DOCUMENTING FOR CARE: EVALUATING AN EMR FOR PRIMARY CARE PROVIDERS

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Abstract

Healthcare providers generate a large volume of patient documentation. Healthcare facilities adopt EMRs as one strategy to store and manage the data generated by providers, however these systems do not allow for easy information input or extraction. We conducted a cognitive walkthrough study to understand the user interface and interactions with the EMR system. Our qualitative observational study of 10 providers, which collected 52 hours of data, found that providers do not always interact with meaningful patient information. Follow-up interviews with 7 of those providers verified our findings from the observational studies.

We analyzed our data and report different places, processes, tools and motivations for creating documentation of patient encounters. Providers either document in the exam room or in their pod office space. Providers either document a patient encounter during one sitting or iterate on the note over several sessions. The various ways providers document have different strengths and weaknesses, but a single theme persists - providers attempt to document to improve the care of the patient, but often struggle because their duties require them to document for billing.

From this understanding we present a reconceived model of the EMR that better supports patient information input and retrieval. This model would center around linking patient information, then presenting that information to the provider. The goal for information presentation would be delivering only the information they need, when they need it. In addition to presenting a long-term design goal, we also recommend short-term solutions to improve EMR usage and provider workflows. In the short term, additional staff should be utilized to offload administrative tasks for providers and paper documents designed for patient care should be scanned into the EMR.

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1 Introduction

1. Introduction

Electronic Medical Records (EMRs) have the potential to revolutionize patient care. They can provide an interoperable repository to capture a lifetime of patients' health stories and link relevant health metrics to personal health information leading to improved patient care. In addition, administrators would be able to acquire information about care to inform policy and charging for services without unduly burdening care providers.

Unfortunately, the current reality of EMRs does not support these ideal interactions. Initiatives to create interoperable EMRs through Regional Health Information Organizations and Health Information Exchanges have been largely unsuccessful at enabling sharing between the silo data repositories of different health facilities [10, 13, 28]. Small health

clinics suffer the most because they do not have the resources or expertise to select and deploy a suitable EMR system. The EMR systems that they choose will most likely be directly linked with administrative processes in an attempt to streamline their billing. Providers are forced to bounce between their goal of documenting for care and their requirement to document for billing, sometimes failing to meet the requirements of both.

Researchers have explored what tools providers use to document for care - from transitional objects [7] to provider-driven interface personalization[30]. In addition, work has been done to identify the needs of patients during provider encounters [27] and how this personal health and psychosocial information should be captured [34]. This research informed the design of EMR user interfaces by identifying some patient and provider information needs. These studies did not, however account for the broader interactions providers have with the system to support documenting for care.

In this thesis, we studies the providers' EMR documentation workflows. We collaborated with a small clinic at a large, public university to evaluate their EMR system usage. We shadowed 10 providers for 52 hours interacting with 15 patients. We confirmed observations and discussed problems we observed of the providers we shadowed during semi-structured interviews.

The study found providers documented patient encounters in different places, using different processes, and interacting with different EMR interfaces. A portion of providers documented their patient encounters in the exam room while the rest completed the documentation in the shared pod office space. The providers were also divided into an iterative note creation process as opposed to completing documentation for a patient encounter in one sitting. But all of the providers had problem-some interactions with the documentation form and the patient summary information screens.

This thesis helps clinical informatics researchers and practitioners understand provider workflows and EMR system needs. Based on these needs We present a new model for EMR design based on our understanding of the provider-system interactions.

In Chapter 2, we will present a background of the research project including an overview of the research site and the EMR system deployed. In Chapters 3 and 4, we

review related work in the areas of EMR design and medical practice workflow studies. I explain the methods used for the study in Chapter 5, followed by the findings of the study in Chapters 6 and 7. Finally I discuss the implications of my findings and provide design recommendations in Chapters 8 and 9.

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Background

1. Project Background

Administrative staff from the Wardenburg Health Center at the University of Colorado, Boulder approached our team about decreased patient throughput after the implementation of an EMR system. They deployed the system for a year before meeting with our team to discuss system problems. The main goal of our work was to understand the utilization of the EMR system by the clinical staff, find the reasons for diminished performance, and suggest improvements. For my thesis, I focused on how the providers in the medical clinic of Wardenburg used the EMR system to provide primary care.

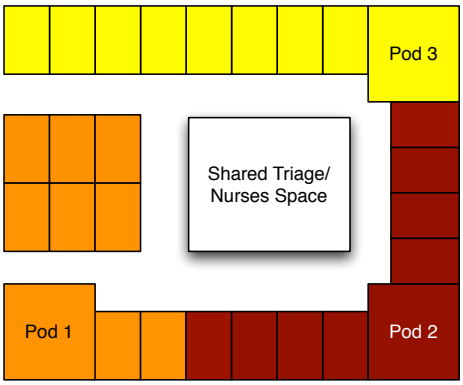

FIGURE 1. An image of the layout at this primary care clinic. The colored rooms without labels are exam rooms that are managed by the pod of the same color.

2. Study Site Overview

The Wardenburg health center at the University of Colorado, Boulder hosted our research study. This health facility served a campus with an undergraduate population of over 27,000. The primary consumers of health services were students, both graduate and undergraduate, typically ranging from age 18-24 years, but non-traditional students made up part of the patient body. The on-site services included a primary care medical clinic, sports medicine, psychological health and psychiatry, women's health clinic, pharmacy, X-ray, and laboratory. All the services utilized a single EMR system and operated under the same administration.

This study covered only on the primary care service operated by 15 providers and additional support staff. Providers were assigned to one of the three pod spaces that served as shared office spaces. Each pod had a laser printer, secure prescription printer, white board for managing exam rooms for that pod, shared computer stations for medical assistants, and assigned computer workspaces for each provider. As seen in Figure 1, each pod was assigned a set of the exam rooms to see their patients. Staff within each pod coordinated exam room utilization by verbal communication and white board usage.

Each exam room contained a computer workstation in addition to standard medical equipment and supplies. These computer workstations provided full access to the EMR

system, but operated noticeably slower than pod space computers. Providers logged into these systems by typing their username and password.

In the center of the medical clinic was a shared triage space and nurses station. Nurses examined walk-in patients in this area prior to placing them in an exam room to see a doctor. They also admitted travel clinic patients and immunized patients within this area. The space includes two shared computer workstations to provide nurses the ability to document patient encounters prior to seeing the doctor. This supports continuity of care for admitted patients.

3. Participants

Our study included direct observations of 4 physicians and 6 nurse practitioners and individual interviews with 4 physicians and 3 nurse practitioners from the original 10 participants. We recruited these 10 providers out of a pool of all medical clinic providers - 13 potential participants. For simplicity in my thesis, we will refer to physicians and nurse practitioners as providers, and to protect confidentiality all providers will be referred to as female. All of the providers in the clinic worked as primary care providers. They completed the same tasks - seeing patients, completing documentation, reviewing test results, and other tasks necessary to provide patient care. Each provider cared for 12 to 21 patients each day depending on the reason for the visit.

Participating providers had worked at this clinic for as few as 4 months to as many as 16 years. EMR usage experience also varied from a single EMR exposure (only the current system) to 3 (including the current system) different EMR systems. All participants claimed to be proficient or better at completing general computer tasks such as email, web browsing and word document production. Our observations supported a moderate skill in computer use across all providers, but some providers struggled to type quickly and accurately.

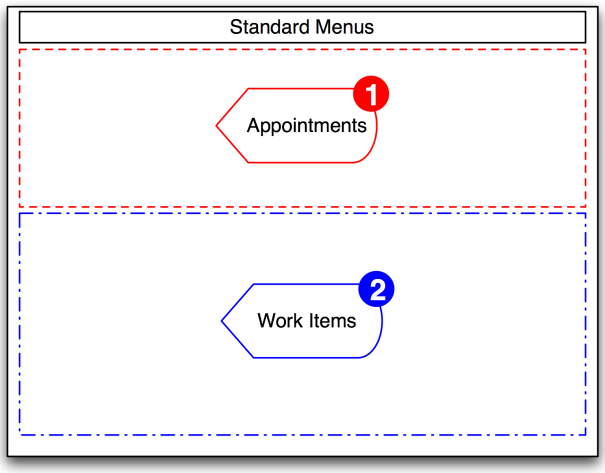

FIGURE 2. Home Screen for the Electronic Medical Record: (1) Upcoming appointment information for providers; (2) Work Items for provider to access (e.g., SOAP notes, lab orders)

4. The Electronic Medical Record system

The system used by providers had three main work spaces - the home screen, the SOAP note, and the patient summary screen. The *home screen* served as the main work space for the provider. It was broken into two windows on the screen. The top window listed upcoming patient appointments, whether patients have arrived yet for their appointments, and the exam room designated for the patient. The other window listed open work items that the provider needed to complete and provided navigation to other areas of the EMR. The open work items included open patient interaction notes, completed lab test results that needed to be reviewed, and unread secure messages from patients or colleagues. As items were completed by the provider - in the case of notes when they are "locked" - they were removed from this screen.

The *Subjective, Objective, Assessment, and Plan (SOAP) note* was used by practitioners to document patient visits. The note contained four main sections to correspond with the acronym. Within each of these sections was the option to add narrative free-text data and templated data. The host facility designed the templates used by providers at the facility, while the EMR vendor developed the rest of the SOAP note. Providers interacted with

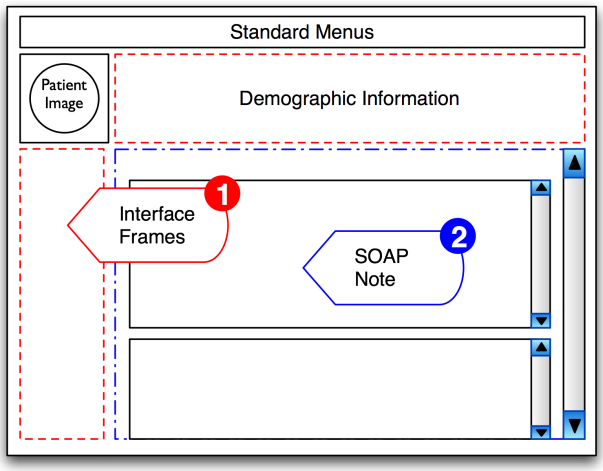

FIGURE 3. SOAP Note screen for the Electronic Medical Record: (1) interface frames available on Patient Summary and SOAP Notes; (2) SOAP Note work area

a single screen to complete the SOAP note - only seeing additional screens when adding templates or orders. This meant that providers scrolled down the long SOAP note screen to reach all of the sections. After working on a SOAP note, providers had the option to save a draft of the note or lock the note. If a note was "locked," it was immutable and sent to administration for billing purposes.

The *patient summary screen* showed providers relevant information regarding each patient. The main page of the patient summary screen listed pertinent history, allergies, medications, discontinued medications, family history, diagnosis history, learning barriers, and immunizations for the selected patient. Providers accessed notes from past visits to this facility, lab results, and xray history for a specific patient by clicking on a navigation bar.

5. Summary

The Wardenburg health center contacted us to evaluate their EMR after they noticed decreased patient throughput. With their assistance we studied over 3/4 of the healthcare providers' workflows and EMR interactions. This involved 52 hours of shadowing, 7

individual interviews, and a focus group. We also studied the EMR system using a cogntivie walkthrough methodology to identify usability concerns.

3

EMR Evaluation and Design

1. EMR Design and Evaluation

1.1. Implementation. Interoperation and implementation of EMR systems continues to be a focus of research and development time. Unlike security, research in this area can, and has, directly improve patient care. Researchers have explored strategies for interoperation since the early 1990's [10]. There have been many proposals to solve the problem, and new models continue to develop. Though the ability for EMRs to interoperate has improved significantly, policy development and the fragmentation in the EMR market remain the biggest barriers. Because of the value of interoperability [28], developers have spent time building interfaces to other systems to increase the value of their offerings [13]. Often health facilities are forced to develop and maintain custom

interfaces to connect their different systems. This turns into an n-squared problem for building these interfaces, as n, the number of systems a facility uses, increases, the more time and money the facility must spend.

