NISTIR 7742

EHR Usability Test Report for Fully integrated Electronic Health Records (FiEHR)

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ADS Technologies

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EHR Usability Test Report of Fully Integrated Electronic Health Records (FiEHR) version 2.0.0.0

Report based on (NISTIR 7741) NIST Guide to the Processes Approach for Improving the Usability of Electronic Health Records.

Date of Usability Test   :   May 22, 2019

Date of Report   :   May 27, 2019

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Executive Summary

A usability test of FiEHR (Fully integrated Electronic Health Records) EHR version 2.0.0.0 was conducted on 22nd May 2019 in 174 Waterfront Street, Suite 330, Oxon Hill by ADS Technologies.

The purpose of this study was to test and validate the usability of the current user interface, and provide evidence of user centered design methodologies to support certification according to criteria outlined in Safety Enhanced Design §170.315(g)(3), specifically:

- § 170.315 (a)(1) Computerized provider order entry – medications
- § 170.315 (a)(2) Computerized provider order entry – laboratory
- § 170.315 (a)(3) Computerized provider order entry – diagnostic imaging
- § 170.315 (a)(4) Drug-drug, drug-allergy interaction checks
- § 170.315 (a)(5) Demographics
- § 170.315 (a)(6) Problem list
- § 170.315 (a)(7) Medication list
- § 170.315 (a)(8) Medication allergy list
- § 170.315 (a)(9) Clinical decision support
- § 170.315 (a)(14) Implantable device list
- § 170.315 (b)(2) Clinical information reconciliation and incorporation
- § 170.315 (b)(3) Electronic prescribing

During the 240-minute usability test, each participant was greeted by the administrator. Participants had prior experience with the EHR.

The administrator introduced the test and instructed participants to complete a series of tasks (given one at a time) using the EHR. During the test, the administrator timed the test and, along with the data logger(s) recorded user performance data on paper and electronically. The administrator did not give the participant assistance on how to complete the task.

The following types of data were collected for each participant.
- Number of tasks successfully completed within the allotted time without assistance
- Time to complete the task (in seconds)
- Number and Types of errors.
- Path deviations
- Participant Verbalizations
- Participant's satisfaction ratings of the system

Following the conclusion of the testing, the participants we asked to complete a post-test questionnaire and were compensated with **$____** for their time.

Following is the Summary of Performance and rating data collected on the EHR.

Measure	N	Task Success	Path Deviation	Task Time		Errors	System Usability Scale Ratings – 5 = Easy
Task	#	Mean (SD)	Deviations (Observed/ Optimal)	Mean (SD)	Deviations (Observed/ Optimal)	Mean (SD)	Mean (SD)
Criteria 170.315(a)(1) - CPOE Medications							
A.1.1 Record CPOE Medication Order	13	100% (0)	10.77/10.00	89.62 (20.44)	89.62/80.00	0 (0)	4.92 (0.28)
A.1.2 Change CPOE Medication Order	13	100% (0)	7.83/8.00	53.83 (19.12)	53.83/51.00	0 (0)	5.00 (0.00)
A.1.3 Access CPOE Medication Order	13	100% (0)	7.00/7.00	38.83 (22.03)	38.83/35.00	0 (0)	5.00 (0.00)
Criteria 170.315(a)(2) - CPOE Laboratory							
A2.1 Record Lab order via CPOE	13	100% (0)	13.69/14.00	79.46 (15.03)	79.46/70.00	0 (0)	4.31 (1.11)
A2.2 Change Lab order via CPOE	13	100% (0)	15.46/16.00	91.31 (25.16)	91.31/80.00	0 (0)	4.46 (1.05)
A2.3 Display changed CPOE Lab order	13	100% (0)	6.92/7.00	25.69 (5.60)	25.69/43.85	0 (0)	5.00 (0.00)
Criteria 170.315(a)(3) - CPOE Radiology							
A3.1 Record Imaging order via CPOE	13	100% (0)	12.00/12.00	56.83 (12.27)	56.83/70.00	0 (0)	4.42 (1.08)
A3.2 Change Imaging order via CPOE	13	99% (0.55)	11.85/12.00	96.08 (29.77)	96.08/80.00	0 (0)	4.38 (1.04)
A3.3 Display changed CPOE Imaging order	13	100% (0)	6.85/7.00	31.92 (11.33)	31.92/40.00	0 (0)	5.00 (0.00)

