

Clinician Perceptions of a Mobile Electronic Health Record Application

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### Abstract

*Problem and Purpose:* Due to healthcare technology advancements, increasing patient acuity, and patient safety efforts, the Informatics Department at a research hospital has undertaken an initiative to provide remote access of the organization's Electronic Health Record (EHR) system to clinicians via a mobile application. The purpose of this quality improvement project was to test the prototype EHR mobile application to ascertain clinicians' perceptions of the system, evaluate potential usability, and gauge overall satisfaction prior to implementation.

*Methods:* Clinicians ( $N=10$ ) who had been working at the hospital for at least 6 months were randomly recruited. Usability testing was completed using the EHR mobile application testing environment. Clinicians completed a pre-test survey regarding their perceptions of the utility of having mobile EHR access prior to reviewing the application. The clinicians were then instructed to navigate the system on their own for a few minutes and were provided with a script with instructions for order entry and results review. Once done with the application, the clinicians completed the post-test survey, a usability questionnaire, and answered several open-ended questions. The responses were captured using Microsoft Forms and Microsoft Excel.

*Results:* The pre-test data indicated that 60% of clinicians strongly agree that having access to the mobile application would be clinically useful. This increased to 80% after the clinicians viewed and used the application. The pre-test data also revealed that 70% of the clinicians agreed that the mobile application would improve patient care. After using the application, this increased to 100%. Prior to using the application, 80% of clinicians agreed that the application would increase clinicians' productivity. After viewing the application, there was an increase to 100%. Additionally, a paired sample t-test indicated that there was a significant difference ( $p<0.005$ ) in the mean score between the pre and post-test, suggesting that there was a significant change in the clinicians' perception of the mobile application after using it. The usability survey revealed that at least 70% of clinicians strongly agreed and 30% agreed that they would use the mobile application frequently, with 100% confidence in its utilization. About 90% thought it was easy to use. Based on the overall responses from the clinicians, the application is viewed as intuitive and user friendly.

*Conclusions:* The goal of this quality improvement project was to determine the usability and usefulness of an EHR mobile application. Findings from surveyed clinicians indicated that the mobile EHR application is user friendly and that it will allow increased access to patient data therefore provide a high-level of patient care.

## Introduction

The increase in patient acuity coupled with ongoing quality and safety efforts, have placed tremendous demands on hospitals to evolve their healthcare technology and provide increased remote access to Electronic Health Record Systems (EHRs). The ability to facilitate remote and early expert professional input in medical decision making contributes to faster diagnosis and treatment for patients. Any delays in diagnosis and treatment could greatly affect patient outcomes and potentially result in morbidity and mortality. To mitigate these possible complications, mobile EHRs provide an opportunity to improve patient care (Choi et al., 2015).

Having remote access to the EHR via a mobile device would provide faster access to patient care information and timely notification when new patient data becomes available, or if there is a change in the patient's clinical status. These changes would allow clinicians the opportunity to respond in real time and would likely lead to improved patient outcomes. A recent study demonstrated that clinicians who use mobile EHRs frequently are more responsive (Jung, et al 2020).

Clinicians at a local research hospital are limited in their ability to access the EHR when they are physically away from the facility. Unless they have an organization-issued laptop, they do not have access to the EHR once they leave the hospital. Thus, in an effort to provide flexibility and increased access for clinicians, the informatics department has undertaken an initiative to provide remote access of the organization's EHR to clinicians via a mobile application. The implementation is forthcoming and has been a part of the overall initiative of the organization since the inception of the EHR.

The research hospital agreed to pilot test a small group of clinicians to obtain user feedback on the mobile application and provide design suggestions prior to actual

implementation. The group of clinicians reviewed and evaluated the functionality of the application prior to the organizational wide implementation. Therefore, the purpose of this quality improvement (QI) project was to user test the prototype EHR mobile application to ascertain clinicians' perceptions of the system, evaluate the extent to which it might be used, and gauge overall satisfaction.

