Recursive, reflective, design and development) provides the ability to update the training plan over time (Willis & Wright, 2000). Reflection involves critically considering work to date, and revising training plans and materials based on observation and other feedback. The recursive nature of the process means making the same decisions many times throughout the design and development process, so initial decisions are not necessarily the "final ones"(Willis & Wright, 2000).

There are several implications from these models to guide health IT training. First, training development should follow a systematic process to explicitly address specific training decisions in each stage. For example, training needs should be defined in an early stage of development. Second, a training design team should actively reflect on and revise current training to meet ever-changing situations. It is difficult to develop an ideal program in just one round of design and development, and prototypes should be vigorously tested in real training situations with real trainees.

2.2.2 Knowledge types, acquisitions and transfer

Human cognition is significant part of IT use, healthcare performance and training, so training development should take into account human cognitive characteristics and limitations, and adopt training methods that align with these characteristics.

2.2.2.1 Knowledge Types

Training methods should account for knowledge type. A well-known model of human cognition is ACT (Adaptive Control of Thought) developed by Anderson (1983). The most important assumption of this model is that human knowledge can be divided into two types: declarative and procedural. Declarative knowledge consists of facts, while procedural knowledge is made of production rules, meaning knowledge about how we do things. A similar distinction exists in the clinical domain as described by the Knowledge-Skill-Attitude (KSA) model, in which knowledge represents declarative knowledge, and skill is similar to procedural knowledge (Cronenwett et al., 2007). EHR use requires both declarative and procedural knowledge and optimal training strategies differ between knowledge types (Koedinger et al., 2012), so training should explicitly account for both knowledge types.

Though how to use a system is primarily procedural knowledge, the declarative knowledge about a system structure can also aid in training. For example, Borgman (1986) performed a study where novice users were trained to use an online catalog. The control group was given a set of procedures for retrieving literature from the catalog, while the experimental group was given the procedures and had the system explained through an analogy with the card catalog. Completion times and number of tasks completed for simple tasks were not different between the groups, but for complicated tasks the group that was trained on the system structure performed significantly better. This may imply that having a more accurate knowledge about a system structure will help users complete complicated tasks. The declarative / procedural knowledge enhances in both ways: studies also found that more procedural knowledge also contributed to more accurate declarative knowledge about a system (Gray, 1990).

2.2.2.2 Knowledge acquisition

The goal of training is often to help novices develop skills that experts have, and one of the most notable differences between novices and experts is a phenomenon called chunking (Chase & Simon, 1973). While working memory is limited, and information retrieval time is similar among individuals (Anderson, 1983), experts can retrieve larger chunks of information in working memory, therefore they can recognize key features of a problem more rapidly, memorize briefly presented material better than novices, exhibit better depth of forward planning or better anticipations of invisible situations, and solve routine problems without exploring many alternatives (Gobet, 2005). Expertise is gained over time primarily through practice, which has been vigorously studied among chess players and IT users (Campitelli & Gobet, 2007, Gray, 1990). The implication for health IT training is that training methods should be designed to facilitate chunking, by teaching experts' chunking patterns and engaging learners in active practice. Chunking phenomenon can also account for the fact that super users of health IT typically have lower cognitive load than novice users.

Training methods should be designed to explicitly facilitate the process of knowledge acquisition. Several different models of the architectures of cognition have been established to explain the processes and phenomena of human learning, particularly the effects of practice and chunking mechanisms (Gobet, 2005, Anderson, 1983).

There are several implications from those models. First, in order to facilitate acquisition of skill (procedural knowledge), a training program should help trainees interpret declarative knowledge. Second, breaking training contents into smaller parts can reduce working memory burden. Third, errors can serve as an important mechanism to refine skills. Fourth, via practice, students can better compile knowledge, refining and reinforcing the learned skills. When a higher level of generalization is reached, knowledge transfer will more likely occur. Fifth, teachers should facilitate the development of perceptual chunks by directing learners' attention to key features of the material, and providing feedback, which highlights the important features of a problem.

2.2.2.3 Knowledge transfer

Training methods should also be designed to facilitate knowledge transfer. According to (Salas, Wilson, Priest, & Guthrie, 2006), trainees must be able to transfer what they have learned in the training environment and apply it to work within the organizational setting. In educational psychology, researchers have defined transfer as "influence of previously learned material on new material" (Woolfolk, 2006). Knowledge transfer is important because one of the fundamental goals of training is the productive use of knowledge, skills, and motivations across a lifetime, creating something new instead of just reproducing a previous application of the tools (Corte, 2003). Transfer is important to health IT training because an ultimate goal of training is to see positive clinical outcome in actual healthcare setting, where the trained skills may be applied to clinical tasks and technologies different from the training.

There are two types of knowledge transfer, near and far transfer. The definition of near transfer, also called low road transfer (Woolfolk, 2006), or analogical transfer (Keith & Frese, 2008), is the spontaneous automatic transfer of highly practiced skills, with little need for reflective thinking (Woolfolk, 2006). Far transfer, also called high-road transfer

(Woolfolk, 2006) or adaptive transfer (Keith & Frese, 2008), is consciously applying abstract knowledge or strategies learned in one situation to a different situation (Woolfolk, 2006). For example, applying trained skills to a similar patient case can be considered as near transfer; but clinicians often have to deal with situations or tools more complicated than what has been trained, which is far transfer. Ideally a training program can facilitate both transfer types.

It is important to know what factors can facilitate transfer. Many factors have been identified in the classic transfer model developed by (Thayer & Teachout, 1995), and I summarize these factors with factors identified by (Salas et al., 2006) in Table 1.

After categorizing these factors into three groups, we find that these factors are also commonly used to predict general training outcomes and technology acceptance, which have been discussed in previous sections. Literature also claims that some training strategies may contribute to positive knowledge transfer, such as exposure to different situations (Anderson, 1983), error guided training (Keith & Frese, 2008), and mindful abstraction (i.e., the deliberate identification of a principle or main idea that is not situation specific) (Woolfolk, 2006). However, chunk-based theories indicate that negative transfer may occur when one reaches high levels of expertise; studies have suggested supplementing the teaching of specific knowledge with the teaching of meta-heuristics that are transferable, in order to reduce the phenomenon of negative transfer (Gobet, 2005).

Table 1. Factors that facilitate knowledge transfer

Individual Differences:
- Reactions to previous training
- Education
- Pre-training self efficacy
- Ability
- Career/job attitudes
- Trainee's reactions to the training/task at hand regarding overall likability
- Perceived instrumentality of training

Contextual Factors:
- Organizational climate
- Job involvement
- Training Strategies
- Locus of control

Transfer-enhancing activities
- Goal setting
- Relapse prevention
- Self-management
- Job aids

The implication of transfer studies for health IT training is that, in order to facilitate knowledge transfer, training should utilize strategies proven to facilitate positive knowledge transfer. In addition, health IT training should not only teach specifics of health IT use, but should also include generalizable and transferable knowledge and principles. For example, the knowledge of a health IT structure may be this type of knowledge.

2.2.3 Training methods

Determining appropriate training methods and techniques are instrumental in designing an effective training program. There are many validated methods from the training literature, such as cognitive mapping (All & Havens, 1997), conceptual vs. procedural training (Santhanam & Sein, 1994), active training (Romoser, 2013), error management training (Keith & Frese, 2008), super user training (Poe, Abbott, & Pronovost, 2011), simulation-based training (Kaakinen & Arwood, 2009), part-task training (So, Proctor, Dunston, & Wang, 2013), and the combination of several training modalities, such as instructor-led lecture and demonstration, practice, and computer interaction (Martin, 2011). Some previous studies have examined the benefits of a subset of these methods for EHR training (Poe et al., 2011) (Martin, 2011). For example, at a large academic medical center, nurses experienced higher satisfaction with training and increased self-confidence in the EHR use after super-user peer coach training (Poe et al., 2011). The study of a blended learning method at another large academic medical center found that clinicians were open to new training methods, and desired more hands-on practice (Martin, 2011).

These training methods are most effective when they are aligned with learners' cognitive characteristics during the design process. In clinical education, nursing educators have called for using foundational learning theory to guide the design and evaluation of training methods. Unfortunately, they have identified significant gaps in current training design. In reviewing simulation-based training literature, one study found only 16 out of 120 simulation-based training articles referenced learning theory to support their simulation design (Kaakinen & Arwood, 2009). A recent qualitative study used social cognitive theory and adult learning theory to identify best practices for EHR training across six exemplary healthcare organizations (McAlearney et al., 2012). Based on their analysis, they propose that "observation and active learning activities", "positive role models, including clinical leaders, persuasive champions, super-users", allowing participants to "reflect on past experiences", and taking into account "the characteristics and assumptions of a particular community of practice" would contribute to better learning outcomes, and they were able to identify some supporting evidence for these propositions (McAlearney et al., 2012).

Because expertise is gained through practice, many training methods emphasize the importance of learners' engagement during training. Active learning, also referred to as enactive learning, is an instructional strategy with emphasis on learning by doing and experiencing the consequences of trainees' actions (Woolfolk, 2006). The opposite training method is called passive learning, also referred to as vicarious learning, is the learning strategy that trainees learn by observing others (Woolfolk, 2006). According to the ACT model (Anderson, 1983), trainees go through several stages during practice to acquire skills, i.e., interpreting the declarative representation of knowledge, compiling the procedures, and refining the skills. The training method of active training emphasizes the trainees' active engagement in the practice process to develop skills, and aligns with the skill acquisition process. Active learning may facilitate knowledge transfer (Woolfolk, 2006), and convert knowledge or skills from short term memory to long term memory (Romoser, 2013).

There are numerous studies comparing active training and passive training, and the results consistently show that active training produces better outcomes in terms of academic program completion time, long term effects, etc (Romoser, 2013, Armbruster, Patel, Johnson, & Weiss, 2009). The reason that active training often produce superior outcomes than passive training may be that people who learn by observing must go through more cognitive processes, and thus the cognitive load is higher before performance and reinforcement (i.e., use of consequences to strengthen behavior) can take place (Woolfolk, 2006). However, passive training or observation training is common and often necessary, because trainers' demonstration guides trainees to develop optimal or required behavior model, and will be particularly useful when potential behavioral alternatives are too many or risky, such as medical procedures and flight operations.

Part task training method is used specifically to reduce novice trainees' cognitive load. Because trainees have to interpret declarative, factual knowledge about the system before the knowledge becomes procedural and rule-based, it can be a heavy burden in their working memory (Anderson, 1983). Thus, novice users typically are slow in executing processes and have more working memory errors; part-task training emphasized the need to break a large training into smaller session to fit trainees' cognitive capacity (So et al., 2013).

Feedback is an important part of practice to help trainees compile the correct procedures, and some training methods, such as super users, can provide timely feedback mechanisms. Errors can also serves as an important feedback mechanism. Error management training (EMT) is defined as a training strategy that involves active exploration as well as explicit encouragement to make errors during training and to learn from them (Keith & Frese, 2008). Keith & Frese (2008) also demonstrated in their work that active exploration, error encouragement, error management instruction and clear feedback are effective elements in EMT. They pointed out that in essence, errors serve as an important feedback function to modify or improve one's mental model. In order to produce positive outcomes, timely corrections are needed to the error occurred. Therefore, error guided training shares some similar features with active training: active engagement and exploration, and timely feedback, but error guided training is more specific about how feedback loops are constructed: by correcting an error and modifying one's decisions or behaviors.

There are four ways of approaching error occurrence: (1) avoid (2) allow (3) induce (4) guide (Salas et al., 2006). Because EMT involves explicit encouragement of errors, strategies that allow, induce and guide errors into training are all considered as EMT. However, guided error training involves intentionally guiding trainees into a particular error, then providing strategies for avoiding that error. Keith & Frese (2008) suggested that EMT may be better than error-avoidant training methods to promote transfer to novel tasks. This approach has also been used in clinical education (King et al., 2013).

Some training methods emphasize the need to consider trainees' existing knowledge and experiences, and promote training by extending or building on their current knowledge. Simulation based training emphasizes training in context, which aligns with trainees' job relevance and experiences (Kaakinen & Arwood, 2009). It can embed the new skills, e.g., health IT skills, into the context of actual use scenarios, e.g., the healthcare environment and the clinical tasks, therefore facilitating the skill in their actual work. The design of a scenario or patient case may be more effective if it reflects the key features of users' mental model about clinical work during the simulation.

Another training method that facilitates learning new skills from previous ones is called cognitive mapping, and it may be particularly useful for health IT training (All & Havens, 1997). Because health IT training should help users mitigate the negative impact of health IT on clinical tasks, cognitive mapping can serve as a promising training technique to achieve this goal. In particular, the impact of health IT on care processes and workflows can be addressed by flowchart mapping, which explicitly maps health IT functions onto these existing clinical processes (All & Havens, 1997). Previous studies have also shown that training that includes conceptual models of an information system can help build accurate mental models of the system, and produce better training outcomes (Borgman, 1986). Another type of mapping called hierarchy mapping can be used to represent the structure of an EHR system, and may facilitate EHR use. However, no studies have explicitly tested the effectiveness of this technique for health IT training.

2.3 Summary

In this chapter, I reviewed two areas of previous work related to health IT training: sociotechnical models and the science of training.

Sociotechnical models are used to guide analysis of sociotechnical interactions to reduce unintended consequences. Those models emphasize the center role of users, and the need to focus on technology use and clinicians' process change for user-center implementation. A training program that is designed to integrate technology with users' tasks may mitigate negative impact of health IT, and improve technology acceptance. Clinical tasks are an important social factor, and medication reconciliation is a task designed to reduce medication errors.

A training program development should follow systematic processes, and should be vigorously tested and updated before implementation. Training methods should be designed to facilitate knowledge acquisition and transfer, by providing practice and feedback, and relating new knowledge to previously learned ones. Cognitive mapping may be an effective method to improve health IT training. Flowchart mapping can be used for integrating health IT into workflows, and hierarchy mapping can be used to represent a system structure.

CHAPTER 3

METHODS

In this section, I detail my model guided systematic approach to develop a health IT training program. I first present a sociotechnical model with focus on cognitive level factors to aid analysis of health IT's impact on users, and identify mitigation strategies with a focus on heath IT integration into clinical processes. Then I detail my design and development processes following instructional development models. Finally I describe the training program details, including its implementation and evaluation measures.

3.1 A Sociotechnical Model for Integrating Health IT into Clinical Processes

This model adopts a sociotechnical systems approach, with a focus on cognitive level integration for health IT training. The three levels included in the model are: the primary domains involved in health IT implementation training, relevant cognitive-level factors associated with these domains, and associated training components and their interactions.

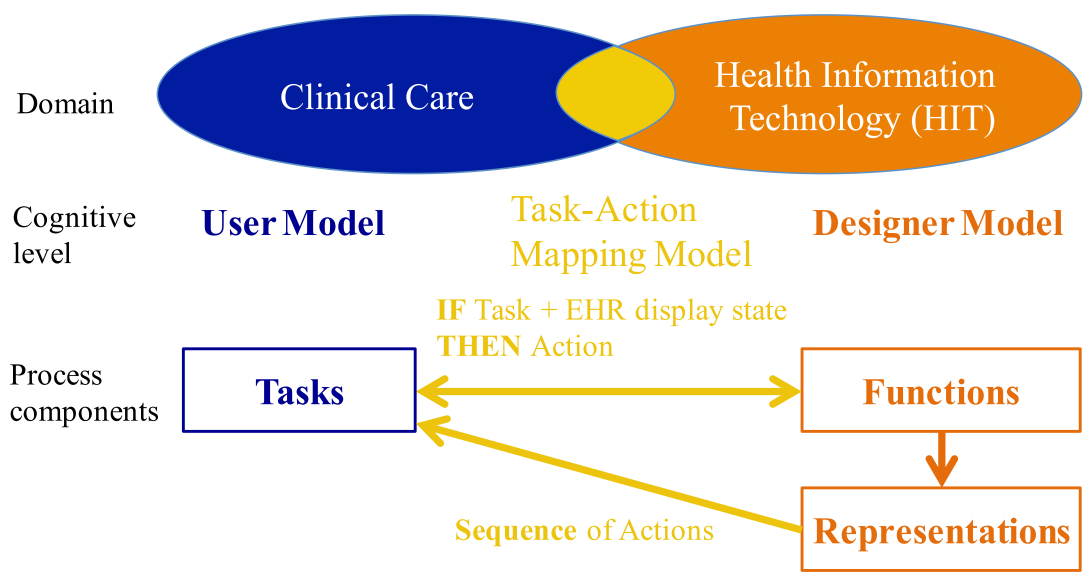


Figure 2. Integrative model of EHR user-centered implementation

3.1.1 Primary domains involved in health IT training

Implementation of new health IT, such as EHRs, will impact and reshape clinical care processes. Therefore, user training occurs at the intersection of *clinical care* processes and the specific type of *health IT*, EHRs in this case. A training program should account for both domains and their interactions, with a specific focus on how health IT may affect the clinicians providing care.

3.1.2 Cognitive-level factors

All healthcare performance is cognitive (Holden, 2011), including health IT use and clinical care. In the cognitive level of our model, I adopt the *User Model* and *Designer Model* to represent the role types within the clinical care and health IT domains (EHRs in this case), and use Howes & Young's (1996) *Task-Action Mapping Model* to reflect the interactions between the EHR and the clinical care processes. The designer model represents internal workings of an EHR, as the functions and structure of an EHR affect the Task-Action Mapping Model. EHR users ideally will iteratively build and modify the *User Model* and *Task-Action Mapping Model* as they complete training on and interact with the EHR.

3.1.3 Training components

In the clinical care domain, the EHR users' mental models about health IT use are task driven, i.e., how to carry out *clinical tasks* with health IT, such as obtaining a medication history or prescribing medications. In the EHR domain, designers often focus on technical aspects of health IT, and determine what *functions* should be provided to users and how the functions should be *represented* in EHR, meaning how those functions look in the system and how they are organized into hierarchies. The *clinical tasks* and technical *functions* and *representations* are linked through the *Task-Action Mapping Model*: *clinical tasks* are completed by clinicians following the mapping rule of *IF task + EHR display state THEN actions* to use the EHR *functions*. EHR *functions* can also add *tasks* for clinicians (e.g., logging into the EHR, or navigating a system). The *representations* of *functions* within the EHR influence the *sequence of actions* that a clinician needs to take. For instance, the hierarchy of an EHR may influence the order of functions a user can access.

