

**Development and Evaluation of Socio-Technical Metrics
to Inform HIT Adaptation**

Final Progress Report

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Structured Abstract: (250 word maximum)

Purpose: The purpose of the project is to develop a fundamental and multi-dimensional survey instrument that can inform the progress of health IT adaptation.

Scope: Health IT adoption requires the redesign of individual and collective workflows but is often evaluated using measures that fail to account for these complex socio-technical interactions. We proposed that through the evaluation of adaptation, we are able to provide informative strategies to improve health IT adaptation. We adapted the socio-technical model to address health IT in complex adaptive healthcare systems.

Methods: We used a mixed-methods approach to develop and validate a health IT adaptation survey instrument. The survey development was guided and informed by the socio-technical theory as well as findings from the qualitative research. The survey validation used field testing to establish its factorial structure, content validity, and discriminate validity.

Results: Our preliminary analysis indicated common themes that affect clinicians' adaptation. The preliminary results generated 13 categories with 163 independent codes that describe clinicians' experience with health IT. Selected major themes include superusers and peers for on-site support, resistance and workarounds, involvement of health IT development and upgrades, user competency, feedback on performance, and leadership. Based on the findings, we developed and validated a health IT adaptation survey instrument, which incorporate six factors with 21 items. The Cronbach alphas range from .703 - .911, indicating acceptable reliability. Organizations are able to use the survey instrument to identify challenging areas that weaken or delay clinicians' adaptation.

Keywords: Health IT adaptation, scale development, electronic health records, socio-technical theory

PURPOSE

Adopting new technology requires the redesign of individual and collective workflows and results in changes in both organizational structure and process [1]. Unfortunately, health IT adoption is often evaluated using a disparate array of measures that fail to account for these complex socio-technical interactions. The measures we have instead focus on the percentage of providers with implemented EHRs, clinicians' technology acceptance, and clinical quality measures [2-5]. We believe that by re-conceptualizing *adoption* through the lens of *adaptation*, defined as “a process of modifying existing conditions in an effort to achieve alignment” [6] – we can provide more informative measures of health IT adoption from both the individual and organizational perspective, particularly in the context of interdisciplinary teams [7]. The purpose of the project is to develop fundamental and multi-dimensional measures that can inform the progress of health IT adaptation. We hypothesize that the success of health IT adoption should be evaluated over time, from both the individual and organizational levels and with multi-dimensional measures that are sensitive to issues of communication channels, culture and team dynamics, user satisfaction, work productivity, and quality [8].

SCOPE

During the past years, Presidents Bush and Obama have signed executive orders to promote health information technology (health IT), providing billions of new dollars to eligible hospitals and professionals to improve health care quality, safety, and efficiency [9, 10]. One such program established incentive payments to advance the adoption and meaningful use of interoperable health IT and qualified electronic health records (EHRs) under the direction of The Office of the National Coordinator (ONC). That program, frequently referred to as Meaningful Use [11-13], has set constantly evolving standards for EHR adoption and reinforced the idea that EHR implementation does not end with the installation of a certified system; instead, it is a journey marked by milestones.

Hospitals have been rapidly responding to these new policies and incentives with large-scale implementations of EHRs during the past few years. Adopting new technology requires the redesign of individual and collective workflows and results in changes in both organizational structure and process [1]. Unfortunately, such a rapid adoption may hinder the interoperability of the EHR system [14]. More upgrades, redesign, and optimization are needed, including both minor and major changes in EHR infrastructures, functions, interfaces, and workflows. For instance, researchers on this team have found a relationship between the speed of adoption and patient safety concerns of clinicians, both across facilities and within different units [15, 16].

As we continue to search for generalizability about the variation that exists across health IT implementations, the issue of consistent measurement becomes increasingly significant. Unfortunately, health IT adoption is often evaluated using a disparate array of measures that fail to account for complex socio-technical interactions, variability across contexts and the different trajectories within organizations that exist because of different implementation plans and timelines. For instance, a facility may install an EHR in a hospital, but maintain shadow systems and workarounds as they learn the new system and then never remove those old supports, resulting in two systems, neither of which is functioning as the level it was intended. While *health IT adoption* takes organizational level change into account, technology acceptance mainly focuses on individual user acceptance [17]. The technology acceptance model (TAM) is a useful model for individual user acceptance assessment, but with limitations [18]. TAM's predictive power in healthcare is lower than what has been found in other domains [19]. It was recommended that it should be integrated with other adoption theories [18] that could include variables related to both human and social change processes [19]. We propose integration with the concept of *adaptation*, “a process of modifying existing conditions in an effort to achieve alignment” [6] involving workflow redesign, user trainings, and technology maintenance [20].

We used the IT implementation framework [21] and a new socio-technical model [22] as foundational theoretical guidance. The IT implementation framework [21] suggests that 1) IT use is complex, multi-dimensional, and influenced by a variety of factors at individual and organizational levels; and 2) success in achieving change is enhanced by active participation of members from the target user groups [21]. The new socio-technical model [22] aims to study health IT in complex adaptive healthcare systems, and suggests investigating eight dimensions, including 1) hardware and software computing infrastructure, 2) clinical content, 3) human-computer interface, 4) people, 5) workflow and communication, 6) internal organizational policies, procedures and culture, 7) external rules, regulations and pressures, and 8) system measurement and monitoring [22]. The proposed

research deployed multi-level and multi-dimensional evaluation to understand the health IT adaptation process. Figure 1 illustrates the adapted socio-technical model [22]. We do not include the seventh dimension, “external rules, regulations, and pressures”, as we focus on factors within the organization.

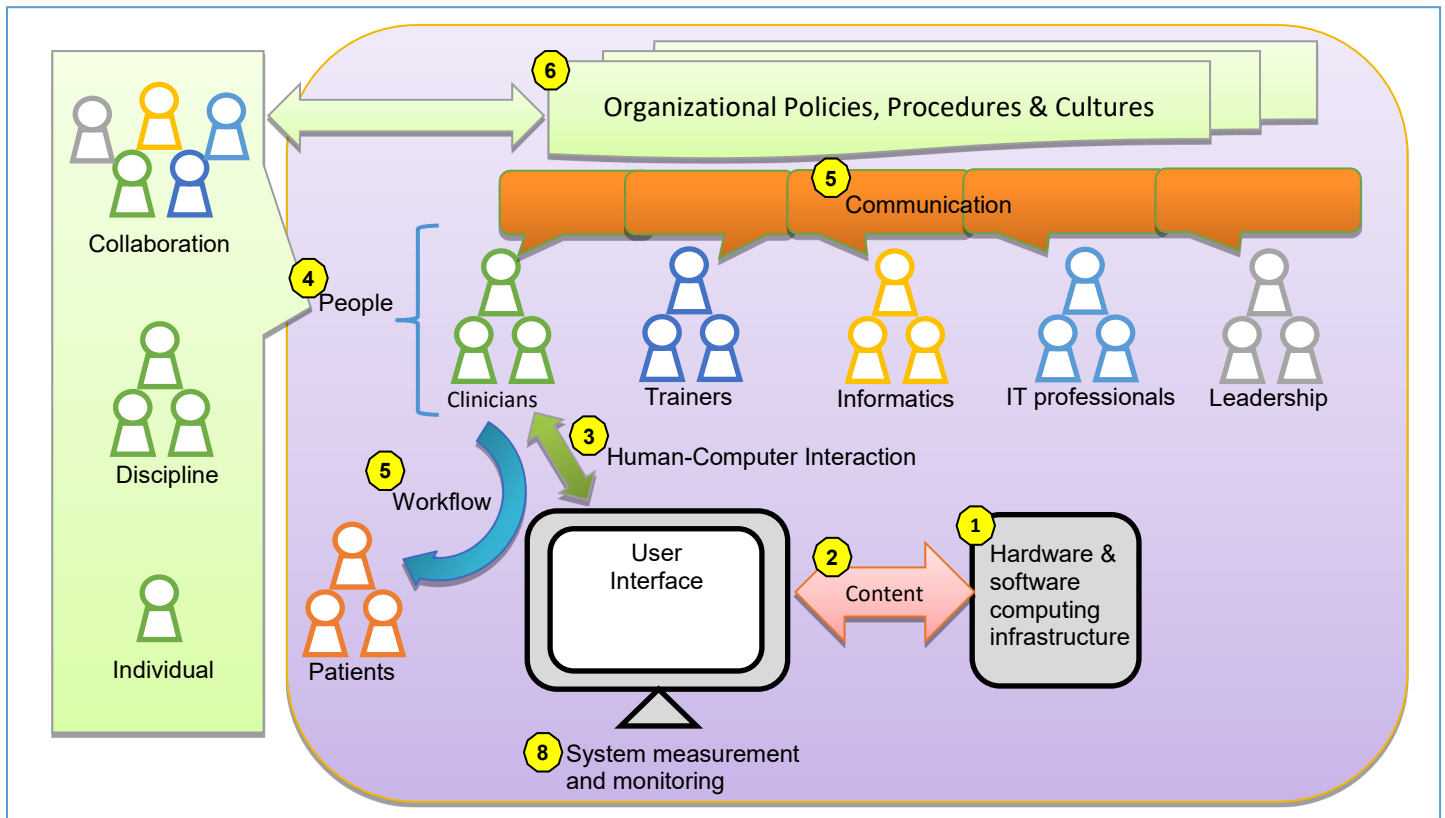


Figure 1. Adapted model from the new socio-technical model [22]