### **Literature Review**

The literature review focused on the usability and effectiveness of mobile or handheld devices in healthcare. An extensive search was completed using the CINAHL and PubMed databases, and Google Scholar. A combination of search terms was used to conduct the research. These search terms included “mobile electronic medical records”, “healthcare mobile applications”, “electronic health records and mobile”, “mEMR”, and “healthcare technology”. The search was limited to include peer reviewed research articles in the English language between the years 2000 and 2020. Over 200 articles were found. A review of article titles, abstract level review, and duplicate entry removal eliminated many of the articles. Additional articles were excluded after full-text screening for relevance. In total, five articles were applicable and included in the final review. These articles provided information related to mobile technology used by healthcare providers and mobile EHR access. Key characteristics of each study included in the review can be found in an evidence table in Appendix A.

Two systematic reviews by Mickan et al., conducted in 2013 and 2014 respectively, provided summaries of the benefits of using mobile devices in healthcare. The first systematic review (Mickan et. al., 2013), evaluated five studies and sought to examine the effectiveness of mobile devices used by healthcare professionals in their clinical work. Effectiveness was measured by evaluating patient documentation outcomes, patient care outcomes, information

seeking outcomes, and professional work patterns outcomes. The authors concluded that the use of handheld computers resulted in improvement in patient care, less documentation errors, increased efficiency, and easy access to clinical decision support systems resulting in an overall improvement in the decision making for patient care. Mobile devices saved clinicians time and allowed early and quick access to new information, thus enhancing efficiency.

The second review (Mickan et. al., 2014), examined seven randomized trials that investigated the use of personal digital assistants to evaluate the effectiveness of accessing information for clinical knowledge, adherence to guidelines, and diagnostic decision making. The main findings of this review demonstrated that the use of handheld computers improved information seeking, adherence to clinical guidelines, and decision making. The authors concluded that mobile devices can provide real time access and analysis of clinical information which may have a positive impact on patient care.

In a controlled prospective crossover trial to evaluate the utilization of tablets with EHRs, Fleischmann and colleagues (2014), indicated that having mobile access during hospital rounds improved physicians' clinical performance. The results indicated that tablet use accelerated pre and post rounding time. Checking medical records was faster with tablets resulting in an increase in physician's' bedside time. The results of this crossover trial suggest that coupling medical information technology with mobility can provide a more efficient and patient-centered health care delivery.

In another prospective cohort study, Horng et al. evaluated the effectiveness of a mobile device (tablet) by physicians in an Emergency Room (ER) . The authors reported that by using a tablet, physicians spent less time sitting at a stationary computer during their shift. The authors documented a 38-minute decrease in time spent at computer workstations per shift ( $p < 0.001$ ).

This denotes a more efficient use of physicians' time in a demanding medical service such as the ER, and also shows an improvement in time available for patient care. In general, mobile applications provide easier and faster access to data when compared to accessing desktop computers. Faster access to patient information can translate to faster diagnosis and treatment.

A qualitative study (Sweeny et. al., 2018), reviewed resident physicians' perceptions of efficiency, effectiveness, and job satisfaction while using handheld computers. The residents were surveyed before and after the introduction of handheld computers. The survey questioned their assessment of the handhelds and perceived impact on clinical tasks, job satisfaction, and quality of patient care. The study concluded that the use of tablets enhanced resident perception of efficiency in clinical performance, improved job satisfaction, increased effectiveness, and improved quality of care. Feedback from the participants in the study highlighted the benefits of portability and consistent access to the EHR regardless of geographic location of providers or patients.