Criteria 170.315(a)(4) - Drug-drug, Drug-allergy Interaction Checks							
A4.1 Using CPOE, trigger a drug-drug interaction by entering a new medication order	13	92% (1.73)	9.62/9.69	88.17 (28.91)	88.17/66.54	0 (0)	4.77 (0.60)
A4.2 Using CPOE, trigger a drug-allergy interaction by entering a new medication order	13	91% (2.33)	9.31/9.38	83.33 (25.08)	83.33/63.08	0 (0)	4.77 (0.60)
A4.3 Adjust the severity level of a displayed drug-drug interaction	13	100% (0)	5.85/6.00	38.23 (28.94)	38.23/25.00	0 (0)	5.00 (0.00)
Criteria 170.315(a)(5) - Demographics							
A5.1 Record a patient's preferred language, date of birth, birth sex, race, ethnicity, sexual orientation, gender identity	13	99% (0.27)	5.77/6.00	186.62 (29.48)	219.69/135.00	0.08 (0.28)	4.77 (0.60)
A5.2 Change the patient's preferred language, date of birth, birth sex, race, ethnicity, sexual orientation, gender identity	13	100% (0)	7.69/8.00	109.92 (27.40)	109.92/100.00	0 (0)	5.00 (0.00)
A5.3 Display the patient's changed preferred language, date of birth, birth sex, race, ethnicity, sexual orientation, gender identity	13	100% (0)	7.54/8.00	26.00 (6.89)	26.00/30.00	0 (0)	5.00 (0.00)

Criteria 170.315(a)(6) - Problem List							
A6.1 Record a problem to the problem list	13	100% (0)	7.92/8.00	81.23 (18.34)	81.23/90.00	0 (0)	5.00 (0.00)
A6.2 Change a problem on the problem list	13	100% (0)	8.92/9.00	40.08 (10.15)	40.08/50.00	0 (0)	5.00 (0.00)
A6.3 Display the active problem list	13	100% (0)	7.69/8.00	30.23 (9.69)	30.23/32.00	0 (0)	5.00 (0.00)
A6.4 Display the historical problem list	13	100% (0)	7.69/8.00	30.23 (9.69)	30.23/32.00	0 (0)	5.00 (0.00)
Criteria 170.315(a)(7) - Medication List							
A7.1 Record a medication to the medication list	13	100% (0)	9.85/10.00	89.62 (20.44)	89.62/140.00	0 (0)	4.92 (0.28)
A7.2 Change a medication on the medication list	13	100% (0)	7.77/7.92	50.92 (19.54)	50.92/49.77	0 (0)	5.00 (0.00)
A7.3 Display the active medication list	13	100% (0)	7.00/7.00	37.92 (21.35)	37.92/35.00	0 (0)	5.00 (0.00)
A7.4 Display the historical medication list	13	100% (0)	7.23/7.23	42.15 (25.72)	42.15/37.69	0 (0)	5.00 (0.00)
Criteria 170.315(a)(8) - Medication Allergy List							
A8.1 Record a medication allergy	13	100% (0)	8.46/9.00	130.23 (27.04)	148.54/100.00	0 (0)	4.85 (0.38)
A8.2 Change a medication allergy	13	100% (0)	9.23/10.00	51.31 (29.98)	51.31/80.00	0 (0)	4.92 (0.28)
A8.3 Display the active medication allergy list	13	100% (0)	7.69/8.00	32.23 (12.01)	32.23/30.00	0 (0)	5.00 (0.00)
A8.4 Display the historical medication allergy list	13	100% (0)	7.69/8.00	32.23 (12.01)	32.23/30.00	0 (0)	5.00 (0.00)