3.2 Model guided health IT training needs analysis

Using the clinical care-health IT integration model, I was able to conduct an implementation impact analysis, and identify strategies to mitigate the negative impact of health IT on clinical care. There are at least two aspects of health IT impact on users illustrated in the model. First, the technical functionalities provided by a new health IT (i.e., how to use a function) may not align with users' experiences and anticipation. A user may have never used an EHR before, or have used EHRs that have different representations than the new one. Therefore, users need to make additional efforts to adapt their mental models to the designer model in order to correctly use the health IT. Second, because the new health IT will be used for part of users' clinical tasks, deciding the context of health IT use (i.e., when to use) will impose additional cognitive load to new users. For example, a clinician should know for a specific situation and task in a complete clinical process, what health IT functions they need to use. They should also know the sequence of clinical tasks and health IT use in the workflow. This impact can be addressed by task-action mapping training.

Therefore, a training program should determine how EHR functions are intended to be used, and how to integrate the EHR into trainees' workflows (i.e., task-action mapping). This information is useful for deciding training needs. In this study, the clinical task to be addressed is medication history taking, following the protocol developed by Henneman et al. (2014).

3.2.1 Analysis of EHR functionality

The training analysis should determine what technical aspects of the EHR (e.g., functions) should be addressed during training. After extensive review of the literature and analysis of EHRs, I identified and studied the EHR functions required to complete the clinical process, including both overhead functions (e.g., logging into the system) and domain functions (e.g., reviewing the current medication list in the EHR) as described by (Zhang & Walji, 2011). Specifically, trainees need at least six EHR functions to complete the specific clinical task, including:

1. Login to the system
2. Search for and retrieve a specific patient's chart
3. Retrieve basic patient information, such as identifiers (e.g., name, DOB), allergies, vital signs
4. Retrieve and document a patient's medication list
5. Retrieve and navigate through a patient's problem list
6. Retrieve and navigate through a patient's past history, such as social, medication, surgery

3.2.2 Analysis of workflow: EHR-clinical care integration

One of the unintended impacts of an EHR is that the EHR can impose high cognitive load for clinicians, making clinical tasks error-prone. In order to mitigate this negative impact, I clearly mapped out the links between the clinical care process and the EHR use, including what tasks should be completed with the EHR, when in the process the EHR will be used, and how the technology will impact the trainee's workflow for the clinical process of interest (task-action mapping), as shown in Figure 3. The results from this analysis can inform the design of training in a dedicated clinical task-EHR integration/workflow section. As an EHR will likely impact the clinical care process, the analysis helps mitigate negative impacts of these changes, and explicitly address any redesigned clinical workflows in the training.

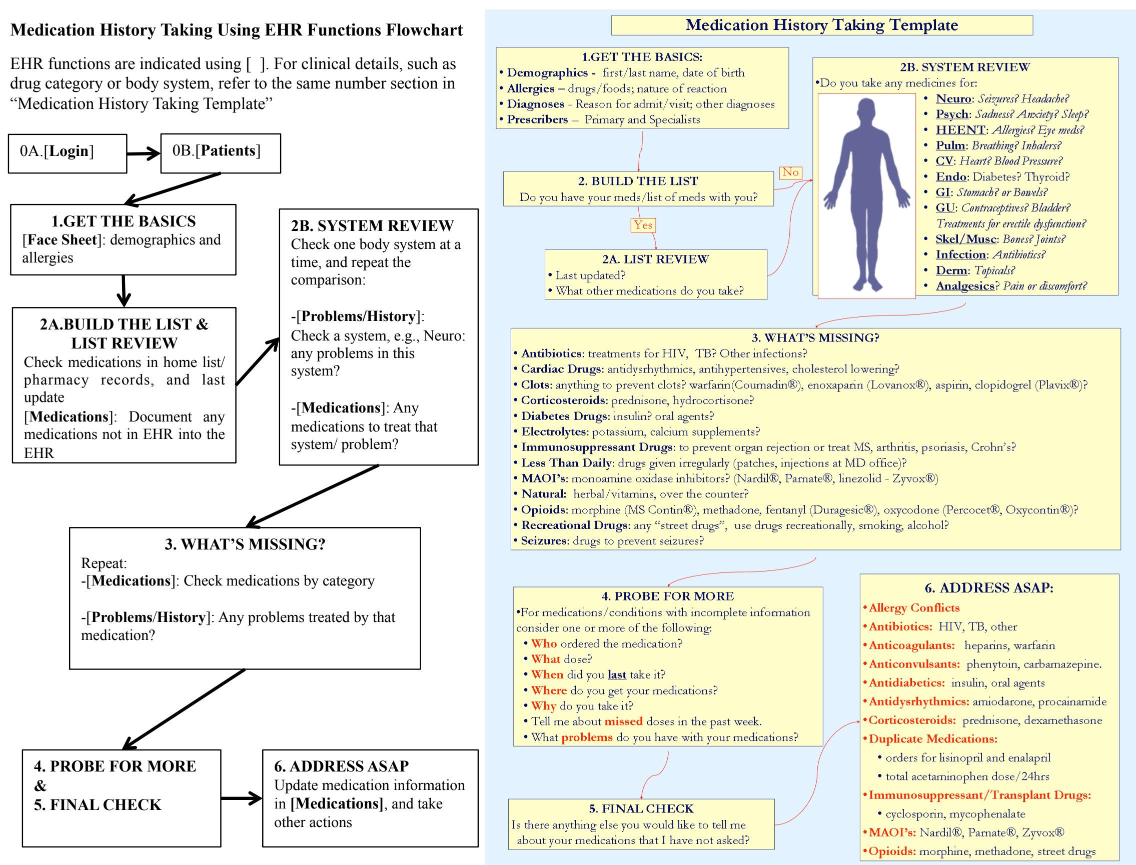


Figure 3. Workflow analysis with EHR implementation (Medication History Taking Template from (Henneman et al., 2014)).

3.3 Training Design and Development Process

In this section, I describe how I designed and developed the training program. I first defined the goal of the training program: to help senior nursing students use an EHR efficiently and accurately while obtaining a patient's medication history. More specifically, after training, nursing students should be able to:

- Use EHR functions related to medication history taking to navigate, search for information, retrieve information, and document new information into the EHR
- Reconcile any potential discrepancies in medication information in the system, such as omissions and out-of-date medications

A multi-disciplinary team participated in the training design process, including individuals with nursing, computer science, and human factors backgrounds. In addition, the targeted nursing students also participated extensively in the development process. The nursing students in our program had received classroom training in pharmacology and obtaining a medication history, had some experience with EHRs through their clinical experiences (though not the EHRs used during training), and were competent with basic operations with computers (e.g., using a mouse and keyboard, and opening software).

We determined the necessary components of the training program, which include clinical process review, pre-training evaluation of EHR competency, EHR use training, workflow integration training, and post-training evaluation. Then we developed the content and process for each component of the training program.

The instructional development models propose to develop training content by prototyping materials for each training section, then testing the materials with real trainees. After developing the first version of training content and process, I started to work with nursing students to understand their perceptions, and reveal any confusions and ambiguity in the training materials. I worked with six different trainees individually on the materials and processes, and update them based on findings from each individual testing until I could identify no remaining issues to be addressed, so I am ready to roll out the training.

With the first three trainees, I focused on the *content* of the training. I asked each trainee to go through the training materials in order, observed them learning without imposing any time limit, and documented their time and questions. I asked them to think out loud so I could understand points of confusion, and tried to clarify verbally until they understood. With the final three trainees, I focused on the *process* of the training. I followed specific training protocols, with time limits for each section. I observed and documented issues as trainees went through the training, and communicated with them about the issues and their concerns at the end of the training.

I summarize major issues identified with each participant, and our corresponding changes in Table 2.

After 6 iterations of design and development, I finalized the training program. Based on the observation during development, I also designed and revised the training methods to fit trainees' characteristics. A summary table for how those methods are utilized in the final training is shown in Table 3.

Table 2. Program development iterations (1-3 content-oriented, 4-6 process-oriented)

Participant	Major Issues	Training Design Changes
1	a. The trainee was unfamiliar with some EHR technical terms not commonly used in clinical care.	a. Simplify or define terms to fit clinicians' language. For example, "search for information" was more familiar than "information retrieval", and "enter data/notes" was more familiar than "documentation".
	b. The trainee lost attention when a video tutorial introduced too much information at a time	b. Instead of introducing all EHR functions at once, introduce two functions at a time, followed by a hands-on practice
	c. The trainee remained confused about what she needed to do with EHR with different medication history sources after clinical process review	c. Add a review question about reconciling with multiple medication history sources and using EHR, and provide answers
	d. The trainee did not understand why the EHR-workflow tutorial was related to "how they conduct clinical care", and did not understand the task-EHR flowchart mapping	d. Make the task-EHR integration tutorial more relevant to clinical care, and present the integrated workflow chart in resemblance to clinical process diagram
	e. The trainee did not feel comfortable in the physical environment, feeling too hot	e. Conduct training in an air-conditioned environment
2	a. The trainee did not get some key details of instructions printed on paper	a. Add a training instruction transcript for all sections, and verbally communicate what to do before each section
	b. The trainee did not know what to do during the hands-on exercise besides repeating what was demonstrated in the video	b. Add specific goals and assignments to the hands-on exercise, which covers the demonstrated content
3	a. The trainee had a problem organizing and finding files	a. Distribute files only when they are needed for each section, and ask trainees to put paperwork away in a file folder after use
	b. The trainee frequently asked, "what's next?"	b. Add a file called progress checklist to list all training sections, tasks and time in order, so a trainee can have expectations and more control
4	a. The trainee was quicker to complete tasks than the time set for the training, and had to wait for next sections to begin	a. In the instruction/protocol, the time set for each section is changed to the maximum time allowance, making it more self-paced; a smaller learning group (1 to 3 trainees per training session) can better accommodate different learning capabilities.
	b. The trainee's cell phone rang during the training	b. Add a welcome PowerPoint slide projected to whiteboard with silenced cell phone reminder
5	The trainee seemed to miss some key information about task-EHR integration tutorial printed on paper	Provide video tutorial in addition to paper version
6	The trainee went through the materials and processes very smoothly. Ready for implementation.	None.

Table 3. Training methods used in the training program

Training methods	Application in the training
Active training and passive training	Trainees first explore the EHR system without any tutorial, then observe video demonstration, and complete assignments
Error management training	The patient cases include embedded discrepancies, and as part of the feedback trainees receive solutions explaining the errors
Cognitive mapping	Trainees are instructed to explicitly map out the integration of clinical care task and EHR functions; they are also instructed to map the structure of the medication function. They were also instructed to use the mapped workflow to identify medication discrepancies
Simulation based training	The training is conducted around how to deal with simulated patient cases using EHR
Part-task training	The video tutorial of EHR functions are divided into 3 sections; each section demonstrates 2 functions, followed by hands-on practices
Conceptual & procedural training	The training not only addresses step-by-step use of EHRs, but also concepts related to EHR system structures and operations
Blended training	Several training modalities, as described above, are employed in the training

3.4 Health IT Training Program Implementation

Implementation phase of a training program takes places after extensive preparation, including trainee sign-ups, mass production of training materials, system set-ups, and scheduling of space and people.

As one of the goals of this study is to identify whether training with cognitive level integration technique can lead to better training outcomes, i.e., cognitive mapping, I tested one independent variable (i.e., without this technique (control) vs. with this technique training (treatment)) using a between subject, randomized experiment design. Specifically, I address the following questions:

a) Does the training program improve trainees' abilities to use EHR functions correctly, by comparing their pre- and post- training performance?
b) Does the training program improve trainees' performance when they use a different system, by comparing their pre- and post- training performance?

c) Does the training program that explicitly addresses health IT's impact on processes improve nursing students' clinical task outcomes, by comparing treatment and control program students' performance?

I detail the training program and its implementation and evaluation in this section, and the training program is outlined in Table 4.

Table 4. Training program outline

Section	Brief Description of Process	Duration (min)
Check in	Trainees are seated and learn the goals and process of the training	5
Clinical process review	Trainees review the medication history taking process, answer review question, and get feedback via presentation of the solution	5
EHR Case 1	Trainees login to the EHR and complete patient Case 1 with no training, as a pre-test.	12
System use tutorial	Trainees watch a video demonstration of the EHR functions, and have hands-on practice of each function.	15
EHR and clinical process integration/ workflow tutorial	Trainees watch a video demonstrating how to integrate the EHR functions into the clinical process, have hands-on practice, and get feedback (Treatment) Trainees read a two-page essay about medication reconciliation and EHRs, and answer questions (Control)	13
EHR Case 2	Trainees complete a more complicated patient case using the EHR	12
EHR Case 2-Transfer	Trainees complete a more complicated patient case using another EHR	12
Check out	Trainees complete a survey regarding their demographics, perceive usability about EHR systems, and self-rated informatics competencies	

3.4.1 Participants

I recruited participants from senior students pursuing a bachelor's degree or second bachelor's degree in the University of Massachusetts Amherst College of Nursing. Participants were recruited on a voluntary basis during nursing clinical courses, and were asked to sign up by providing contact information and preferred time slots. The recruited students were competent in medication history taking and pharmacology knowledge. 37 students participated in the actual training, with 18 in treatment group and 17 in control group.

Participants were informed that the goal of the experiment was to understand how nursing students learn to use an EHR. Participants were not informed that there were two training conditions, and were asked not to communicate training details with their peers. As a motivational incentive, each student received a $30 gift card after participating in the experiment. I obtained approval from the University Institutional Review Board.

3.4.2 Session assignments

Sessions were arranged to fit students' schedule. A training session by design lasted no more than 90 minutes based on students' typical schedules, and each session included 1 to 3 participants. I scheduled three sessions a day (one in the morning, and two in the afternoon) on weekdays to provide large time coverage. I also held holiday and weekend sessions at students' request to include as many students as possible. I randomly assigned the study condition to be control or treatment for each session.

3.4.3 Settings

The study was conducted in the Class Lab in Skinners Hall, College of Nursing, University of Massachusetts Amherst. The location is convenient to the targeted nursing students, and ensured a low level of no show rates (2 out of 37).

A nursing expert developed two hi-fidelity patient cases, one for pre-training evaluation of EHR competency and EHR use tutorial, and the other for post-training evaluation and transfer. The patient cases included pre-populated information in the EHR, such as a problem list and some medications, as well as a list of medications the patient brought in from home. Each case had a type of commonly seen discrepancy in daily clinical practice: the first case has an outdated home medication list, and the other has several potential omissions. Similar patient cases were previously validated in another study (Henneman et al., 2014), but the trainees in this study never saw them before training.

3.4.4 Apparatus

In the Class Lab, there is a projector with speakers. I set up three laptop computers with Windows 7 operating systems each with a wired USB mouse. The website of two EHRs, Kareo (Irvine, CA) and DrChrono (Mountain View, CA), as well as Survey Monkey (Palo Alto, CA) links were pre-configured in the computers' Chrome web browser (Mountain View, CA) before the experiment. I also used a screen capture software (Sketchman Studio) to capture participants' actions on the computer screen (i.e., mouse movement, click, keyboard inputs). The recorded video does not show participants themselves or any personally identifiable information. A file folder and a pen were provided to each participant to organize files, take notes, and work on training assignments.

3.4.5 Procedures

Before each training session, I set up the room environment to ensure proper lighting and comfortable temperature. For each assigned seat, I set up a pen, a file folder, and a computer. I then projected a welcome slide with silenced cell phone reminder to a white board. I waited and greeted participants by door, directed them to an available seat, and collected their signed informed consent.

To ensure consistency between each training session and avoid potential experimenter bias, I prepared an instructional script with all verbal instructions and protocols, shown in APPENDIX A. Following the script, I first welcomed the students, introduced the study, and then started the screen recorder software. Before the first section, clinical review, trainees were also informed on the concept of self-paced learning and use of a progress checklist, shown in APPENDIX B. The progress checklist serves as a complementary to instruction scripts, and lists all tasks they need to complete.

3.4.5.1 Clinical review

Every participant received and reviewed a file with the diagram of the medication history taking process; the participants had related clinical training about the reviewed material. The file on medication history taking was utilized and validated in a previous study by Henneman, Tessier, Nathanson, & Plotkin (2014). They answered a question about how to use an EHR to conduct the clinical process as a preparation for the patient case 1, a pre-training EHR competency assessment, and were given a reference solution as a feedback. The complete materials for this section can be found in APPENDIX C.

3.4.5.2 Patient Case 1

Participants received a patient case and a system credential sheet for using the EHRs. The patient case and the credential sheet are shown in APPENDIX D. In the patient case, there was an embedded discrepancy: the home medication list was out of date (i.e., last update time was 2 years ago). They had 10 minutes to document and edit the medication history in the EHR for this given patient, and another 2 minutes to file a report in Survey Monkey regarding the accuracy and completeness of the medication history after their documentation. The survey questions are shown in APPENDIX E. Though the purpose of this section is to assess their competency before any training, this can also be viewed as an active training session: participants actively explored how to use the system with no guidance in using the system, and observed the system responses.

3.4.5.3 System Use Tutorial

The system use tutorial began after every participant submitted the Case 1 survey. I provided a handout summarizing 6 EHR functions necessary to complete the medication reconciliation process as shown in APPENDIX F, similar to what might be given to participants in a clinical setting. Participants watched a 15-minute lecture style video introducing the medication reconciliation-related functions. Participants were told all information was in the handout.

The video link and screen shot are shown in APPENDIX G. The video demonstrated step by step how to use each of the six functions, including login, (how to find) patients, face sheet, history, problems, and medications. The training video was uploaded online and played during the training session through the projector. The video has 3 sections with 2 functions in each section. At the end of each section there was a hand-on practice assignment for using the functions demonstrated, and participants were asked to use the patient case 1 for the video assignments. At the end of the last function demonstration section, the video summarizes key learning points, and participants were asked to review all functions and check answers for patient case 1 as a feedback shown in APPENDIX H.

3.4.5.4 EHR and clinical process tutorial

3.4.5.4.1 Treatment Condition

The treatment condition included a cognitive mapping tutorial and practice assignments. The aim of this mental model based tutorial is to teach explicitly the strategy of building system structures (hierarchy mapping) and integrated workflows (workflow mapping). Participants were given a paper hand out with tutorials and tasks, shown in APPENDIX I. They also watched a short video about how workflow mapping can help medication reconciliation process; the video tutorial link and screen shots are provided in APPENDIX J. They were instructed to explicitly map the relevant EHR functionalities to the steps in the medication reconciliation process. In addition to the workflow mapping, they were also asked to execute part of the workflow to identify discrepancies. This step facilitates the process of building procedural knowledge from the declarative form, and emphasizes the job relevance of these assignments. They also learned to conduct hierarchy mapping -- drawing the hierarchical representation of a key EHR function in this system, medications. They were also asked to observe how this *hierarchical representation* affects the *sequence of actions* they need to complete the *task* of documenting a medication: they need to first access the higher level function, i.e., “Medications” available on the opening screen, move on to the second level function, i.e., “+ Med List” after clicking on “Medication”, and then to the third level functions. After they finished the assignments, I provided them a reference solution, also shown in APPENDIX J.