In summary, results from these studies indicated that the use of mobile applications, including tablets may: 1) improve the efficiency of clinicians' performance through easier and faster access to data, 2) contribute to effective time management through reduced time of gathering patient data from a desktop computer, and 3) possibly improve quality of patient care delivery. These results suggested that in the face of increasing health care demands, mobile technology may enhance clinical care. However, health information technology including the use of mobile devices in healthcare is a new and evolving arena that requires continued research. Unfortunately, no studies looked at the remote usability of mobile EHRs with increased access to patient information. This project thus aims to provide some information regarding the usefulness of mobile EHR in patient information access.

### **Theoretical Framework**

The theoretical framework that was used to guide this quality improvement project was The Information Systems Success Model developed by Delone and McClean (1992). The framework was designed to provide a thorough understanding of information system implementation and adoption success and includes six critical dimensions that are all interrelated. The six dimensions of the model include: 1) information quality, 2) system quality, 3) service quality, 4) user satisfaction, 5) usage intentions, and 6) system use/net benefits.

Information quality refers to the ability of the system to convey information effectively for intended use, and also addresses the integrity of the information. System quality refers to the technical capacity of the system and focuses on issues such as convenience of access, and data and system accuracy. Service quality refers to a users' comparison of service expectations based on a system's performance within the respective industry. If the contents of the first three dimensions are credible and sound, then users are more likely to rely on and use the system. User satisfaction refers to how pleased a user is with the information system. Usage intentions defines the extent and manner in which a system is utilized by its users. Finally, net benefits refer to the degree in which the system contributes to the overall success of its stakeholders. The satisfaction of users, intention of use and net benefits of the information system creates a feedback mechanism which aids in evaluating the overall value of the system.

In this project, the clinicians' access to the testing environment of the EHR prior to implementation allowed them to review the quality of the information that would be available in the actual application and allowed them to critique the overall functionality of the system. Their level of satisfaction with the system will influence usage and contribute to the increased net benefits of the system.

## Methods

### Sample/Setting

Participants of this project included 10 volunteer clinicians from the critical care medicine department at a local research hospital. Clinicians included physicians (7), nurse practitioners (2), and a physician assistant (1). Only individuals who had been working at the hospital for at least 6 months and had adequate ability to navigate/utilize the current EHR independently were asked to participate. The participants also had experience in using standard applications on mobile devices; however, none had used the new EHR mobile application. Participants were recruited via email and in-person communications. The testing was conducted in a dedicated training room located in the informatics department at the hospital.

### Procedures

Usability testing was completed using the EHR testing environment for the mobile application. The system was designed and programmed with simulated patient cases and data. The testing was completed at the convenience of the participants. The mobile devices used for testing were an Apple iPhone and a Samsung Android cell phone. Prior to completing the testing, the providers were asked to complete a six question Likert-type pre-test survey regarding their perceptions of mobile EHR access (See Appendix B for questions). The survey was completed on a computer and responses were captured using Microsoft Forms.

Clinicians were then instructed to navigate the EHR application on their own for a few minutes and were subsequently provided with a script with step-by-step instructions of tasks to be completed (See Appendix C for script). The instructions included testing order entry and results/vital signs review. Providers were observed while they performed the scripted tasks. After completion of the testing, providers were asked to complete the same six question survey



regarding their perceptions of mobile EHR access (See Appendix D for questions). They were also asked to complete the ten question Likert-type System Usability Scale (SUS) and answer several open-ended questions regarding the application (See Appendix E for questions). On average, the clinicians spent about 25-30 minutes to complete the usability testing.

### **Instruments**

Data was collected using pre and post perception surveys, The System Usability Scale (SUS), and open-ended questions to provide qualitative data. The six pre/post survey questions were developed for this project based on a literature review of mobile computing devices, utilization, and usability and with examples from the National Institutes of Health (Zhou, 2019) and guidance from the website usability.gov. The pretest and post-test surveys utilized a five item Likert-type rating scale ranging from “strongly agree” to “strongly disagree” (See Appendix B and D for Pre-Test and Post-test survey questions). A panel of healthcare informatics experts and healthcare professionals reviewed the questions and pilot tested the survey before data was collected. These individuals are employees of the research hospital, who work in the Department of Clinical Research Informatics group (DCRI). They are masters prepared registered nurses and some are Certified Professionals in Healthcare Information and Management Systems (CPHIMS). Minor revisions were made to the survey based on the reviewers’ feedback.