Criteria 170.315(a)(9) - Clinical Decision Support

A9.1 Add a CDS intervention and/or reference resource for each of the required elements: Problem List, Medication List, Medication Allergy List, at least one Demographic, Laboratory Test, Vital Signs, and a Combination of at least 2 of the elements above	13	95% (0.52)	25.58/26.30	197.76 (29.74)	197.76/165.17	0.01 (0.11)	4.24 (1.11)
A9.2 Trigger the CDS interventions/resources added using the applicable data elements from each of the required elements	13	100% (0)	7.85/8.00	130.00 (27.76)	130.00/90.00	0 (0)	4.75 (0.62)
A9.3 View the intervention/resource information using the Infobutton standard for data elements in the problem list, medication list, and demographics	13	100% (0)	13.69/14.00	124.77 (27.18)	124.77/90.00	0 (0)	4.85 (0.38)
A9.4 Trigger the CDS interventions/resources based on data elements in the problem list, medication list, and medication allergy list by incorporating	13	100% (0)	17.08/17.00	184.17 (25.39)	184.17/195.00	0 (0)	5.00 (0.00)

patient information from a transition of care/referral summary							
A9.5 Access the following attributes for one of the triggered CDS interventions/resources: bibliographic citation, developer, funding source, release/revision date	13	100% (0)	13.69/14.00	134.54 (27.04)	108.38/75.00	0 (0)	4.85 (0.38)

Criteria 170.315(a)(14) - Implantable Device List

A14.1 Record UDI	13	100% (0)	7.92/8.00	71.54 (34.00)	71.54/80.00	0.08 (0.28)	5.00 (0.00)
A14.2 Change UDI Status	13	100% (0)	10.00/10.00	48.08 (17.71)	48.08/150.00	0 (0)	5.00 (0.00)
A14.3 Access UDI, Device Description, Identifiers and Attributes	13	100% (0)	7.00/7.00	33.38 (12.93)	33.38/55.00	0 (0)	5.00 (0.00)

Criteria 170.315(b)(2) - Clinical Information Reconciliation and Incorporation

B2.1 Incorporate a CCDA and conduct reconciliation of the medications, medication allergies, and problems in the CCDA with the information currently in the patient's record	13	100% (0)	17.08/17.00	262.33 (95.02)	262.33/195.00	0 (0)	4.17 (1.27)
B2.2 Generate a new CCDA with reconciled data	13	100% (0)	10.92/11.00	207.17 (27.99)	207.17/195.00	0 (0)	4.62 (0.65)

Criteria 170.315(b)(3) - E-Prescribing							
B3.1 E-prescribe New Prescription	13	100% (0)	11.00/11.00	171.77 (28.92)	171.77/180.00	0 (0)	4.38 (1.19)
B3.2 Change Prescription (dosage or duration)	13	100% (0)	9.54/10.00	55.08 (14.81)	55.08/70.00	0 (0)	5.00 (0.00)
B3.3 Cancel Prescription	13	100% (0)	11.46/12.00	80.77 (27.12)	80.77/70.00	0 (0)	5.00 (0.00)
B3.4 Refill Prescription	13	100% (0)	9.69/10.00	75.62 (23.25)	75.62/70.00	0 (0)	4.92 (0.28)
B3.5 Receive Fill Status Notification	13	100% (0)	5.92/6.00	71.69 (20.85)	71.69/60.00	0 (0)	4.92 (0.28)
B3.6 Request and Receive Medication History Information	13	100% (0)	14.54/15.00	92.62 (29.49)	92.62/70.00	0 (0)	4.85 (0.38)

Table 1: Summary of Data Collected

System Usability Scores

The results from the System Usability Scale scored the subjective satisfaction with the system based on performance with these tasks to be: **96.76[2]**

In addition to the Performance Data, the following quantitative observations were made:

Major Findings

- o In Medication History Screen, rename label viz. "Recipient" to "Source". These changes are already incorporated in the latest release of the EHR Software i.e. FiEHR (Version 2.0.0.0).

- o In CDS Setup screen for creation of new CDS, the drop-down value item viz. "English" should be the first item for "Preferred Language" drop down.   Currently, "English" is appearing Alphabetic wise in the drop down. In order to save time and ease of use the participant suggested moving "English" to be the first item in the Preferred Language Drop down.

  The above two points are considered and modification and testing is already done in the latest release of the EHR Software i.e. FiEHR (Version 2.0.0.0).

[2] See Tullis, T. & Albert, W. (2008). Measuring the User Experience. Burlington, MA: Morgan Kaufman (p. 149). Broadly interpreted, scores under 60 represent systems with poor usability; scores over 80 would be considered above average.