Software architecture and design is also an active area of research for EMR systems. Jakob Bardram developed a software architecture for EMR systems around the activity based computing concept [4]. In this model, "computational activity" represent real-world actions of providers. Actions are taken on these activities and their states. This represents a clear case where the software model must be considered when design the user interface for the system. In this case, the UI design approach would vary significantly from the approach taken with a personnel object centered EMR model [17, 24].

If facilities adopt systems that interoperate with a large array of facilities, usability designers may have a concern about displaying information from the local facility separate than information from outside facilities. If patients are the main object of interaction within a system, the usability designer may choose to deploy controls for interacting and displaying information for each object in one place. They may group all results and history for each patient on their screen. Or they may choose to group all the labs together regardless of the patient. They may choose both display methods. Regardless, there is significant consideration that must be given to interoperability and software design choices that directly impact usability research.

1.2. Usability in EMR Systems. Sources have cited usability problems as being a major barrier to EMR adoption among physicians [6, 12, 33]. Chief among these are problems with information presentation, excessive UI customizations, complex or excessive user interface interactions, and data entry problems [5, 16].

Studies have been conducted to try and find better solutions for organizing and presenting patient information [19, 30]. Previous research on the importance of information presentation in EMR systems, and the lack of research on the topic directly in primary care medicine motivated our team to focus on information presentation as one of the themes for our study. Because of the distinct differences in primary care workflow and treatment

focus [18], it is possible that the information demands are different for this population of clinicians.

Commercial EMR systems have struggled with balancing the presentation of information to be meaningful for providers. Systems overwhelm practitioners with excessive data presented in a non-meaningful way [25, 31, 32]. Several studies have proposed different methods of presenting data to providers [9, 32], yet EMR implementations have not deployed solutions to information overload problems. These studies focused primarily on the information retrieval process, not the information input process. Alternatively studies have looked at the way that providers enter information into EMR systems [26]. They have looked at different approaches for practitioners to document information into the EMR [3]. Speech recognition software represents a possible solution to the time consumption of free-text input [2]. However this technology is immature and performs inconsistently in most clinical use [8]. Our study builds on these previous works, simultaneously looking at both the information input and output from EMR systems.

4

Observational Studies of EMR Usage

1. Workflow Studies of EMR Implementations

In order to design usable systems and effective user interfaces, researchers have realized the importance of understanding the target users [11] and their workflows [30]. There is a history of significant workflow study of hospital work and EMR usage [15, 27]. The complexities of hospital work, and the high cost of care in these facilities make it a priority for developing ideal EMR solutions. Recently, Chen [7] and other researchers [34] studied workflows of hospital staff in different facilities.

Chen discovered the usage of transitional objects, both permanent and temporary, at a hospital emergency department. Our research identified similar behaviors but in a primary care setting. The different "transitional artifacts" [7] served to bridge the gap

between patient visit and computer documentation, as well as to workaround limitations within the system itself. Our study builds on that research identifying different transitional artifacts within a primary care facility, clarifying their role in the bigger picture of the clinical workflow, and the illuminating the process of translation into the EMR system.

Workflow studies conducted in primary care settings have not focused on the provider-computer interaction [14, 18, 21]. Alternatively Walsh mixed his personal experiences with a literature review to discuss the impact of the computer on the provider documentation process [29]. Our study looks at the same topic as that paper, narrative documentation in the EMR, and we expand on his work by completing an observational study of the topic.

5 Methods

1. Data Collection

We used a mixed methods approach to collect data for this study. Initially, we collaborated with the Systems Training Coordinator at Wardenburg to identify tasks and conduct a cognitive walkthrough to better understand the system and identify potential usability issues. After we completed the initial cognitive walkthrough, we shadowed providers in the primary care unit while they met with patients. Based on these observations, we continued the cognitive walkthrough study to evaluate the system with how providers use the system in practice. The final part of the data collection included interviews where we could discuss and confirm what we observed and usability problems we identified.

1.1. Usability Evaluation. In addition to working directly with providers, we conducted a cognitive walkthrough on the user interface of the EMR system. The cognitive walkthrough elucidates usability problems in completing common tasks [20]. This specific type of study evaluated if user action intentions were being met by the system, users were able to locate and use necessary controls, and that the system provided feedback to drive the provider to complete their task [22]. Because of the task oriented nature of the work completed by providers, this type of usability study fit well.

Previous usability evaluation studies cited an evaluation perspective of a human actor that has no expert computer knowledge being a key criteria for usability analysis [6]. This type of study minimizes impact on the host institution because it does not require user time. Beginning the interface inspection study prior to shadowing allowed researchers to become familiar with the system that providers would use during observations.

We needed to compile a list of tasks from users of the system to complete this study. We initially assembled the list of tasks and associated interactions based on training manuals created by the facility. We added tasks and different interactions as we identified variations during the shadowing. For each item in the task list, we developed the set of user interface actions necessary to complete that task. We studied the EMR system on a test environment deployed by the facility for training new providers and testing new system updates. This environment ran the same software as the production system used by providers, but contained test patients with potential dummy data.

1.2. Observations. Before beginning observations, we obtained IRB approval for the study from the governing university and approval from the administrative leadership from the host institution and the student health board. We observed providers for 3.5 - 5 hour sessions. An even distribution of observations occurred in the morning and the afternoon. Four providers scheduled two observation sessions, while the rest of the providers were shadowed a single time. We observed a total of 52 hours of provider work, using written documentation, not voice or video recording. All observations were collected by a single researcher, and verified by the research team.

The majority of observations were made in the pod space and the movement between the different on-site services. We observed the order in which the providers completed work tasks, and how those tasks related to the overall process of patient care. Our observations were able to capture screens and screen patterns used by providers in their work. This helped to better understand the interactions of providers with the system. We also documented observations of colleague interaction, phone communications, and paper artifact usage.

We observed 15 patient visits in the exam room to better understand the role of the computer system in the patient-provider interaction. Patients signed informed consent forms after researchers fully explained the study. Because our study focused on the computer interaction, we did not document any information regarding the patient. Instead we documented what EMR tasks, if any, the providers completed in the exam room and whether that usage hindered patient-provider communication.

1.3. Interviews. After completing the shadowing events, 4 physicians and 3 nurse practitioners participated in semi-structured interviews. These events lasted between 22 and 55 minutes. We asked a small set of identical questions to all providers and questions specific to each provider about events we observed during shadowing. A total of eight interviews were conducted, with one provider being interviewed twice because she wanted to provide additional information. Five of the interviews were audio recorded, while the other three were only documented by writing due to scheduling constraints. The audio recorded interviews were transcribed for analysis.

2. Data Analysis

We used elements from Grounded Theory to analyze our data. Our observation notes and interview transcriptions were open coded using the TAMS Analyzer Qualitative Research Tool [1]. Our analysis was informed by the constant comparative method where we iteratively analyzed the data individually (analyst triangulation) for thematic content. We met as a team to discuss and debate codings until consensus was reached. Once the data was coded, we confirmed observed behavioral commonalities with coding

frequencies. We used co-frequency analysis to further refine a set of findings from our data.

In addition to studying the codes of the data, we reviewed the specific quotes and observations surrounded by recurrent codes. We had cases where the whole picture of provider behavior was not captured in the information we coded. In these cases, we gained a "bigger picture" of the workflow by looking outside the quotes. These details became cases in support of our findings.

6

Design for Use : The Cognitive Walkthrough Study

The cognitive walkthrough revealed usability problems with input and output of information. In this section we report the findings of our cognitive walkthrough with respect to the most problematic interfaces. The findings are broken into a section looking at problems with information input and a section focused on the problems with information extraction. The complete findings of the cognitive walkthrough can be found in Appendix B.

1. Information Input

1.1. SOAP Note. Providers spent the most time working with the SOAP note interface. This interface was built to capture all patient information from a visit, however it was

tedious and time consuming. The SOAP note interface was a single window that providers scrolled through to get to each section. In the various windows on this screen there were additional scroll bars. This created a series of nested scroll bars within the main SOAP note. Each section allowed providers to enter patient information using free-text narrative and placing templated responses. The following are different sections of the SOAP note which had problematic usability interaction.

1.1.1. *Medication Orders.* When providers needed to add a medication, they would enter a search term to generate a list of related medications from which to choose. In many cases these lists held too many options for the user to reasonably look through, thereby decreasing visibility of the medication items the provider may select.

Adding any medication in the EMR would generate a medication interaction pop-up. This window would list every interaction imaginable, making it difficult for users to find meaningful medication interactions. The default sorting of the system from least to most severe interactions compounded this problem. In the cases we studied, the severe medication interaction warnings were not immediately visible, requiring the user to scroll down to see them. This problem may have lead providers to assume there were no severe medications interactions, since it would be sensible to assume the most important alerts propagated to the top.

When completing a medication order, providers were required to set values for the "Route" the medication would be administered and the unit of measure for the order. The "Route" was set via a drop-down menu which never changed, regardless of the medication. Every medication had only a small set of potential routes for administration - most medications only having one route. Nexium was only taken orally, however the provider had to set this using the drop-down. Nexium also only came in capsule form, yet the system required the provider to specify a unit of measure which ranged from liquid to capsule to powder.

1.1.2. *Diagnosis Entry.* Providers struggled to enter diagnosis for their patients into the SOAP note. The system provided a method of filtering by using a single user input word to seed the search. When the user wanted to add a diagnosis to a SOAP note, they

could type into the diagnosis field. Based on this word the system would generate a list of diagnosis with names containing the input text. For example, if a provider wanted to add the diagnosis of "Esophageal Reflux" to a SOAP note, they could type "esoph" or "reflux" into the diagnosis field. After hitting return, the system would generate a list containing the diagnosis "Esophageal Reflux" below the input field. The provider would then click on that entry to add the diagnosis. However, if the user were to type "gerd", "gastro", "acid", or other words related to the diagnosis, they would not be presented with the diagnosis of "Esophageal Reflux". This meant the provider tried to guess the correct search term every time they added a diagnosis.

1.1.3. *Templates.* Templates allowed providers to quickly document portions of patient interactions by clicking on pre-developed answers to common questions or prompts. Administrative staff and providers collaborated to build templates for providers using tools supplied by the EMR vendor. Template usability suffered because many of the templates had too many questions, the lists of answer options for some questions were excessive and repetitive, and templates overused acronyms.

The "Basic Illness Exam" objective template had 14 prompts for providers to input information including Skin, Eyes, Ears, and Nasal Passages. Each prompt could have as many as 10 different responses, which were not mutually exclusive meaning they could all be selected. On most occasions when a provider selected abnormal for a prompt, the system generated a pop-up window allowing the provider to further clarify the abnormal state. This forces users to make numerous clicks, and manage additional windows. The provider also scrolled down a large portion of the screen to find all the prompts. Although we included the "Basic Illness Exam" template specifically in our cognitive walkthrough, we noticed that other templates suffered from similar problems.

Most templates had duplicated answers for some of the prompts and questions. In the case of the "Basic Illness Exam", the "Skin:" prompt had options for "Warm and dry", "No lesions", "No rashes", "Warm and dry, No lesions, no rashes", and several additional abnormal options. There was an opportunity to consolidate some of these options by determining the minimal set of options that would allow providers to document the

different cases. Additionally the providers could type text into fields next to the values to provide additional details. Instead of having a larger number of options to cover all the possible cases, it may be more effective to prompt providers to type clarifying details in these fields.

Medical facilities commonly use acronyms to communicate in written and verbal form. The medical field accepts many acronyms as official medical lingo, but many facilities adopt their own acronyms. Wardenburg staff utilized many acronyms in their template prompts and answers. In the "Basic Illness Exam" template the "Eyes:" prompt utilized the acronyms EOM-I, "Extraocular Movements Intact" and PERRLA, "Pupils equal round, reactive to light and accommodation". The "Lungs:" section used the acronym CBTA, which refers to clear bilateral air movements, but was not a normally recognized medical acronym. The "Neck Exam:" prompt and the "Abdomen:" prompt also had acronyms. All of these prompts were part of one template, but many other acronyms were found throughout the entire template library. Most acronyms would be recognized by providers, but some acronyms were likely to cause confusion in providers, especially new providers.