The System Usability Scale (SUS), (usability.gov, 2019) developed by John Brooke in 1986, consists of ten items and utilizes the five response Likert-type scale ranging from “strongly agree” to “strongly disagree”. This scale allows individuals to evaluate a wide range of information technology products and services including websites, mobile devices, and software. The SUS provides a reliable tool for measuring usability of a product or service since it can be used with a very small sample size to detect differences and generate reliable results. The SUS

is also a validated tool, and can also measure perceptions of usability, and differentiate between usable and unusable systems effectively. The SUS scores are calculated per question and then an aggregated number is determined for the user. First, each response from “strongly agree” to “strongly disagree” is assigned a numeric score from 0 to 4 (with 4 being the most positive response). Secondly, for each odd question, one is subtracted from the user’s response and for each even question, the user’s response is subtracted from five. Thirdly, all the converted values are added for each user, then multiplied by 2.5 thereby converting the range from 0 to 100. A mean score of more than 68 per user is considered average. Scores greater than 68 are an indication that people will use the application and scores less than 68 indicate people may not use the application.

### **Data Collection and Analysis**

Data collection was completed over a 2-week period in mid-December 2019. The surveys were completed via computer through Microsoft forms transcribed into Microsoft Excel. Descriptive statistics, frequencies/percentages, means, and qualitative analysis of open-ended responses were used to analyze the data. A paired samples t-test was also used to analyze the pre/post data. Significance was set at a p value of  $< 0.05$ .

## **Results**

### **Sample Demographics**

A total of 10 clinicians participated in the usability testing. All participants had been working at the hospital for over 6 months but the majority (60%) have been at the organization less than 5 years. Over half (60%) of the participants were female and the majority (80%) were

less than 45 years of age. All participants reported adequate experience with the current EHR. (See Table 1).

Table 1

*Participant Demographics*

	Frequency	Percent
<b>Gender</b>		
Female	6	60%
Male	4	40%
<b>Age Group</b>		
<35	4	40%
35-45	4	40%
46-55	2	20%
>55	0	0%
<b>Years employed at Hospital</b>		
0-5	6	60%
6-10	2	20%
11-15	1	10%
>15	1	10%

**Perceptions Pre-Post Test**

All survey questions were completed and there were no missing data. The pre-test data indicated that 60% (n=6) of clinicians strongly agree that having access to the mobile application will be clinically useful. This increased to 80% (n=8) after the clinicians viewed and used the application. The pre-test data also revealed that 40% of the clinicians strongly agreed and 30% agreed that the mobile application would improve patient care. After using the application, this increased to 60% and 40% respectively. Prior to using the application, 80% of clinicians agreed that the application would increase clinicians' productivity. After viewing the application, there

was an increase to 100%. The pre-test data indicated that 50% of clinicians strongly agreed that the mobile application would increase access to patient information. After using the application, the posttest data indicated that the clinician's perception was increased to 80% who strongly agreed with this question. Please see Table 2 for detailed results for each question.

Table 2

*Pre-test and Post-test Data; N =10*

		Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
I perceive access to the Mobile application will be clinically useful	Pre	60	40			
	Post	80	20			
I perceive utilizing the Mobile application will improve patient care	Pre	40	30	30		
	Post	60	40			
I perceive the Mobile application will increase efficiency in your work schedule	Pre	50	40	10		
	Post	80	20			
I perceive the Mobile application will improve patient care and ultimately patient satisfaction	Pre	20	10	70		
	Post	30	30	40		
I perceive the Mobile application will increase access to patient information	Pre	50	50			
	Post	80	20			
I perceive the Mobile application will increase clinician's productivity	Pre	40	40	20		
	Post	70	30			

A paired sample t-test was computed to evaluate the mean difference between the pre-test and post test data. It was hypothesized that after reviewing the application, there would be no change in the clinicians' perception regarding the impact of mobile access on patient care, clinicians' productivity and clinical usefulness. The mean pretest score on the survey was 25.3 and the mean posttest score was 27.6 which was significant ( $p < 0.005$ ) difference (See Table 3).