Areas of Improvement

- o At the time of adding a new medication for creation of new CDS in the CDS Setup Screen, there was a performance issue where in the population of medication in the list box took some amount of time.

     The above performance issue is already solved in the latest release of the EHR Software version i.e. FiEHR (Version 2.0.0.0).

Introduction

The EHRUT tested for this study was Ambulatory EHR viz. **FiEHR (Fully Integrated Electronic Health Records)** version 2.0.0.0. This software is designed to present medical information of Patients to Healthcare Providers in Ambulatory Clinical Settings.

The usability testing attempted to represent realistic exercises and conditions.
The purpose of this study was to test and validate the usability of the current user interface and provide evidence of usability in the EHR under Test (EHRUT). To this end, measures of effectiveness, efficiency, and user satisfaction, such as task successes, path deviations, time on task, errors, and SUS rating were captured during the usability testing.

Method

Participants

A Total of 13 participants were tested on the EHRUT (Electronic Health Records under Test). Participants had a mix of backgrounds and demographic characteristics. Refer to Table 2 below containing participant's details viz. by characteristics, including demographics, professional experience, computing experience, and user needs for assistive technology.

Participant ID	Gender	Age Group	Education	Occupation/ Role	Professional Experience (In Months)	Computer Experience (In Months)	Product Experience (In Months)	Assistive Technology Needs
ID01	Female	30-39	Master's Degree	Office Manager	240	276	39	No
ID02	Female	50-59	Bachelor's Degree	Operations Consultant	432	408	6	No
ID03	Female	40-49	Bachelor's Degree	Coder	312	348	1	No
ID04	Male	30-39	Bachelor's Degree	Operations Consultant	170	276	60	No
ID05	Male	40-49	Some college credit, no degree	System Administrator	240	240	60	No
ID06	Female	20-29	Bachelor's Degree	Training and Implementation	96	240	60	No
ID07	Female	30-39	High school graduate, diploma or the equivalent (for example: GED)	CMA	132	200	1	No
ID08	Female	30-39	High school graduate, diploma or the	CMA	108	180	1	No

			equivalent (for example: GED)					
ID09	Male	40-49	Doctorate degree (e.g., MD, DNP, DMD, PhD)	MD	240	240	12	No
ID10	Female	40-49	High school graduate, diploma or the equivalent (for example: GED)	Front Desk Manager	216	216	1	No
ID11	Female	30-39	High school graduate, diploma or the equivalent (for example: GED)	CMA	180	180	1	No
ID12	Female	30-39	High school graduate, diploma or the equivalent (for example: GED)	Front Desk Manager	240	240	1	No
ID13	Male	30-39	Master's Degree	Training and Implementation	190	250	15	No

Table 2: Summary of Participant Demographics

Participants were scheduled and were allotted 240 minutes sessions. An Excel sheet was used to keep track of the participant schedule and included each participant's Demographic characteristics.

Study Design

Overall, the objective of this test was to uncover areas where the application performed well – that is, effectively, efficiently, and with satisfaction – and areas where the application failed to meet the needs of the participants.

The data from this test may serve as a baseline for all future tests with an updated version of the same EHR.

During the EHR Test, each of the participants created their unique patient and entered the data accordingly. The Participants used the same EHR application in the same location and was provided with the same instructions.

Here is a risk summary of the above tasks. Following each task is an estimate of the patient-risk associated with the task.

Tasks I-III CPOE
- Create / Change / Review orders
  Medium Risk – The creation, review, and changing of orders is a medium risk.
- Prescribe / Change medications
  Medium Risk – Prescribing medications can always be risky, but the consequences of prescribing medications are related to the later tasks (i.e., reviewing medication and allergy list; seeing any possible interaction warnings).

Task IV – Drug-Drug/Drug-Allergy Interaction Check
- Review potential allergy / medication interactions
  Very High Risk –Reviewing the current medication and allergy lists is required in the prescription workflow, and the consequence for missing a warning related to potential interactions could range from an irritating adverse reaction to a life-threatening interaction.

Task V – Demographics
- Update patient demographics
  Medium Risk – Ensuring accurate demographic information is necessary to convey test results or other patient healthcare reminders.