Providers completed most templates by using checkbox controls. Occasionally, a template required use of text input, radio buttons, or drop-downs. Marking certain checkboxes in a template generated additional pop-ups with more questions allowing providers to further clarify information. The problem was that the controls were not consistent throughout the same interface and across separate interfaces. Mixing checkboxes with radio button inputs presented a confusing series of interactions.

1.1.4. *Documentation Tools.* The EMR system we studied provided several tools for decreasing the time required for inputting information into the system. These tools worked by automatically populating fields for the provider based on their specifications, but required configuration by the user. The tools included Default Medication Settings and Favorites.

The setup process for these tools differed from the the process a reasonable user would intend to take. The average user would want use a "Create Medication Default" or "Create Favorite" type of control. However these controls did not exist. Instead the

system required providers to fill out the information, as if they were completing the documentation for a patient, then click a "Set Default" button. In the case of creating a default medication setting, the provider would open a SOAP note for any patient, add the medication according to the normal process, then before submitting the medication, click the "Set Default Rx" button at the bottom. After doing this the provider could cancel the prescription, close the note, and not bother to save. This process would fit well if the provider was thinking about creating a default medication entry when they were ordering a medication for a patient, but this did not always occur. Setting the default medication should be uncoupled from the workflow of ordering medications for a patient.

The same problem occurred when creating a favorite for later use. Favorites allowed providers to set default entries for all, or some, of the sections of a SOAP note. To create the favorite, the provider would need to create a SOAP note and fill in the different sections according to their preference. After this they would click a button on the SOAP note to create the favorite. Again, this process worked well if the provider was thinking about creating a favorite while they were completing documentation on a patient, but this was not common. There should be a control for creating favorites separate from workflow.

1.2. Patient Summary Screen. To update the patient summary screen, providers would manually enter significant medical history for the patient. Although the provider already entered diagnosis into the SOAP notes for their patients, this information would not populate the patient summary screen under the medical history section into which it belonged. Providers were forced to input this information more than once because the system already had the information in another location.

2. Information Output

2.1. Home Screen. The home screen helped providers get a quick glance at their appointments for the day and the pending work items they needed to complete. In the upper half of the home screen providers would have a list of patients for the day, including those already seen, and those yet to be seen. When a patient arrived, their name would change color on the home screen for the provider. When they completed the check-in form

their name would change color again. After being taken to an exam room and seen by the MA, their name would change color yet again. The meaning of the color changes was not clear without clarification or exposure. Even when the providers knew the meaning of colors, they had difficulty discerning different colors from a distance. If the patients name was selected, the provider would be unable to see any coloring.

In the bottom half of the home screen, the system listed pending work items for the provider to complete. These included incomplete SOAP notes, unreviewed test results, secure messages from patients or colleagues, and to-do items. Because so many items could appear in this window, we found items began to move off screen. Some providers had the majority of their open work items off the screen, which required scrolling to see everything. This posed a problem because it increased the chance providers would miss important tasks.

2.2. Patient Summary Screen. On the patient summary screen, the system listed current medications, discontinued medications, immunizations, medical histories, allergies, family medical histories, and several other categories of information. It was rare to see a patient summary screen where the information did not go beyond the screen requiring providers to scroll. The patient summary screen had no obvious controls for sorting these lists or searching the lists for pertinent information.

2.3. Past Notes. Past visit notes were accessed from an interface called "All Notes". This interface listed all notes from past visits. SOAP notes from visits were the items providers most often needed to review. This interface was cluttered with additional notes including templates that were already embedded in the SOAP notes, secure message communications, and progress notes used to document minor patient interactions such as phone calls. There was no use in having the templates listed in this interface alone, when they were already included in the SOAP note and held little meaning outside of the SOAP note. Much like the patient summary screen described above, this interface could hold many items, especially if the patient was seen often. Relevant SOAP notes could be pushed off the screen, which increased the likelihood that they would be missed.

There was not a good mechanism to sort or search these notes to help the provider find relevant information. If a provider tried to sort by the type of note, it would only sort within each separate visit date, instead of across all the notes. In this case, all SOAP notes from November 1st would be grouped together and all the templates completed on November 1st would be grouped together. All the SOAP notes from November 14th would be grouped together but separate from the SOAP notes from November 1st, and so on. Many notes were poorly labeled because the system used the visit summary field to describe each note, and that field was optional. The field did not have a set format and was free-text input by providers. The only way to find relevant notes was through manually reviewing the contents of each note.

2.4. Lab Results. The lab results interface suffered from the same problem as the previous two interfaces - too many items and no mechanisms to identify the relevant information. Lab results had cryptic labels based on ordering codes. Much like the "All Notes" interface, providers searched through the lab results one by one to identify relevant information.

3. Summary

The cognitive walkthrough revealed problems with information input and export in the EMR system. The main interfaces used by providers, including the patient summary screen, the home screen, and the SOAP note, all had problems identified by the cognitive walkthrough. At times, the system overwhelmed providers with too much information. In other cases, providers could not locate the information they were looking for in one intuitive location.

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Design for Administration : The Shadowing Study

We were originally asked by clinical staff at the Wardenburg health center to evaluate their EMR because they noticed a significant decrease in the volume of patients being seen by providers after adopting the EMR system over three years ago. Based on discussions, we thought that this decrease in productivity was because of the EMR user interface design and workflows - providers were going back and forth between exam rooms and pods to interact with the system. Based on our analysis, we theorized that impressions of workflow productivity depended on one's preference for patient care or administrative efficiency. Although going back to the pod may have been time consuming, the documentation was

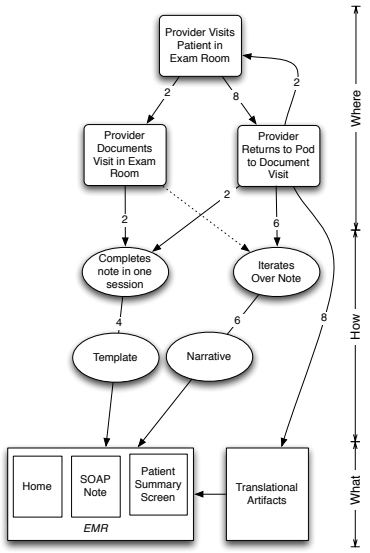

FIGURE 1. Patient Encounter Documentation Process. The numbers on each line represent the number of providers who documented in the particular way.

more complete because there was time to provide rich patient descriptions and thus could be better for patient care. Whereas documenting in the room and utilizing summary tools, ensured notes were completed more efficiently and processed for billing and thus better for administration. Here we discuss our findings in detail describing *where* providers documented patient interactions, *how* these interactions are documented, and *what* tools were used in the documentation process. An overview of this documentation process is shown in Figure 1. *When* providers documented was a function of where and how they document these items, thus *when* can be thought of throughout our findings.

When examining provider workflows and interactions with the EMR, we realized that documentation could be broadly categorized into where providers document, how they chose to document information, and finally what tools they used to document patient information. We found that there were two distinct places where providers would complete their documentation - in the pods or in the exam rooms. Depending on their location, providers documented patient encounters by iterating on a note or finishing the note in one sitting. We found that providers have multiple EMR interfaces and features

with which they interacted to complete their documentation, and in some cases retrieve information. We found that although inputting and retrieving information from the EMR were usually done at different times, the way information was input into the system often had a direct impact on the ability for providers to retrieve that information.

1. Where Providers Document Patient Encounters

In this primary care facility, providers utilized the EMR system in their pod work space or in patient exam rooms. Some providers favored EMR interactions in one area over the other, forming two distinct groups. Documenting in each location had unique benefits and barriers that we outline below.

1.1. Return to Pod for EMR Usage. Providers that returned to the pod to complete documentation had limited interaction with the EMR system during the patient interaction. Returning to the pod to document was beneficial because it allowed providers to focus on the patient interaction during a visit, to have better awareness of patient care coordination, and to create more detailed narratives. Documenting in the pod space carried with it several disadvantages as well, including forgetting information and losing transitional artifacts.

P1 walked into exam rooms and did not interact with the EMR at any point. After finishing a patient interaction, the provider returned to the pod to complete the orders and documentation for the patient. Returning to the pod for documentation allowed the provider to more effectively communicate with the patient. The computer system did not have the opportunity to capture the provider's attention from the patient.

This workflow also supported the providers ability to prioritize patient care even before seeing the patient. They could participate in the coordination of patient treatment more readily because they were present in the pod space more often than providers documenting in the exam room. If a patient required a test or treatment prior to seeing the provider, this could be communicated between the provider and MA because they were more accessible. P2 was completing documentation from a previous visit encounter as a MA explained to her that the next patient had a sore throat and might need a strep

test. The provider agreed and gave an order for the MA to complete conduct a strep test on the patient. If the provider had not been available the MA would have kept the patient waiting until the procedure could be verified with the provider. This made efficient use of the patient's time allowing the provider to gather required information necessary to treat the patient before examining them. The MA did not need to sit in the pod waiting for the provider to arrive, allowing them to get back to completing other work.

The last benefit we found in providers that returned to the pod was that they had more time to document details of the patient encounter. Because they went back to the pod, they were less rushed to complete the documentation and could give more thought to their narratives.

Like I will write down everything on [a piece of paper] and then when I get back into my [pod], not only will I have had some more time to think about it, but if I had transcribed things directly as the patient said them, it would be kind of gobbelty gook.

Writing a narrative at a separate time from the patient encounter avoided their note reading as an unconnected set of actions - a "gobbelty gook" with no common themes or meaning. And the quote supported the idea that better documentation can come out of additional thought about an interaction.

The return to pod workflow displayed *problems* that may inhibit the provider from successfully completing patient documentation. All of the providers that returned to the pod to document wrote on pieces of paper, creating transitional artifacts [7], to temporarily hold notes of the patient encounter. Providers were at risk of losing their notes during the day. Two providers encountered this problem during shadowing, including P5 in Case 1 below.

> Case 1: P5 visited a patient during her day without using the EMR in the exam room. She interacted directly with the patient, taking notes of pertinent findings on a piece of paper. She returned to her pod space to enter a pharmacy order into the EMR system and drop off the notes from the visit. Once the order was entered, the practitioner returned to

> finish the patient visit. This visit was not documented until over two hours later. When the provider began documenting the visit they could not locate the paper containing the visit notes. Even with the help of a medical assistant, the provider was unable to locate the note after fifteen minutes of searching. The provider had concerns about missing details of the visit because of the lost note, but proceeded to document as best she could.

A majority of providers expressed concern about missing visit documentation. Not simply due to losing notes, but because extra time passed between seeing patients and being able to document their interaction. For some providers, there could be as many as eight hours between seeing a patient and documenting the visit. Losing a paper note, missing paper or a pen to take notes, or choosing not to write notes about the visit only served to exacerbate the problem. If all practitioners had the opportunity to return to the pod space then this risk might be mitigated, however this rarely happened in this busy clinic. As demonstrated by P1 above, returning to the pod for documentation allowed the provider to more effectively communicate with her patient. But if the provider had another patient waiting after the visit, she may not have had time to document the previous visit. We found that the more time between the visit and documentation, the more problem a provider had recalling information about that visit. Several providers commented that they tried not to leave visits undocumented for long because they can ”forget what’s going on” (P9) with that patient. The similarities among many acute care patients also makes it more likely to forget specific details for a patient. P9 worried that after a while she might lose track of patients:

> *And yea, I don’t like to leave charts sitting. Cus then I also forget whats going on. I don’t feel like, I think theres safety issues there ... or like if there are a lot of things that are similar, then it can start being like - which patient is that?*

Returning to the pod to document allowed providers to interact more closely with their MAs. Since this relationship had shown to be beneficial for providers in our observations,

returning the pod provided an advantage. Our team considered the idea, however, that spending more time in the pod increased the chance for providers to be distracted from their work by colleagues. This intuitively would be a problem, but our data did not capture enough of these interactions to confirm. We observed participants spent more time at work when they returned to the pod to document than providers that documented in the exam room.