3.4.5.4.2 Control Condition

To rule out the possibility that treatment group’s performance was a result of longer time of training, control group trainees were provided a two-page literature review that described background information in medication reconciliation and the effects of EHRs on patient safety. They then answered 5 questions based on the reading. The amount of work and time needed for completion are similar to those of treatment condition. After they completed answering the questions, I provided them a reference solution to check answers. The materials used are shown in APPENDIX K.

3.4.5.5 Patient Case 2

This section was designed to evaluate the effectiveness of training for using the system. The process was the same as Patient Case 1: they had 10 minutes to document and edit the medication history in the EHR for this given patient, and another 2 minutes to file a report in Survey Monkey regarding the accuracy and completeness of the medication history after their documentation. The patient case was more complicated, including potential medication omissions, with no corresponding medications or treatment documented in the system for two problems. The patient case used is shown in APPENDIX L.

3.4.5.6 Patient Case 2 Transfer

This section was designed to evaluate the effectiveness of training for using a different system, DrChrono. By using a different EHR for the same patient case during evaluation, this was considered to be a skill transfer ability, another frequently used approach from the training literature. The rationale for including transfer as part of the evaluation is that these students will likely work for different health organizations using different EHRs, so learning should transfer to other contexts. They had 10 minutes to document and edit the medication history in the EHR for this given patient, and another 2 minutes to file a report in Survey Monkey regarding the accuracy and completeness of the medication history after their documentation. Because the patient case is the same as Patient Case 2, the response to the Survey Monkey should be the same, but I intended to see whether a new system may facilitate identification of discrepancies.

3.4.5.7 Survey

The last part of the training program was a set of questionnaires. Participants were asked to rate each EHR's usability using a questionnaire developed by Brooke (1996) and shown in APPENDIX M. They were also asked for demographic information such as degree program as shown in APPENDIX N, and computer and general nursing informatics competencies using a validated tool (Choi & Bakken, 2013), shown in APPENDIX O. After a participant completed the survey, I administered the payment and dismissed the participant; I then marked all training files with an assigned unique ID for the participant's folder.

3.5 Training Evaluation and Performance Measurements

In my study, I used two methods to record trainees' performance for evaluation: screen recorder software (Sketchman Studio) and survey responses using Survey Monkey (Palo Alto, CA). The screen recorder data can be considered as a type of time and motion data, where the time refers the timestamp in the video, and the motion refers to the behavioral events, such as login, mouse movements, and report submission. The survey responses are used as a proxy to evaluate patient care outcomes, i.e., whether trainees were able to identify intended discrepancies in the patient cases.

In addition, I used two pre-validated standardized questionnaires to collect trainees' self-rated informatics competencies and their perceptions of the EHR systems. Theses data are useful to determine whether and how individual differences influence the training effectiveness.

There are two main sets of collected data: computer interactions and survey data.

The effectiveness of the training program is evaluated through computer interactions data. There are three aspects in terms of trainees' performance:

a) EHR use competency: based on the training goal, a trainee is considered to be competent in using the EHR if the trainee was able to correctly identify and document the intended medication(s) within given time period. This measure is a binary outcome for each participant, competent or not competent. The outcome was determined by checking the corresponding patient record against the solutions.

b) Clinical outcome, accuracy: the discrepancies in patient cases serve as an indicator to measure the clinical outcome, accuracy. A patient case is considered to be documented accurately, if in the report a trainee clearly included a statement about the potential discrepancies that the development team designed and predetermined. This measure is a binary outcome for each participant, identified or did not identify. The outcome was determined by checking the Survey Monkey responses against the solutions.

c) Duration of completion: the duration of completing a patient case is the time from when a participant logs into a system to when she/he submits a report in Survey Monkey, measured in seconds. It can be recorded using screen recorder video and Survey Monkey submission timestamps. This measure can be considered as a speed measure, and by comparing with the accuracy measure, identified discrepancies or not, one can observe potential speed-accuracy trade offs.

The survey data includes demographic data and answers to the questionnaires (e.g., informatics competencies), and can be analyzed using descriptive statistics for participants as a whole, and for each of the two training conditions. Computer experience, EHR experience, usability rating, and self-rated competencies are assessed to describe condition assignment balances between two training groups, and may describe potential differences between groups.

There are two types of comparisons: within the two training condition groups (within group) and between these two groups (between group). The comparison within group utilized patient case 1 as a baseline, and can evaluate the effectiveness of the training program on system use competency. A within group comparison will assess and compare system use competency changes between pre-tutorial patient case 1, after tutorial patient case 2 and patient case 2 transfer.

The comparisons between two training conditions can test the effects of the cognitive mapping training technique on accuracy and transfer. A robust clinical process directly improves clinical outcomes such as accuracy, therefore the treatment training group was hypothesized to perform better in the accuracy measure after training. A generalized knowledge about system structures may facilitate transfer, therefore the treatment training group was hypothesized to perform better in terms of system use competency and time completion during Patient Case 2 transfer.

CHAPTER 4

RESULTS

There were two key training components in the training program, including to health IT use and workflow integration. The evaluation measure of EHR competency aims to address the training program effectiveness on health IT use, and the hypothesis is that the training program can improve trainees' abilities to use EHR functions correctly, by comparing their pre- and post- training performance. The health IT use competency can also transfer to a new health IT, and the hypothesis is that the training program improve trainees' performance when they use a different system, by comparing their pre- and post- training performance. The evaluation measure of clinical outcome aims to address treatment training effectiveness on workflow integration, because processes directly influence clinical outcomes. The hypothesis is that the training program that explicitly addresses health IT's impact on processes improve nursing students' clinical task outcomes, by comparing treatment and control program students' performance.

In this chapter, I first present the results from the trainees' background surveys, and evaluate the results of training program effectiveness measures.

4.1 Standardized Surveys

There are three sets of questions to survey trainees' background information that may influence their health IT training performance: a) academic and EHR experience, b) self-rated informatics competencies, and c) EHR usability rating.

4.1.1 Academic and EHR experience

The first survey asks for education, computer, and EHR experiences, and the results are summarized in Table 5. The academic and EHR background are similar between the two training conditions.

Table 5. Academic and EHR experience

	Treatment (total n = 18)	Control (total n = 17)
Academic Program		
Traditional bachelor's	15	16
Second bachelor's	3	1
Years using computer		
More than 2 years	18	16
6 month – 2 years	0	1
Computer use frequency		
Several times per day	18	15
Once per day	0	1
Several times per week	0	1
Prior EHR experience?		
Yes	18	17
No	0	0
EHR hours		
No more than 19 hours	2	2
20-40 hours	5	7
More than 40 hours	11	8

4.1.2 Competency ratings

Table 6 summarizes the responses from the informatics competency self-rating questionnaire developed by Choi & Bakken (2013). Each question has a rating scale from 1 (least competent) to 5 (most competent). For each individual, I added his/her ratings by competency categories (e.g., basic computer knowledge and skills) as well as by all questions (i.e., total score), and compare the scores between the treatment and control group.

Each row shows four items in order: a) competency categories and corresponding questions in the questionnaire, e.g., clinical informatics role with questions 1-5, b) average score with 95% confidence interval for the treatment group, c) average score with 95% confidence interval for the control group, d) p values using two tailed t test to compare treatment and control groups. This questionnaire shows the trainees in two groups are identical in their self-rated competencies.

Table 6. Summary for clinical informatics competency self-rating

Competency (Questions #)	**Treatment (n = 18)**	**Control (n = 17)**	**p value**
Clinical informatics role (1-5)	14.6 (2.3)	14.2 (2.3)	0.80
Basic computer knowledge and skills (6-20)	57.3 (4.9)	58.5 (5.5)	0.74
Applied computer skills: Clinical informatics (21-24)	7.7 (1.5)	9.6 (2.3)	0.18
Clinical informatics attitudes (25-28)	17.7 (1.5)	16.1 (1.7)	0.16
Wireless device skills (28-30)	7.3 (1.1)	7.4 (1.2)	0.87
Podcast, RSS (31-32)	4.9 (0.7)	5.2 (1.2)	0.74
Total	109.5 (9.5)	111.0 (12.0)	0.85

4.1.3 Usability ratings

Table 7 summarizes the responses from system usability survey (Brooke, 1996), and I calculated the total score for the survey for each participant following the survey scoring protocol. The final score for a survey has a range of 0 to 100.

Each row shows four items in order: a) the name of an EHR b) average rating score with 95% confidence interval for the treatment group, c) average rating score with 95% confidence interval for the control group, d) p values using two tailed t test to compare treatment and control groups. This questionnaire shows the trainees in two groups are identical in their perceived usability of the two systems.

Table 7. Usability rating for two EHRs

EHR	Treatment	Control	p value
Kareo	68.1 (10.6)	65.2 (11.1)	0.96
DrChrono	51.9 (11.9)	62.1 (11.0)	0.23

4.2 System Use Competency Measures

Table 8 shows the number of trainees who completed each patient case correctly for each group. The performance is similar between two groups for Case 1 ($X^2(1, N = 35)$, $p = 0.86$) and Case 2 (Fisher's Exact, $p = 1$). The performance improved significantly from Case 1 to Case 2 (Fisher's Exact, $p < 0.01$) for both groups.

Table 8 also shows the number of trainees who completed Case 2 in another system (transfer task) for each group. Their performance is similar between two groups in case 2 transfer task (Fisher's Exact, $p = 0.49$). Using Case 1 as a baseline, the performance improved significantly in case 2 transfer task (Fisher's Exact, $p < 0.01$). This suggests the training was also effective to improve system use competency in systems other than the system trained. There were two trainees who did not complete case 2: one documented only one medication in the transfer task, but she correctly documented two medications in Case 2, so this is likely due to forgetting; the other was unable to figure out how to use the system.

Table 8. Number of trainees who correctly documented medication(s)

	Pre Tutorial (Case 1)	After Tutorial (Case 2)	After Tutorial Transfer (Case 2 Transfer)
Treatment (n = 18)	9	18	16
Control (n = 17)	9	17	17

4.3 Accuracy Measures

Table 9 shows number of trainees who correctly identified potential discrepancies: out of date discrepancy in case 1, and omission discrepancies in case 2. The performance is similar between two groups in case 1 (Fisher's Exact, $p = 0.23$). However, treatment group trainees performed significantly better in case 2 (Fisher's Exact, $p < 0.01$). Among treatment group trainees who identified omission discrepancies in case 2 (n = 10), 5 explicitly stated both asthma and diabetes discrepancies, and 2 stated the diabetes discrepancy. The one who was in the control group did not state which problem may have omission discrepancies.

Table 9 also shows the number of trainees who correctly identified potential discrepancies in case 2 in another system (transfer task) for each group. Trainees used the same patient case as Case 2, and it was useful to know whether a different system design may influence their ability to identify the error. There was one trainee in the treatment group and two in the control group who only identified omission discrepancies in the transfer task. Treatment group trainees still performed significantly better than control group in case 2 transfer task (Fisher's Exact, $p = 0.02$). For those who identified omission discrepancies during the transfer trial only (n = 1 in treatment, n = 2 in control), none of them explicitly stated the specific types of medications omitted.

Table 9. Number of trainees who identified intended discrepancies

	Pre Tutorial (Case 1)	After Tutorial (Case 2)	After Tutorial Transfer (Case 2 Transfer)
Treatment (n = 18)	0	10	11
Control (n = 17)	2	1	3

4.4 Duration of Clinical Tasks

Table 10 shows the duration of each patient case for each group, and the average durations are reported in seconds with 95% confidence interval. A repeated-measures analysis of variance revealed that there is significant decrease in durations of clinical tasks after training ($F(2, 66) = 53.75$, $p < 0.01$), and there is no significant difference between the two training conditions (F(1, 33) = 0.06, p = 0.80). However, the interpretations of durations are different between those who were able to complete a case and those who were not: for those who were able to complete the case, this duration measures how long it took them to complete the case, while for those who were not able to complete the case, the time measures how long it took before they stopped attempting the case.

Table 10. Durations (in seconds) of each patient case assignment, Mean (95% CI)

	Pre Tutorial (Case 1)	After Tutorial (Case 2)	After Tutorial Transfer (Case 2)
Treatment (n = 18)	566 (66)	434 (55)	375 (50)
Control (n = 17)	618 (66)	372 (57)	362 (54)

In order to further detail the training effects on durations for different conditions, I divided the trainees into four groups, and the results of mean duration in seconds with 95% confidence interval are shown in Table 11, and visualized in Figure 4.

The overall trend of durations across three patient case assignments was similar between different groups. Although every group had significant improvement in the speed of completing a case, there is an intriguing phenomenon: the treatment group who completed Case 1 was the fastest group in Case 1, and became the slowest group in Case 2. This observation inspired the next measurement to check speed-accuracy trade offs.

Table 11. Durations (in seconds) of each patient case assignment by training conditions and Case 1 completion, Mean (95% CI)

	Pre Tutorial (Case 1)	After Tutorial (Case 2)	After Tutorial Transfer (Case 2)
Treatment/ Completed Case 1 (n = 9)	533 (77)	444 (68)	389 (83)
Treatment/ Did not complete Case 1 (n = 9)	598 (102)	425 (88)	361 (53)
Control/ Completed Case 1 (n = 9)	624 (53)	341 (78)	376 (77)
Control/ Did not complete Case 1 (n = 8)	611 (107)	407 (81)	344 (79)

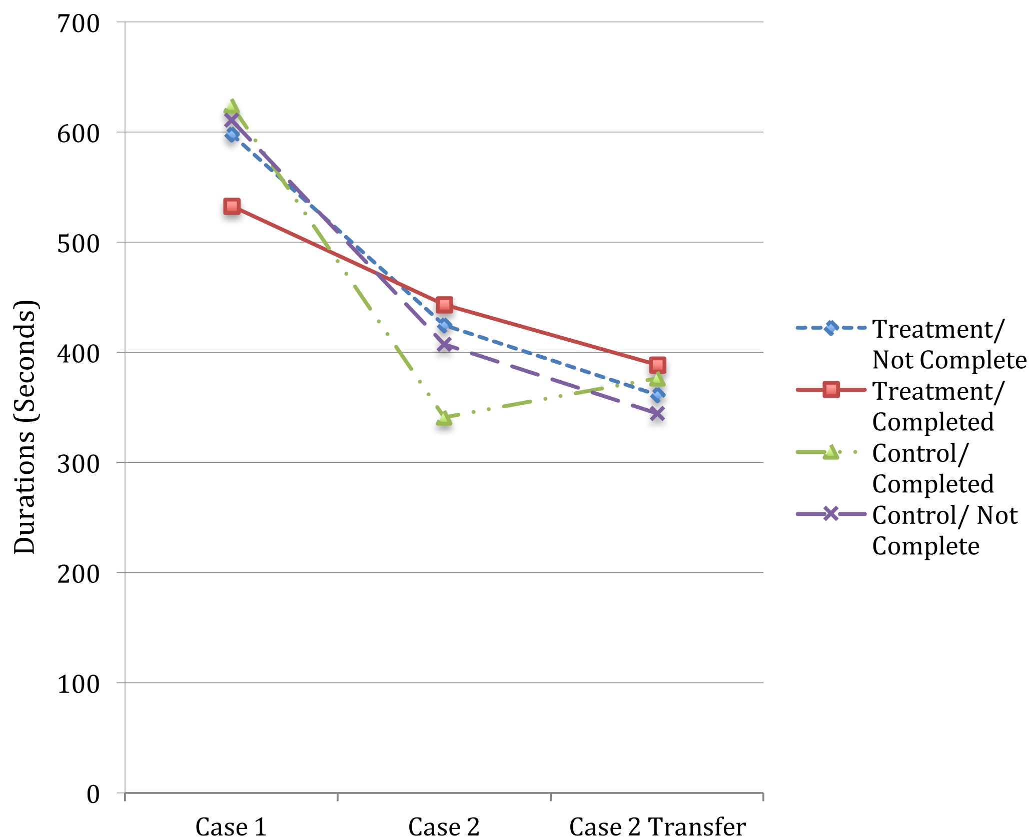


Figure 4. Durations for patient cases for each group (in seconds)

4.5 Speed-Accuracy Trade-off

One observation in durations is that the treatment group in general did not improve their speed as much as the control group between Case 2 and Case 1, and this phenomenon became more evident with further divided groups.

One hypothesis is that most treatment group trainees checked discrepancies in addition to documenting medications, so they spent more time on the patient Case 2. For Case 2 transfer task, those who identified discrepancies in Case 2 did not have to check discrepancies again because the case was the same, so their time is similar to other groups. I categorized trainees into two groups based on whether they identified omission discrepancies in Case 2, and compare whether the durations were different across the three sessions. The results were summarized in Table 12.

Table 12. Durations of each patient case for groups categorized by whether they identified discrepancies in Case 2

	Pre Tutorial (Case 1)	After Tutorial (Case 2)	After Tutorial Transfer (Case 2)
Identified discrepancies (n = 11)	566 (91)	468 (42)	408 (57)
Did not identify (n = 24)	603 (48)	375 (51)	350 (44)
p value	0.49	<0.01	0.12

The results suggest that in order to identify discrepancies, trainees spent more time to conduct this task in addition to documenting medication using the EHR. The differences in duration between the two groups are unlikely caused by individual differences in system use proficiency, because there is significant difference only in Case 2, when those trainees identified discrepancies. This finding is also consistent with previous studies that accuracy often comes at the cost of longer durations (Henneman et al., 2014).

CHAPTER 5

DISCUSSION

5.1 Training Program Effectiveness

The results showed both training programs were effective: for both treatment and control group, it improved trainees' system use competencies pre- post training, as measured by their ability to document medications in the system. Most trainees were also able to transfer the competency to another system. Because this training program adopted the so-called "blended training" approach, and included many methods such as active training and instructor led demonstration, error management training, simulation based training, and part-task training, it is difficult to distinguish which training method contributed most to trainees' learning and transfer. Previous studies that conducted controlled experiments suggest these methods all have some positive influence in facilitating learning and/or transfer, so they should be adopted if the methods are appropriate for a training scenario.

The controlled comparison in my study is about the effects of cognitive mapping techniques in health IT training. The results of accuracy measures suggest that this technique is helpful for users to keep track of both clinical and computer tasks as a complete process, because for those who identified omission discrepancies, they likely spent more time for clinical tasks of a patient case, while the others focused most of their attention on the system use. This implies that while a new health IT may increase cognitive load, an external cognitive aid tool can help clinicians reduce the burden of keeping track of tasks and reduce errors. Another implication is that speed, or time, is not always an appropriate indicator to measure competencies for safety critical tasks, because speed increase may come at the cost of ignoring some tasks and thus lowering accuracy.