This indicates that after reviewing and using the mobile application, there was a change in the clinician's perception of the application.

Table 3

*t-Test: Paired Two Sample for Means*

	<i>Posttest Scale</i>	<i>Pretest Scale</i>
Mean	27.6	25.3
Variance	4.93	12.9
Observations	10	10
Pearson Correlation	0.85	
Hypothesized Mean Difference	0	
Df	9	
t Stat	3.53	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.83	
P(T<=t) two-tail	0.01	
t Critical two-tail	2.26	

### **Usability**

The SUS indicated that at least 70% of clinicians strongly agreed and 30% agreed that they would use the mobile application frequently, with 100% confidence in its utilization. About 90% of the clinicians felt that it was not cumbersome, and 90% thought it was easy to use. More than 50% of the clinicians perceived that they would not need additional support to use the mobile application while 90% of the clinicians felt that the various functions in the mobile application were well integrated. All clinicians (100%) agreed that most people would learn to use the mobile application very quickly (See Table 4). The calculated SUS score for clinicians ranged from 70 to 97.5, which indicates a high perceived usability of the mobile application.

Table 4

*Usability Data*

	Strongly Agree (% of total)	Agree (% of total)	Neutral (% of total)	Disagree (% of total)	Strongly Disagree (% of total)
I think that I would like to use Mobile application frequently.	70	30			
I found Mobile application unnecessarily complex and cumbersome			10	60	30
I thought Mobile application was easy to use.	40	50	10		
I think I would need support to use Mobile application	20	10		50	20
I found that the various functions in Mobile application were well integrated.	50	40	10		
I thought there was too much inconsistency in Mobile application.	10		20	60	10
I would imagine that most people would learn to use Mobile application very quickly.	40	40			
I know where to find help for Mobile application.			10	60	30
I felt very confident using Mobile application.	50	50			
I needed to learn a lot of things before I could get going with Mobile application	10	10	10	50	20

**Qualitative Responses**

Documented responses received via the qualitative survey provided both constructive feedback and recommendations for improvement. When asked what features they liked about the mobile application, six participants highlighted the mobility, simplicity, and ease of use of the system. Others liked the fact that the system was intuitive and that they were able to navigate the system without much instructions. Few clinicians highlighted features that they disliked, such as how the information is laid out on the results review pages. They described the view as crowded and overwhelming. When asked what would encourage increased usage of the system, the majority of responses stated easy access, fast and reliable connectivity off campus, and the

quick notification of new information. Some suggestions for improvement were related to specific functionality such as how some data is displayed on the screen, for example making some buttons easier to recognize on the mobile application. Five of the clinicians reported that they would like the option to view lab results and vital signs using different display features such as trending over a period of time. In addition, they suggested that frequently used buttons should be more visible.

## **Discussion**

### **Perceptions Pre-Post Test**

The results of the pretest and posttest surveys and usability testing revealed a favorable perception of the mobile EHR application. Clinicians were open and ready to embrace the practice of a mobile application that would increase their level of access to the EHR. Consistent with the results in the existing literature (Mickan et. al., 2013), clinicians in this project believed that mobile access would impact patient outcomes in a positive way. After the clinicians reviewed the mobile application, there was an optimistic change in their perception of the system. This is evident in the number of responses that were scored “strongly agreed”. In the post survey responses, there was at least a 30% increase in the number of strongly agreed rating for each question compared to the pre survey responses. The t-test analysis indicated a significant difference between the pretest and post test data ( $p < 0.005$ ). This implies that clinicians’ perception of the mobile system was substantially changed after using the application. This significant finding is consistent with the study conducted by Sweeney and colleagues (2018) that examined the perception of efficiency and effectiveness of handheld computers, where the results indicated that more than 70% of the residents reported that the use of tablets enhanced their efficiency and productivity.