Task VI – Problem List
- Update patient problem list
  High Risk – Providers need to keep patient problem lists updated to be aware of any condition's contraindication with medications or treatments.

Task VII – Medication List
- Update patient medication list
  High Risk – Providers need to keep patient medication lists updated to be aware of any contraindication with medications, procedures, or conditions.

Task VIII – Medication Allergy List
- Update patient medication allergy
  Very High Risk – The consequence for incorrectly prescribing a medication the patient is allergic to can be life-threatening.

Task IX-- Clinical Decision Support
- Identify recommended interventions as recommended by Clinical Decision Support rules
  Low Risk – Missing a recommended order or medication could result in a reduced patient care experience.

Task X – Implantable Devices
- Update implantable device list
  Medium Risk – Providers need to be aware of implantable devices patient has in the event of a recall or other malfunction.

Task XI – Health Summary Reconciliation

- Review the imported CCD against the patient's current problems, allergies, and medications
  High Risk –If the data cannot be imported, reviewed, and reconciled, there is a patient risk for contraindications with treatments recommended by other provider.

Task XII—Electronic Prescribing

- Prescribe a new medication from the Health Summary window
  High Risk – Prescribing medications can always be risky, but the consequences of prescribing medications are related to the earlier tasks (i.e., reviewing medication and allergy list; seeing any possible interaction warnings)

Procedures

For each of the tasks, the participants were given a printed copy of tasks wherein against each of the task the participants are required to enter Time Taken in Seconds. The task time was completed once the participant indicated they had successfully completed the task.

Participants were instructed to perform the tasks as per the following instructions

- To complete the tasks as quickly as possible, make a few errors and deviations as possible
- Without assistance; administrators were allowed to give immaterial guidance and clarifications on tasks, but not instructions on use
- Without using a think aloud technique

For each task, the participants were given a printed copy of the task. Task timing began once the administrator finished reading the question. The task time was completed once the participant indicated they had successfully completed the task.

Following the session, the administrator gave the participant the post-test questionnaire (e.g., the System Usability Scale, see Appendix 5), and thanked each individual for their participation.

Participants' demographic information, task success rate, time on task, errors, deviations, verbal responses, and post-test questionnaire were recorded in a spreadsheet.

Test Location

The test was conducted in a testing room and the noise levels were kept to a minimum with the ambient temperature within a normal range. Only the Administrator and the participant were present in the test room. All the participants were provided a table, computer. All the safety instructions and evacuation procedures were valid, in place, and visible to the test participants.

Test Environment

For testing, the computer was DELL desktop running Windows 7 (Service Pack 1) with 4GB RAM, Processor as Intel I3-3220 CPU @3.30 GHz and the system type is 64-bit Operating System. The participants used mouse, keyboard, 17-inch display, running at 1280 x 1024 resolution and the color settings were RGB.

The application was installed in the participant's computer and the database was running on a remote server using a test Database on a WAN Connection. Technically, the system performance i.e. response time was representative of what actual users would experience in a field implementation. Additionally, participants were instructed not to change any default system settings viz. Font size.

During the usability test, the following documents and instruments were used, including:

1. Informed consent
2. Moderator's Guide
3. Post-Test Questionnaire

Examples of these documents can be found in Appendices 3-5 respectively. The Moderator's Guide was devised to be able to capture required data.

The participant's interaction with the EHRUT was captured and recorded digitally with screen capture software running on the test machine. Verbal comments were recorded with a microphone. The test session was later transmitted to a nearby observation room where the data logger observed and recorded the test session.

The administrator reads the following aloud to each participant (also see the full moderator's guide in Appendix 4)

Thank you for participating in this study. Your input is very important. Our session today will last about 240 minutes.

I will ask you to complete a few tasks using this system and answer some questions. You should complete the tasks as quickly as possible making a few errors as possible. Please try to complete the tasks on your own following the instructions very closely. Please note that we are not testing you we are testing the system, therefore if you have difficulty all this means is that something needs to be improved in the system. I will be here in case you need specific help, but I am not able to instruct you or provide help in how to use the application.
Overall, we are interested in how easy (or how difficult) this system is to use, what in it would be useful to you, and how we could improve it. All of the information that you provide will be kept confidential and your name will not be associated with your comments at any time. Should you feel it necessary you are able to withdraw at any time during the testing.