1.2. Documenting in the Exam Room. Two of the observed providers completed the entirety of their patient documentation in the exam room during and immediately after the patient interaction. These providers had the benefit of having all the patient information available during their visit and completing notes more quickly. They were also less likely to forget information obtained during a patient interaction by documenting as they worked. A negative side effect of documenting in the exam room, however was the increased distraction from the patient interaction during a visit. It also left less time for the provider to think about the content of the note before locking it.

During shadowing, we observed that providers who documented in the room would complete all the work for a patient before seeing the next. Here we highlight this *benefit* of documenting in the exam room:

> Case 2: During one shadowing period, P4 saw three patients at the beginning of the day before turning on the computer in the pod space. She went directly from one exam room, to the next exam room without stopping to interact with any individuals. The researchers were unable to observe these patient interactions and the documentation associated with them, but P4 identified that the notes for all three patients were completed before touching the pod space computer. At this time the provider had not fallen behind on her schedule.

This process appears to be effective for completing documentation and seeing patients. Neither of these providers had to spend much additional time working on their notes outside of the time spent in the exam room. The only time P4 was observed working on

notes in the pod was when a patient arrived late and disturbed her workflow. Since these providers were inputting the information for the patient interaction into the EMR as the interaction occurred, there was very little time between the interaction and the providers documentation of the interaction. This meant the information in the SOAP note had an increased chance of being more accurate.

Providers documenting in the exam room had easier access to patient information during the visit because they were already working in the EMR system. We observed P4 check the immunization and histories for one patient during the visit, switching from the open SOAP note to the patient summary screen, then back. This provider would be more likely to check this information than providers who returned to the pod to document because she already completed the tasks of logging in and opening the patients records.

There were *negative* consequences associated with documenting in the exam room. The most problematic was the distraction from the patient interaction due to the provider being engaged with the computer system as shown below.

> Case 3: Before she began discussing the symptoms of the patient, P7 logged into the system and pulled up the patient's summary information. As they began discussing the problem, the provider started typing into the Subjective narrative section of a SOAP note about the encounter. As the conversation between the patient and provider continued, the provider kept documenting the interaction in the SOAP note, not verbalizing what she was doing in the system. Throughout the visit the provider conversed with the patient while looking at the computer screen.

We were unable to follow-up with patients and understand their perceptions of the computer usage. It was intuitively clear that the computer distracted from their interaction. Although P5 did not document in the exam room, she was able to clearly summarize the potential problem with documenting in the exam room:

> *Yes, I know that is the problem with the computer system - it just sucks you right in enough so that you move your focus. You move your attention to that. It takes attention away from the patient, whereas jotting notes does not.*

When a note was completed in the exam room, there was less time for the provider to review that note and think about any additional information that might be necessary. Occasionally the missed information would be necessary to have in the note, so the provider would have to make sure this information was added into the system. This EMR system did not make that easy, as demonstrated by the following case.

> Case 4: We observed P7 during a patient encounter complete the entire note for the visit. She used several templates while speaking with the patient then flushed out the note with a small amount of free-text and orders before locking the note in the exam room. Before the provider left the exam room at the end of the visit, she realized she had not input the lab order for this patient. She then had to append the locked SOAP note saying that a specific lab test was ordered and to refer to a second SOAP note for the details. The provider then had to open up a second SOAP note for the same visit, add some necessary diagnosis information required for ordering the lab test, complete the order, and lock this note.

In the end, what seemed to be a time savings, by documenting in the exam room, turned out to take extra time and create documentation clutter. The additional documentation did not add additional meaning to the visit, it only served to make sure the lab test was ordered and that the order was documented.

2. How Providers Document Patient Encounters

Figure 1 shows the two processes of *how* a provider documented their encounters - an iterative process or a single session of documentation. The figure also highlights the number of providers which adhered to the different methods - six providers used an iterative process and four providers completed a note in one sitting. When iterating on a note, providers would document a portion of the visit, then temporarily save the note, and

return to it later to complete it or add additional information, then save again. Providers following this process typically used more free-text narratives in their documentation. In the single sitting approach, providers worked through the note in a more sequential process and locked the note before moving on to another task. Providers following this process typically used more templates in their documentation.

It is important to note that although these providers completed the majority of their notes one way or another, no provider was 100 percent consistent in their approach to note completion due to the exceptional nature of medicine (ie patients arriving late, colleagues asking for advice, patients arriving to the visit with a laundry list of problems). All providers used some templates and some narratives, regardless of the way they completed their documentation. The associations between template and narrative use, and the way a provider documented were based on the majority of their interactions.

2.1. Iterative Note Development. Providers who iterated on notes completed some of the work on a note, then saved it to be added to later. Upon return, some notes might get completed, others edited and saved again for later addition. The process of adding and saving continued for an indefinite amount of time. Iterating on notes provided the *benefits* of building a more complete story by considering the encounter over a longer period of time and then creating more elaborate documentation to portray this story. This process had *negative* consequences because it built up a list of open items on the home screen, typically took more time, and increased the chance providers would forget patient information.

P10 preferred iterating on notes because of the time it gave her to think about the patient interaction. This was so valuable that the provider typically stayed one to three hours after her last patient of the day to further refine documentation. She said:

And actually at the end of the day or at the end of the morning, whenever I get around to the subjective [note], it doesnt take me that long, but going back to what I said earlier it has given me a chance to think about it in between.

To capture the additional details described above, the researchers observed more free-text style narrative documentation from providers that iterated on their notes. Although this study could not draw the conclusion that this additional information improves patient care there was a general consensus that it was valuable for care. P9 appreciated "[a provider's] thoroughness" when they provided additional narrative information about a patient. "[She knew] what [was] going on" with those patients after following a provider documenting details in complete narratives. P5 agreed that detailed narratives are so important "so that the next [provider] seeing the patient really has a meaningful description thats extremely precise of that person", allowing for a better overall healthcare experience and continuity of care. P8 explained that detailed narratives were imperative to be able to "trigger [their] memory" about their own past patients.

Providers that completed notes in an iterative process, also returned to earlier already completed sections of a note after working on another section. During individual interviews, researchers found later sections of the note reminded the providers of different aspects of the visit that they would then add to the appropriate section. This required a significant amount of scrolling and moving around in the note which was fairly time consuming. During an interview P2 summarized that the process was:

[Jumping to an earlier section of the note] was the result of remembering something pertinent while working on a later section. The biggest one she thought of during the interview was regarding a patient being new. She needs to charge and document a visit different based on patient being new or established and often needs to look to earlier sections to remember this

Jumping between sections may have helped remind the provider to add additional information to the note, but it also slowed down the providers documentation. This problem was not the only negative consequence of iterating on notes. Because all documentation notes, results, and messages appeared on the home page for a provider if they were temporarily saved and had not been locked they could accumulate on this screen. A build up of uncompleted notes and work items represented a primary concern when a provider iterated on her documentation.

> Case 5: P3 hesitated to lock notes after working on them. The practitioner would document as many as three different patient encounters simultaneously. The researchers observed the provider complete one section of one SOAP note, switch to another SOAP note and complete one section in that SOAP note, then switch to yet another SOAP note and complete a single section. After working on each note the provider would ”draft” the note. This would temporarily save the note for completion at a later time. As many as sixteen different notes persisted on the providers home screen because they had not been locked. These items pushed more recent matters outside the initial view of the home page.

The provider needed to scroll down in the home screen to see additional work items. Even more important, time sensitive work items were pushed outside the view of the provider if too many notes remained open. This represented a possible hazard to patient safety because providers might miss important labs or forget to finish a note. The issue stemmed from the failure of the EMR system to provide a reasonable sorting methodology. Additionally, when providers did not consistently lock their notes, more items appeared on the home screen making it more difficult to find important items.

The story of P3 above also exemplified a potential loss of time in an iterative note completion. By switching between different notes, the provider lost time navigating between screens to get to each note. In the EMR system studied, a provider would need to navigate through at least four screens, and make at least six clicks to get from one note to the next note. Over time this would amount to a substantial amount of time that had no direct correlation to the ability to treat patients.

Forgetting information because of iterating on a note over time has a similar process to that identified in the return to pod workflow. The choice of *where* to document and *how* to document both contribute to providers forgetting information. P5 identified her process of iterating on notes that was high risk for forgetting information:

What tends to happen is that I get as far as I can in the note and I try real hard to do the physical exam because I'd forget that ... I put the history notes in, and then whenever I get time I go back to the note and theres a list of open notes. And I just open the note, scroll down and find where I was and go back in.

This provider understood that some parts of the note were more at risk for forgetting than others. In this case, and for most providers, the details of a physical exam, which were documented into the objective section, were more likely to be forgotten.

A small note: P3 did not use significant narration in documentation, although heavily iterated on notes. This formed an outlier case for providers iterating on notes. The five other providers conformed to the concept of heavy utilization of free-text narratives in patient documentation.

2.2. Completing Documentation in One Sitting. Some providers chose to complete a note in a single sitting from top to bottom. This process *benefited* providers by limiting the accumulation of notes on the home screen and allowing providers to quickly complete documentation to move on to the next patient interaction. It presented *problems* because notes created in this way were less likely to have the rich narrative details found in iterated notes.

We observed P1 and P7, both providers who documented in one sitting, had very few items on their home screen. The struggles of providers, such as P8, who documented iteratively demonstrted the value of closing notes quickly by documenting in one sitting:

> *It still is easy to miss things, you know phone calls that are coming in. there is a lot of stuff that doesnt need immediate attention, like the open template, the template that somebody fills out today for an appointment tomorrow. I would rather not see that. It just clutters my screen. And potentially I miss a phone call or I miss a forwarded note from a nurse or something like that which really does need to be paid attention to.*

Providers who documented in one sitting had less open items present on the home screen, making it less likely to have important items pushed off the screen.

Some providers would complete every section in the order it appeared, which intuitively seemed like an efficient process since it supposedly followed the cognitive process for patient interactions. We observed providers were able to close more open work items and completed their documentation quicker than providers documenting by iteration when they documented in one sitting. We observed that P1 would return to her pod after seeing a patient, then begin the note. She would complete each section in the order S-O-A-P, and then lock the note upon completion. This provider spent noticeably less time documenting visits than individuals that iterated on their notes. She left the office sooner than her colleagues who had documented iteratively because she completed her documentation in a more timely manner.

The provider relied more heavily on templated data entry in order to complete patient documentation so efficiently. The simple interaction of clicking check boxes to identify symptoms, concerns, or physical examination allowed templates to be completed quickly. Templates also reminded providers about parts of an examination they may have forgotten to complete, or questions they forgot to ask for a patient presenting with a specific set of symptoms. P2 stated she would be working through a template and see a question that reminded her about a piece of educational information handed to the patient, or a prescription she wrote by hand but did not document. The template increased the chances that the provider documented all of the care provided to the patient.

Using templates typically minimized the amount of narrative information existing in these notes. The templates could capture most of the information from the visit and a provider may feel a narrative is not necessary. As discussed above, narrative data provided rich patient information, much of which directly influenced a patient's care. Templated data entry could not capture every detail about a patient, so pertinent patient history may escape a provider without detailed narratives. Although P8 did not follow the "complete documentation in one sitting" workflow, she explained the weakness in relying on templates and why she used narratives:

I tend to write a narrative with a cold anyway, because it sort of personalizes it for me, so it helps me remember and understand who the person was and maybe get a sense of how sick they are. Whereas I dont think the templates adequately capture that

This points to a problem with utilizing *only* templates for documentation as was observed in a small portion of providers. Their notes may not be useful at a later date, especially if seen by another provider. Providers found it frustrating when they pulled up the past notes of their next patient and found no details to build a story of what happened during the last visit.