METHODS

Study Design

We used a mixed-methods approach to incorporate both quantitative and qualitative research to develop and validate the health IT adaptation survey instrument. We followed the NIH PROMIS® model [23], a nine-step standard considered best practice for instrument development and validation. The survey development was guided and informed by the socio-technical theory as well as findings from the qualitative research. The survey validation used field testing to establish its factorial structure, content validity, and discriminate validity.

Scale Development

Sample: We used a purposeful sampling to recruit different stakeholders (e.g., clinicians, leaders, trainers, informaticians) who experienced the EHR implementation and the ongoing optimization.

Data Collection: A semi-structured interview guide were used to facilitate interviews, with additional probes to clarify and discover in-depth information during health IT adaptation. All interviews were audio recorded for later transcription. We also collected basic demographic information including age, gender, position, education, and years of experience.

Data Analysis: We used the grounded theory approach to conduct data analysis. Grounded theory has systematic steps that involve 1) identifying key information (open coding), 2) grouping codes to be categories (axial coding), and 3) explicating a story from the interconnection of these categories (selective coding). Researchers independently read and located key information in the transcripts. We generated common categories by grouping the open codes from iterative discussion. Selected codes reflected a general theory of participants’ health IT adaptation process. Atlas.ti, a qualitative research analysis tool, was used for data management and analysis.

Based on the qualitative study findings, we developed a draft survey instrument. We also collected self-reported involvement in EHR development, the EHR usage frequency (several times every day, daily, 2-3 times per week, several times a month, rarely, or never), and demographics, such as age, gender, education, and years of working experience,

Scale Validation

Sample & Data Collection: Clinicians who had worked at the academic medical center for more than 2 years were eligible to participate in the study. We distributed the drafted health IT adaptation survey to clinicians in all departments to understand their experience with EHR. To obtain adequate statistical power, we aimed to receive at least 250 respondents.

Data Analysis:

We performed exploratory factor analysis (EFA) with Principal Axis Factoring extraction method and non-orthogonal Promax rotation to allow factors correlation. The EFA process was conducted iteratively to examine factor loadings. The EFA also eliminates items cross-loading on more than one factor, for example items with factor loadings as .32 or higher on two or more factors or less than half the difference of factor loading with other factors in order to establish the discriminate validity.[24, 25] In addition, we performed descriptive analysis, one-way ANOVA, and regression to examine associations between demographics and factors found in EFA.

RESULTS

Qualitative Study Results:

Our preliminary analysis indicated common themes that affect nurses' adaptation to health IT. The preliminary results generated 13 categories with 163 independent codes that describe clinicians' experience with EHR, including EHR functions/features, health IT development, user competency, specific health IT devices, implementation, training and education, adaptation factors, communication collaboration, leadership, performance, policy, and other uncommon themes (e.g., compliance, difficult to quantify adaptation, patient interaction with technology). Below are selected major themes expressed by clinicians, with representative quotations.

EHR/health IT

Participants identified two main themes when asked about their perceptions of the electronic health record/health information technology (EHR/health IT): the role of EHR/health IT in the healthcare setting and the importance of the end user and technology designer relationship.

Role of EHR/health IT. Staff nurses reported that the role of EHR/health IT was, "to increase efficiency, effectiveness, safe patient care" and to positively impact, "patient satisfaction or patient outcome(s)". Examples of increasing patient safety and quality included using technology to record patient information rather than transcribing such information onto written forms as this decreased confusion; another example was the use of bar-code scanning for medications to decrease the likelihood of medication errors.

- *"I bet med errors have gone down from scanning. I think our scanning compliance – that's one of the best things that's happened tech-wise is the scanning of meds"*
- *"Did that affect patient satisfaction? [...] we can see the result of the technology".*

End User/Technology Designer Relationship. Additionally, participants shared their view of the role of the End User/Technology Designer relationship during the interviews. They believed that often there is a "gap in communication" between the designer and clinical users and that the designers of clinical EHRs/Health IT are not always clinically experienced. An example was provided in which a previously used paper Kardex system was eliminated and nurses were directed to utilize the EHR. One nurse related frustration as a non-nursing designer "appeared" to be determining nursing clinical function.

- *"That, I think, was a big struggle, is the philosophy of going paperless. I just remembered [...] she kept saying, "No. No. We're not gonna have any paper." The nurses were not happy [with this change]. Now they were trying to develop this Kardex in the system to try to help people. I thought, "it's basic nursing*

principles.” I was actually a little angry. I thought, “Why is this non-nurse telling me how to practice nursing?”

- *“The person that comes in after me, they see what I have written. If they do not click the erase button, they can continue to write their note, their narrative note, and save that to chart. If they don’t erase what I have written, they save to chart. Now, they have documented in the nursing—in the chart—in the note everything I said, again, plus anything they’ve added. It looks like they wrote it all.”*

Health IT Development

The common themes evident for Health IT Development included the use of a liaison between the clinical departments and the technology development teams. Another theme that impacts Health IT Development cited was the influence of external organizations such as regulatory bodies and health IT vendors.

Liaison Between End Users and Technology Developers. This liaison’s role was to act as a go-between carrying requests and ideas back and forth between the clinical staff and health IT development teams. An important aspect of the liaison role was to establish “trust” with the clinical staff and other stakeholders as they represented nursing on various development committees and policy making groups.

- *“Our role is to be a liaison between our clinical end users and our IT department to help bridge that gap and be that translator for both clinicians and also to translate for IT when there are enhancements to health information technology tools that are used here at the university or at the medical center”*
- *“[we] help educate our end users of any changes that are happening with our electronic system or any health information technology tools”*
- *“I [liaison] go to nursing leadership, our nurse exec council, because we needed to look at how are we gonna support this, right? How are we going to educate all of our staff, because everyone was impacted.”*

External Organizational Influence. Participants cited that technology designers were influenced by organizations external to the host organization such as the vendor’s parent company and regulatory agencies such as the Joint Commission for Accrediting Healthcare Organizations (JCAHO).

- *“[EHR vendor] is pushing at them that they need to change.”*
- *“[EHR vendor] really is pushing for a standard build as much as possible. They want us to minimize customization whenever and wherever possible and they actually incentivize us to take things out of the box and to adopt their functionality out of the box with their technology.”*
- *“The reason that the care planning education—we try to standardize it across the enterprise. The reason that that was brought up was because the Joint Commission came and cited us for our lack of documentation for care planning, so then we felt that there needed—we needed to do an education for all staff”.*

User Competency

Respondents were asked about their competency with using technology and a major theme of “comfort” arose from the analysis, along with the belief that younger nurses had more experience and greater comfort level with using technology than more mature nurses.

Competency with Technology. When self-describing competency, participants incorporated the word “comfort” into their answers as a common theme and descriptions ranged from “fairly” to “pretty” to “very” comfortable with use of health IT.

- *“Pretty comfortable, okay”*
- *“I’m very comfortable with it”*

Perception Younger Nurses More Competent. Most participants believed that younger nurses were more computer savvy but that a short period of time was all that was required to learn new health IT.