Before the commencement of each task, participants were shown the EHR and the participants were given 5 minutes to understand the tasks.

Before the start of each of the tasks, the administrator read the tasks and said "Start". Once "Start" is announced the participants will start the tasks.

Once the task is completed by the participant, the participant said "Done". If the participant failed to say "Done", the time was stopped when the participant stopped performing the task.

At the end of the tasks finish time, the administrator said "Stop" and the participants will end the tasks.

Administrator also said to the participants that we are recording the audio and screen shots of our session today. All the information that the participant provided will be kept confidential and the participant name will not be associated with their comments at any time.

At the end administrator asked the participants as "Do you have any questions or concerns?"

The task timing started as soon the administrator said "Start".

Participants were then given 43 tasks to complete. Refer to Table 4 below for the Tasks defined.

According to the NIST Guide to the Processes Approach for Improving the Usability of Electronic Health Records, EHRs should support a process that provides a high level of usability for all users. The goal is for the users to interact with the system effectively, efficiently, and with an acceptable level of satisfaction. Metrics for effectiveness, efficiency, and user satisfaction were captured during the usability testing.

The goal of the test was to access:

1. Effectiveness of ADS Technologies's Fully Integrated Electronic Health Records (FiEHR) by measuring participant success rates and errors
2. Efficiency of ADS Technologies's Fully Integrated Electronic Health Records (FiEHR) by measuring the average task time and path deviation
3. Satisfaction with ADS Technologies's Fully Integrated Electronic Health Records (FiEHR) by measuring the ease of use ratings.

The following table below viz. Table 3 details how tasks are scored, error evaluated, and the time data analyzed.

Measures	Rationale and Scoring
Effectiveness: Task Success	A task was counted as a "Success" if the participant was able to achieve the correct outcome, without assistance, within the time allotted on a per task basis. The total number of successes were calculated for each task and then divided by the total number of times that task was attempted. The results are provided as a percentage. Task times were recorded for successes. Observed task times divided by the optimal time for each task is a measure of optimal efficiency. Optimal task performance time, as benchmarked by expert performance under realistic conditions, is recorded when constructing tasks. Target task times used for task times in the Moderator's Guide must be operationally defined by taking multiple measures of optimal performance and multiplying by some factor [e.g., 1.25] that allows some time buffer because the participants are presumably not trained to expert performance. Thus, if expert, optimal performance on a task was [x] seconds then allotted task time performance was [x * 1.25] seconds. This ratio should be aggregated across tasks and reported with mean and variance scores.
Effectiveness: Task Failures	If the participant abandoned the task, did not reach the correct answer or performed it incorrectly, or reached the end of the allotted time before successful completion, the task was counted as an "Failures." No task times were taken for errors. The total number of errors was calculated for each task and then divided by the total number of times that task was attempted. Not all deviations would be counted as errors. [11]This should also be expressed as the mean number of failed tasks per participant. On a qualitative level, an enumeration of errors and error types should be collected.
Efficiency: Task Deviations	The participant's path (i.e., steps) through the application was recorded. Deviations occur if the participant, for example, went to a wrong screen, clicked on an incorrect menu item, followed an incorrect link, or interacted incorrectly with an on-

	screen control. This path was compared to the optimal path. The number of steps in the observed path is divided by the number of optimal steps to provide a ratio of path deviation. It is strongly recommended that task deviations be reported. Optimal paths (i.e., procedural steps) should be recorded when constructing tasks.
Efficiency: Task Time	Each task was timed from when the administrator said "Begin" until the participant said, "Done." If he or she failed to say "Done," the time was stopped when the participant stopped performing the task. Only task times for tasks that were successfully completed were included in the average task time analysis. Average time per task was calculated for each task. Variance measures (standard deviation and standard error) were also calculated.
Satisfaction: Task Rating	Participant's subjective impression of the ease of use of the application was measured by administering both a simple post-task question as well as a post-session questionnaire. After each task, the participant was asked to rate "Overall, this task was:" on a scale of 1 (Very Difficult) to 5 (Very Easy). These data are averaged across participants.[12] Common convention is that average ratings for systems judged easy to use should be 3.3 or above. To measure participants' confidence in and likeability of the [EHRUT] overall, the testing team administered the System Usability Scale (SUS) post-test questionnaire. Questions included, "I think I would like to use this system frequently," "I thought the system was easy to use," and "I would imagine that most people would learn to use this system very quickly." See full System Usability Score questionnaire in Appendix 5. [13]

Table 3 - Details of how observed data were scored

[10] An excellent resource is Tullis, T. & Albert, W. (2008). Measuring the User Experience. Burlington, MA: Morgan Kaufman. Also see www.measuringusability.com

[11] Errors have to be operationally defined by the test team prior to testing.