3. What Tools Are Used to Document Patient Information

The providers voiced two primary complaints during our study in regards to the EMR itself. The first was that they were often presented with too much information. The other was that they were unable to access some of the information in the system when they actually needed it. When providers are unable to access all of the pertinent information for a patient, or are unable to identify the pertinent information, there is an increased risk of adverse outcomes [23]. Our team did not observe this problem across all EMR features. The SOAP note data entry form and patient summary screen were two specific screens in the EMR that presented the most common difficulties for the provider in terms of their information presentation and accessibility.

3.1. SOAP Note. The major usability concern identified with the SOAP note was the excessive data entry requirements. The whole note felt overwhelming because it required large amounts of scrolling to move around it. Every section of the note contained a free-text input field which consumed a lot of the screen real estate. P4, P8, and P10 were observed struggling with scrolling to the correct section of the SOAP note, each of them deploying different navigation methods. P4 [*scrolled*] *by dragging the scrollbar even though* [*the provider had*] *a mouse wheel to scroll through*. We later found out that because of the software implementation some sections of the EMR did not allow scroll wheel interactions, while others did.

> Case 6: P10 used tab to navigate down a long note, but would often overshoot the target field and be forced to scroll back manually. The provider became frustrated with the amount of movement around the note to get different information so she kept a pre-developed narrative assessment in a Word document. When documenting a physical exam, the provider would edit the Word document template to fit the current patient, then copy and paste it into the EMR. While editing the Word template the provider kept the subjective section visible in the EMR window to reference information. A useful spell checking system and the easier interaction with Microsoft Word were cited as the main reasons for using this process.

This provider developed a workaround because the system did not support the interaction she desired. The idea of working around problematic EMR interactions was a common observance during our study. Some interactions, such as entering diagnosis codes, required paper workarounds because there was no electronic solution available. The diagnosis code entry field found in the assessment section of the SOAP note was intended to support providers typing a word relating to the diagnosis, then hitting return. Immediately the EMR would return all possible diagnosis the provider might use in a window below the field. Our cognitive walkthrough, in Chapter 6, identified multiple usability concerns with this task. It was possible the provider might not have seen the diagnosis she looked for in the first place. Even when a provider would find the correct diagnosis in the list she may not have recognized it as the correct diagnosis for the patient since the naming was inconsistent and often confusing. If the diagnosis was stored in the database under a different name, or it was an abbreviated form of the name, and the provider typed the entire name, she would not see the desired result.

> Case 7: P5 consistently had trouble adding diagnosis to her patient documentation. On one occasion she tried more than 5 different text inputs to try and find a diagnosis that would match her needs. When

> she typed in ”ankle”, the system presented a list of too many possible diagnosis that she would have had to look through to pick the correct one. When she typed ”sprain” into the field, the system presented her with a list that was longer than before. She tried a few more different strings to try and find the correct diagnosis before returning to the input of ”ankle”. The system forced her to pick a diagnosis that she claimed was ”close enough”.

This presents a problem since the diagnosis entered by the provider partly determines the ability to bill a patient. P8 gave an example of her difficulties and paper-based workaround she has used:

> *Yes, it is because I [do not] find typing in this EMR that you get what you are looking for ... Well the cheat sheet I use is by systems, so here is the GI list, here is the cheat sheet of the 200 most commonly used codes probably that is put out by the American Academy of Family Practice and it is by system or symptom ... an example from this morning, I am seeing somebody because he had an abnormal chest x-ray and there is a code to follow up an abnormal test. How do you find that? I dont know, so that is when I look at that cheat sheet.*

P5 provided his interpretation of the method behind the mechanism:

> *... if you put in the word fever and there is actually a code for fever, you get I think six choices or something to start with. It is eighth, so you actually have to scroll down, you just typed in fever. You have to scroll down to get to the one that says fever, because there is Scarlett fever and rheumatic fever and it goes through a bunch of other ones first.*

Both quotes conveyed the extra work required to find correct diagnosis codes. Sometimes the system would return the desired diagnosis code, other times it would require using paper tools or multiple attempts. An update to the EMR system sought to alleviate this problem by allowing providers to add diagnosis from lists grouped by type or area of injury/illness. Once a list of a certain type was selected, specific diagnosis codes could be

selected from these smaller subsets. Only 1 provider consistently used this feature. The rest of the providers claimed to not have time outside of seeing patients and generating documentation to learn new EMR features.

The researchers observed an inefficiency in the way providers had to document office visit (OV) levels for billing purposes. Within a "Procedures" field in the *Plan* section of the SOAP note the administration requires providers document the level of care provided to the patient. Although three providers directly expressed frustration at the process of documenting office visit levels, we observed one provider struggle. There was no clear indication as to whether a patient was a new patient to Wardenburg of not. To document correctly, P6 had to temporarily draft the note in progress, to switch to the patient summary screen to check if the patient had a visit history at Wardenburg, then return to the SOAP note and document the OV level based on that.

P8 clarified the process for documenting the office visit level for a patient interaction. She also identified that there are standards by which to document this information defined by The Center for Medicare Services, which is a federal guideline. P8 seemed confused why the system could not automate this process if there were standards for the visit level. This would further decrease the amount of non-patient centric work required of the provider.

> *There is a category for new patients and a category for established patients and the numbers are 99211, 99212, 213, 214, 215 and so it is [pause] level of complexity, how much history you gathered, how detailed the exam was, how much data you had to analyze, did you order an x-ray, is there lab data, did you prescribe a medicine. It all increased the complexity of the visit ... So in an ideal world to code a level four, you need six symptoms and an exam that has ten elements. So the ideal system counts those for you and suggests a coding level.*

3.2. Patient Chart. The patient summary theoretically presents a picture of the current status of a patient's health and care history. We have seen that this record may contain inaccuracies and be out-of-date. Within the patient chart is a summary screen that provides

a quick snapshot of some of the most important information about a patient. One of these sections is the discontinued and current medication lists. P2 had problems using the information on these screens:

> *The lab results from patient summary screen is overwhelming and busy. Discontinued medications should be hidable or on a different screen that it is linked to. If a patient has had a long history with Wardenburg, they may have a discontinued medication history that is just huge ... Education bulletin history could be removed. Standing orders could also be removed. The current medication list is based on prescription but does not actually tell the "story". An example being a patient prescribed 1 mg and 5 mg of a med but overall the dosage is 12 mg daily. The fact that the patient was prescribed 1 mg and 5 mg tabs is not useful, the fact that they take 12 mg total daily is useful.*

From this provider's explanations, it became clear that human-error and software deficiencies both contribute to the problem. The clinic does not adhere, even if it were defined, to a strict policy in regards to who, when, and how these lists should be managed. In this case the ability to retrieve information from the system relies on the quality of information entered into the system. The system did not provide the proper tools to manipulate the data into a meaningful form without manually doing calculations, such as the medication dosage to a patient. It also failed to provide a way to suppress certain information at a useful granularity when it got out of control. At the time of the study the system only allowed providers to set preferences for all the notes they view, not per note.

Within the patient chart, providers could access lab results for studies completed at the health facility. The lab staff and systems documented this information in the EMR automatically, without the need for provider interaction. Providers did access this information on a regular basis. One theme persisted from all the providers; the idea of correlating lab results with other patient information. In medical practice, a flowsheet fits this need of providers. In the EMR, however, there was no way to view lab result

information and other patient information at the same time. Two workarounds arouse in this clinic to alleviate the problem.

P2, P5, P9, P10 kept permanent paper flowsheets that allowed them to track patients with chronic diseases or medications that needed to be tracked.

> Case 8: We observed P5 working with a flowsheet for a patient taking Coumadin, a blood thinner which required tracking dosages and a lab value known as INR indicating the effectiveness of the drug. It was impossible to get this information out of the EMR in a usable format, so the provider manually put all of the visits with the patient, the dose of medication at that time, and the INR lab value at that visit, into the flowsheet. The flowsheet even included a table of dose references at the bottom that told the provider - based on the current dosage, the current INR value, and the desired INR value, adjust the medication dosage to a certain value.

The other option was seen by almost every provider observed during our study. They wrote the information from the lab result screen on a temporary piece of paper then switched to the patient medication history to cognitively correlate the values. Our team did not observe any providers document the outcome of these cognitive reviews in the permanent electronic medical record.

4. Summary

Providers documented in different places. The majority of providers returned to the pod to document, allowing them to craft more elaborate narratives to capture complex patient information. Additionally these providers were not distracted by the EMR system during patient encounters and were more present in the pod space to collaborate with their MA and other colleagues. Providers who documented in the exam room finished their notes more quickly and were less likely to forget patient information in their documentation.

We found that providers that documented in the pod space were able to prioritize care over the demands of administration. They had more time to craft comprehensive notes that supported quality care and were able to collaborate more readily with colleagues. Providers that documented in the exam room were able to finish their documentation more quickly, increasing the throughput of patients and allowing patient encounters to be billed more expediently.

Providers documented in different ways. One group of providers iterated on their notes over a period of time. This methodology allowed providers to give more thought to narrative free-text notes in their documentation and ensure time to review all potential diagnosis. Another group of providers completed notes in one session. This methodology allowed providers to close their notes more quickly, and spent less time documenting patient encounters.

The different EMR tools used by all providers, including SOAP notes and patient charts were difficult to use by providers. The usability concerns with these interfaces drove providers to develop EMR system workarounds to improve documentation and develop workflows that allowed them to document as much patient information as possible.

8

Design for Care : Discussion and Recommendations

Based on the plethora of research on EMR usability and pracitioners' experiences with various EMR systems reported to the researchers in this study, we acknowledge that there is not an ideal EMR system. Since EMRs are expensive to adopt [28], we suggest short-term solutions to problems identified in this study. Additionally, we conceptualize long-term design goals to move the community closer to an ideal EMR system that meets providers' needs.

Providers wanted to document patient encounters to improve patient care - in a sense, documenting for care. We assert that the EMR we studied did not support capturing or

interacting with rich patient information; instead it was designed to document procedures and diagnoses for efficient patient categorization and administrative processes. In the best interest of the patients, the providers' attempted to overcome the limited input capabilities by creating excessive free-text narratives to capture complex, psychosocial patient information.

To accomodate documenting for care in the current system, we found that providers' needs were best met when they *returned to their office space (pod) to document and iteratively created elaborative narratives.* Unfortunately, this was not an ideal solution without sophisticated natural language processing. Although free-text narratives captured patients' current health state, they were not easy to use for long-term care because providers do not have time to sort through a lifetime of narratives.

A long term goal would be to rethink the EMR as a system that *captures as much patient information as possible, stores the information in small discrete units, and allows interactions with discrete pieces of information being linked together*. Our system must *give providers an expanded toolset to capture as much information about the patient as possible in a structured format*. This information could include pertinent medical information, psychosocial information [34], personal information, and information from outside healthcare facilities. Psychosocial information can be patient-generated in the case of Personal Health Records or provider-generated through patient interactions [34]. Researchers have implored the design community to include psychosocial information in EMRs to improve patient care [34]. Based on our results we refine this request and urge the community to make psychosocial information not only accessible when demanded by the provider, but also available to link with medical data to improve the trajectory of care. The need to consider this information as part of the medical record implies that there must be a process for storing, retrieving, and linking this data. However, there must be more research in the translation of qualitative personal health information to current quantitative medical standards.

To this end, information should be *stored in the smallest representational unit possible*. For example, a provider might order a batch of lab tests to help diagnose a patient problem. A smaller representation would be the specific lab tests, such as a complete blood count

(CBC) and a basic metabolic panel (BMP). An even smaller representation would be the specific lab values tested within that test, such as a sodium level in the basic metabolic panel. The sodium test and its result should be represented as a distinct object. The other values in the CBC and BMP should also be represented as separate distinct objects as well.

This process would *allow the smallest informational objects to be linked with each other based on the providers needs at the point of patient care*. This model represents a dynamic information linked EMR system as opposed to the static data repository model that persists in EMR systems today. Once information pieces are linked together, providers could draw diagnostic and prognostic conclusions based on the information.