**Usability**

Based on prior studies, an average SUS score is 68 (Affairs, 2013), with scores greater than 68 suggesting higher perceived usability, while scores less than 68 implies lower perceived usability. This number, which is not a percentage, gauges the usability performance of the technology based on efficiency, effectiveness, and overall ease of use. The minimum SUS score that was calculated for the survey participants was 70. This number is higher than the average SUS score of 68 and indicates that there is a high perceived usability of the mobile application. These calculated scores are significant in that they provide the organization's informatics department with tangible information about what future users think about the utility of accessing the mobile EHR from their phones and tablets. It also provides information about the efficiency of the current prototype application system and provide suggestions for improvement. These findings are similar to the results obtained by Horng and colleagues (2012) that handheld mobile technology will provide significant benefits of time management, along with increased productivity and efficiency.

**Qualitative Responses**

Based on the overall qualitative responses from the clinicians, the application is intuitive, and user friendly. The comments also suggest that as a result of easy and faster access there would be an increased usage of the mobile application once it is implemented. This is aligned with the findings of a systematic review (Mickan et al., 2013), where use of handheld computers provided earlier and quicker access to new information that enhanced clinicians' work patterns and efficiency.

**Clinical Implications**

The objective of providing remote EHR access to clinicians is to improve timely access to patient data with the overall goal of improving patient care. These results suggest that with the increase in usability, clinicians would have easy access to patient data regardless of their physical location and will be able to react appropriately to any change in patient results or patient condition.

The participants in this study were given little to no instructions on the mobile application prior to viewing it. However, they all were able to navigate the application within a short period of time (each participant spent about 25-30 minutes completing the test). Due to the reported intuitiveness of the system, one tangible positive outcome is that the training team may be able to decrease the amount of time designated for training of the general clinician population once the application has been implemented.

### **Strengths/Limitations**

There are several strengths of this project. One is that all the responses were consistent across clinicians. Additionally, a diverse group of clinicians participated which represents the overall clinician groups at this research hospital. This is important because it indicates that findings may be similar among the larger population of clinicians.

A main limitation of the findings is that the sample size was small. A larger sample size may have provided a broader perspective of the usability of the mobile application. This was however addressed by including a diverse sample of clinicians who represented the clinician population at the research hospital. For optimal mobile application assessment, the user would need a working understanding of basic mobile technology. This project did not address the inability to use mobile devices and assumed that all users are technologically skilled. Lastly, as this was a quality improvement project at one facility only, the findings are not intended to create

generalizable knowledge beyond this organization or group of intended users. This is a unique research hospital and the intricacies of the current EHR are specific only to this hospital which limits generalizability.

### **Conclusions**

The goal of this quality improvement project was to determine the usability and usefulness of an EHR mobile application with a small sample population of clinicians across a variety of disciplines in one hospital. Findings from surveyed clinicians indicated that having remote access to the mobile application is a great enhancement for using the current EHR. Increased access will accelerate clinicians' perceived productivity and may result in enhanced and efficient patient care. The suggestions for improvement in the functionality of the application have been provided to the research hospital's mobile health information technology team for consideration prior to implementation. There will be continued evaluation to make the mobile application more effective and efficient once it is implemented and in the maintenance phase.

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## Appendices

### Appendix A Evidence Review Table

The evidence review table for the DNP project proposal should include only studies that support the implementation of the practice change. While studies that support the significance of the problem are important, you should refer to them in the overview of the proposal, and not include them in the evidence review table.