While the focus of my study is the training effect on clinicians' EHR use, system design has more direct impact. Three trainees identified potential omission discrepancies only in the transfer task, likely due to the simple cue provided by the system used in the transfer task: the number of medications and number of problems documented. A trainee explicitly noted that there are many more problems than medications, therefore some medications may have been missing. This highlights the importance of user-centered system design approach.

In addition to the quantitative measures, I asked some participants at the end of their training sessions to comment in terms of usefulness, clarity and any other aspects related to the training quality. Their feedback was highly positive, and some quotes including:

- "It (the training process) is smooth and well-planned."
- "They (the materials) are really clear and well explained."

The positive feedback was expected, because negative feedback should have been addressed in development phase before program roll out, not afterwards.

5.2 Health System and System Models

A healthcare system is a life-critical system. Ideally such systems require thoughtful, rigorous design to prevent unwanted consequences, such as adverse events. However, medical errors are still common, and may lead to adverse health outcomes or death (Institute of Medicine, 2000). There are several reasons for this reality. First, *people* are a critical element in a healthcare system, and "to error is human" (Institute of Medicine, 2000). It is difficult to eliminate human errors, but an appropriate design may reduce the likelihood or impact. Second, we are still limited in the knowledge of system mechanisms, and what constitute an optimal system. System level knowledge can guide designs of individual components as well as their integrations, so that a system can perform optimally. For example, a computer system may perform best when its hardware and software are designed together. Similarly, a process-driven health IT system that integrates some clinical tasks into the electronic tool, e.g., providing built-in medication/ treatment – problem check, may better streamline workflow than it is designed separately.

System models have been developed to aid understanding of a healthcare system and guide better designs. The relationship between system models and a healthcare system is similar to that of maps and the real world: based on the needs, we can adopt different levels of details (e.g., country, state, county) and types of abstractions (e.g. topographical map or traffic map) to represent and emphasize some aspects of reality. In that sense, a user-centered health IT implementation model, such as the one developed in the paper, can be viewed as a zoomed-in version of a general sociotechnical system model: it provides further details at cognitive level to guide how to proceduralize clinical care tasks with health IT use. The model developed in this study specifies how to integrate health IT with clinical care into cognitive processes and workflow, which directly influence clinical outcomes according to human factors paradigm. This model bridges macro-level system models with cognitive level factors, by addressing user technology interactions in a healthcare context, and specifies cognitive level dynamics between key factors most relevant to clinical user. The explicit mapping between clinical tasks with IT functions also emphasizes the need and application of job relevance in implementation design.

Although the model proposed in this paper focuses primarily on cognitive level factors, it is beneficial to understand other contextual factors as depicted in other general sociotechnical models, such as internal and external regulations and environment. Using different models in complementary to each other may further improve health IT implementation success.

5.3 Health IT Unexpected Consequences on Cognition

Health IT will have unexpected consequences, according to sociotechnical systems models. The impact on cognition is inevitable, partly because of a phenomenon called chunking. When a clinician becomes proficient in a complicated task with many sub-processes, those sub-processes have been proceduralized and stored as a whole chunk of memory. Therefore the clinician can perform complicated tasks with lower cognitive load. However, with the introduction of a new health IT, the original whole chunk becomes fragmented, and a clinician has to learn and practice in order to form a new chunk. Before chunking with new health IT occurs, the cognitive load will increase, and a complicated health IT will further demand more cognitive resources, making the chunking process even slower. Moreover, some clinical tasks may be ignored, posing potential patient safety risks.

To mitigate the cognitive level negative impact, there are several strategies. The first strategy is better-designed health IT that integrates clinical processes into IT functions, so the new processes and workflow will be very similar to the previous ones; the IT system should also be easy to learn and use.

Another strategy is to provide sufficient user support, including training. Training should facilitate learning and chunking processes, and provides useful tools to help reduce the cognitive load during the transition period. The cognitive mapping technique, for example, may be a good candidate tool. First, it builds new knowledge with explicit link to the old knowledge, so clinicians may learn faster. Second, flowchart mapping is more than a training technique: it also serves as a checklist with ordered sequences of tasks, a tool commonly used by clinicians as an external cognitive aid. These methods will be particularly effective when there are many sub-tasks and may overwhelm clinicians.

5.4 Science of Training

The most valuable lessons and experiences for my training program are gained through the development process: it should follow instructional models that emphasize vigorous testing and revision, and involve actual trainees. The science of training, particularly theories about how human learn, provide theoretical support to help understand observed training effects, and guide directions in design and revision.

Instructional models, such as ADDIE or R2D2, can be helpful to guide a successful EHR training program development process. They help identify and remedy potential issues before the training program execution, to avoid potential costly failures, do-overs and clinician frustration. It is a best practice to involve targeted trainees in the process, and understand their work, needs, characteristics, and current competencies, and update the training materials and processes to best serve their needs. However, the training design and development process can be frustrating during early stages; for example, during our early development phase, a trainee involved in testing told us, "do not teach us how to use the (cumbersome) system, go fix it." While an ideal and user friendly EHR is the ultimate goal, a good training program is necessary for users to take full advantage of any EHR system.

In order to make progress in the correct direction during training design and development, instructional models suggest explicitly defining training goals and training needs. Based on the analysis results, one can go through iterations of prototyping, testing, redesign and development until they are confident the program is ready to be implemented. It is difficult to have a perfect training program through just one round of development, and one can always learn new things based on different feedback. The trainees who involved in the development process can also serve as super user instructors to other trainees.

An effective health IT training program should address and mitigate health IT negative impact on clinical processes. This paradigm is similar to training in other domain, such as driving, where they first identified the hazard mitigation strategies through novice and experienced driver comparisons (Lee et al., 2008), and utilized the identified strategies to train novice drivers. For health IT training, we can identify impact mitigation strategies by either studying how super users use health IT for their clinical tasks, or utilizing the sociotechnical model developed for this study to analyze mitigation strategies.

In order to facilitate the development process, developers should have knowledge about sociotechnical interactions, particularly human computer interaction, and cognitive science and learning theories, including existing training methods and adult learner characteristics, as well as deep understanding of clinical care tasks. The models and knowledge from those domains can guide design decisions, and help generate better alternatives when original plan does not work as expected during testing.

The development of an EHR training program should focus on both training content and process, which are both key factors to ensure success. Training content and process are interactive factors, as different content may be best trained using different methods or durations. My experience was to emphasize more on content clarity and learnability during early stages in the development, and focus more on the training process toward later stage to avoid trainees' loss of attention and fatigue, such as self-pace learning, video demonstration vs. paper based content presentation. However, everything should be vigorously tested, as there is "no one size fits all" training template or formula.

Individual differences are less accounted for in my training program, because of the generally identical background in my targeted trainees. For training programs that need to address individual differences, more personalized support should be developed. Possible strategies include peer coach, smaller groups, and more flexible user support, so that clinicians with different competency levels and needs can learn what they need to learn. In my training, for example, I provided some flexibility in time to meet individuals' different pace.

The implementation of a training program, similar to other technology implementation plans, is influenced by other factors. These factors may include organizational resources (e.g., equipment, budget, training staff, and management support) and constraints (e.g., time and space limits). For example, because clinicians typically work on tight schedules, finding training time is not easy. Based on these factors, training programs should have realistic expectations and success criteria, and progression through training should be planned accordingly. Nevertheless, the principles and science behind an effective training program still apply, and can guide the design process and help avoid common pitfalls during training.

The ultimate goal of training is to improve trainees' performance in the actual workplace. Therefore, evaluation will be more comprehensive and informative if I can observe how this training transfers to actual working environment, and study long-term training effects.

5.5 Limitations and Future Work

There are several limitations in this study that need to be addressed in future work.

First, this study was conducted in a laboratory setting with nursing students, and focused mainly on short term training effects. In order to further validate the approach, it should be used to develop and evaluate health IT training programs for clinicians in real healthcare settings. The long term training effects can also be studied in real healthcare settings. Nevertheless, the controlled study in a laboratory setting contributed valuable evidence for effectiveness; healthcare organizations may not conduct controlled study to compare different training approaches.

Second, this study only studied one clinical task that can be completed individually, and investigated limited transfer scenarios. For clinical tasks completed by teams, the coordination and communication between different clinicians using new health IT should also be addressed during training, and it remains to be determined how to conduct health IT training for team based tasks. In addition, other transfer scenarios should be evaluated. For example, it can be studied whether training clinicians to use EHR with medication reconciliation tasks, can facilitate their ability to use EHR for medication administration processes. It can be studied whether the health IT competency students learn in academic programs may facilitate their health IT learning and use of potentially more complicated systems in real healthcare settings.

In addition to better training, future work should also focus on user-friendly IT design. As observed in this study, simple cues provided by EHRs can improve trainees' performance to identify discrepancies and reduce their cognitive load. An ideal system interface should be process-driven: the system navigation and information retrieval should be straightforward and quick during clinical tasks, and the documentation process in an EHR ideally should be as simple as typing in a text file. Fortunately, some intelligent systems have been developed to improve human computer interaction for clinical care, such as HARVEST, a visualized patient record summarizer (Hirsch et al., 2014).

5.6 Conclusions

Evaluation of participants' training performance showed that the developed training program was effective in improving their system use competency and clinical outcomes. This result implied the proposed methodology could be used as a systematic approach to health IT training, and may be generalizable to other clinical tasks, IT systems, environments, or role-types.

APPENDIX A

INSTRUCTIONS AND PROTOCOLS FOR EACH SECTIONS

Note: all actions are specified in ().
(After all students signed consent form and are seated, start section 1)
Section 1:
Welcome! This study aims to understand if a training program can help you better use an electronic health record system.
Please now open the folder, and take out the first file- progress check list, and put it by your right hand-side, and keep your folder by the left hand-side. If you write with your left hand, you can switch sides.
This study has several short sections and small tasks. **Please complete each task, and *check off* the task using the progress checklist.** If you complete the tasks faster than the time set for the section, please raise your hand and let me know. We may move on faster.
Now please take out the rest of files from the folder. First review "medication history taking template", then answer "Medication history taking review questions". You will have 4 minutes.
Now please start.
(At 3.5 minutes distribute solutions)
Please check the solution, and check off the tasks in this section. You will have 1 minute.
(Distribute case 1, credential sheet at the end of 1 minute, start section 2)

Section 2:
In Section 2, we would like to know how you currently use an electronic health record aka EHR to take a medication list. You may have little or no prior experience with any EHRs, which is fine. Please try your best to work through the patient case.

We will use a Web based real electronic health record called Kareo. You will do three things:

1. (Use my computer to demo) Use the web browser to login the EHR, the login credential is in the credential sheet
2. Build a medication list using Kareo for the patient: you need to follow the template, and figure out what to input and how to input for this section
3. (Use my computer to demo) Start a new tab in the web browser, click on the survey monkey link for "Case 1", and answer the questions. The electronic signature code you will need is also in the credential sheet.

You will have 10 minutes. If you cannot complete the case, that is OK.

Please raise your hand if you have questions. Now please start.
(At the end of 9.5 minutes)
Now please stop doing the case in EHR, and start a new tab, and respond to survey questions for case 1, and check off tasks in this section. If you tried but did not finish the case, please still check it off. You will have 2 minutes.
(At the end of 2 minutes, distribute system use tutorial, and start section 3)

Section 3:
In Section 3, we will play a 15 minute tutorial video about how to use Kareo functions. Please watch the video, and follow the steps using your patient from "Case 1".
(At the section **"practice and review"** in the video, hand out the **solution to case 1)**
(At the **"Thanks for watching",** distribute **tutorial for EHR and medication history taking,** start section 4)

Section 4:
In Section 4, you will read a tutorial about EHR and medication history taking, and answer questions. After you are done, please raise your hand. You will have 10 minutes.
(At the end of 10 minutes, distribute the rest of solutions)
Please check the solution, and check off the tasks on the checklist. 2 minutes.
(Meanwhile, distribute case 2)

Section 5:
In Section 5, we would like you to complete another patient case using Kareo. You may refer to any training files. You will have ten minutes. Now please start.
(At the end of 10 minutes)
Now please stop doing the case in EHR, respond to survey questions for case 2, and check off tasks in this section. You will have 2 minutes.

Section 6:
In Section 6, we would like you to complete the patient case 2 using a different real EHR called DrChrono. Please start a new tab, click on the link. The login information is in credential sheet. Your will have 10 minutes, and if you cannot complete the case, that is OK. Please raise your hand if you have questions.

(At the end of 10 minutes)
Now please stop doing the case in EHR, and respond to survey questions for case 2, and check off tasks in this section. You will have 2 minutes.
(At the end of 2 minutes, distribute surveys, take the computer, and stop and copy the screen capture file)

Section 7:
After you check off all the tasks in the checklist, please raise your hand, and I will come to your seat and check you out.
Thank you for your participation. If you like it, please let your peers know! But like other studies, please no content details. Enjoy the rest of the day!
(Come to each participant, and check their checklist, and signed receipt, and give them gift card, and take the folder)

APPENDIX B

PROGRESS CHECKLIST

This study has several short sections and small tasks. Please complete each task, and ***check off*** the task using the checkbox beside the task once you complete it.

Section 1. Clinical Process Review (5 minutes)

- ☐ Review file "Medication history taking template"
- ☐ Answer the question in "Medication history taking review question"
- ☐ Check your answers with solution
- ☐ Keep "Medication history taking template" out, and put all other files into the folder

Section 2. Electronic Health Record Tryout (12 minutes)

- ☐ Open Kareo EHR login page using the web browser, and use information on "Credential Sheet" to login
- ☐ Review "Patient Case 1"
- ☐ Following "medication history taking template", take medication history and make updates in the patient profile
- ☐ Answer survey monkey question "Case 1" in the web browser

Section 3. Video Tutorial (15 minutes)

- ☐ Watch a tutorial video, and follow the steps using the patient from **"Patient Case 1"**
- ☐ Review the functions using "System Use Tutorial"
- ☐ Check solutions for patient case 1
- ☐ Put all files into the file folder

Section 4. Medication history and electronic health record tutorial (12 minutes)

- ☐ Review the tutorial material, and answer the questions
- ☐ Check with solutions

Section 5. Patient Case 2 (12 minutes)

- ☐ Review "Patient Case 2"
- ☐ Take medication history for the patient in the Kareo EHR, referring to any training materials you need

- [ ] Answer survey monkey question “Case 2”

Section 6. Patient Case 2 Session 2 (12 minutes)

- [ ] Open DrChrono EHR login page, and use information on “Credential Sheet” to login
- [ ] Review “Patient Case 2”
- [ ] Take medication history for the patient in the DrChrono EHR, referring to any training materials you need
- [ ] Answer survey monkey question “Case 2 S2”
- [ ] Put all files into the file folder, except this checklist

Section 7. Surveys

- [ ] Fill out the questionnaires, including the receipt form
- [ ] Raise your hand

Section 8. Payment
When you raise your hand, we will give you $30 Amazon gift card and check you out☺

APPENDIX C

CLINICAL REVIEW MATERIALS

Medication History Taking Template

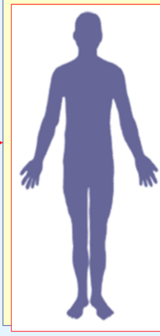
1.GET THE BASICS:
- **Demographics -** first/last name, date of birth
- **Allergies –** drugs/foods; nature of reaction
- **Diagnoses** - Reason for admit/visit; other diagnoses
- **Prescribers** – Primary and Specialists

2. BUILD THE LIST
Do you have your meds/list of meds with you?

Yes → 2A. LIST REVIEW; No → 2B. SYSTEM REVIEW

2A. LIST REVIEW
- Last updated?
- What other medications do you take?

2B. SYSTEM REVIEW
•Do you take any medicines for:



- **Neuro**: *Seizures? Headache?*
- **Psych**: *Sadness? Anxiety? Sleep?*
- **HEENT**: *Allergies? Eye meds?*
- **Pulm**: *Breathing? Inhalers?*
- **CV**: *Heart? Blood Pressure?*
- **Endo**: Diabetes? Thyroid?
- **GI**: *Stomach? or Bowels?*
- **GU**: *Contraceptives? Bladder? Treatments for erectile dysfunction?*
- **Skel/Musc**: *Bones? Joints?*
- **Infection**: *Antibiotics?*
- **Derm**: *Topicals?*
- **Analgesics**? *Pain or discomfort?*

3. WHAT'S MISSING?
- **Antibiotics**: treatments for HIV, TB? Other infections?
- **Cardiac Drugs**: antidysrhythmics, antihypertensives, cholesterol lowering?
- **Clots**: anything to prevent clots? warfarin(Coumadin®), enoxaparin (Lovanox®), aspirin, clopidogrel (Plavix®)?
- **Corticosteroids**: prednisone, hydrocortisone?
- **Diabetes Drugs**: insulin? oral agents?
- **Electrolytes**: potassium, calcium supplements?
- **Immunosuppressant Drugs**: to prevent organ rejection or treat MS, arthritis, psoriasis, Crohn's?
- **Less Than Daily**: drugs given irregularly (patches, injections at MD office)?
- **MAOI's**: monoamine oxidase inhibitors? (Nardil®, Parnate®, linezolid - Zyvox®)
- **Natural:** herbal/vitamins, over the counter?
- **Opioids**: morphine (MS Contin®), methadone, fentanyl (Duragesic®), oxycodone (Percocet®, Oxycontin®)?
- **Recreational Drugs**: any "street drugs", use drugs recreationally, smoking, alcohol?
- **Seizures**: drugs to prevent seizures?

4. PROBE FOR MORE
•For medications/conditions with incomplete information consider one or more of the following:
- **Who** ordered the medication?
- **What** dose?
- **When** did you **last** take it?
- **Where** do you get your medications?
- **Why** do you take it?
- Tell me about **missed** doses in the past week.
- What **problems** do you have with your medications?

5. FINAL CHECK
Is there anything else you would like to tell me about your medications that I have not asked?

6. ADDRESS ASAP:
- **Allergy Conflicts**
- **Antibiotics:** HIV, TB, other
- **Anticoagulants:** heparins, warfarin
- **Anticonvulsants:** phenytoin, carbamazepine.
- **Antidiabetics:** insulin, oral agents
- **Antidysrhythmics:** amiodarone, procainamide
- **Corticosteroids:** prednisone, dexamethasone
- **Duplicate Medications:**
  - orders for lisinopril and enalapril
  - total acetaminophen dose/24hrs
- **Immunosuppressant/Transplant Drugs:**
  - cyclosporin, mycophenalate
- **MAOI's:** Nardil®, Parnate®, Zyvox®
- **Opioids:** morphine, methadone, street drugs

Medication History Taking Review Question

Suppose you are now a nurse working at a hospital, and you are taking medication history for a patient. The patient brings a home medication list, and you have also received the patient's medication list from her/his pharmacy. Describe how you will utilize the template to get a complete medication history using available resources?