An implication of providing access to a large set of patient data that can be linked together in a nearly endless number of ways is providers may have difficulty understanding data relationships. The challenge is determining meaningful interactions with the information and how to guide providers to having meaningful interactions. We considered a rule set to guide and control interactions as one possible approach to the problem. Utilizing context based views of the information is a well documented approach to presenting information. This means, for example, a patient with a history who is over 40 years of age, and a 20 year old individual with no pertinent medical history would have different information presented. More research would need to be done to identify what information providers might want linked together to support patient care.

Another implication of having a large set of data available is that there an increased risk of overloading providers with information. From a design perspective, we need to explore how to visualize a lifetime of data, or an long list of tests. We also need more research to develop a more effective process for providers to capture psychosocial data beyond free-text narratives.

1. Managing Flowsheets

Correlating lab results and medication dosages over time was an example of where we could apply dynamic information linked EMRs. We identified this need by observing the interations with physical flow sheets documented in Case 8. Paper flowsheets were

tedious to manage since values had to be manually transcribed from the EMR. They had limited impact because individual providers managed the flow sheets and other providers would not easily be able to share this information.

A short term improvement to the process of managing paper flow sheets problem would be to scan the paper flow sheets into the EMR so all providers can view the flow sheet for a given patient. An expanded *EMR should support storage of other multimedia and information outside the scope of basic text documentation*, which would help capture some forms of psychosocial information.

This improvement is not ideal, but the idea of a dynamic information linked EMR presented above could provide an ideal solution. In this model the physical flowsheet would be translated to an electronic version where a specific lab value, such as a drug marker level (e.g., INR with Coumadin), could be grouped from all the labs that included that drug marker level. The drug marker levels could be correlated with a grouping of medication information units based on date.

2. Managing Administrative Information

We acknowledge that it is necessary for providers to document treatment so that they can track their services. We argue, however, that treatment tracking for administrative purposes (e.g., office visit levels) should be automated as much as possible and separated from the documentation of care. For example, in the "what" section of our shadowing findings, we observed that providers manually input the office visit level into the documentation based on their perceptions of care. Since there is a guideline for documenting office visit levels, it can be automated.

A short term solution for administrative treatment tracking is to have *a dedicated, trained staff member to review patient documentation and procedurally generate the office visit level*. There would be a cost associated with having a dedicated individual do this task, but the individual would most likely be more accurate in billing for treatments because currently providers estimate their levels without reflecting on accuracy. A long term solution would

be *developing algorithms that utilize natural language processing and coded data to automatically generate office visit levels*.

9

Conclusion

1. Cognitive Walkthrough Study

We found this EMR system had significant problems supporting the input and extraction of data. The full cognitive walkthrough results in Appendix B point out specific problems in completing different tasks with regard to visibility, labeling, matching the intentions of users, and feedback. In Chapter 5 we summarized the results in a narrative form, describing usability concerns with the Home Screen, Patient Summary Screen, All Notes interface, Lab Results interface, and the SOAP note. Tedious information input interfaces slowed the documentation of patient interactions. We found the EMR failing to automate information input, which led to providers replicating their information input into the system.

The EMR system did not present information in a meaningful manner to providers. This forced them to search through various interfaces to find relevant information in order to treat their patients. We found that information was most useful to providers when it could be connected with other information, such as a treatment plan with treatment outcomes. The EMR system did not support this type of information retrieval.

2. Shadowing Study

In Chapter 6 we described the different workflow patterns of providers at the Wardenburg health center. More specifically, we described a difference in where and how providers document patient encounters.

Providers documented in either the exam room or their pod office space. Each different location had benefits and disadvantages. Documenting in the exam room allowed provider to completed documentation quicker, however documenting in the pod space allowed for providers to craft extensive narratives that identified the patient's problems and resolutions more completely.

Providers iterated on their notes over a several sessions or they completed their documentation in one sitting. As time passed between when a provider saw a patient and when the provider documented the visit, they had an increase chance of forgetting information, but they were able to develop more thorough narratives regarding their patient encounter. In contrast, providers that completed their note in one session were less likely to forget information, but had less details in their notes.

Our study had several limitations, which suggest further study of the EMR system, the practices of Wardenburg healthcare providers, and other facilities. The Wardenburg administration explained to our team that the volume of patients fluctuates throughout the semester. Our study took place during the last 5 weeks of the semester which may be significantly different from the beginning of the semester. The work habits would need to fluctuate to accomodate changes in patient volume.

Updates to the EMR system would also change the typical work patterns of individuals. Our study began two weeks after our host facility deployed a new update to the system.

This change added a useful feature called "favorites", which could change documentation behaviors. We observed that providers did not use this feature during our study. Some providers cited a lack of familiarity as their reason for not using this feature. It is possible that when providers became more familiar with the feature, that they would use it more readily and adjust their work process.

Although we found that providers notes were more detailed when they returned to the pod and iterated on their notes, we cannot claim that these notes were more effective for patient care or for other providers. Providers explained that they found detailed narratives of previous visits made it easier to see a patient, which suggested that the notes crafted by providers returning to the pod and iterating were more useful. Additional research into the readability and usability of notes created by providers following different work patterns would be required to verify this hypothesis.

We studied only a single EMR system at a single primary care facility. It is probable that other facilities would have different workflows and operational attributes. We cannot extend our findings with regard to the usability of the EMR system to other EMR systems without seeing those systems. We propose that, because many EMR systems are based on database-centric administrative systems, many of the same problems may exist in these systems.

3. Recommendations

We suggested that EMR systems need to be reimagined from the point of view of the users, the medical professionals utilizing the system. Reinventing the EMR will require additional research on the needs of providers across different facilities. This process will take time but will yield more effective systems than adding additional layers of functionality on top of already problematic software. In the meantime, we suggest that providers document in their office spaces and seek to capture as much information about the patient as possible with the tools at their disposal. We also suggest facilities utilize additional staff to offload administrative tasks, such as billing, from providers, so they

can focus on working with patients. Additional staff could also support scanning paper artifacts into the system to improve continuity of care for patients.

A

Acronyms

- EHR - Electronic Health Record
- EMR - Electronic Medical Record
- MD - Medical Doctor
- NP - Nurse Practitioner
- MA - Medical Assistant
- SOAP Note - A note used for documenting almost all patient encounters broken into the sections: Subjective, Objective, Assessment, Plan
- OV level - Office Visit level, referring to the tier of treatment that the facility can bill a patient based on the interaction with the provider

B

Cognitive Walkthrough Raw Results

Steps for Medical Assistant Tasks

Task 1: Set Patient As Admitted

Return to the Home Screen	**Match to intent** – The MA was just working on the patients record and SOAP note for intake, why wouldn't the next step be in the same place instead of going back several levels
Refresh Home Screen	**Match to intent** – The system can be unreliable in refreshing information on the home screen, in order to ensure the most recent information. The user will make the assumption most times that the information is updated and not think about this step.
Right click on Patient Listing	**Visibility** – Users may not think of, or have prior experience with, a right click menu. There is no indicator that a right click will bring up the menu that allows the completion of the task
Click on Admitted from Right-Click Menu	None

Task 2: Complete Patient Intake with SOAP Note

Check for Patient Completed Templates in "All Notes"	**Match to intent** – The patient completed templates should be accessible from the places the MA will already be intending to go. Not in an additional location.
Lock Patient Completed Templates	**Visibility** – This list of notes contains all the notes associated with this patient for all time, so it is difficult to find the specific templates that are created by the patient for this specific visit. **Match to intent** – The lock action is typically associated with work completed by the individual. This template was not completed by the MA, yet they have to lock.
Open New SOAP Note	**Visibility/Labeling –** The "SOAP Note" icon is in the upper right corner of the left navigation bar. It is hard to tell that the left navigation bar control items are actually clickable buttons at first. The left navigation bar is too crowded.
Add Patient Completed Template to SOAP Note	**Match to intent** – The user already reviewed this template, what would indicate they had more to do with this template, especially after locking it, which is typically a final action on an item. **Visibility** – The MA must already know ahead of time that the patient completed template can be found in the Subjective template dropdown. **Labeling** - There is no separate control for adding a patient template. There is no clear indication that a template in the list is completed by the patient, except by the fact that certain templates are typically completed by patients.

Tasks for Provider

Task 1: Review Upcoming Patients

Return to Home Page	**Match to intent** – More of a convenience piece, but the only good place for a provider to check their schedule is on the home screen. The schedule is a common piece of information a provider should always be able to view from any point. Maybe trying to locate the "Schedule" navigation control, which does not exist.
Use date dropdowns to set to current date	**Match to intent** – Unless this has been changed during that session, it will already be today's date. But it could have been changed which means the patient information would not be correct.

Task 2: Check Past Notes for Patient (Asthma Patient)

Double click on patient name on home screen to open record	**Labeling** – No indication regarding the double click being the action of choice to open the patient record. It is not clear that the record can even be open in this way.
Click "All Notes" from the left navigation bar	**Match to intent** – Provider is looking for past notes, yet they have to use the "All Notes" which includes many more notes than they most likely need. **Labeling** – Buttons on the left navigation panel are difficult to discern as control items.
Find notes relating to respiratory problems or asthma	**Labeling** – Notes are not well labeled, so it is impossible to find every note where respiratory problems and asthma were addressed without looking through the contents of all notes.
Single click on note to open it in lower viewing window	**Visibility** – Most interactions in the system use double click to open, which would work in this case, but it would open the note in a completely different window which does not match best practices workflow. **Feedback –** When the provider clicks on another note after finishing with the next, it is difficult to tell that the note has changed in the viewing window. There is no reloading indication, and the header of notes looks similar.

Task 3: Open Note for Patient Appointment from Patient Chart

After reviewing the patient notes, click on the SOAP note from the left navigation menu	**Visibility** – The note cannot be accessed in the right format from the "All Notes" section the provider might already be at, instead the provider must use a link in the left navigation bar **Labeling** – This note is not clearly indicated as the current note that was opened for the upcoming visit. It just appears as an open note.

Task 3 Alternative: Open Note for Patient Appointment from Home Screen

Double click on note in lower (pending items) section of home screen	**Visibility** – The note being the control is not clear, and the double click action is not clear either. **Feedback** – The provider is not at the note yet, and there is no indication of the next step to get the note open.
Provider clicks on the SOAP note from the "Open Notes" section of left navigation menu	**Match to intent** – The provider clicks on the note from the home screen, yet the note did not launch, instead another step is taken. Why open the note again to actually get the note? **Labeling** – May be difficult to find the correct note, if there are multiple notes. There is no labeling indicating this as the note for the visit that the provider should use.

Task 4: Enter Subjective Data for Patient Visit

Review patient completed subjective template	**Visibility** – The template listing for the subjective section is above the subjective heading so it is not clear that these are the subjective templates
Type information gathered from patient into "Narrative" box of "Subjective" section	**Feedback** – After typing into the field the provider does not complete any actions, there is no submit for this section, or lock for this section.

Task 5: Enter Objective Data for Patient Visit (Throat, cough, nasal congestion)

Select "MC – A Basic Illness Exam" from Template dropdown next to "Objective" heading	**Match to intent** – Provider is simply trying to get information into the document, may not think of template as a way to do this effectively, more obvious to just type **Labeling** – Many templates to look through, and many descriptors may not be clearly identifying the control as the one the provider is looking for **Feedback** – After selecting the template nothing occurs. The next step is required before anything actually happens.
Click the plus icon next to the dropdown	**Labeling** – Not clear that this icon adds the template to the note, looks more like a click to see more options
Click Checkbox next to "Well Developed, well nourished, A&O, NAD" for "General Appearance"	**Labeling** – (This feedback on this set of template questions is he same for the rest of the questions in this template in the rows below) There are too many options for these templates for providers to complete. Some of the options are replicated. "Warm and dry, no lesions, no rashes" as well as "No lesions", "No rashes", "Warm and dry" are all options that can be selected. This makes the template excessively long, and more difficult to read; Abbreviations found throughout the template make it difficult to quickly figure out which options to select, some providers might not use the same abbreviation, which destroys extensibility.