Author, year	Study objective/intervention or exposures compared	Design	Sample (N)	Outcomes studied (how measured)	Results	*Level and Quality Rating
Mickan, S., Tilson, J. K., Atherton, H., Roberts, N. W., & Heneghan, C. (2013).	To evaluate existent and available evidence that would provide a quick overview of the effectiveness for health care professionals who use handheld computers at their clinical site.	Systematic review	Five systematic reviews met the quality and inclusion criteria, encompassing the review of 138 primary unique studies mostly descriptive intervention studies	Effectiveness highlighted through patient documentation outcomes, patient care outcomes, information seeking outcomes, and professional work patterns outcomes, using both self-report and objective measures.	The use of handheld computers resulted in improvement in patient care, less documentation errors, increased efficiency, and easy access to clinical decision support systems thus improving decision making for patient care. They saved time and gave earlier and quicker access to new information thereby enhancing work patterns and efficiency.	1A

Fleischmann, R., Duhm, J., Hupperts, H., Brandt, S. (2014).	To examine the impact of using tablets with EMR on clinical rounding performance (ward rounding time, physicians time to check medical record)	Controlled Prospective crossover trial	N = 9 resident neurologists over 14 weeks	Primary outcome included changes in unit rounding time and time shifts between work processes. Second measure included physicians' time to check medical record verses bedside time.	Tablet use accelerated pre ( $p = 0.004$ ) and post rounding ( $p < 0.001$ ). Checking medical records were faster with tablets ( $p=0.001$ ) thus causing an increase in physician's bedside time ( $p < 0.001$ )	3A
Mickan, S., Atherton, H., Roberts, N. W., Heneghan, C., & Tilson, J. K. (2014).	To evaluate whether the use of handheld computers by health care professionals improve their access to information and support clinical decision making at the point of care?	Systematic Review	Seven randomized trials investigating medical use of PDAs	Effectiveness evaluated across three specific functions that emerged from the data: accessing information for clinical knowledge, adherence to guidelines and diagnostic decision making	Healthcare professionals' use of handheld computers may improve information seeking, adherence to clinical guidelines and decision making.	1A
Sweeney, M., Paruchuri, K., & Weingart, S. N. (2018)	To assess residents' perceptions of efficiency, effectiveness and job satisfaction using handheld computers	Qualitative Design	Convenience sample of resident physicians from 4 different specialties at a 415-bed teaching hospital. N = 49	Residents were surveyed before and after introduction of handheld computers. Survey questioned their assessment of the handhelds and perceived impact on clinical task, job satisfaction and	Use of tablets enhanced perception of efficiency (73%), job satisfaction (84%) and effectiveness (70%) and improved quality of care (65%)	6B

				quality of patient care.		
Horng S, Goss FR, Chen RS, Nathanson LA. (2012).	To evaluate the effectiveness of mobile device (tablet) use by physicians in an ER while delivering direct patient care.	Prospective cohort study that compared physician workstation usage with and without a tablet	N =13 ER physicians with greater than 55,000 visits/year at a Level 1 ER at a tertiary teaching hospital.	The primary outcome measure: time spent using the ER Information System at a stationary desktop computer workstation per shift.  The secondary outcome measure was the number of ER Information System logins at a computer workstation per shift.	By using a tablet, there was a 38-minute decrease in time spent per shift ER Information System at a computer workstation (p<0.001) after adjustments (clinical role, location, shift length).  By using a tablet, there was also a decrease in login per shift (p<0.001) after adjusting for other covariates.	4A

### Rating System for Hierarchy of Evidence

#### Level of the Evidence Type of the Evidence

- I (1) Evidence from systematic review, meta-analysis of randomized controlled trials (RCTs), or practice-guidelines based on systematic review of RCTs.
- II (2) Evidence obtained from well-designed RCT
- III (3) Evidence obtained from well-designed controlled trials without randomization
- IV (4) Evidence from well-designed case-control and cohort studies
- V (5) Evidence from systematic reviews of descriptive and qualitative studies
- VI (6) Evidence from a single descriptive or qualitative study
- VII (7) Evidence from the opinion of authorities and/or reports of expert committees