Write your answers here:

Medication History Taking Review Reference Solution

Suppose you are now a nurse working at a hospital, and you are taking medication history for a patient. The patient brings a home medication list, and you have also received the patient's medication list from her/his pharmacy. Describe how you will utilize the template to get a complete medication history using available resources?

At step 2, first consolidate multiple sources of medication list into one list.
(*Note:* this ensures all information from home list and pharmacy records is in your drafted list)

Then follow step 2A to 6 to review the consolidated list, and reconcile any discrepancies.
(*Note:* those steps help you identify other potential discrepancies, such as potentially missing medications, and/or wrong medications, and you can take actions accordingly)

APPENDIX D

PATIENT CASE 1 MATERIAL (PRE-TRAINING)

Admission chart:

Name: Ellen Pepper DOB: 12/20/1950 Reason for visit: sudden onset of upper GI bleeding last night with nausea. Vomited bright red blood 4 times, and has begun to feel weak and dizzy.	Age: 65

Home medication list (last update: Sept 9, 2013):

Tylenol 650 mg PO every 4-6 hours as needed for mild pain Conjugated Estrogen 0.625mg PO per day for 3 weeks, then one week “off” without meds Methotrexate 25 mg once a week

Pharmacy list:

Prednisone 20 mg PO every day Etanercept (Enbrel) 25 mg SC twice a week Tylenol 650 mg PO every 4-6 hours as needed for mild pain

Case 1 Trainer Reference Page

This is second page of Case 1, for system set up purpose only, and will not be distributed to trainees

EHR Med List (for EHR entry reference only)
Etanercept (Enbrel) 25 mg SC twice a week

Tylenol 500 mg PO every 4-6 hours as needed for mild pain

Methotrexate 25 mg once a week

Prednisone 20 mg PO every day

History:
rheumatoid arthritis (custom item)
total left knee replacement
total hysterectomy

Problem:
Upper GI bleeding (with nausea and vomiting)
Stomach pain

Students are supposed to enter this medication:
Conjugated Estrogen 0.625mg PO per day for 3 weeks, then one week "off" without meds

Complete story:
Mrs. Ellen Pepper is a 65 year old woman with a history of rheumatoid arthritis, total left knee replacement, and total hysterectomy. She is being admitted to the hospital for sudden onset of upper GI bleeding. She has had stomach pain on and off for the last two days, and woke up suddenly last night with nausea. She went into the bathroom, and began to vomit bright red blood. She has vomited 4 times, and has begun to feel weak and dizzy.

Not on any of the patient list (Note: this is the list of omitted meds, do not need to enter into EHR during system set up, only for training question reference only)

Glucosamine with Chondroitin and MSM- PO 4 capsules per day **(Trainee will enter this med as part of video tutorial practice)**

Electronic Health Record System Login Credentials

Please keep it at a convenient place.

Email Address (for Kareo):

UserName (for DrChrono):

Password (for Both):

Electronic Signature Code (for Survey Monkeys):

APPENDIX E

SURVEY MONKEY QUESTIONS

*** 1. Is the medication history you have taken and updated *now complete in the system*?**

- Yes
- No (please list ALL disprepancies in the textbox below)

2. If you think the medication history is not complete, what will you do?

*** 3. Please sign with your electronic signature code below:**

Done

APPENDIX F

KAREO SYSTEM USE TUTORIAL- HAND OUT

In this tutorial, we will demonstrate step-by-step how to use Kareo EHR system functions. You can refer to this file when you use the system. We will cover six functions: *Login, Patients (find a patient), Face Sheet, History, Problems,* and *Medications*.

There are two basic ways to use an EHR. You can **search/retrieve** information from an EHR, or **enter** information into an EHR. You may do both when you use EHR functions depending on your clinical needs.

Function 1: Login

- Open the website of the EHR login page
- Enter credentials
- Click "OK"

Function 2: Patients (Find a patient)

You can find a specific patient by searching the name:

- Click the search box input field
- Enter the patient name
- Click on the intended patient

Alternatively, you can also:

- Click on "Menu"
- Click on "Patients"
- Scroll down the list of patients
- Click on the name of the patient

Please note, you need to verify the patient identities to ensure the identifiers match correctly.

Function 3: Face Sheet

The function of Face Sheet is displayed after you select a patient. Or you can find it:

- Click on "Face Sheet" on the left-hand side column

The function Face Sheet is comparable to the cover page of patient charts if the patient charts are printed on paper. In Face Sheet, you can get an overview of the patient information, such as demographics, allergy, active problems, and medications.

It is best practice to use Face Sheet to verify patient identity, and obtain basic information. However, in order to work on complex clinical processes, such as taking medication history and/or check detailed problems and history, you need to **use dedicated functions**; you cannot rely on the Face Sheet function, as some histories/ problems/ medications may not be displayed or may not provide details. In addition, you may need to enter information using those dedicated functions.

Function 4: History
You can check detailed patient history by:

- Click on "History"
- In the new page, click on subcategories for details or add new history, such as "Past Medical History"

Function 5: Problems
You can check detailed patient problems by:

- Click on "Problem"
- In the new page, click on "Active" or "Inactive" tab to see detailed problem list

Function 6: Medications
You can check detailed patient medications by:

- Click on "Medications"
- In the new page, click on "Active" or "Discontinued" tab to see detailed medication list

You can add a new medication by:

- Click on the "+Med List" icon
- Search the drug name by typing in "Drug", and selecting the medication
- Add additional information for the medication by clicking on "Add more details…"
- Click on "Save"

After you add a medication to the list, you cannot delete it. However, you can mark a medication as error or discontinued by:

- Check the box before the medication
- Pick either "Mark as Error" or "Discontinue", and confirm following system prompt

Important:
After you finish taking the medication history, you need to check the box beside "Medication reconciliation performed".

APPENDIX G

SAMPLE SCREENSHOTS OF VIDEO TUTORIAL FOR SYSTEM USE

The video can be found at the following link:
https://youtu.be/zaaaLgM6wzc

Kareo Electronic Health Record (EHR) System Use Tutorial

Ze He

Tutorial Outline

- Total duration of the tutorial is 15 minutes, including practice time
- We will cover six functions: *Login, Patients, Face Sheet, History, Problems,* and *Medications*
- Video tutorial has three short sections; each section demonstrates how to use two different functions
- After the demo in each section, you will have 1-3 minutes to practice. Please use your patient from Case 1 for practice
- When the video resumes demo, please stop practice and return your attention to the big screen
- No need to take notes; all information is in the handout

Two Basic Ways to Use EHR Functions

- Search/retrieve information
  - Obtain information ***from*** the system, e.g., finding a patient
- Enter/document information
  - Record information ***into*** the system, e.g., documenting a new medication into the system

Function 1: Login

Function 2: Patients (Find a patient)

Practice: Login & Patients (1 minute)
Find your patient in Case 1 in two ways

Function 3: Face Sheet

Function 4: History

Practice: Face Sheet & History (2 minutes)
Click on each section to check details

Function 5: Problems

Function 6: Medications

Practice: Problems & Medications (3 minutes)
- Review Problems function
- Add a new medication for the patient:
Glucosamine Chondroitin MSM Complex PO 4 Pills Daily

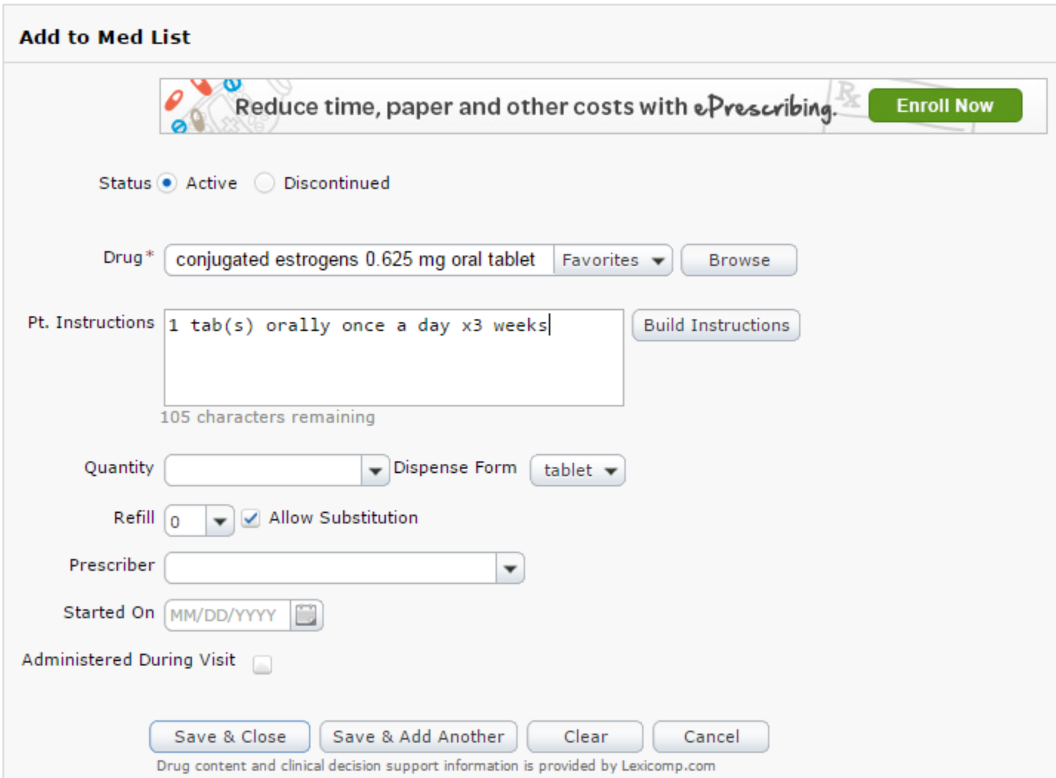
Practice: Review all functions /
Check Case 1 Solution/ Check off tasks
(2 minutes)

Thank you!

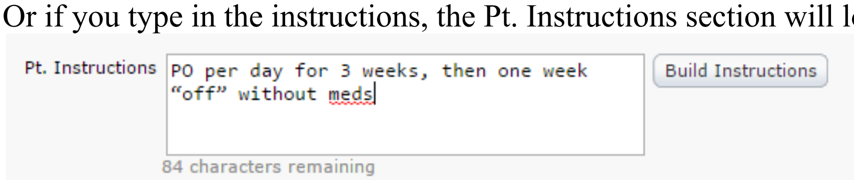
APPENDIX H

CASE 1 REFERENCE SOLUTION

If you use "Build Instructions", the entry should look like:



Or if you type in the instructions, the Pt. Instructions section will look like:



Survey Monkey Reference Solution

- The medication list may be not complete.
    - The last update was two years ago, so it may be outdated (Step 2A).
- Check the list following step 2B - 6, and/or gather more information from the patient, family members or pharmacy/ primary care doctor.

APPENDIX I

MEDICATION HISTORY AND ELECTRONIC HEALTH RECORDS TUTORIAL FOR TREATMENT GROUP USING COGNITIVE MAPPING TECHNIQUE

Medication History and Electronic Health Records Tutorial

Medication history is important to ensure proper care of patients. But many medication lists are not accurate, and common discrepancies include:

– **Outdated list**: Not updated to reflect recent changes
– **Omission**: Missing medication for a problem on record

The *Medication History Taking Template* (Henneman et al, 2014) is a systematic process to build a complete list, and some steps can address these types of discrepancies. For example, by doing step 2B, you may have a mapping table as follows:

Problems/History	Medications (Active)
Rheumatoid arthritis	Methotrexate, Enbrel
Left knee replacement	Prednisone
Stomach pain	
Hysterectomy	

Because some problems have no medication, it suggests potential omission. However, you need to conduct step 6 to gather more information, as not all problems are treated by medications.

We will now learn how to integrate the EHR functions into this nursing care process.

.

Task 1: Flowchart Mapping

We will adapt *Medication History Taking Template* to create a flowchart of building a medication list using an EHR.

On the next page, fill in the blank [   ]s in the *Medication History Taking Using EHRs* diagram with appropriate EHR function names:

- Login
- Patients
- Medications
- Problems
- Face Sheet
- History

Some blank [   ]s are filled in to give you examples of how to complete this task.

Medication History Taking Using EHR Functions Flowchart

EHR functions are indicated using [ ]. For clinical details, such as drug category or body system, refer to the same number section in "Medication History Taking Template"

0A.[**Login**] → 0B.[**Patients**]

1.GET THE BASICS
[**Face Sheet**]: demographics and allergies

2A.BUILD THE LIST & LIST REVIEW
Check medications in home list/ pharmacy records, and last update
[ ]: Document any medications not in EHR into the EHR

2B. SYSTEM REVIEW
Check one body system at a time, and repeat the comparison:

-[ ]: Check a system, e.g., Neuro: any problems in this system?

-[ ]: Any medications to treat that system/ problem?

3. WHAT'S MISSING?
Repeat:
-[ ]: Check medications by category

-[ ]: Any problems treated by that medication?

4. PROBE FOR MORE & 5. FINAL CHECK

6. ADDRESS ASAP
Update medication information in [**Medications**], and take other actions

Medication History Taking Template

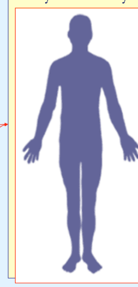
1.GET THE BASICS:
- **Demographics -** first/last name, date of birth
- **Allergies –** drugs/foods; nature of reaction
- **Diagnoses** - Reason for admit/visit; other diagnoses
- **Prescribers** – Primary and Specialists

2. BUILD THE LIST
Do you have your meds/list of meds with you?

Yes → **2A. LIST REVIEW**
- Last updated?
- What other medications do you take?

No → **2B. SYSTEM REVIEW**

2B. SYSTEM REVIEW
•Do you take any medicines for:



- **Neuro**: *Seizures? Headache?*
- **Psych**: *Sadness? Anxiety? Sleep?*
- **HEENT**: *Allergies? Eye meds?*
- **Pulm**: *Breathing? Inhalers?*
- **CV**: *Heart? Blood Pressure?*
- **Endo**: Diabetes? Thyroid?
- **GI**: *Stomach? or Bowels?*
- **GU**: *Contraceptives? Bladder? Treatments for erectile dysfunction?*
- **Skel/Musc**: *Bones? Joints?*
- **Infection**: *Antibiotics?*
- **Derm**: *Topicals?*
- **Analgesics**? *Pain or discomfort?*

3. WHAT'S MISSING?
- **Antibiotics**: treatments for HIV, TB? Other infections?
- **Cardiac Drugs**: antidysrhythmics, antihypertensives, cholesterol lowering?
- **Clots**: anything to prevent clots? warfarin(Coumadin®), enoxaparin (Lovanox®), aspirin, clopidogrel (Plavix®)?
- **Corticosteroids**: prednisone, hydrocortisone?
- **Diabetes Drugs**: insulin? oral agents?
- **Electrolytes**: potassium, calcium supplements?
- **Immunosuppressant Drugs**: to prevent organ rejection or treat MS, arthritis, psoriasis, Crohn's?
- **Less Than Daily**: drugs given irregularly (patches, injections at MD office)?
- **MAOI's**: monoamine oxidase inhibitors? (Nardil®, Parnate®, linezolid - Zyvox®)
- **Natural**: herbal/vitamins, over the counter?
- **Opioids**: morphine (MS Contin®), methadone, fentanyl (Duragesic®), oxycodone (Percocet®, Oxycontin®)?
- **Recreational Drugs**: any "street drugs", use drugs recreationally, smoking, alcohol?
- **Seizures**: drugs to prevent seizures?

4. PROBE FOR MORE
•For medications/conditions with incomplete information consider one or more of the following:
- **Who** ordered the medication?
- **What** dose?
- **When** did you **last** take it?
- **Where** do you get your medications?
- **Why** do you take it?
- Tell me about **missed** doses in the past week.
- What **problems** do you have with your medications?

5. FINAL CHECK
Is there anything else you would like to tell me about your medications that I have not asked?

6. ADDRESS ASAP:
- **Allergy Conflicts**
- **Antibiotics:** HIV, TB, other
- **Anticoagulants:** heparins, warfarin
- **Anticonvulsants:** phenytoin, carbamazepine.
- **Antidiabetics:** insulin, oral agents
- **Antidysrhythmics:** amiodarone, procainamide
- **Corticosteroids:** prednisone, dexamethasone
- **Duplicate Medications:**
  - orders for lisinopril and enalapril
  - total acetaminophen dose/24hrs
- **Immunosuppressant/Transplant Drugs:**
  - cyclosporin, mycophenalate
- **MAOI's:** Nardil®, Parnate®, Zyvox®
- **Opioids:** morphine, methadone, street drugs

Task 2: Using the flowchart mapping

2.1 Do step 2A for patient case 1, *BUILD THE LIST AND LIST REVIEW*, and find out: when was the home list last updated?

Write your answers here:

2.2. Do step 2B *SYSTEM REVIEW*: fill out the table below. The first four rows are filled as examples. Suppose the remaining problems currently in the system include stomach pain, hysterectomy and diabetes; and remaining medications include Tylenol, Conjugated estrogen.

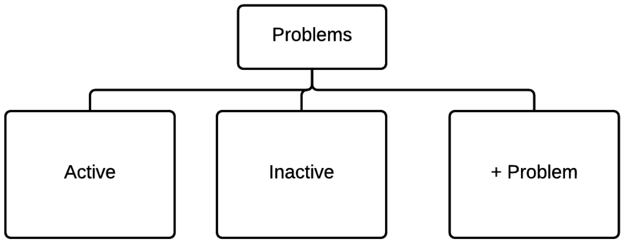
Problems/History	Medications
GI bleeding	
Rheumatoid arthritis	Methotrexate, Enbrel
	Glucosamine Chondroitin MSM
Left knee replacement	Prednisone

2.3. Based on the above table, are there any potential discrepancies? If yes, what are they?

Write your answers here:

Task 3: Electronic Health Record System Structure

Although the functions you just learned are provided by *every* certified EHR system, each system may differ in its structure: how it *organizes* these functions into a ***hierarchy***. The figure below shows an example *hierarchy* for "Problems" in Kareo.