- *“some of the younger nurses are very comfortable with more technology and utilize it because that’s how they’ve grown up and they use technology for everything. Maybe some of the older nurses aren’t quite as comfortable and as trusting in the technology.”*
- *“we found a significant number of staff that didn’t even know what a mouse was or how to use it. I remember in particular one nurse picked up the mouse and actually put it on the screen and moved it across the screen of the monitor in front of her. We actually, back then, set up a special computer basics course of just how to turn on a computer, utilize a mouse, click the buttons, use a drop-down box, because they didn’t know how to do it.”*
- *“get one or two shifts under your belt, and it was pretty easy.”*

Devices/Initiatives

When asked about the various technologies utilized in their clinical practice, participants were able to identify devices that they used on a daily basis. Additionally, a theme of “trust” was discovered as it related to staff trying new technology. A third theme that evolved was related to how the technology functioned in the clinical setting and how it was used by the end user.

Devices Used in Clinical Setting. Participants often identified the various health IT utilized in their clinical roles (e.g., barcode medication administration, MyChart Bedside).

- *“barcode med administration”*
- *“MyChart Bedside”*

Trust. Additionally, they related the importance of “trust” and relationship-building and end user understanding of the function and use of new technology to help with the incorporation of new health IT into clinical areas.

- *“building trust, and when you tell that person just try it, please just give it try, and if they trust you, then maybe they will, right?”*
- *“if they don’t, they certainly won’t, but if they trust you and you have a relationship, you’re a little more likely to get a buy-in versus not.”*

Function Determines Use. How technology is adapted into the daily clinical environment was a major factor in how the technology was used and adopted by the end user. Technology whose use was determined beneficial was utilized with regularity by clinical staff.

- *“[Mobile EHR product], it seems much less clinical, more casual [...] and with our clientele, with what we’re dealing with, our psychiatric patients, you need that comfort. When I go in there with something that looks like the size of my phone and it’s—it seems more casual. It seems—you seem more approachable than standing behind a computer.”*
- *“Because doctors will use their phone sometimes, and has an app that they can put it down to the computer, but they can also get that [mobile EHR product] and take a picture, and it automatically will go where you can put it in the computer and have the pictures right where you want them.”*
- *“varying comforts with [mobile EHR product], especially with the nursing. The techs – we pretty much use that for vitals and some pictures, and it could be used for more. Nurses are a little bit squeamish about passin’ meds with it. It’s a little clunky.”*

Implementation

Implementation of new health IT was determined to be successful when accomplished as one initiative (i.e., Big Bang) rather than by incremental (departmental) rollouts. Command Centers were seen as a successful tactic to assist with “go-live” of the new health IT. Additionally, another factor viewed as important to consider for “go-live” was the decision on whether the host agency would make changes to health IT during the “go-live” implementation or wait for a determined period of time to give participants time to adjust to the technology.

Command Center Use During Implementation. The use of a command center for coordination of new health IT roll-out was determined to be essential with one measurement of success of the roll-out to be the number of calls the command center takes in a given time.

- “[...with use of a] command center, and people were sort of fixing things on the fly.”
- “We tracked how many calls, because people were not happy with the changes, couldn’t find what they were looking for.”
- “we’re saying that we believe that upgrade was successful, because the first day we had 112 calls come in and by—that was on a Sunday morning, and by Thursday we only had 12 calls for the whole day.”

Making Technology Changes During Implementation. Participants cited two approaches to resolving users concerns regarding new health IT: one approach is to not make any changes (i.e., Dwell time) to allow the users time to get used to the new health IT first, and the second approach is to make changes in the health IT as users bring their concerns forward.

- “We ask people to give it a chance and just work with it a little bit. It’s been 4 weeks, and I have talked to some folks in leadership to say can we have a philosophy that post-upgrades, we won’t make any changes for 60 days unless it is stopping you from working, a patient’s safety, or you just cannot complete your work? [...] They were in support of that, because ultimately, what will happen people will get used to the layout. Even if I do it right now, if I changed it back today, after four weeks, I would get calls saying I just remembered this new way and now you’ve changed it back.”
- “we have the opportunity to get things turned around quickly—fixed quickly, so I encouraged people to do that during that go-live time.”

Successful Implementation. Four themes emerged regarding the success of implementation of new health IT which included requesting resources for the implementation; end users understanding (i.e., usability) of health IT and information dissemination; use of one-on-one training support (i.e., Redcoats) and leadership support for new health IT use.

- “We had Red Coats everywhere. I think our hospital system was one of the biggest at the time that had gone live with [EHR system], and we were prepped pretty well for it.”
- “That’s what I try to relay to leadership when I ask for—I need you to dig in your pocket and give up some budget to give me some nurses, and I’m like, and this is not a one and done thing.”
- “information dissemination need to have some of the backup from the leadership level.”

Training and Education

Various approaches to training and education of EHR/health IT were mentioned by the participants including use of e-learning, face-to-face (superuser), use of simulation, standard classroom instruction, vendor provided instruction, tip sheets, HELP lines, and IT liaisons. Nurses preferred a “one-on-one” method of learning new technology and favored email messages the least. One theme discovered was to use a “blended” approach of several different communication/education platforms for educating and communicating about new technology.

One-on-One Learning. Overwhelmingly, the participants favored some type of face-to-face education or instruction while learning new technology. Titles such as “superuser”, “red coats”, “preceptor” and “peers” were used during the interviews to describe those who fulfilled this role. These individuals often wore red jackets to set themselves apart from other clinical staff for easy spotting for support. For implementation of significant new technology (such as implementing a new EHR, when one has not existed before) the use of superusers was continuous for a significant period of time often lasting weeks to months. Additionally, participants cited utilizing each other as a source for assistance with technology as they’d “ask a peer” and utilize “word of mouth” to disseminate information.

- “we had super users on the units all the time. The first couple of months there were super users around all the time helping us out. I was able to learn quickly. If I had any questions, there was somebody right there to ask.”
- “we could let one person on the unit get the training and train the rest of us.”
- “they would share the information to try to help one another.”

Blended Learning Approach. Participants cited that a “blended” approach to education/communication techniques worked as there were multiple methods of communication/learning available. The importance of tailoring the education/communication to the user’s individual needs was reported to be important.

- *“blended learning is the most effective.”*
- *“I sometimes think this is where we could get creative with other disciplines, like someone in the arts, or in graphic design or in computer design. Can they come and help us develop some short videos [...] this cartoonist [...] he would explain some phenomenon in human existence, such as maybe something in the economy. They would draw pictures as they were explaining it. Something like that might be fun and entertaining if you did short videos.”*

Emails. Tactics that participants cited as least helpful included learning new technology through the use of emails, over communicating and educational plans that do not incorporate “hands on” learning with new technology.

- *“emails about updates with screenshots – lay everything out from A, B, C – just lay it out on what they need to do “Oh, I didn’t see that,” a couple a weeks later. It gets lost, and we get, well, there’s another update. They probably delete my email.”*
- *“even if they look at the email, they skim it.”*
- *“it’s not a priority. It’s too mixed in with all of the other stuff that people have to hear about.”*

Adaptation Factors

When asked to describe factors facilitating or hindering their adaptation to various health IT, nurses discussed 1) having a voice in the development and upgrades, 2) the ability to provide feedback on suggested changes, 3) having a high enough comfort level, 4) staffing barriers preventing off-unit training, and 5) knowing the purpose behind the new or upgraded technology being implemented.

Nurses’ Voice in Development and Upgrades. More than half of participants felt that clinical staff aren’t included in the decisions that impact them and should be involved throughout the health IT development process. Some explained that the lack of clinician involvement has led to the creation of systems that are not intuitive or do not flow well for clinical practice. This has caused inefficiencies and disruptions in nurses’ workflow. One participant pointed out the potential opportunity of utilizing both clinician and IT perspectives when developing new tools or features that are both intuitive and efficient for clinical practice.

- *“I think we don’t include staff in a lot of the decisions that impact them [...] I get all the time, they’re like, well, who was—who made these decisions, and you should have staff nurses on there.”*
- *“I think that there is a lack of input from the clinicians into how things are created, how the applications are developed. [...] For example, with the recent upgrade or recent content upgrade in our documentation system, a lot of customizations were written over that had been carefully created through the years [...] Also, certain things were switched around, really, for no good reason. I don’t believe that there was a lot of clinical input into the changes so that when things aren’t in a logical order for clinicians [...] it makes things very difficult and not intuitive for a clinician.”*
- *“It might be interesting to see what’s the perspective of the clinician versus the perspective of IT and how it’s gonna be used and oftentimes, so there probably is a gap in communication. Then, you know, there’s an opportunity there. [...] would a clinician find it effective and efficient to use versus, you know, from an IT perspective that this would be great and people need to use it.”*

Ability to Provide Feedback. Nurses noted that having the ability to provide feedback for suggested changes to current health IT is an important factor in their adaptation. Some commented on the lack of resources preventing feedback, though most expressed concern with the ineffectiveness of current processes for providing feedback. Many believed that nurses’ feedback is not a high priority for stakeholders, claiming there’s often an absence of follow-up on submitted enhancement requests.