[13] The SUS survey yields a single number that represents a composite measure of the overall Perceived usability of the system. SUS scores have a range of 0 to 100 and the score is a relative benchmark that is used against other iterations of the system.

Results

Data Analysis and Reporting

The results of the usability test were calculated according to the methods specified in the Usability Metrics section above. Participants who failed to follow session and task instructions had their data excluded from the analyses, however no such observation of participants failing to follow instructions occurred.

The usability testing results for the EHRUT are given in Table 4 below. The results should be seen in light of the objectives and goals outlined in Section 3.2 Study Design. The data should yield actionable results that, if corrected, yield material, positive impact on user performance. Furthermore, the data should be presented in forms such as the table below so that the tasks can be easily identified, and their performance results examined and compared.

Measure	N	Task Success	Path Deviation	Task Time		Errors	System Usability Scale Ratings – 5 = Easy
Task	#	Mean (SD)	Deviations (Observed/ Optimal)	Mean (SD)	Deviations (Observed/ Optimal)	Mean (SD)	Mean (SD)
Criteria 170.315(a)(1) - CPOE Medications							
A.1.1 Record CPOE Medication Order	13	100% (0)	10.77/10.00	89.62 (20.44)	89.62/80.00	0 (0)	4.92 (0.28)
A.1.2 Change CPOE Medication Order	13	100% (0)	7.83/8.00	53.83 (19.12)	53.83/51.00	0 (0)	5.00 (0.00)
A.1.3 Access CPOE Medication Order	13	100% (0)	7.00/7.00	38.83 (22.03)	38.83/35.00	0 (0)	5.00 (0.00)
Criteria 170.315(a)(2) - CPOE Laboratory							
A2.1 Record Lab order via CPOE	13	100% (0)	13.69/14.00	79.46 (15.03)	79.46/70.00	0 (0)	4.31 (1.11)
A2.2 Change Lab order via CPOE	13	100% (0)	15.46/16.00	91.31 (25.16)	91.31/80.00	0 (0)	4.46 (1.05)
A2.3 Display changed CPOE Lab order	13	100% (0)	6.92/7.00	25.69 (5.60)	25.69/43.85	0 (0)	5.00 (0.00)
Criteria 170.315(a)(3) - CPOE Radiology							
A3.1 Record Imaging order via CPOE	13	100% (0)	12.00/12.00	56.83 (12.27)	56.83/70.00	0 (0)	4.42 (1.08)

A3.2 Change Imaging order via CPOE	13	99% (0.55)	11.85/12.00	96.08 (29.77)	96.08/80.00	0 (0)	4.38 (1.04)
A3.3 Display changed CPOE Imaging order	13	100% (0)	6.85/7.00	31.92 (11.33)	31.92/40.00	0 (0)	5.00 (0.00)
Criteria 170.315(a)(4) - Drug-drug, Drug-allergy Interaction Checks							
A4.1 Using CPOE, trigger a drug-drug interaction by entering a new medication order	13	92% (1.73)	9.62/9.69	88.17 (28.91)	88.17/66.54	0 (0)	4.77 (0.60)
A4.2 Using CPOE, trigger a drug-allergy interaction by entering a new medication order	13	91% (2.33)	9.31/9.38	83.33 (25.08)	83.33/63.08	0 (0)	4.77 (0.60)
A4.3 Adjust the severity level of a displayed drug-drug interaction	13	100% (0)	5.85/6.00	38.23 (28.94)	38.23/25.00	0 (0)	5.00 (0.00)
Criteria 170.315(a)(5) - Demographics							
A5.1 Record a patient's preferred language, date of birth, birth sex, race, ethnicity, sexual orientation, gender identity	13	99% (0.27)	5.77/6.00	186.62 (29.48)	219.69/135.00	0.08 (0.28)	4.77 (0.60)
A5.2 Change the patient's preferred language, date of birth, birth sex, race, ethnicity, sexual orientation, gender identity	13	100% (0)	7.69/8.00	109.92 (27.40)	109.92/100.00	0 (0)	5.00 (0.00)
A5.3 Display the patient's changed preferred language, date of birth, birth sex, race, ethnicity, sexual orientation, gender identity	13	100% (0)	7.54/8.00	26.00 (6.89)	26.00/30.00	0 (0)	5.00 (0.00)