Typically, you complete a task using EHR functions starting at the top of the hierarchy and moving downward. For example, to look up active problems for a patient, you need to: 1) access "Problems", 2) select "Active". To document a new problem, you need to: 1) access "Problems", 2) access the "+ Problem" function.

Please follow the example, and organize the six Kareo functions below into a hierarchy, looking at the system as needed. Once you create the hierarchy, note how you would work through the hierarchy to arrive at each function. Each function should be used once.

Active

Medications

Add more details… (quantities, dispense form,

Drug

Discontinue

+ Med List

Medication History Taking Using EHR Functions Flowchart

EHR functions are indicated using [ ]. For clinical details, such as drug category or body system, refer to the same number section in "Medication History Taking Template"

0A.[**Login**] → 0B.[**Patients**]

1.GET THE BASICS
[**Face Sheet**]: demographics and allergies

2A.BUILD THE LIST & LIST REVIEW
Check medications in home list/ pharmacy records, and last update [**Medications**]: Document any medications not in EHR into the EHR

2B. SYSTEM REVIEW
Check one body system at a time, and repeat the comparison:

-[**Problems/History**]: Check a system, e.g., Neuro: any problems in this system?

-[**Medications**]: Any medications to treat that system/ problem?

3. WHAT'S MISSING?
Repeat:
-[**Medications**]: Check medications by category

-[**Problems/History**]: Any problems treated by that medication?

4. PROBE FOR MORE & 5. FINAL CHECK

6. ADDRESS ASAP
Update medication information in **[Medications]**, and take other actions

Medication History Taking Template

1.GET THE BASICS:
- **Demographics -** first/last name, date of birth
- **Allergies –** drugs/foods; nature of reaction
- **Diagnoses** - Reason for admit/visit; other diagnoses
- **Prescribers –** Primary and Specialists

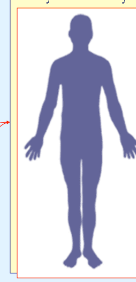
2. BUILD THE LIST
Do you have your meds/list of meds with you?

Yes

2A. LIST REVIEW
- Last updated?
- What other medications do you take?

No

2B. SYSTEM REVIEW
•Do you take any medicines for:



- **Neuro**: *Seizures? Headache?*
- **Psych**: *Sadness? Anxiety? Sleep?*
- **HEENT**: *Allergies? Eye meds?*
- **Pulm**: *Breathing? Inhalers?*
- **CV**: *Heart? Blood Pressure?*
- **Endo**: Diabetes? Thyroid?
- **GI**: *Stomach? or Bowels?*
- **GU**: *Contraceptives? Bladder? Treatments for erectile dysfunction?*
- **Skel/Musc**: *Bones? Joints?*
- **Infection**: *Antibiotics?*
- **Derm**: *Topicals?*
- **Analgesics**? *Pain or discomfort?*

3. WHAT'S MISSING?
- **Antibiotics**: treatments for HIV, TB? Other infections?
- **Cardiac Drugs**: antidysrhythmics, antihypertensives, cholesterol lowering?
- **Clots**: anything to prevent clots? warfarin(Coumadin®), enoxaparin (Lovanox®), aspirin, clopidogrel (Plavix®)?
- **Corticosteroids**: prednisone, hydrocortisone?
- **Diabetes Drugs**: insulin? oral agents?
- **Electrolytes**: potassium, calcium supplements?
- **Immunosuppressant Drugs**: to prevent organ rejection or treat MS, arthritis, psoriasis, Crohn's?
- **Less Than Daily**: drugs given irregularly (patches, injections at MD office)?
- **MAOI's**: monoamine oxidase inhibitors? (Nardil®, Parnate®, linezolid - Zyvox®)
- **Natural**: herbal/vitamins, over the counter?
- **Opioids**: morphine (MS Contin®), methadone, fentanyl (Duragesic®), oxycodone (Percocet®, Oxycontin®)?
- **Recreational Drugs**: any "street drugs", use drugs recreationally, smoking, alcohol?
- **Seizures**: drugs to prevent seizures?

4. PROBE FOR MORE
•For medications/conditions with incomplete information consider one or more of the following:
- **Who** ordered the medication?
- **What** dose?
- **When** did you **last** take it?
- **Where** do you get your medications?
- **Why** do you take it?
- Tell me about **missed** doses in the past week.
- What **problems** do you have with your medications?

5. FINAL CHECK
Is there anything else you would like to tell me about your medications that I have not asked?

6. ADDRESS ASAP:
- **Allergy Conflicts**
- **Antibiotics:** HIV, TB, other
- **Anticoagulants:** heparins, warfarin
- **Anticonvulsants:** phenytoin, carbamazepine.
- **Antidiabetics:** insulin, oral agents
- **Antidysrhythmics:** amiodarone, procainamide
- **Corticosteroids:** prednisone, dexamethasone
- **Duplicate Medications:**
  - orders for lisinopril and enalapril
  - total acetaminophen dose/24hrs
- **Immunosuppressant/Transplant Drugs:**
  - cyclosporin, mycophenalate
- **MAOI's:** Nardil®, Parnate®, Zyvox®
- **Opioids:** morphine, methadone, street drugs

2.1 Do step 2A, *BUILD THE LIST AND LIST REVIEW*, and find last update date

Answer: It was updated two years ago, and may be outdated.

2.2 Do step 2B, *SYSTEM REVIEW*, and fill out the table.

Answer:

Problems/History	**Medications**
GI bleeding	
Rheumatoid arthritis	Methotrexate, Enbrel
	Glucosamine Chondroitin MSM
Left knee replacement	Prednisone
Stomach pain	Tylenol
Hysterectomy	Conjugated estrogen
Diabetes	

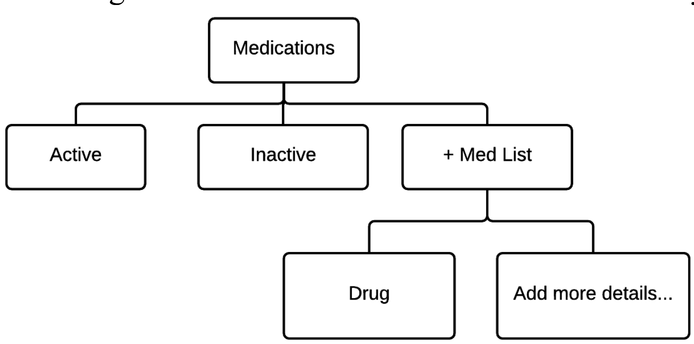
2.3 Are there any potential discrepancies?

Answer:
Yes! **Any incomplete row suggests potential discrepancies.**

- GI bleeding and Diabetes have no medications recorded
- Glucosamine Chondroitin MSM has no corresponding problems/history.

Note: Some medications, such as Glucosamine, are taken for wellness; if a problem is the reason for visit, it is common no medication has been prescribed for that problem. Therefore Step 6 is needed for further investigation.

Task: Organize the six Kareo functions into a hierarchy.



Note: If two functions can be first retrieved on the same page, then they are at the same level of the hierarchy; you *can* access them in any order (e.g., drug and add more details).

APPENDIX J

SAMPLE SCREENSHOTS OF VIDEO TUTORIAL FOR TREATMENT GROUP

The video for this tutorial can be found at the following link:
https://youtu.be/SPbxw2VThk8

Medication History and Electronic Health Record Tutorial

- Ze He

Medication History - Why

- Medication histories is important
  - Clinicians rely on accurate medication lists to prescribe and infer disease state information
  - Inaccuracies might result in improper care of patients.

Medication Discrepancy

- Common types of discrepancy in a list:
  - **Outdated list**: Not updated to reflect recent changes
  - **Omission**: Missing medication for a problem on record

- After consolidating all sources of medication lists in EHR, is it complete now?

Is it complete?

- If after documenting all sources of medication lists, we have the following medication list:
  - Methotrexate
  - Enbrel
  - Prednisone
- And we have the following problem list for this patient
  - Rheumatoid arthritis
  - Left knee replacement
  - Hysterectomy
  - Stomach pain
- No!
  - Some problems, such as Stomach pain, have no medications
  - Potential omissions

How to Build a Good List

- A systematic step-by-step review process (Henneman et al, 2014). For example:
  - 2. Build the list: Consolidate all sources
  - 2A: Check last update
  - 2B: Check omission

How to Build a Good List with EHR

- For step 2B, repeat the following using EHR:
  - First check a problem in Problems/History function, and
  - Find the relevant active medication(s) in Medications function, and map to the problem
- When every problem and medication is checked, see if anything is missing

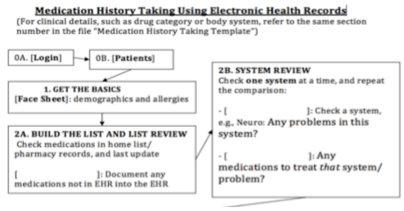
Example

Problem/ History	Medications
Rheumatoid arthritis	Methotrexate, Enbrel
Left knee replacement	Prednisone
Stomach pain	
Hysterectomy	

- *Note:* Not all problems are treated using medications, you may need to gather more information at Step 6.

Exercise 1

- Fill in blank [ ] with function names, e.g., Medications, to complete the diagram of how to use EHR functions for medication history taking process



Exercise 2

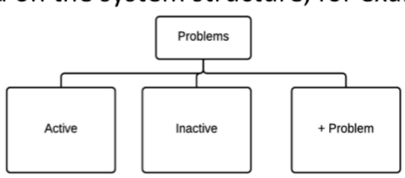
- Practice some steps of this process with a patient case, similar to the example in the demo

Example

Problem/ History	Medications
Rheumatoid arthritis	Methotrexate, Enbrel
Left knee replacement	Prednisone
Stomach pain	
Hysterectomy	

Exercise 3

- Organize several functions into hierarchies based on the system structure, for example:



Thank you for watching!

You will now have 8 minutes to do the exercise

APPENDIX K

MEDICATION HISTORY AND ELECTRONIC HEALTH RECORDS TUTORIAL FOR CONTROL GROUP

Medication History and Electronic Health Records

Background

One of the national patient safety goals in 2005 by Joint Commission is to accurately and completely reconcile patient's medications "across the continuum of care". Unfortunately, discrepancies between preadmission medications and those ordered at admission have been estimated to occur in about 60% of admitted patients by some studies. Clinicians rely on the medication histories recorded in patient's hospital admission notes for prescribing and inferring disease state information, and inaccuracies in the admission note might subsequently result in improper care of patients.

Medication history and sources

A medication history is a list of a patient's medication and dosage information. A good medication history should encompass all currently and recently prescribed drugs, previous adverse drug reactions including hypersensitivity reactions, any over-the counter medications, and adherence to therapy.

The potential sources for obtaining medication history include the following:

- Medication bag, or "brown bag", in which contains bottles and containers of medications a patient used to take or is currently taking.
- Home medication list, provided by a patient or his/her family members.
- The primary care provider, and/or the patient's pharmacist
- A patient's health record, including community pharmacy record, electronic health record, etc

Electronic Health Records

Electronic health records provide several potential benefits to improve the accuracy of medication history collection. First, healthcare facilities can incorporate clinically validated procedures or methods into the system, so that the information becomes part of standardized workflow embedded in the system. For example, at a 14-bed surgical ICU in the Johns Hopkins University Medical Center, researchers first implemented a medication reconciliation process, validated its effectiveness in eliminating medication errors, and then embedded this medication reconciliation intervention into EHR.

Second, electronic health record can provide information redundancy at a very low cost but in a very convenient manner. If a patient's medical profiles from various sources are in electronic records, health professionals can easily access, aggregate and cross check the information, and have a better starting point for medication history taking.

Third, more and more artificial intelligence (AI) technologies allow automatic clinical data collection and validation, automate processes or provide supports when healthcare workers need them, and relieve cognitive load and pressures for healthcare workers. Such systems include reminder systems, automatic omission detection systems, and alert system. In a recent effort, for example, researchers utilized accurate previous patient records to train a computer system to automatically identify missing drugs in current patients' medication history. Results showed the methods identified missing drug in the top-10 frequently missed drug list about 40-50% of the time and the therapeutic class of the missing drug 50%-65% of the time at three clinics.

Questions:

a. Why do we need an accurate medication history?

b. If possible, what additional information or sources you would request for the medication history taking process for the previous patient you just saw?

c. What are potential advantages of collecting from different sources of medication history?

d. What are potential advantages of using EHRs for taking medication history?

e. In the medication history taking process diagram, why can those tasks potentially improve medication history accuracy in addition to multiple information sources?

Medication History and Electronic Health Records Reference Solutions

a. Why do we need an accurate medication history?

(Open end) It is a patient safety issue; clinicians rely on that history to take care of patients, and inaccurate information may result in improper care.

b. If possible, what additional information or sources you would request for the medication history taking process for the previous patient you just saw?

(Open end) primary care provider, medication containers, etc

c. What are potential advantages of collecting from different sources of medication history?

Multiple sources may include different medication history information; by including more information the final list will be more complete.

d. What are potential advantages of using EHRs for taking medication history?

EHR may help incorporate the tasks into the process by built-in functions; it may also facilitate collecting from multiple sources, and it can also help validate the information.

e. In the *Medication History Taking Template* diagram, why can those tasks potentially improve medication history accuracy in addition to multiple information sources?

Multiple sources increase the amount of information available from different people (e.g., family members, other clinicians) and using different tools (e.g., electronic records, medication bottles), while those tasks provide systematic methods from different perspectives to cross validate that information in terms of accuracy and completeness.

APPENDIX L

PATIENT CASE 2 MATERIAL (POST-TRAINING)

Case 2

Admission chart:

Name: Sheryl Finn DOB: 8/29/1951 Reason for visit: shortness of breath and fever/ chills	Age: 65

Home medication list:

Aspirin 1 tablet (81 mg) daily Dilantin 100 mg PO three times/day Echinacea oral tablet 2 grams of dried root in 9 ml PO of juice prn “cold symptoms”

Pharmacy list:

Dilantin 100 mg PO three times/day Effexor XR 150 mg PO daily Aspirin 1 tablet (81 mg) daily Echinacea oral tablet 2 grams of dried root in 9 ml PO of juice prn “cold symptoms”

Case 2 Trainer Reference Page

This is second page of Case 2, for system set up purpose only, and will not be distributed to trainees

EHR Med List (for EHR entry reference only)
Effexor 150 mg PO daily

Aspirin 1 tablet (81 mg) daily

Omeprazole 20 mg daily

History:
Asthma, depression, anxiety, seizures, diabetes, GERD, angina, arthritis

Problem:
Asthma, depression, anxiety, seizures, diabetes, GERD, angina, arthritis, shortness of breath and fever/ chills

Students are supposed to enter this medication:

Dilantin 100 mg PO three times/day

Echinacea oral tablet 2 grams of dried root in 9 ml PO of juice prn "cold symptoms"

Complete story:

Ms. Sheryl Finn is a 65 year old woman who presents to the ED with shortness of breath and fever/ chills times 2 days. Her past medical history includes asthma depression, anxiety, seizures, diabetes, GERD, angina and arthritis. She has no allergies to any medicines, foods, environmental factors or latex products.

Not on any of the patient list (Note: this is the list of omitted meds, do not need to enter into EHR during system set up, only for training question reference only)

Glyburide 5 mg 2 times per day, diabetes

Albuterol inhaler, 2 puffs INH prn difficulty breathing, wheezing

Pulmicort inhaler, 2 puffs INH two times/daily

Lorazepam 1 mg PO up to two times/day prn anxiety

APPENDIX M

USABILITY SURVEYS

Please complete this survey regarding ***Kareo EHR***, i.e., "this system" in the survey.

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

Please complete this survey regarding ***DrChrono***, i.e., “this system” in the survey.

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

APPENDIX N

DEMOGRAPHICS

What program (year) are you currently in? (Pick one below)

A. Traditional, senior
B. Traditional, junior
C. Second Bachelor's

How long have you used computers? (Pick one below)

A. Less than half a year
B. 6 months to 2 years
C. More than 2 years

How often do you use computers on average in the past year (pick the most applicable)?

A. Several times per day
B. Once per day
C. Several times per week
D. Several times per month

Have you ever used ANY electronic health record system as a student nurse before the study? (Pick one below)

A. No   B. Yes

- If yes, how many hours have you worked with any EHR in total? (Pick one below)

A. Less than 1 hour
B. 1–5 hours
C. 6– 19 hours
D. 20- 40 hours
E. More than 40 hours

Please list names of all EHRs you used, and specify the number of hours for each EHR

EHR name	Hours

APPENDIX O

INFORMATICS COMPETENCY SELF RATING QUESTIONNAIRE

For each statement, indicate your current level of competency on the scale of 1 to 5, where:
1 = Not competent, 2 = Somewhat competent, 3 = Competent, 4 = Proficient, and 5 = Expert.