- *“I still don’t think that staff nurses are being heard. Maybe, it’s because they can’t get to these meetings, or they’re not appointed, but there needs to be a way for nurses to be able to offer feedback that’s a*

better connection for them, and they're listened to. They should be able to have more say in how things get designed."

- *"There needs to be a way for nurses to offer feedback that's a better connection for them, and they're listened to. [...] there needs to be a place that they can give feedback. When things are not intuitive and very hard, IT should take it down and start over and get more feedback. Pilot it, first, on a unit."*
- *"Nurse's requests aren't a very high priority, and I think they should be because they affect so many people in our organization. The majority of our employees are in our system. I feel like if it's 3,000 people saying there's a problem, that needs to be looked at and, maybe, re-upped in the prioritization ladder."*
- *"It's not a great process, and a lot of the people are frustrated by it, so they give up in submitting them 'cause if they don't go anywhere and nothing happens, they're not gonna waste their time pursuing it."*

Comfort Level. Several nurses stated that a comfort level needs to be met first in order for nurses to be willing to try new technologies or features. Engaging in unfamiliar tools or systems inflicted hesitation on staff. One nurse explained that when a new application had a glitch with recording data, hesitation and discomfort with the technology increased. Another nurse noted that generational factors play a role in comfort level, saying that younger staff are familiar with technology and generally more likely to utilize new health IT.

- *"They're not as comfortable with the technology so they've not played around to see all the different things that it has to offer. They just do strictly what they have to do as far as flow sheets, documenting medication, that kind of thing."*
- *"[It's] gonna be a slow process, I think, to get everybody on board. Because of our comfort level, I think, and because of some of the hiccups, especially with it not recording data."*
- *"It's a comfort level and a decision that you can use it or not use it."*

Staffing Barriers. A number of nurses mentioned that their adaptation to health IT was limited due to staffing barriers. The lack of budgeted monies available to provide staff with meaningful off-unit time for training on new health IT or major upgrades was commonly cited by participants. One nurse expressed that the lack of off-unit training led to a more difficult transition following an EHR upgrade. Such concerns were voiced for other technologies outside of the EHR as other nurses made similar statements about the lack of time to train. Another participant commented on leadership's responsibility to budget for continued training in order to promote increased nurse satisfaction and retention.

- *"I'm gonna use the pump integration as an example. How are they gonna get trained if they don't come out of the unit for a couple of hours to understand these pumps? [...] If you got 4,000 nurses that we're saying we need 4 hours of your time, that's what, 16,000 times—nurses make about 50 to 60 dollars an hour. That's how much money will be spent— just to train the nurses for four hours. This is what leadership hears, right? [...] They hear that we're implementing new things, but what they hear you gotta train my nurses and that's gonna cost money."*
- *"This last time that we rolled out, I wasn't able to pull outta staffing, so that made the transition harder."*
- *"I try to relay to leadership when I ask for—I need you to dig in your pocket and give up some budget to give me some nurses [...] I talk to leadership and I beg for resources, I try to tell them [...] giving nurses time off to actually learn, then what I envision is that you'll have better nurse satisfaction, and you'll have less turnover and greater retention because you've allowed them the time to learn the tool, versus learning it in a very sporadic way."*

Purpose. The final adaptation factor noted was that nurses voiced a need to know the purpose behind new or upgraded health IT. Many nurses explained that much of the resistance from fellow staff members stemmed from not knowing the reason or benefit behind the implementation of new technology or changes in its features. Other nurses said that possessing the understanding of the need for a particular health IT can help increase staff acceptance and adaptation. However, one participant explained that nurses can be more resistant to change if the reasons for the change are based on outside regulatory bodies or finances.

- *"just tell me why, just give us a reason. Why are we doing this and what is in it for me is what they really wanna know. If there's nothing in it for them, they don't find it of any value."*
- *"People have to understand why the change is made. If they understand the why, then generally they're accepting."*

- *“they don't really appreciate when changes are made based on regulatory or financial reasons. They don't take that well.”*

Communication and Collaboration

When asked about health IT's effect on communication and collaboration, participant response primarily focused on decreased face-to-face communication, over-reliance on technology, and email as an ineffective source of communication.

Decreased Face-to-Face Communication. Several nurses commented on the decreased face-to-face communication resulting from technology use, claiming that it is causing healthcare to be less personal. For example, clinicians are spending more time documenting in the EHR than they are communicating that information to their team members directly. Many stated that a primary source of their worry related to ensuring that all pertinent patient care information is documented and in the correct place within the record for other care team members to view. Furthermore, they believe that face-to-face communication between care team members as well as clinicians and patients is decreasing. As clinicians spend more time documenting and reviewing information in the EHR, less time is dedicated to interacting with patients directly.

- *“it hinders face-to-face communication, the personal. Just as we're talking back and forth, and you're able to determine what I've said or I've determined what you've said and the intent of it, on the computer you're not able to do that. [...] in general that's a problem because somebody can say something, can send somebody an e-mail, or you can put—document something, and if you say it to somebody face to face, they get more of the gist, more of what you're trying to say than if you're just writing it down.”*
- *“I also feel like you're actually less productive, because you learn a lot just by spending time with your patients and talking to them. When you have to worry about charting an assessment and charting these vital signs and putting this note in and charting on this and charting a care plan and charting education and charting on this and putting a note into cover yourself on this, you're spending a lot of time at the computer, and you're not spending that time with the patient.”*
- *“I feel nursing is supposed to be a personal thing. The lack of personal intervention between two people lacks, because everybody wants to send you an email. [...] That's overwhelming for me to sit there and read each one of 'em. One, I don't have time to do it during the day.”*

Over-reliance on Technology. Decreased face-to-face communication was identified as a concern. Many nurses highlighted the tendency to over-rely on technology to communicate within care teams. A number of participants expressed their concern with this dependency, saying that vital information could get lost in translation or assumptions could be made if notes are interpreted incorrectly or without proper context. Most participants seemed to recognize the benefits of using email to communicate about patients but believe that it should not be used as a complete replacement for care team communication.

- *“Where I see a problem is there's an over-reliance and a dependency on the technology to communicate and collaborate for you, so there's this tendency to assume that the EMR, for example, is gonna tell you about my patient [...] There's an assumption that the EMR is gonna remind me, or if I put something in, that you're automatically gonna know that I did that. If I say, “This patient's family is very concerned about the condition”, and I put that in the note, I don't have to tell you because my assumption is that you're gonna know that you're gonna read that somewhere. That's not always the case [...] There's always an assumption that if I put it in a note or I put it in a flow sheet, or I rely on a clinical alert, that's enough, or I put in a consult and you're automatically gonna know that it's there. That's an over-reliance on the technology to communicate on my behalf on something that could be very serious.”*
- *“if we get communication about anything, [...] They wanna send an email out and a thing out to you. [...] I need to hear things. I don't need to see things. [...] Instead of having a true staff meeting and going through these things, a email's sent out.”*

Email About EHR Changes is Ineffective. One source of communication commonly found to be ineffective by participants was email. Many stated that email usage should be more personalized or tailored to the clinicians' roles in order to prevent information fatigue or alert fatigue. Many admitted that it's common for nurses to not read emails due to the high volume received each day.

- *“Even if they look at the email, they skim it. They might not get it if they don’t live it right away and don’t practice it,” and “They tell us, I don’t read my emails. You don’t read your emails. I don’t know how else to communicate.”*
- *“Email gets in the way. [...] I think because we get so many emails through a large university like this that, even when I’ve sent out updates or emails about updates with screenshots – lay everything out from A, B, C – just lay it out on what they need to do, I frequently hear, “Oh, I didn’t see that,” a couple a weeks later. It gets lost [...] It’s almost an alarm-fatigue with email.”*
- *“we get so much information from every different thing that maybe that’s—we’ve kind of become immune to it and don’t pay attention to it all the time.”*

Health IT Usage

Nurses also discussed their experiences specifically regarding how various health IT is used by clinicians. Two themes frequently mentioned by participants were inconsistent usage by clinicians and leadership’s role in monitoring the usage to increase compliance.