## Appendix B

**Mobile Care Pre-Test**

Please circle the item that most represent your response to the statement

1. I perceive access to the mobile EHR will be clinically useful

Strongly Agree    Agree            Neutral            Disagree            Strongly Disagree

2. I perceive utilizing the mobile EHR will improve patient care

Strongly Agree    Agree            Neutral            Disagree            Strongly Disagree

3. I perceive the mobile EHR will increase efficiency in your work schedule

Strongly Agree    Agree            Neutral            Disagree            Strongly Disagree

4. I perceive the mobile EHR will improve patient care and ultimately patient satisfaction

Strongly Agree    Agree            Neutral            Disagree            Strongly Disagree

5. I perceive the mobile EHR will increase access to patient information

Strongly Agree    Agree            Neutral            Disagree            Strongly Disagree

6. I perceive the mobile EHR will increase clinician's productivity

Strongly Agree    Agree            Neutral            Disagree            Strongly Disagree

## Appendix C

**Mobile Application Testing Script**

Find: 3SW-S ICU Census list

Go back to All Inpatient Lis

**Enter Order:**

Find patient: CRISMOBILE, TWO CORY (Outpatient admission)

- Enter CBC STAT
- Discontinue CBC
- Enter Consult – Cardiology
- Enter Restraints – Medical/Surgical
- Enter Single view CXR for December 12, 2019; reason Cough
- Enter Metoprolol Tartrate 5mg IVP, one-time dose
- Cancel Losartan 25 mg PO
- Cancel Audiology Consult

**VIEW Data:**

Find patient: BARCODEONE, TEST SNOOPEY

- Go to Summary page
- View data since start of all charts
- Find: Rehabilitation Medicine Note from 12/21/18
- Find: List of Home Medications
- Find: Patient contact information

Find: Results of Urine culture

## Appendix D

**Mobile Care Post-Test**

Please circle the item that most represent your response to the statement

1. I perceive access to the mobile EHR will be clinically useful

Strongly Agree    Agree            Neutral            Disagree            Strongly Disagree

2. I perceive utilizing the mobile EHR will improve patient care

Strongly Agree    Agree            Neutral            Disagree            Strongly Disagree

3. I perceive the mobile EHR will increase efficiency in your work schedule

Strongly Agree    Agree            Neutral            Disagree            Strongly Disagree

4. I perceive the mobile EHR will improve patient care and ultimately patient satisfaction

Strongly Agree    Agree            Neutral            Disagree            Strongly Disagree

5. I perceive the mobile EHR will increase access to patient information

Strongly Agree    Agree            Neutral            Disagree            Strongly Disagree

6. I perceive the mobile EHR will increase clinician's productivity

Strongly Agree    Agree            Neutral            Disagree            Strongly Disagree

## Appendix E

Please answer the below 10 questions based on your experience with the system:

<i>System Usability Scale</i> © Digital Equipment Corporation, 1986.					
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I think that I would like to use this system frequently					
2. I found the system unnecessarily complex.					
3. I thought the system was easy to use.					
4. I think that I would need the support of a technical person to be able to use this system.					
5. I found the various functions in this system were well integrated.					
6. I thought there was too much inconsistency in this system.					
7. I would imagine that most people would learn to use this system very quickly					
8. I found the system very cumbersome to use.					
9. I felt very confident using the system.					
10. I needed to learn a lot of things before I could get going with this system.					

Please provide feedback on the following based on your exposure to the test environment:

1. What feature do you like most about the application

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2. Any suggestions for improvement of the application

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3. What will encourage you to use the application more frequently

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4. Any other comments

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