	Not competent	Somewhat	Competent	Proficient	Expert
1. As a clinician (nurse), participate in the selection process, design, implementation and evaluation of systems	1	2	3	4	5
2. Market self, system, or application to others	1	2	3	4	5
3. Promote the integrity of and access to information to include but not limited to confidentiality, legal, ethical, and security issues	1	2	3	4	5
4. Seek available resources to help formulate ethical decisions in computing	1	2	3	4	5
5. Act as advocate of leaders for incorporating innovations and informatics concepts into their area of specialty	1	2	3	4	5
6. Use different options for connecting to the internet (phone line, mobile phone, cable, wireless, satellite) to communicate with other systems (e.g., access data, upload, download)	1	2	3	4	5
7. Use the Internet to locate (e-learning, teleworking), download items of interest	1	2	3	4	5
8. Use database management program to develop a simple database and/or table	1	2	3	4	5
9. Use database applications to enter and retrieve information	1	2	3	4	5
10. Conduct on-line literature searches	1	2	3	4	5
11. Use presentation graphics (e.g., PowerPoint) to create slides, displays	1	2	3	4	5
12. Use multimedia presentations	1	2	3	4	5
13. Use word processing	1	2	3	4	5
14. Use networks to navigate systems (e.g., LAM, WLAN, WAN)	1	2	3	4	5
15. Use operating systems (e.g., copy, delete, change directories)	1	2	3	4	5
16. Use existing external storage devices (e.g., network drive, CD, DVD, USB flash drive, memory card, online file storage)	1	2	3	4	5
17. Use computer technology safely	1	2	3	4	5
18. Navigate Windows (e.g., manipulate files using file manager, determine active printer, access installed applications, create and delete directories)	1	2	3	4	5
19. Identify the basic components of the computer system (e.g., features of a PC, workstation)	1	2	3	4	5
20. Perform basic trouble-shooting in applications	1	2	3	4	5
21. Use applications for diagnostic coding	1	2	3	4	5
22. Use applications to develop testing materials (e.g., e-learning)	1	2	3	4	5

23. Access shared data sets (e.g., Clinical Log Database, Minimum Data Set)	1	2	3	4	5
24. Extract data from clinical data sets (e.g., Clinical Log Database, Minimum Data Set)	1	2	3	4	5
25. Recognize that health computing will become more common	1	2	3	4	5
26. Recognize that the computer is only a tool to provide better nursing care and that there are human functions that cannot be performed by computer	1	2	3	4	5
27. Recognize that one does not have to be a computer programmer to make effective use of the computer in nursing	1	2	3	4	5
28. Recognize the value of clinician involvement in the design, selection, implementation, and evaluation of applications, systems in healthcare	1	2	3	4	5
29. Use wireless device (PDA or cellular telephone) to locate and download resources for patient safety and quality care	1	2	3	4	5
30. Use wireless device (PDA or cellular telephone) to enter data	1	2	3	4	5
31. Understand the Really Simple Syndication (RSS) feed term and the purpose of subscribing it.	1	2	3	4	5
32. Understand the term podcast and the purpose of subscribing it.	1	2	3	4	5

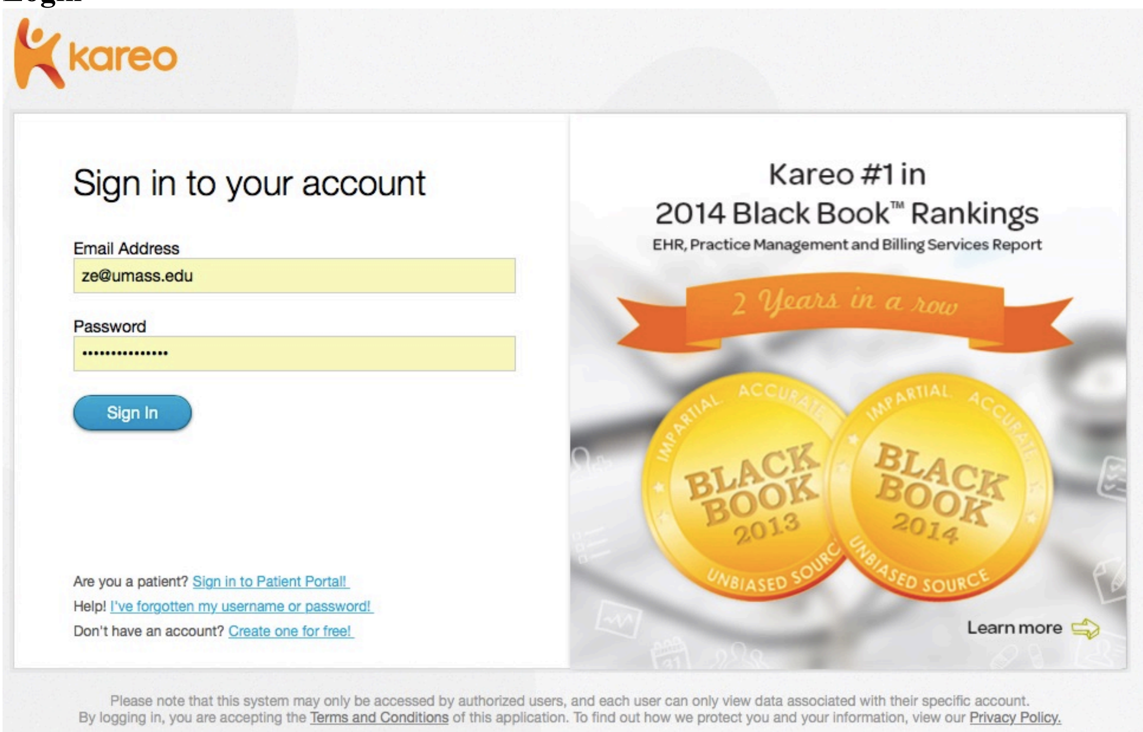
Adapted from (Choi & Bakken, 2013)

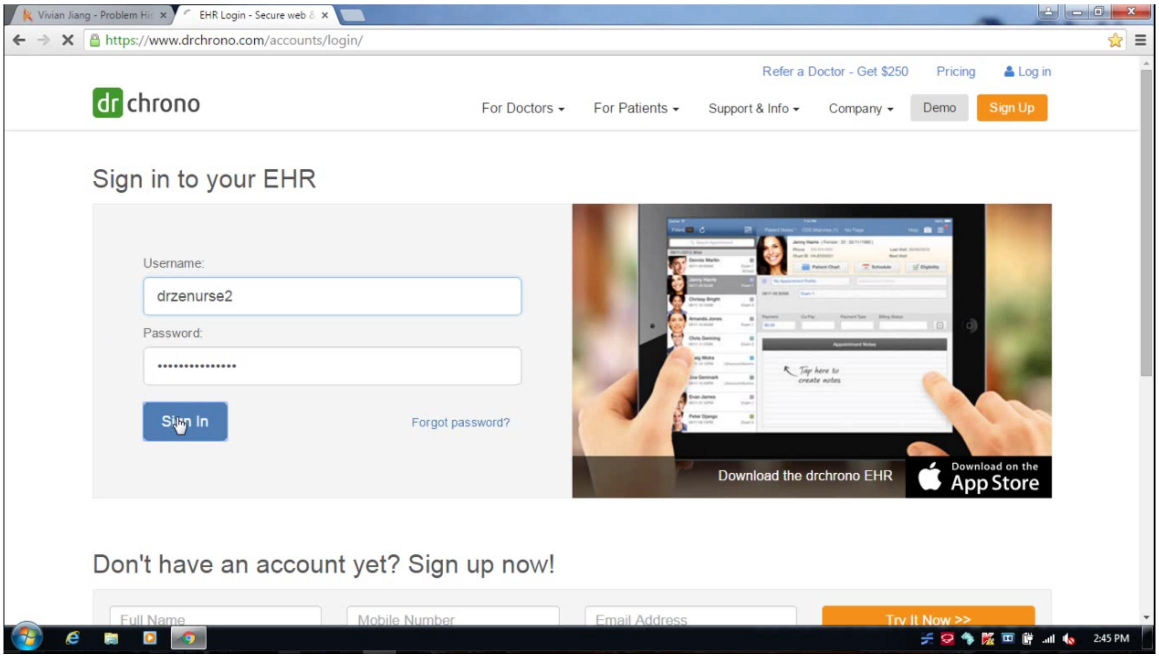
APPENDIX P

SAMPLE SCREENSHOTS OF EHRS

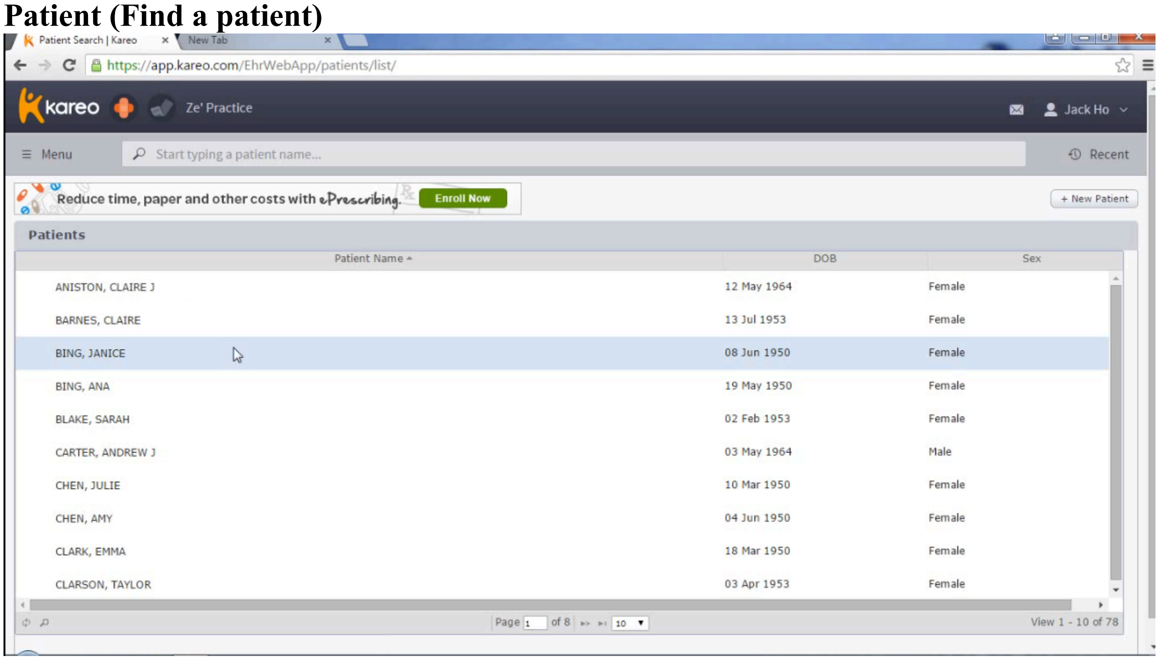
I present two EHRs side by side ordered by functions.
The link:
Kareo (used for training): http://www.kareo.com
DrChrono (used for transfer tasks): https://www.drchrono.com

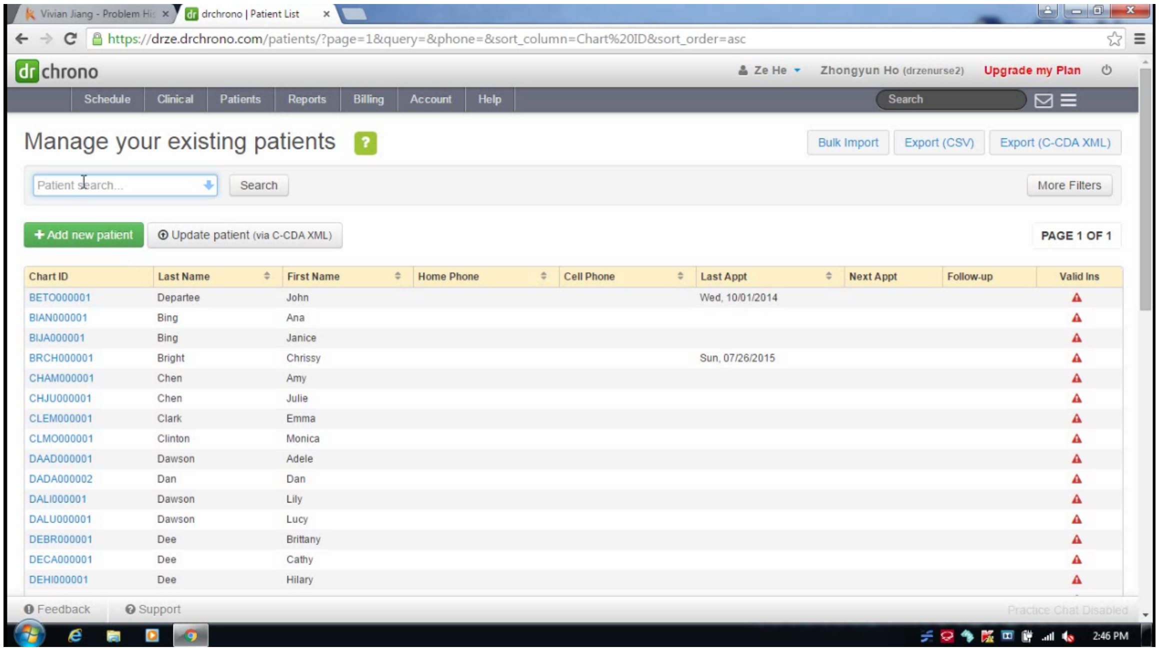
Login



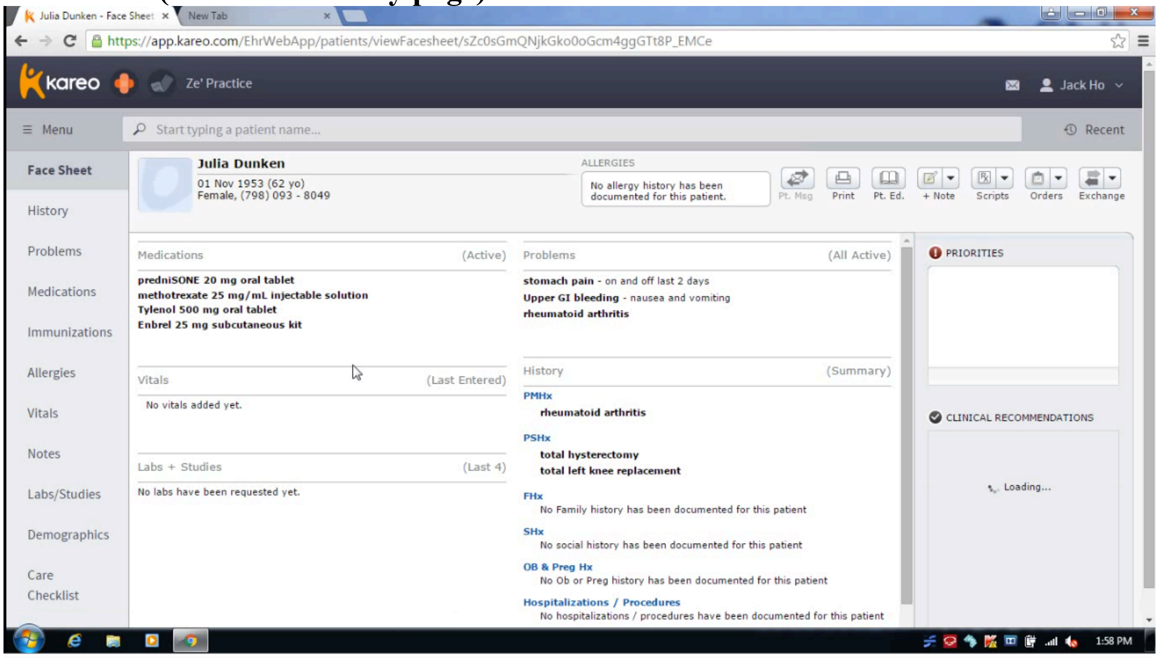


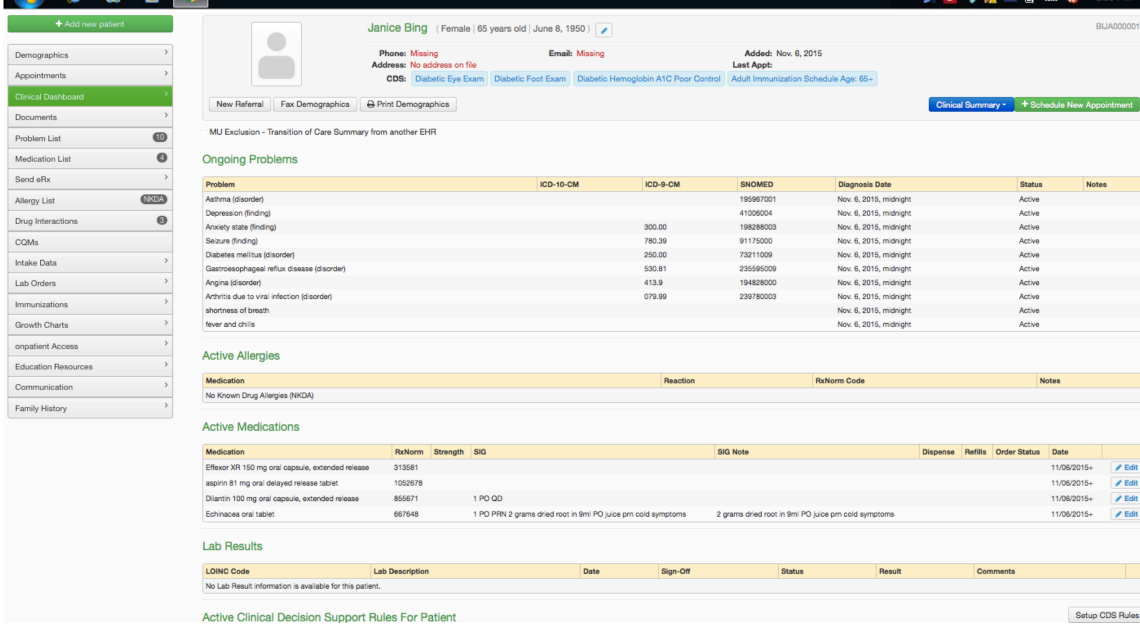
Patient (Find a patient)



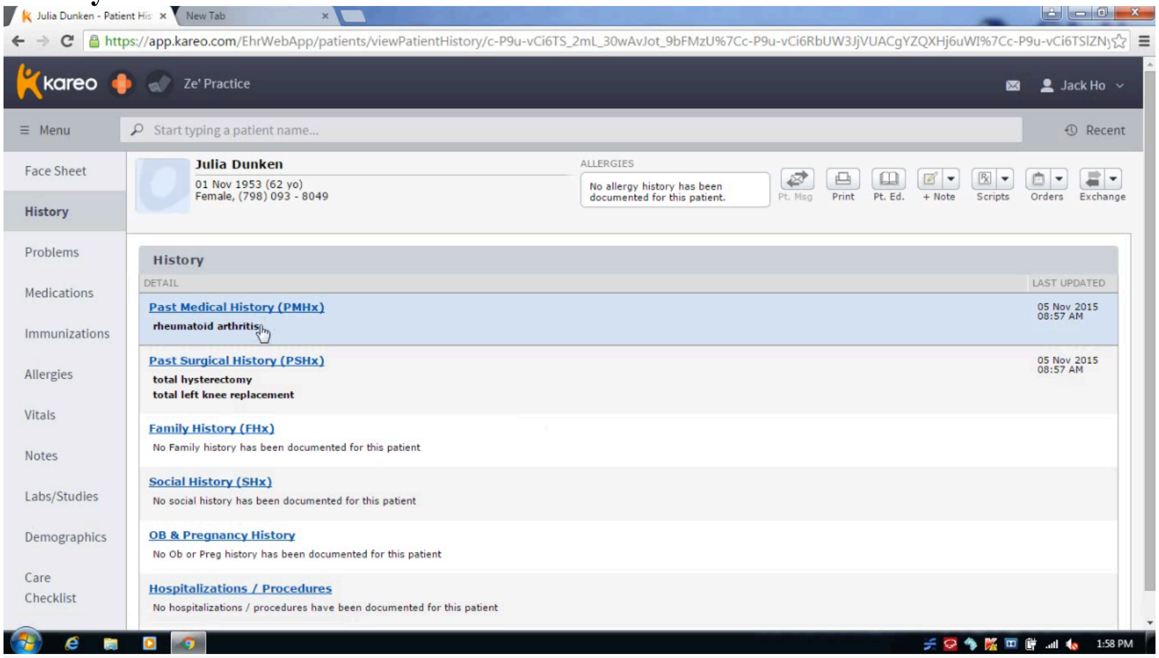

drchrono | Patient List
https://drze.drchrono.com/patients/?page=1&query=&phone=&sort_column=Chart%20ID&sort_order=asc
Schedule Clinical Patients Reports Billing Account Help
Manage your existing patients
Bulk Import
Export (CSV)
Export (C-CDA XML)
Search
More Filters
+ Add new patient
Update patient (via C-CDA XML)
PAGE 1 OF 1
Chart ID | Last Name | First Name | Home Phone | Cell Phone | Last Appt | Next Appt | Follow-up | Valid Ins
BETO000001 Departee John Wed, 10/01/2014
BIAN000001 Bing Ana
BIJA000001 Bing Janice
BRCH000001 Bright Chrissy Sun, 07/26/2015
CHAM000001 Chen Amy
CHJU000001 Chen Julie
CLEM000001 Clark Emma
CLMO000001 Clinton Monica
DAAD000001 Dawson Adele
DADA000002 Dan Dan
DALI000001 Dawson Lily
DALU000001 Dawson Lucy
DEBR000001 Dee Brittany
DECA000001 Dee Cathy
DEHI000001 Dee Hilary
Feedback
Support
2:46 PM