Inconsistent Usage. One perceived issue identified by nurses was the inconsistent usage of health IT by various clinicians. One factor thought to be contributing to this inconsistent usage is the lack of direction for use from the vendor and leadership to guide end users. Participants provided an example in which they had not received specific directions for the entry of various clinical information into the EHR. Another factor involved with this issue is that not all clinicians have the same access to the EHR and location of information is not standardized between different types of clinicians.

- *“Everybody had an inconsistent way of how they thought they should enter the data. No one told ‘em, “Hey, this is the way to do it’.”*
- *“When people write code, right, for a new software, it’s pretty precise on how each step is supposed to go. When we put it out, hey here is what it is, without really defining the actual steps. Then people implement it [...] but the medical record allows them to try 1000 different ways to get to the end point. It shouldn’t be. It should be one way.”*
- *“Nurses have access to the care plans, social workers have access to the care plans, OTs have access to the care plans, physicians don’t for the nursing care plan, we say. Then we make this work around, everybody documents in this other area, but it doesn’t flow through the medical record well. [...] There’s too many backdoor ways of getting things done I think and no consistent standard way.”*

Monitoring Usage by Leadership. Participants who hold a leadership role discussed examples of how they monitor usage in order to improve compliance. Many stated they review audits to evaluate how compliant staff are inputs into the EHR. An example provided was the use of audits to monitor care plan documentation. Another nurse leader cited the use of audits for compliance rates as incentive to promote proper usage, saying that audits would cease once a certain percentage was reached. Staff nurses found this helpful as it motivated them to hold themselves accountable.

- *“Then we have, again, reports that we run to see how often are people applying care plans. Do your patients have care plans applied to them? There’s reports are being ran for that to see if they’re being compliant and adding those care plans.”*
- *“we have to be 90 percent compliant for three months in a row. Once we do that, we agreed we would take off—there’s certain reports that they have to do—manually enter that we said we would get rid of once they hit 90 percent three months in a row. [...] We’re not to that point yet where we can get rid of the audits. We’re getting closer though, which is encouraging.”*
- *“It puts you on your toes. [...] It also shows how efficient you’ve been and compliant you’ve been with the system [...] That puts you on your toes, so you do the right thing.”*

Policy

When asked about organizational policy related to health IT, nurses commented on how policies should serve as a guideline for health IT usage, the need for keeping policies up to date, and how policies can sometimes be too detailed or too broad to be useful.

Policy as a Guideline. Some participants found policies to be useful for serving as a guideline for health IT usage. Specifically, nurses stated that policies helped remind them of the “why” and standards for documentation.

- *“We call it a philosophy, a guideline, I would say. We don't really call them policies as much. There's a guideline. It provides a philosophy on why, why are we doing this, so we wanted to make sure we put that in the guideline, and then here's the expectations that should be done.”*
- *“as far as the policies, I think the interaction [...] is helpful, okay? [...] It helps remind you that you need to document it.”*
- *“to me, the policies are there to set expectations and guide you, but the policy is also, in a perfect world, this is what they want, and it's never a perfect world when you go to work. I think it's good to have a policy in place and know what this expectation is and at least abide by this expectation.”*

Updated Policies. Several participants commented on the need to update policies as health IT is implemented or upgraded. Since some nurses utilize policies as a guideline for what they document and why, it is important to ensure that any changes or additions to health IT are reflected in the respective policy.

- *“I'm not sure it's been—that the policy has been upgraded since this last upgrade. It has not included all the new areas that are covered in the flow sheet, are now not covered in the policy.”*
- *“I know that we have to change nursing policy based on changes that are made in [EHR system].”*

Policy Detail. Many nurses stated that in order for policies to be useful for nurses, they cannot be too detailed nor too broad. If too much detail is in the policies, enforcing and strictly following them can become difficult.

- *“sometimes our policies are so detailed that Joint Commission holds us to our policy. [...] Sometimes our organization can be our own enemy, because sometimes our policies are so detailed, and then Joint Commission will come in and say, well, you say here you do this and I don't see where you're doing it. You could be a little more general.”*
- *“I think when you make policies rigid, you start really getting into difficulty enforcing them. You really want your policies to be more broad.”*

Development of the Health IT adaptation survey instrument

Base on the results from the qualitative studies, we developed a health IT adaptation survey that can facilitate the screening/evaluation of health IT adaptation. To establish the content/face validity of items and concepts in the instrument, we tested the survey with clinicians and refined the survey iteratively to reflect clinicians' feedback until no further changes were recommended. Content validity was also established through discussions about the instrument and the conceptual model. Below is the current version of the health IT adaptation survey with 10 themes, 32 items. All questions are answered with a 5-point Likert Scale. We also collect self-reported involvement in EHR development, the EHR usage frequency (several times every day, daily, 2-3 times per week, several times a month, rarely, or never), and demographics, such as age, gender, education, and experience.

Training/Education

1. After going through the Epic training program, my level of understanding was substantially improved.
2. The Epic training I received aligned with my role and responsibilities.
3. The timing of the Epic training was appropriate for me to learn Epic in time for implementation.

Help Desk and Support

4. I contact the help desk when I encounter issues with Epic.
5. When I contact the help desk, the support staff understands my problem.
6. When I contact the help desk, the support staff are able to solve my problem in a timely manner.
7. I am satisfied with IT's maintenance of Epic (i.e., system updates, maintenance of system speed, cleaning up of old files).
8. I provide feedback and/or recommendations regarding Epic to my organization.

Usability Assessment

9. Compared to the previous electronic health record (EHR) system, I am more comfortable with my ability to use Epic.
10. Compared to the previous electronic health record (EHR) system, learning to operate Epic has been easier for me.

11. Compared to the previous electronic health record (EHR) system, I find Epic easier to use.

12. I can always remember how to use Epic.

13. Whenever I make a mistake using Epic, I recover easily and quickly.

Workflow/Workaround

14. Compared to the previous electronic health record (EHR) system, reading and responding to Epic alerts interferes with my workflow more often.

15. Compared to the previous electronic health record (EHR) system, Epic enables me to work more efficiently (e.g., internal workflows, accessing support or information retrieval).

16. IT professionals effectively customize and/or update Epic to support appropriate clinical workflows.

Information Dissemination

17. The medium of information distribution about Epic updates is appropriate (i.e., email, dashboard).

18. The frequency of information distribution about Epic updates is adequate.

19. The content of the distributed information about Epic updates is helpful.

Interdisciplinary Collaboration Assessment

20. Epic has helped my organization enhance and improve collaboration within the organization.

21. Epic provides me with appropriate tools for interaction and collaboration with other colleagues.

Communication Channel Assessment

22. Epic caused an increase in communication between hospital departments.

23. Epic caused an increase in communication between clinicians.

24. Compared to the previous electronic health record (EHR) system, using Epic makes communicating with other clinicians faster.

25. Compared to the previous electronic health record (EHR) system, using Epic makes communicating with other clinicians more reliable.

Policy Assessment

26. I know my organization's electronic health record (EHR) policies.

27. My organization is updating policies gradually to help me adapt to Epic.

28. My organization's policies are an obstacle for me to use Epic in practice.

Leadership Assessment

29. The executive leadership of my practice (i.e., department, division, unit) is visionary and supportive of Epic.

30. The direct supervisor in my practice (i.e., department, division, unit) ensures that important processes and outcomes are regularly measured, with information communicated to clinicians.

Epic Expectations and Involvement

31. I clearly understand the organization's reason and goals of Epic implementation for patient care.

32. I believe that the implementation of Epic has improved the quality of patient care in general.

After the pilot testing and iterative discussion with clinicians, comparative questions are recommended as they are easier to answer for comparing the old and new EHR system. Also, we also noticed that our adapted socio-technical framework captured the interaction between stakeholders and the technology. The qualitative research helped support our rationale as well as the formation of survey questions.