Click Checkbox next to “Ill appearing” for “General Appearance”	
Click Checkbox next to “Warm and dry, no lesions, no rashes” for “Skin:”	
Click Checkbox next to “EOM-I, PERRLA”, “Clear eyes: no discharge, no erythema”, “Bilateral normal” for “Eyes:”	
Click Checkbox next to “No cerumen impaction”, “Left “Right abnormal” for “Ears:”	
In the pop-up generated for “Right abnormal”, click Checkboxes next to “Erythema” and type “Red and warm, difficult to see inner ear”	
Click submit at the bottom of the pop-up window	
Click Checkboxes next to “Left normal” and “Right abnormal” for “Tympanic membranes:”	
Click Checkbox next to “Erythema” in the Pop-up for “Right abnormal” section	
Click Checkboxes next to “Nares patent, mucosa pink and moist”, “No polyps, lesions or performation”, and “Septum midline” for “Nasal Passages:”	
Click checkbox next to “No sinus tenderness” for “Sinuses:” section	
Click the checkboxes next to “Bilateral abnormal” for “Oropharynx:” section	
In the pop-up generated for “Bilateral abnormal”, click checkboxes next to “Red”, “Tonsils enlarged”, and “Postnasal drainage”	
Click submit at the bottom of the pop-up window	
Click checkbox next to “Neck soft and supple with FROM”, “No thyromegaly”, and “Abnormal:” for “Neck Exam:” section	

In the pop-up generated for “Abnormal:” click checkbox next to “Adenopathy”	
Click submit at the bottom of the pop-up	
Click checkboxes next to “Respirations are even and unlabored, CBTA, Good ait entry” and “Abnormal:” for the “Lungs:” section	
In the pop-up generated for “Abnormal:”, provider clicks checkbox next to “Strong retching cough”	
Click submit at the bottom of the pop-up	
Click checkboxes next to “Regular rate and rhythm” and “S1, S2 without murmurs, rubs or gallops” for the “Heart:” section	
Click checkboxes next to “Active bowel sounds throughout”, “Soft and nontender without rebound or guarding” for the “Abdomen:” section	
In the text input box labeled “Other narrative:”, provider types information about cough and throat.	**Match to intent** – Provider is using this template to quickly click through and complete documentation, not intending to add text. There is also a narrative outside of the template that is used by most providers, do not need double.
Provider hits “Submit” at the bottom of the template	

Task 6: Enter Diagnosis (Swelling and Ankle Pain, Heartburn)

Uses dropdown labeled “Dx Groups” to select “MskFractur”	**Labeling –** Title may lead user to think that the menu will allow the addition of an entire group of diagnosis. **Feedback** – After clicking on the desired dx group, the name is populated in the dropdown, but nothing else changes **Visibility** – There are a lot of diagnosis groups from the list of diagnosis groups, which makes it hard to find them. **Labeling** – There are several diagnosis groups that begin the “Msk” which makes it hard to determine the exact type of grouping the provider might want
Click plus icon to launch a	**Match to intent** – After already selecting from a dropdown,

selection pop-up	not clear that this very small icon is required to actually launch the selection menu
Click checkboxes next to “FX ANKLE LATERAL MALLEOLUS” and “STRESS FX METATARSALS” from list	**Visibility** – The list is not well sorted, and it becomes difficult to find the different diagnosis one would want from the long list. One may expect alphabetical or a body systems approach but there is no sorting.
Click “OK” at bottom of pop-up	
Uses dropdown labeled “Dx Groups” to select “PAIN”	**See dropdown usage in first step.** **Match to intent** – Why would the provider need to go to another diagnosis group to find the pain option. Most fractures are painful so why is this option not found there? Provider may skip adding this diagnosis.
Click plus icon to launch a selection pop-up	
Click checkbox next to “PAIN JOIN ANKLE/FOOT” from list	
Click “OK” at bottom of pop-up	
Type “reflux” into the “Dx Groups” field “4.” and hit return	**Match to intent** – Other menus have dropdowns to add, this however is an empty text field with no prompt to type a keyword in order to get a listing of diagnosis. **Feedback** - After typing there is no response from the system, no preview of results, only after hitting return is this available. **Labeling** – Typing gerd, gastro, acid, or other tag words would not retrieve the right code, so it is up to the provider to know to type those exact words.
Click code “53081” with label “Esophageal Reflux”	
Clicks box with green check mark once to switch it to display a question mark	**Labeling** - It is not clear that this is a control. Even if the provider knew this was a control, how would they know what each of the two settings meant without any clarification or labeling. A question mark and a green check mark could mean anything.
Type details to support diagnosis in “Narrative” field within the “Assessment” section	**Visibility** – Difficult to determine if this free-text field is for the assessment section, since the section heading is not obviously associated with this

Task 7: Check “up to date” database for practical guidelines

Type “up” into “Procedures” field of “Plan” section	**Match to intent** – No reason to think a provider would type into the procedures field to get clinical support information
Hit return	**Feedback** – As soon as the provider hits return the system sits there for several moments while launching the web browser pointed at the website but at first no reaction from

	system
Use web browser that is launched	**Match to intent** – Provider is trying to research a condition, but they are forced to go outside their EMR environment to get this information. Information should be available within EMR

Task 8: Add treatment set to document treatment process (URI and Kidney)

Select “RENALPROF” from dropdown labeled “Treatment Sets”	**Labeling** – The name treatment set does not clearly identify the purpose of this menu **Feedback** – After selecting the desired treatment group nothing occurs, requiring additional input which is not clearly described **Labeling** – The RENALPROF title is confusing; instead “Renal” seems sufficient. The names for different treatment sets in this list are not consistent.
Click plus icon next to dropdown	**Match to intent** – After already selecting from a dropdown, not clear that this very small icon is required to actually launch the selection menu **Labeling** – The plus icon does not look like a control to be used, and doesn’t identify the goal
Click checkbox next to “BMP WHC”, “CREATININE WHC”, and “Urine Dip WHC”	**Labeling** – Very little to no description for each of these options, just the information conferred in the title.
Click “OK” button	
Select “Clean Catch Midstream Urine” in Urine Analysis Pop-up	**Match to intent** – The provider has already selected the urinalysis option and moved on. Then at this later point they need to add information about the exam.
Click “Submit” button	**Feedback** – Provider is placed at a window that has the lab information on it, with no prompt regarding what to do.
Click “Lock” at the bottom of the form	**Match to intent** – The provider already clicked “submit” for this lab, but they are required to lock it as well.
Select “URI” from dropdown labeled “Treatment Sets”	**Feedback** – After selecting the desired treatment group nothing occurs, requiring additional input which is not clearly described
Click plus icon next to dropdown	**Match to intent** – After already selecting from a dropdown, not clear that this very small icon is required to actually launch the selection menu **Labeling** – The plus icon does not look like a control to be used, and doesn’t identify the goal
Click checkbox next to “OV Est Level 3”, “Cold Care Kit Given”, “Instructed On Details Of Condition”, “Instructed On Medication Use And Side	**Match to intent** – The provider is trying to select their treatment for the patient so selecting the charge level for the visit is out of place **Labeling** – The descriptions for the different office visit levels

Effects", "Culture Throat WHC", and "Zithromax"	are not clear, requires outside knowledge on how to bill (which providers should have) **Labeling** – The documentation of instructions and the cold care kit are under the procedure section, even though they are not really procedures.
Click "OK" button	
Click "Add" at the bottom of drug Interactions pop-up	**Match to intent** – Not enough direction on what to do nor the intention of this list. Provider may completely ignore it.
Provider completes prescription pop-up form	**Match to intent** – The provider just submitted the whole treatment set, but is now prompted to complete information about the prescription instead of when they add it **See the "Enter Pharmacy Orders"**

Task 9: Enter Lab Orders

Types "glucose" into the field labeled "Lab Orders" in Plan section and hit return	**Match to intent** – This is always found in a SOAP note or a progress note, so to order any lab you will always need a SOAP note. Questionable whether it makes sense to not have a stand-alone lab order. Appears to effectively fit the patient documentation workflow **Feedback** - After typing there is no response from the system, no preview of results, only after hitting return is this available
Selects "GLUCOSE RANDOM WHC" from small list generated under input field	**Labeling** - There is a "Glucose Random WHC", "Glucose 2PP WHC", "Glucose Fast WHC", "Glucose Gestational 1 hour 50 Gr Load" generated from the glucose input that need to be selected. Should be clear when each is used. Maybe highlight most common.
Types "CMP" into the field labeled "Lab Orders" in Plan section and hit return	**Match to intent** – The text you have to type does not match the intuitive search terms one might use, "metabolic", "complete", "panel" **Feedback** - After typing there is no response from the system, no preview of results, only after hitting return is this available

Task 10: Remove Lab Order

Before saving a note	**Match to intent** – It is unreasonable there the providers would expect saving a note to render a lab order to the lab. They would expect this to happen as soon as they add the lab. However they might also expect that the note is a temporary device that can be edited and changed. So the fact that the lab becomes irremovable after saving is very concerning.
Click black "X" icon to the left of the order in the list of lab	**Labeling** – Not clear that this X icon is a control since it is built into the lab listing. There is also no indication that this control,

orders	would be used to delete.

Task 11: Enter Radiology Order (Ankle and Ribs)

Type “ankle” into text input field labeled “Radiology Orders” and hit return	**Match to intent** – No guidance on using the text input field to find orders to add. No indication to just type and hit return to add.
Type “ribs” into the field labeled “Radiology Orders” and hits enter.	
From the list generated they click “Ribs Bilateral W/Pa Chest Min 4 Views”	**Visibility** - The descriptions of the three options for rib x-rays go outside the view because the space allocated for descriptions is small. This means that they have to either resize the window, or hover over the name if they notice this is an option.

Task 12: Enter Pharmacy Order (Acid Reflux)

In the text input field next to the “Pharmacy Orders” heading the provider types “nexium” and hits return	
From the list generated select “Nexium 40mg DR Cap”	
Click on the “Severity” heading in the “Medication Interactions” pop-up to move most important interactions to top, then review list by scrolling through	**Match to intent** - More importantly; the list is sorted from least severe to most severe. The severe interactions and by far the most important to concern with, so it should be sorted in that way. The provider would not think to sort by severity, and may never think to scroll down to see the severe interactions. **Visibility** – There are so many medication interactions for most medications that it is difficult to find the truly important interactions
Click “Add” at bottom of interactions menu	
Select “Oral” from route dropdown	**Match to intent** - However there is no reason to think this should be done at all. There is only one-way to take this medication, why do I have to sort through a list to find the route?
Select 1 Times per day” from “Freq” dropdown	**Visibility** - The list is really long, with no reasonable sorting methodology **Labeling** - There are several different spellings, capitalization patterns, and formulas that are actually the same thing. How is the provider to know which of these is the correct one? **Feedback** - after selecting one of the options it gets put into the field, but nothing changes with the prescription itself. It

	does not get propagated to the prescription as a whole, it is still only the freq.
Types "30" into the "Dispense" field	**Visibility** - This control is at the bottom of the screen, and to be honest doesn't look like it is even a part of the RX. **Labeling** - On top of that, there is not enough description to know this is where you put the quantity of the medication to be dispensed, no indication to put a number here. Also there are up and down controls, so the provider may think they need to use those to input the number, when in truth then can quickly type the number into the field.
Types "Capsule" into the "UOM"	**Match to intent** - There is little reason to think to set the unit of measure for a medication, especially when it only comes in pill form. The majority of meds only come in one form. **Visibility** - The field is at the bottom and difficult to find **Labeling** - The dropdown is labeled UOM – not a very good acronym, many people may ignore it
Uses arrow controls to set # of refills to 3	**Visibility** - This is mainly problematic because refills are very common in prescriptions yet it is in the furthest most obscure corner of this screen. **Labeling** - It is also just a simple check box at first which may make providers think that it is not the control they are looking for at first. Once the box is checked the other fields become visible and it is pretty clear at that point.
Uses dropdown calendar to set the expiration date a year from today	
Click "OK" at bottom of prescription form	
	An additional problem across the entire pharmacy screen, is that there seems to be no method to the listing of information. The actual prescription information is towards the bottom of the screen and there are plenty of other fields that look like fields to be completed for the prescription itself. There is a large field for the favorites, and a large field for the allergies and current meds in the center. These should be on the sides and the pharmacy form itself should be centered. There should probably be a complete prescription form that has all of the pieces (route, freq, desc, dispense, UOM) in one place so the provider can see the complete version of the rx as they built it, and can review it as a whole to ensure it is all together.