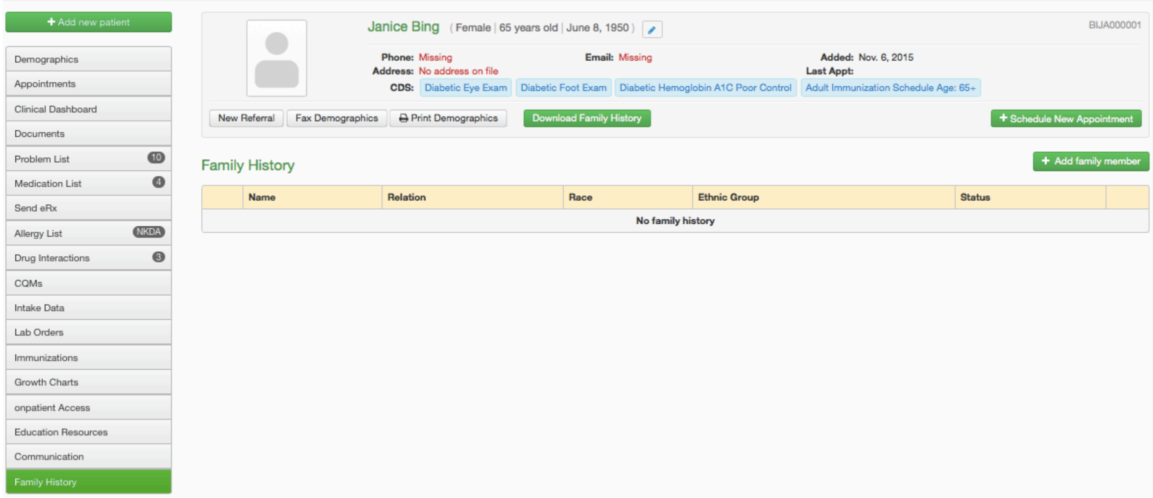
Face Sheet (Patient summary page)



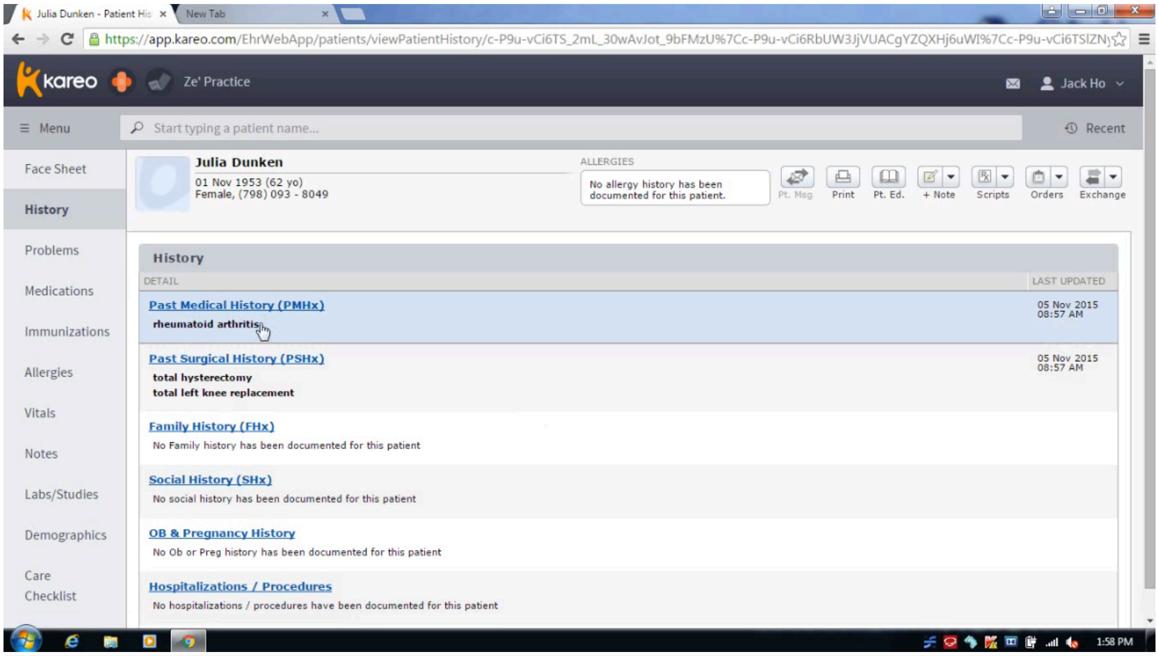


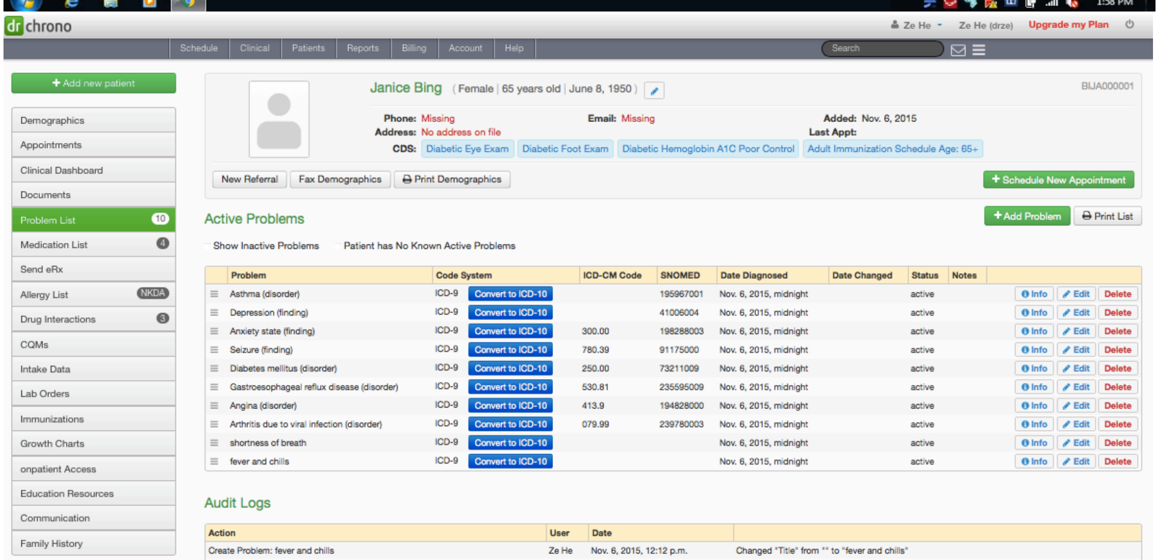
History


Julia Dunken - Patient His
New Tab
https://app.kareo.com/EhrWebApp/patients/viewPatientHistory/c-P9u-vCi6TS_2mL_30wAvJot_9bFMzU%7Cc-P9u-vCi6RbUW3JjVUACgYZQXHj6uWI%7Cc-P9u-vCi6TSlZNy
kareo
Ze' Practice
Jack Ho
Menu
Start typing a patient name...
Recent
Face Sheet
History
Problems
Medications
Immunizations
Allergies
Vitals
Notes
Labs/Studies
Demographics
Care Checklist
Julia Dunken
01 Nov 1953 (62 yo)
Female, (798) 093 - 8049
ALLERGIES
No allergy history has been documented for this patient.
Pt. Msg
Print
Pt. Ed.
+ Note
Scripts
Orders
Exchange
History
DETAIL
LAST UPDATED
Past Medical History (PMHx)
rheumatoid arthritis
05 Nov 2015 08:57 AM
Past Surgical History (PSHx)
total hysterectomy
total left knee replacement
05 Nov 2015 08:57 AM
Family History (FHx)
No Family history has been documented for this patient
Social History (SHx)
No social history has been documented for this patient
OB & Pregnancy History
No Ob or Preg history has been documented for this patient
Hospitalizations / Procedures
No hospitalizations / procedures have been documented for this patient
1:58 PM

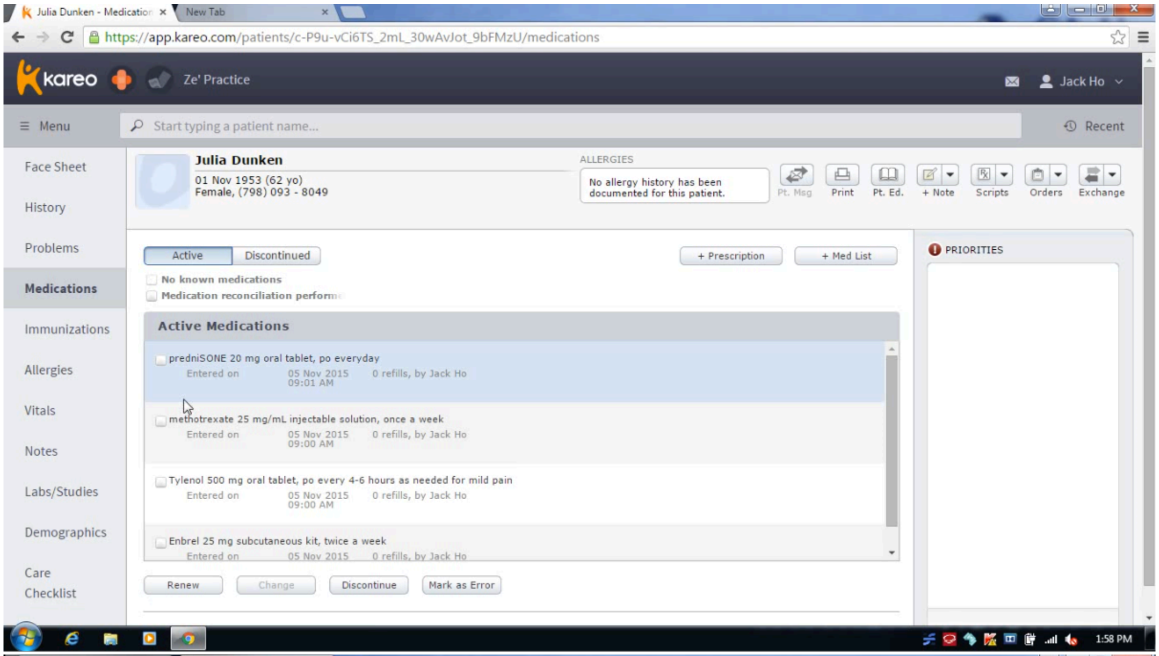

+ Add new patient
Demographics
Appointments
Clinical Dashboard
Documents
Problem List
Medication List
Send eRx
Allergy List
NKDA
Drug Interactions
CQMs
Intake Data
Lab Orders
Immunizations
Growth Charts
onpatient Access
Education Resources
Communication
Family History
Janice Bing (Female | 65 years old | June 8, 1950)
BIJA000001
Phone: Missing
Email: Missing
Added: Nov. 6, 2015
Address: No address on file
Last Appt:
CDS: Diabetic Eye Exam
Diabetic Foot Exam
Diabetic Hemoglobin A1C Poor Control
Adult Immunization Schedule Age: 65+
New Referral
Fax Demographics
Print Demographics
Download Family History
+ Schedule New Appointment
Family History
+ Add family member
Name
Relation
Race
Ethnic Group
Status
No family history

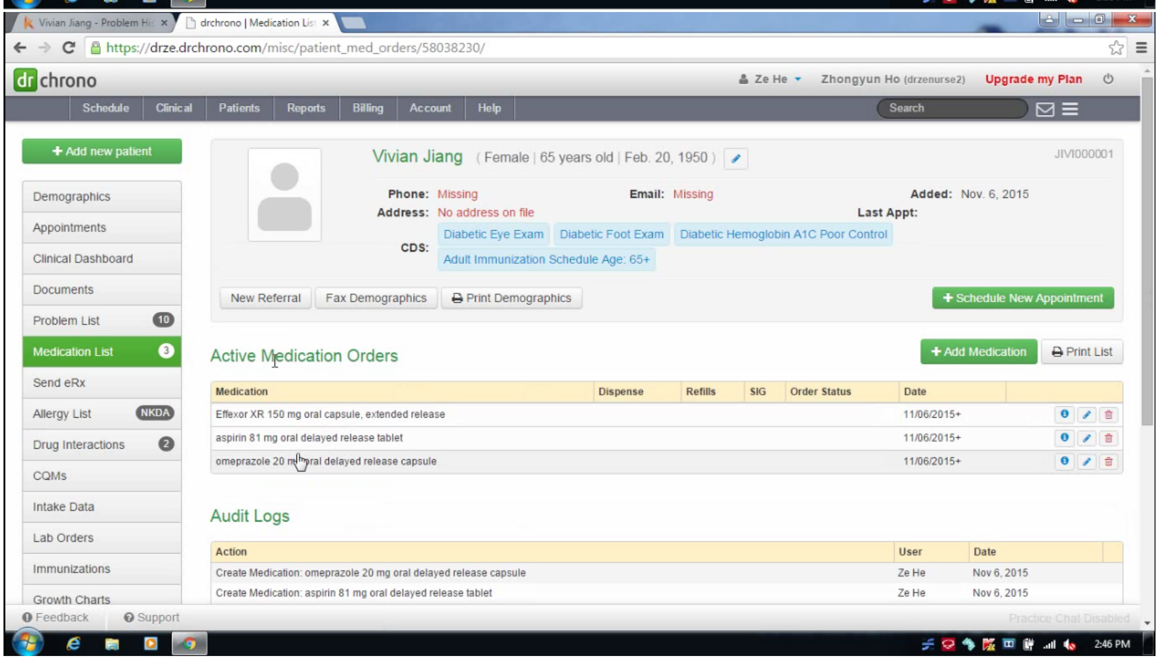
Problems


Julia Dunken - Patient His
New Tab
https://app.kareo.com/EhrWebApp/patients/viewPatientHistory/c-P9u-vCi6TS_2mL_30wAvJot_9bFMzU%7Cc-P9u-vCi6RbUW3JjVUACgYZQXHj6uWI%7Cc-P9u-vCi6TSlZNy
kareo
Ze' Practice
Jack Ho
Menu
Start typing a patient name...
Recent
Face Sheet
History
Problems
Medications
Immunizations
Allergies
Vitals
Notes
Labs/Studies
Demographics
Care Checklist
Julia Dunken
01 Nov 1953 (62 yo)
Female, (798) 093 - 8049
ALLERGIES
No allergy history has been documented for this patient.
Pt. Msg
Print
Pt. Ed.
+ Note
Scripts
Orders
Exchange
History
DETAIL
LAST UPDATED
Past Medical History (PMHx)
rheumatoid arthritis
05 Nov 2015 08:57 AM
Past Surgical History (PSHx)
total hysterectomy
total left knee replacement
05 Nov 2015 08:57 AM
Family History (FHx)
No Family history has been documented for this patient
Social History (SHx)
No social history has been documented for this patient
OB & Pregnancy History
No Ob or Preg history has been documented for this patient
Hospitalizations / Procedures
No hospitalizations / procedures have been documented for this patient
1:58 PM


dr chrono
Ze He
Ze He (drze)
Upgrade my Plan
Schedule
Clinical
Patients
Reports
Billing
Account
Help
Search
+ Add new patient
Demographics
Appointments
Clinical Dashboard
Documents
Problem List 10
Medication List 4
Send eRx
Allergy List NKDA
Drug Interactions 3
CQMs
Intake Data
Lab Orders
Immunizations
Growth Charts
onpatient Access
Education Resources
Communication
Family History
Janice Bing (Female | 65 years old | June 8, 1950)
BIJA000001
Phone: Missing
Address: No address on file
Email: Missing
Added: Nov. 6, 2015
Last Appt:
CDS: Diabetic Eye Exam Diabetic Foot Exam Diabetic Hemoglobin A1C Poor Control Adult Immunization Schedule Age: 65+
New Referral
Fax Demographics
Print Demographics
+ Schedule New Appointment
Active Problems
+ Add Problem
Print List
Show Inactive Problems
Patient has No Known Active Problems
Problem Code System ICD-CM Code SNOMED Date Diagnosed Date Changed Status Notes
Asthma (disorder) ICD-9 Convert to ICD-10 195967001 Nov. 6, 2015, midnight active Info Edit Delete
Depression (finding) ICD-9 Convert to ICD-10 41006004 Nov. 6, 2015, midnight active Info Edit Delete
Anxiety state (finding) ICD-9 Convert to ICD-10 300.00 198288003 Nov. 6, 2015, midnight active Info Edit Delete
Seizure (finding) ICD-9 Convert to ICD-10 780.39 91175000 Nov. 6, 2015, midnight active Info Edit Delete
Diabetes mellitus (disorder) ICD-9 Convert to ICD-10 250.00 73211009 Nov. 6, 2015, midnight active Info Edit Delete
Gastroesophageal reflux disease (disorder) ICD-9 Convert to ICD-10 530.81 235595009 Nov. 6, 2015, midnight active Info Edit Delete
Angina (disorder) ICD-9 Convert to ICD-10 413.9 194828000 Nov. 6, 2015, midnight active Info Edit Delete
Arthritis due to viral infection (disorder) ICD-9 Convert to ICD-10 079.99 239780003 Nov. 6, 2015, midnight active Info Edit Delete
shortness of breath ICD-9 Convert to ICD-10 Nov. 6, 2015, midnight active Info Edit Delete
fever and chills ICD-9 Convert to ICD-10 Nov. 6, 2015, midnight active Info Edit Delete
Audit Logs
Action User Date
Create Problem: fever and chills Ze He Nov. 6, 2015, 12:12 p.m. Changed "Title" from "" to "fever and chills"

Medications





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