Validation of the health IT adaptation survey instrument

We distributed the health IT adaptation survey to clinicians six months after the Epic implementation. We received a total of 653 responses. After excluding cases listwise, 411 cases without missing values were used for EFA. The Kaiser-Meyer-Olkin and Bartlett's Test was examined and indicated that the sample and correlation matrixes were appropriate for an EFA analysis. We investigated the number of factors suitable for the factor structure using the rule of eigenvalue > 1. The rule of eigenvalue suggested six factors with justifiable constructs. Based on our baseline assumption of ten constructs in the survey instruments, we explored five to seven numbers of factors to examine potential factorial structures. After iterative analysis with careful elimination of cross-loadings items and discussion, a six-factor solution provides the most meaningful and justifiable factorial structure with a total of 21 survey items and 67.62% variance explained. Table 1 presents the variance explained by each factor. Table 2 presents the factor loadings (coefficients) of the final 6-factor solution of the health IT adaptation survey. High coefficient represents that the item has a high contribution to the factor. The six factors are *Usability, Communication, Information Dissemination, Training, Help Desk, and Leadership*. *Usability*

contributes most (41.38%) to clinicians' experience with health IT, followed by *Communication* (7.88%). The six factors exhibit Cronbach alphas from .703 - .911, indicating acceptable reliability. Table 3 shows the factor correlation matrix. The low correlation (<0.7) between factors also confirmed the discriminant validity.

Table 1. Total Variance Explained by Each Factor

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings ^a
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	9.000	42.857	42.857	8.690	41.380	41.380	7.026
2	1.942	9.248	52.106	1.655	7.880	49.260	6.670
3	1.560	7.431	59.536	1.259	5.997	55.257	5.154
4	1.402	6.676	66.212	1.135	5.403	60.660	5.116
5	1.131	5.385	71.597	.793	3.778	64.438	3.603
6	1.029	4.901	76.499	.670	3.189	67.627	3.587

Extraction Method: Principal Axis Factoring.

a. When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.

Table 2. Factor Pattern Matrix

Factor		Factor					
		1	2	3	4	5	6
Usability Cronbach α = .911 Variance Explained = 41.38%	Q11. Compared to the previous electronic health record (EHR) system, I find Epic easier to use.	1.014	-.044	-.109	.012	.001	.009
	Q10. Compared to the previous electronic health record (EHR) system, learning to operate Epic has been easier for me.	.999	-.097	-.044	-.018	.025	-.056
	Q9. Compared to the previous electronic health record (EHR) system, I am more comfortable with my ability to use Epic.	.885	.025	-.013	-.064	.028	.003
	Q15. Compared to the previous electronic health record (EHR) system, Epic enables me to work more efficiently (e.g., internal workflows, accessing support or information retrieval).	.626	.207	.003	.078	-.080	-.003
	Q12. I can always remember how to use Epic.	.593	.003	.094	-.010	-.013	.033
	Q13. Whenever I make a mistake using Epic, I recover easily and quickly	.534	.007	.130	.048	.045	.084
Communication Cronbach α = .905 Variance Explained = 7.88%	Q23. Epic caused an increase in communication between clinicians.	-.081	.944	-.069	-.043	.048	.028
	Q22. Epic caused an increase in communication between hospital departments.	-.123	.874	-.095	.040	.043	.048
	Q25. Compared to the previous electronic health record (EHR) system, using Epic makes communicating with other clinicians more reliable.	.117	.803	.108	-.085	-.038	-.095
	Q24. Compared to the previous electronic health record (EHR) system, using Epic makes communicating with other clinicians faster.	.126	.785	.026	.017	-.060	-.057
	Q21. Epic provides me with appropriate tools for interaction and collaboration with other colleagues.	.175	.530	.058	.094	.041	.081
Information dissemination Cronbach α = .869 Variance Explained = 6.00%	Q18. The frequency of information distribution about Epic updates is adequate.	-.017	-.044	.982	-.022	-.006	-.032
	Q17. The medium of information distribution about Epic updates is appropriate (i.e., email, dashboard).	-.021	-.046	.912	-.023	.025	-.007
	Q19. The content of the distributed information about Epic updates is helpful.	.002	.104	.571	.085	.000	.092
Training Cronbach α = .814 Variance Explained = 5.40%	Q2. The Epic training I received aligned with my role and responsibilities	-.068	.007	-.109	.877	.002	.062
	Q3. The timing of the Epic training was appropriate for me to learn Epic in time for implementation.	.012	.022	.090	.756	-.032	-.100
	Q1. After going through the Epic training program, my level of understanding was substantially improved.	.088	-.067	.041	.750	.029	-.001

Factor		Factor					
		1	2	3	4	5	6
Help Desk Cronbach α = .854 Variance Explained = 3.78%	Q6. When I contact the help desk, the support staff are able to solve my problem in a timely manner.	.019	.032	.007	-.035	.894	-.031
	Q5. When I contact the help desk, the support staff understands my problem.	.000	-.001	.016	.037	.793	.019
Leadership Cronbach α = .703 Variance Explained = 3.19%	Q29. The executive leadership of my practice (i.e., department, division, unit) is visionary and supportive of Epic.	.042	.004	.062	-.074	-.055	.796
	Q30. The direct supervisor in my practice (i.e., department, division, unit) ensures that important processes and outcomes are regularly measured, with information communicated to clinicians.	-.027	-.017	-.053	.049	.039	.702

Extraction Method: Principal Axis Factoring.
 Rotation Method: Promax with Kaiser Normalization; Rotation converged in 6 iterations.

Table 3. Factor Correlation Matrix

Factor	1	2	3	4	5	6
1	1.000	.652	.513	.557	.343	.368
2	.652	1.000	.520	.493	.416	.445
3	.513	.520	1.000	.476	.397	.476
4	.557	.493	.476	1.000	.477	.431
5	.343	.416	.397	.477	1.000	.457
6	.368	.445	.476	.431	.457	1.000

Extraction Method: Principal Axis Factoring.
 Rotation Method: Promax with Kaiser Normalization.

Descriptive Analysis

With the six-factorial structure found in EFA, we further performed descriptive analysis of the responses (Table 4). In general, clinicians were least satisfied with the usability of the EHR (Mean=2.55; SD=1.04), followed by the training they received (Mean=2.76; SD=1.05). They were slightly positive about the support received from the leadership (Mean=3.42; SD=0.93), compared to other factors.

When comparing different professions (medicine, nursing, pharmacy, etc.), we do not find any significant difference in any factors ($p > 0.05$). When considering group differences in demographics, there is no difference in gender, but clinicians with a master's degree rated significantly poorer experience in *Usability* with EHR than clinicians with a doctorate degree ($p = 0.009$). Also, not surprisingly, older clinicians rated poorer experience in *Usability* with EHR than younger clinicians ($p < 0.000$); but rated better experience in *Communication* with EHR than younger clinicians ($p = 0.039$). Clinicians with more years of working experience also rated poorer experience in *Usability* with EHR than younger clinicians ($p < 0.000$). In addition, clinicians who reported a higher level of involvement in EHR development reported a better experience in *Training* ($p = 0.005$), but no significant difference in other factors. The frequency of using EHR (several times per day to rarely) does not show any association with experience in any factors ($p > 0.05$).

Table 4. Descriptive Statistics

		N	Mean	SD
Usability Mean = 2.55 SD = 1.04	Q11. Compared to the previous electronic health record (EHR) system, I find Epic easier to use.	626	2.38	1.307
	Q10. Compared to the previous electronic health record (EHR) system, learning to operate Epic has been easier for me.	623	2.32	1.250
	Q9. Compared to the previous electronic health record (EHR) system, I am more comfortable with my ability to use Epic.	624	2.49	1.282
	Q15. Compared to the previous electronic health record (EHR) system, Epic enables me to work more efficiently (e.g. internal workflows, accessing support or information retrieval).	612	2.52	1.275
	Q12. I can always remember how to use Epic.	634	2.77	1.188
	Q13. Whenever I make a mistake using Epic, I recover easily and quickly	622	2.72	1.141
Communication Mean = 2.97 SD = 0.99	Q23. Epic caused an increase in communication between clinicians.	568	3.05	1.135
	Q22. Epic caused an increase in communication between hospital departments.	574	3.02	1.152
	Q25. Compared to the previous electronic health record (EHR) system, using Epic makes communicating with other clinicians more reliable.	564	2.89	1.156
	Q24. Compared to the previous electronic health record (EHR) system, using Epic makes communicating with other clinicians faster.	570	2.88	1.178
	Q21. Epic provides me with appropriate tools for interaction and collaboration with other colleagues.	611	2.94	1.203