Task 13: Enter Referral (Allergy)

Types "allergy" into the field	**Labeling** – Potentially difficult to find if you type the wrong

labeled “Referrals” in the “Plan” section and hits return	seeding phrase. Immunology may not actually give you the same.
Clicks on the option labeled “Allergy and Immunology Out” with the code “AllergyImm”	**Labeling** – There is more than one allergy/immunology option listed in the table, they seem like a replica but makes it confusing.
Checks the fields for first name, last name and SID to ensure they are correct	
Types working diagnosis into “Diagnosis” section	**Match to intent** – There most likely was already a working diagnosis assigned to this patient, why can’t that be auto populated like name
Select “Allergy and Immunology” from “Speciality referred to:” dropdown	**Match to intent** – Provider clicked on the allergy and immunology referral at the beginning, why do they need to select it again?
Selects “Referral Start Date” from calendar dropdown if different from today	
Selects “”Consult and treat” from dropdown labeled “Referral services requested:”	**Labeling** – The prompt for this control is not clear what it accomplishes without looking at options in the dropdown.
Types additional details into “Comments:” field	
Clicks “Lock” button at bottom of referral	**Match to intent** – Why would a provider think to lock a small piece of their note, typically locking is more relevant to the overall note.
Clicks “Close” button at bottom of referral	**Match to intent** – Locking would end the ability to work on the note, so it is no use to remain open. Should either lock or close.

Task 14: Add a pharmacy order to quick list (Nexium)

In the text input field next to the “Pharmacy Orders” heading the provider types “nexium” and hits return	**Match to intent** – Provider is required to open up a note, just to be able to set his or her own system setting. There should be a menu for changing settings separate from the workflow of documenting a patient.
From the list generated select “Nexium 40mg DR Cap”	
Complete pharmacy order as normal	**See *Task 12: Enter Pharmacy Order***
Cicks the “Set Rx Default” buutton	**Labeling** - This control label is not indicative of its purpose, it does not make it clear that this will add it to the favorites list. It may be mistaken for using the default or the name default will make them think that it will make it a default for all providers which would break it for other people
Click “Cancel” at the bottom of the Pharmacy window	**Feedback** – After hitting the “Set Rx Default” button the provider gets no feedback. There is no way to know at this point they should just cancel the order and then get rid of the note.

Task 15: Order Education Bulletin

In the text input field labeled “Education Bulletins” in the “Plan” section, the provider types “depression” and hits return	
From the list that presents the provider clicks on the item labeled “EDGRIF DEPRESSION”	**Labeling** – Three different depression bulletins, none have clarifying enough names to know which one would be correct without opening them. **Feedback** – After clicking the adobe program launches, but there is no indication whether or not the bulletin actually printed. No way to know if they should continue to the next step or are done.
In the adobe acrobat program that launches, the provider selects file -> print, selects the correct printer and then clicks print	**Match to intent** – The provider is removed from the EMR to acrobat, when all they wanted was to order and print an education bulletin.
Close acrobat using the red X at top right corner	**Match to intent** – User needs to return to the EMR, but there is no “return to emr” option. They are left to figure out that they need to close the adobe program, and that closing it will not end the session. Both may be points of contest.

Bibliography

[1] Tams analyzer. `http://tamsys.sourceforge.net/`.

[2] A. Alapetite, H. Bojeandersen, and M. Hertzum. Acceptance of speech recognition by physicians: A survey of expectations, experiences, and social influence. *International Journal of Human-Computer Studies*, 67(1):36–49, January 2009.

[3] G. J. Arvary. The limited use of digital ink in the private-sector primary care physician's office. *Journal of the American Medical Informatics Association : JAMIA*, 6(2):134–142, 1999.

[4] J. E. Bardram. Activity-based computing for medical work in hospitals. *ACM Trans. Comput.-Hum. Interact.*, 16(2):1–36, 2009.

[5] T. Brinck and G. York. User interfaces for computer-based patient records. In *CHI '98: CHI 98 conference summary on Human factors in computing systems*, pages 214+, New York, NY, USA, 1998. ACM.

[6] W. Chan. Increasing the success of physician order entry through human factors engineering. *Journal of healthcare information management : JHIM*, 16(1):71–79, 2002.

[7] Y. Chen. Documenting transitional information in emr. In *CHI '10: Proceedings of the 28th international conference on Human factors in computing systems*, pages 1787–1796, New York, NY, USA, 2010. ACM.

[8] E. G. Devine, S. A. Gaehde, and A. C. Curtis. Comparative evaluation of three continuous speech recognition software packages in the generation of medical reports. *Journal of the American Medical Informatics Association : JAMIA*, 7(5):462–468,

2000.

[9] R. B. Elson and D. P. Connelly. The impact of anticipatory patient data displays on physician decision making: a pilot study. *Proceedings : a conference of the American Medical Informatics Association / ... AMIA Annual Fall Symposium. AMIA Fall Symposium*, pages 233–237, 1997.

[10] D. J. Essin and T. L. Lincoln. Healthcare information architecture: elements of a new paradigm. In *NSPW '94: Proceedings of the 1994 workshop on New security paradigms*, pages 32–41, Los Alamitos, CA, USA, 1994. IEEE Computer Society Press.

[11] D. Forsythe. Expanding the concept of medical information: An observational study of physicians' information needs. *Computers and Biomedical Research*, 25(2):181–200, April 1992.

[12] M. S. Granlien and M. Hertzum. Implementing new ways of working: interventions and their effect on the use of an electronic medication record. In *GROUP '09: Proceedings of the ACM 2009 international conference on Supporting group work*, pages 321–330, New York, NY, USA, 2009. ACM.

[13] I. S. Kohane, P. Greenspun, J. Fackler, C. Cimino, and P. Szolovits. Building national electronic medical record systems via the world wide web. *Journal of the American Medical Informatics Association : JAMIA*, 3(3):191–207, 1996.

[14] M. Linzer, L. B. B. Manwell, E. S. Williams, J. A. Bobula, R. L. Brown, A. B. Varkey, B. Man, J. E. McMurray, A. Maguire, B. Horner-Ibler, M. D. Schwartz, and MEMO (Minimizing Error, Maximizing Outcome) Investigators. Working conditions in primary care: physician reactions and care quality. *Annals of internal medicine*, 151(1), July 2009.

[15] J.-T. Lium, H. Lærum, T. Schulz, and A. Faxvaag. From the front line, report from a near paperless hospital: Mixed reception among health care professionals. *Journal of the American Medical Informatics Association*, 13::668–675, November 2006.

[16] H. Miller-Jacobs and J. Smelcer. Usability of electronic medical record system: An application in its infancy with a crying need. In M. Smith and G. Salvendy, editors, *Human Interface and the Management of Information. Interacting in Information*

Environments, volume 4558 of *Lecture Notes in Computer Science*, chapter 83, pages 759–765–765. Springer Berlin / Heidelberg, Berlin, Heidelberg, 2007.

[17] Y. Nisanbayev, H. Na, D. Lim, and F. Ko. Designing an electronic medical records system using design patterns. In *ICIS '09: Proceedings of the 2nd International Conference on Interaction Sciences*, pages 1410–1415, New York, NY, USA, 2009. ACM.

[18] L. Pizziferri, A. F. Kittler, L. A. Volk, M. M. Honour, S. Gupta, S. Wang, T. Wang, M. Lippincott, Q. Li, and D. W. Bates. Primary care physician time utilization before and after implementation of an electronic health record: a time-motion study. *J. of Biomedical Informatics*, 38(3):176–188, June 2005.

[19] C. Plaisant, R. Mushlin, A. Snyder, J. Li, D. Heller, and B. Shneiderman. Lifelines: using visualization to enhance navigation and analysis of patient records. *Proceedings / AMIA ... Annual Symposium. AMIA Symposium*, pages 76–80, 1998.

[20] P. G. Polson, C. Lewis, J. Rieman, and C. Wharton. Cognitive walkthroughs: a method for theory-based evaluation of user interfaces. *Int. J. Man-Mach. Stud.*, 36:741–773, May 1992.

[21] G. Samoutis, E. S. Soteriades, D. K. Kounalakis, T. Zachariadou, A. Philalithis, and C. Lionis. Implementation of an electronic medical record system in previously computer-naive primary care centres: a pilot study from cyprus. *Informatics in Primary Care*, 15(4):207–216, January 2008.

[22] K. A. Siek, D. U. Khan, and S. E. Ross. A usability inspection of medication management in three personal health applications. In *HCD 09: Proceedings of the 1st International Conference on Human Centered Design*, pages 129–138, Berlin, Heidelberg, 2009. Springer-Verlag.

[23] P. C. Smith, R. Araya-Guerra, C. Bublitz, B. Parnes, L. M. Dickinson, R. Van Vorst, J. M. Westfall, and W. D. Pace. Missing clinical information during primary care visits. *JAMA*, 293(5):565–571, February 2005.

[24] A. Taddei, C. Carpeggiani, M. Emdin, R. Balocchi, S. Dalmiani, G. Cecchetti, A. Macerata, D. Pierotti, and C. Marchesi. Development of an electronic medical record for patient care in cardiology. pages 641–644, 1997.

[25] P. C. Tang, M. A. Jaworski, C. A. Fellencer, M. P. LaRosa, J. M. Lassa, P. Lipsey, and W. C. Marquardt. Methods for assessing information needs of clinicians in ambulatory care. *Proceedings / the ... Annual Symposium on Computer Application [sic] in Medical Care. Symposium on Computer Applications in Medical Care*, pages 630–634, 1995.

[26] H. Tange, A. Hasman, P. Devriesrobbe, and H. Schouten. Medical narratives in electronic medical records. *International Journal of Medical Informatics*, 46(1):7–29, August 1997.

[27] K. T. Unruh, M. Skeels, A. C. Hartzler, and W. Pratt. Transforming clinic environments into information workspaces for patients. In *CHI '10: Proceedings of the 28th international conference on Human factors in computing systems*, pages 183–192, New York, NY, USA, 2010. ACM.

[28] J. Walker, E. Pan, D. Johnston, J. Adler-Milstein, D. W. Bates, and B. Middleton. The value of health care information exchange and interoperability. *Health Aff*, pages hlthaff.w5.10+, January 2005.

[29] S. H. Walsh. The clinician's perspective on electronic health records and how they can affect patient care. *BMJ (Clinical research ed.)*, 328(7449):1184–1187, May 2004.

[30] L. Wilcox, J. Lu, J. Lai, S. Feiner, and D. Jordan. Physician-driven management of patient progress notes in an intensive care unit. In *CHI '10: Proceedings of the 28th international conference on Human factors in computing systems*, pages 1879–1888, New York, NY, USA, 2010. ACM.

[31] A. S. Young, E. Chaney, R. Shoai, L. Bonner, A. N. Cohen, B. Doebbeling, D. Dorr, M. K. Goldstein, E. Kerr, P. Nichol, and R. Perrin. Information technology to support improved care for chronic illness. *Journal of general internal medicine*, 22 Suppl 3(0):425–430, December 2007.

[32] Q. Zeng and J. J. Cimino. Providing multiple views to meet physician information needs. *Hawaii International Conference on System Sciences*, 5:5006+, 2000.

[33] K. Zheng, R. Padman, M. P. Johnson, and H. S. Diamond. An interface-driven analysis of user interactions with an electronic health records system. *Journal of the American Medical Informatics Association*, 16(2):228–237, March 2009.

[34] X. Zhou, M. S. Ackerman, and K. Zheng. Doctors and psychosocial information: records and reuse in inpatient care. In *CHI '10: Proceedings of the 28th international conference on Human factors in computing systems*, pages 1767–1776, New York, NY, USA, 2010. ACM.