		N	Mean	SD
Information Dissemination Mean = 3.09 SD = 0.89	Q18. The frequency of information distribution about Epic updates is adequate.	613	3.18	1.006
	Q17. The medium of information distribution about Epic updates is appropriate (i.e. email, dashboard).	608	3.17	1.010
	Q19. The content of the distributed information about Epic updates is helpful.	611	2.94	.993
Training Mean = 2.76 SD = 1.06	Q2. The Epic training I received aligned with my role and responsibilities	650	2.63	1.272
	Q3. The timing of the Epic training was appropriate for me to learn Epic in time for implementation.	644	2.96	1.232
	Q1. After going through the Epic training program, my level of understanding was substantially improved.	649	2.70	1.218
Help Desk Mean = 2.92 SD = 1.05	Q6. When I contact the help desk, the support staff are able to solve my problem in a timely manner.	557	2.82	1.146
	Q5. When I contact the help desk, the support staff understands my problem.	558	3.03	1.104
Leadership Mean = 3.42 SD = 0.93	Q29. The executive leadership of my practice (i.e., department, division, unit) is visionary and supportive of Epic.	586	3.49	1.011
	Q30. The direct supervisor in my practice (i.e., department, division, unit) ensures that important processes and outcomes are regularly measured, with information communicated to clinicians.	562	3.31	1.075
	Valid N (listwise)	411		

DISCUSSION:

Although it has been recognized that clinicians' feedback is essential to inform socio-technical factors that impact their adaptation process and progress with health IT, there was no clear process of how clinicians' feedback should be incorporated in the redesign of health IT nor the support of a better adaptation of health IT. Lack of adaptation can lead to issues, such as "workarounds", and decreased communication between providers of care. While research evidence supports the use of socio-technical evaluation to assess clinicians' "healthy" use of health IT, our project supports the rapid screening/evaluation of socio-technical factors that impact clinicians' adaptation to health IT.

Nurse Involvement in Health IT Development and Upgrades

Several studies show that clinician participation is needed in all stages of health IT development, but few studies provide strategies to accomplish this. One study revealed that by including nursing staff in health IT development, the end result was that health IT usage was tailored to the practice environment, used consistently, and increased quality of workflow.[26] In this instance, nurses worked with the software developer to create electronic versions of the charting specific to their patient population. Clinicians, especially those at point of care (POC), are often not involved in the health IT development process. The result can be that health IT does not support the current workflow leading to frustrated clinicians. It is commonly believed that involvement of stakeholders should occur throughout any process changes that affect workflow. Currently, clinician involvement is viewed as sparse and often later in the implementation phase, when it's too late to incorporate their input. In these cases, health IT use by clinicians is inconsistent and unmotivated.[27] Lack of use affects the organization and devalues the investment made for the project. Clinicians provided with systems that do not fit into their workflow or complicate it are less likely to use the health IT as a tool.[28] The goal of health IT at point of care is to empower the clinician to provide quality patient care while supporting current workflow.[29] This goes hand in hand with a tool that is customized for the location and field of practice.[26] For example, a goal would be to have electronic flowsheets specific to the patient population for nursing units with acuity of care consideration. Patient care quality is enhanced by clinicians empowered with tools designed to efficiently document and communicate care. Clinician participation throughout the health IT process increases workflow stability and consistency of use, as well as matches the specific needs of different patient populations. Currently there is no standard for clinician involvement in health IT development. Future research should explore the benefits of clinician involvement in order to improve clinician satisfaction and quality of care.

One-on-One Learning

The utilization of One-on-One Training pedagogy is common in healthcare and the profession of nursing in particular. For example, newly hired nursing staff spend considerable time with assigned preceptors in their new units to learn new skills and acclimate to the patient care environment. Likewise, this pedagogy has proven its worth across many disciplines outside of healthcare.[30-33] Researchers have discovered that this approach provides a social presence that assists with, "learning outcomes, learner satisfaction and faster assimilation of technology".[30] A use of this pedagogy for the introduction of new health IT is the utilization of "redcoats" (name

is derived from the red jackets they wear for easy identification), or superusers, and is one tactic identified by staff nurses to have a positive influence on learning new health IT. Redcoats are individuals trained in the new technology and assigned to a unit for the purpose of supporting the users of the technology during work time to facilitate adoption of that technology. Redcoats provide One-on-One assistance in the “live setting” to provide guidance and support the new user.

Learning Approaches

Balancing clinical care with the intensive educational requirements involved in training healthcare providers in the electronic health record, involving time “away from the clinical setting”, is a challenge for health care leaders. Additionally, the associated costs of this training and any “go-live” support remains a challenge. Identifying the most efficacious, efficient and cost-effective teaching/learning methods for busy clinicians must be incorporated into any strategic plan regarding health IT adoption. Our respondents spoke clearly of the value of using a blended approach to health IT education including the use of superusers, peers and simulation experiences. This supports previous work that suggests that the traditional classroom approach alone is not sufficient.[34] Timing of the training is important; gaps in the timing of training/education and the actual use results in difficulties in learning recall and provider frustration.[34] Consistent with other reports, our respondents indicated that as healthcare providers gain experience with health IT, organizations need to seek innovative educational strategies for differentiating educational experiences for novice and experienced health IT users.[35] Most notable in our findings was that respondents articulated that communication via email about changes or upgrades in the EHR system is not effective.

Communication Across Organizational Levels

In our study, nurses expressed their belief of a non-transparent or poor communication system exists between the leaders and point-of-care nurses. Nurses were not aware of any communication system to provide or receive feedback regarding the use of EHR. As we continue to enhance health IT adaptation, EHR optimization is one a key goal, which should include the redesign of interfaces, processes, and infrastructure to enhance its use by caregivers. However, due to the conflicting demands of organization expectations (standardization) versus expectations from teams or individuals (customization), optimization is critically challenging without a proper communication between the leadership and provider teams and health IT developers.[36] Aligning goals and strategies between and within organizational levels are essential to minimize confusion and support continuous improvement.[36-38] Mid-level leaders, such as nurse managers and informaticists, play a critical role to the success of EHR adoption for staff nurses.[36, 39, 40] Emphasizing the roles and responsibilities of these mid-level leaders may promote the communication, thus progress nurses’ adaptation to health IT.

Best Practice for Adapting to Health IT

1. Involve staff in design of health IT
2. Provide feedback mechanisms from users to designers to enhance product
3. Use of multiple means to communicate changes, mindful of overuse of one method causing fatigue (e.g., email usage)
4. Use of a One-on-One pedagogy for training during go-live (Redcoats)
5. Assessing and securing resources for development and implementation of health IT (e.g., funds for proper equipment, FTEs needed to support go-live)
6. Adjust workload during implementation (e.g., reduced assignments).

CONCLUSION:

Measuring health IT adaptation can provide a more thorough understanding of the connection between health IT use and health care outcomes. Following the scale development process, we developed and validated a health IT adaptation survey instrument. While the “outcome measures” (health IT adoption rate, acceptance, and clinical quality measures) have been established, our health IT adaptation survey instrument includes multi-dimensional measures to capture clinicians’ experience with EHR and to capture their adaptation in difference areas. The health IT adaptation survey includes six factors: usability, communication, information dissemination, training, help desk and leadership. Organizations could use the survey instrument to identify challenging areas and to investigate further areas that weaken or delay clinicians’ adaptation.

LIST OF PUBLICATIONS and PRODUCTS

- Yen P, McAlearney AS, Sieck C, Hefner J, Huerta T. HIT Adaptation: Refocusing on the Journey to Successful HIT Implementation. *Journal of Medical Internet Research*. 2017;5(3):e28. PMID: 28882812. doi: 10.2196/medinform.7476. (Selected in the Nursing Informatics Year in Review 2018 by the Nursing Informatics Working Group at the American Medical Informatics Association Symposium 2018)
- Tussing T, Pearl N, Chipps E, Yen P. Evaluation of Socio-technical Factors to Inform Health IT Adaptation - Nursing Perspectives. *Nursing Excellence Fair*, The Ohio State University Wexner Medical Center. 2017
- Pearl N, Tussing T, Chipps E, Sieck C, Bright T, Yen P. Comparing Nurse and Physician Perspectives on Health IT Adaptation. *Proceedings of the American Medical Informatics Association*. 2019. Nov 16-20. Washington, DC
- Tussing T, Pearl N, Chipps E, Yen P. Evaluation of Sociotechnical Factors to Inform Health IT Adaptation. *Association for Leadership Science in Nursing (ALSN) International Conference*, Nov 5-7, 2019. Los Angeles, CA
- Tussing T, Pearl N, Chipps E, Yen P. Evaluation of Socio-technical Factors to Inform Health IT Adaptation - Nursing Perspectives. *Applied Clinical Informatics* (under review)
- Sieck C, Pearl N, Bright T, Yen P. Physicians' experience with Health IT Adaptation. *Applied Clinical Informatics*. *BMC Medical Informatics & Decision Making* (under review)
- Yen P, Pearl N, Lai A, Schallom M. Development and Validation of a Health IT Adaptation Survey Instrument to Assess Clinicians' Experience with Health IT. (In preparation)

References

1. Ammenwerth E, Graber S, Herrmann G, Burkle T, Konig J. Evaluation of health information systems-problems and challenges. *International Journal of Medical Informatics*. 2003;71(2-3):125-35.
2. Phichitchaisopa N, Naenna, T. Factors affecting the adoption of healthcare information technology. *EXCLI Journal*. 2013;12:413-36.
3. Venkatesh V, Sykes, T., Zhang, X., editor 'Just what the doctor ordered' A revised UTAUT for EMR system adoption and use by doctors. *Proceedings of the 44th Hawaii International Conference on System Sciences*; 2011.
4. Patel V, Jamoom E, Hsiao CJ, Furukawa MF, Buntin M. Variation in electronic health record adoption and readiness for meaningful use: 2008-2011. *Journal of general internal medicine*. 2013;28(7):957-64.
5. Steininger K, Stiglbauer B, Baumgartner B, Engleder B, editors. Factors explaining physicians' acceptance of electronic health records. *47th Hawaii International Conference on System Science*; 2014; Hawaii: IEEE computer society.
6. Majchrzak A, Rice R, Malhotra A, King N. Technology adaptation: The case of a computer-supported inter-organizational virtual team. *MIS Quarterly*. 2000;24(4):569-600.
7. Cresswell KM, Sheikh A. Undertaking sociotechnical evaluations of health information technologies. *Informatics in primary care*. 2014;21(2):78-83.
8. Sittig DF, Classen DC. Safe electronic health record use requires a comprehensive monitoring and evaluation framework. *Jama*. 2010;303(5):450-1.
9. Adler-Milstein J, DesRoches CM, Furukawa MF, Worzala C, Charles D, Kralovec P, et al. More Than Half of US Hospitals Have At Least A Basic EHR, But Stage 2 Criteria Remain Challenging For Most. *Health Aff (Millwood)*. 2014.
10. DesRoches CM, Charles D, Furukawa MF, Joshi MS, Kralovec P, Mostashari F, et al. Adoption of electronic health records grows rapidly, but fewer than half of US hospitals had at least a basic system in 2012. *Health Aff (Millwood)*. 2013;32(8):1478-85.
11. Services CfMM. EHR Incentive Programmes 2014 [Available from: http://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/Stage_2.html].
12. Blumenthal D, Tavenner M. The "meaningful use" regulation for electronic health records. *The New England journal of medicine*. 2010;363(6):501-4.
13. Marcotte L, Seidman J, Trudel K, Berwick DM, Blumenthal D, Mostashari F, et al. Achieving meaningful use of health information technology: a guide for physicians to the EHR incentive programs. *Arch Intern Med*. 2012;172(9):731-6.
14. Studeny J, Coustasse A. Personal health records: is rapid adoption hindering interoperability? Perspectives in health information management / AHIMA, American Health Information Management Association. 2014;11:1e.

15. Huerta TR, Pettit L, Silvera G, Ford EW. EMR Implementation Speed: Patient Safety Culture Paradox. *Journal of Healthcare Information Management*. 2014;28(3):24-31.
16. Ford EW, Pettit L, Silvera G, Huerta TR. EMR Implementation Speed: Patient Safety Culture Paradox. *Journal of Healthcare Information Management*. 2014;28(3):24-31.
17. Liu Z, Min Q, Ji S, Ieee. A Comprehensive Review of Research in IT Adoption 2008. 12060-4 p.
18. Gangwar H, Date Hm, Raoot AD. Review of IT adoption: insights from recent technologies. *Journal of Enterprise Information Management* 2014;27(4):488-502.
19. Ward R. The application of technology acceptance and diffusion of innovation models in healthcare informatics. *Health Policy and Technology*. 2013;2:222-8.
20. Cooper RB, Zmud RW. Information Technology Implementation Research: A Technological Diffusion Approach. *Management Science*. 1990;36:123-39.
21. Kukafka R, Johnson SB, Linfante A, Allegrante JP. Grounding a new information technology implementation framework in behavioral science: a systematic analysis of the literature on IT use. *Journal of biomedical informatics*. 2003;36(3):218-27.
22. Sittig DF, Singh H. A new sociotechnical model for studying health information technology in complex adaptive healthcare systems. *Quality & safety in health care*. 2010;19 Suppl 3:i68-74.
23. National Institutes of Health (NIH). PROMIS® Instrument Development and Validation Scientific Standards Version 2.0 (revised May 2013) [Available from: http://www.nihpromis.org/Documents/PROMISStandards_Vers2.0_Final.pdf].
24. AB C, JW O. Best practices in exploratory factor analysis: four recommendations for getting the most from your analysis. *Practical Assessment Research & Evaluation*. 2005;10(7):1-8.
25. RL W, TA W. Scale development research - A content analysis and recommendations for best practices. *Counseling Psychologist*. 2006;34(6):806-38.
26. Qin Y, Zhou R, Wu Q, Huang X, Chen X, Wang W, et al. The effect of nursing participation in the design of a critical care information system: a case study in a Chinese hospital. *BMC Med Inform Decis Mak*. 2017;17(1):165.
27. McKay C, Vanaskie K. Partnering for Success The Role of the Nurse Leader in Health Information Technology Implementation for Coordination of Care. *Nurse Lead*. 2018;16(6):385-8.
28. Asan O, Flynn KE, Azam L, Scanlon MC. Nurses' Perceptions of a Novel Health Information Technology: A Qualitative Study in the Pediatric Intensive Care Unit. *Int J Hum-Comput Int*. 2017;33(4):258-64.
29. Samal L, Dykes PC, Greenberg JO, Hasan O, Venkatesh AK, Volk LA, et al. Care coordination gaps due to lack of interoperability in the United States: a qualitative study and literature review. *BMC Health Serv Res*. 2016;16:143.
30. MacNeill H, Telner D, Sparaggis-Agaliotis A, Hanna E. All for one and one for all: understanding health professionals' experience in individual versus collaborative online learning. *J Contin Educ Health Prof*. 2014;34(2):102-11.
31. Luhanga FL, Billay D, Grundy Q, Myrick F, Yonge O. The one-to-one relationship: is it really key to an effective preceptorship experience? A review of the literature. *Int J Nurs Educ Scholarsh*. 2010;7:Article21.
32. de Bruin LR. Dialogic Communication in the One-to-One Improvisation Lesson: A Qualitative Study. *Australian Journal of Teacher Education*. 2018;43(5).
33. Carey G, Grant C. Teacher and student perspectives on one-to-one pedagogy: practices and possibilities. *British Journal of Music Education*. 2015;32(1):5-22.
34. Bygholm A. Staff Training on the Use of Health Information Systems: What Do We Know? *Stud Health Technol Inform*. 2018;247:191-5.
35. Nicklaus J, Kusser J, Zessin J, Amaya M. Transforming Education for Electronic Health Record Implementation. *J Contin Educ Nurs*. 2015;46(8):359-63.
36. Pandhi N, Yang WL, Karp Z, Young A, Beasley JW, Kraft S, et al. Approaches and challenges to optimising primary care teams' electronic health record usage. *Inform Prim Care*. 2014;21(3):142-51.
37. Moon MC, Hills R, Demiris G. Understanding optimization processes of electronic health records (EHR) in select leading hospitals: a qualitative study. *J Innov Health Inform*. 2018;25(2):109-25.
38. Kraft S, Caplan W, Trowbridge E, Davis S, Berkson S, Kamnetz S, et al. Building the learning health system: Describing an organizational infrastructure to support continuous learning. *Learn Health Syst*. 2017;1(4).
39. Yang L, Cui D, Zhu XM, Zhao QL, Xiao NN, Shen XY. Perspectives from Nurse Managers on Informatics Competencies. *Sci World J*. 2014.

40. Collins SA, Alexander D, Moss J. Nursing domain of CI governance: recommendations for health IT adoption and optimization. *J Am Med Inform Assoc.* 2015;22(3):697-706.