Criteria 170.315(a)(6) - Problem List							
A6.1 Record a problem to the problem list	13	100% (0)	7.92/8.00	81.23 (18.34)	81.23/90.00	0 (0)	5.00 (0.00)
A6.2 Change a problem on the problem list	13	100% (0)	8.92/9.00	40.08 (10.15)	40.08/50.00	0 (0)	5.00 (0.00)
A6.3 Display the active problem list	13	100% (0)	7.69/8.00	30.23 (9.69)	30.23/32.00	0 (0)	5.00 (0.00)
A6.4 Display the historical problem list	13	100% (0)	7.69/8.00	30.23 (9.69)	30.23/32.00	0 (0)	5.00 (0.00)
Criteria 170.315(a)(7) - Medication List							
A7.1 Record a medication to the medication list	13	100% (0)	9.85/10.00	89.62 (20.44)	89.62/140.00	0 (0)	4.92 (0.28)
A7.2 Change a medication on the medication list	13	100% (0)	7.77/7.92	50.92 (19.54)	50.92/49.77	0 (0)	5.00 (0.00)
A7.3 Display the active medication list	13	100% (0)	7.00/7.00	37.92 (21.35)	37.92/35.00	0 (0)	5.00 (0.00)
A7.4 Display the historical medication list	13	100% (0)	7.23/7.23	42.15 (25.72)	42.15/37.69	0 (0)	5.00 (0.00)
Criteria 170.315(a)(8) - Medication Allergy List							
A8.1 Record a medication allergy	13	100% (0)	8.46/9.00	130.23 (27.04)	148.54/100.00	0 (0)	4.85 (0.38)
A8.2 Change a medication allergy	13	100% (0)	9.23/10.00	51.31 (29.98)	51.31/80.00	0 (0)	4.92 (0.28)
A8.3 Display the active medication allergy list	13	100% (0)	7.69/8.00	32.23 (12.01)	32.23/30.00	0 (0)	5.00 (0.00)
A8.4 Display the historical medication allergy list	13	100% (0)	7.69/8.00	32.23 (12.01)	32.23/30.00	0 (0)	5.00 (0.00)

Criteria 170.315(a)(9) - Clinical Decision Support							
A9.1 Add a CDS intervention and/or reference resource for each of the required elements: Problem List, Medication List, Medication Allergy List, at least one Demographic, Laboratory Test, Vital Signs, and a Combination of at least 2 of the elements above	13	95% (0.52)	25.58/26.30	197.76 (29.74)	197.76/165.17	0.01 (0.11)	4.24 (1.11)
A9.2 Trigger the CDS interventions/resources added using the applicable data elements from each of the required elements	13	100% (0)	7.85/8.00	130.00 (27.76)	130.00/90.00	0 (0)	4.75 (0.62)
A9.3 View the intervention/resource information using the Infobutton standard for data elements in the problem list, medication list, and demographics	13	100% (0)	13.69/14.00	124.77 (27.18)	124.77/90.00	0 (0)	4.85 (0.38)
A9.4 Trigger the CDS interventions/resources based on data elements in the problem list, medication list, and medication allergy list by incorporating	13	100% (0)	17.08/17.00	184.17 (25.39)	184.17/195.00	0 (0)	5.00 (0.00)

patient information from a transition of care/referral summary							
A9.5 Access the following attributes for one of the triggered CDS interventions/resources: bibliographic citation, developer, funding source, release/revision date	13	100% (0)	13.69/14.00	134.54 (27.04)	108.38/75.00	0 (0)	4.85 (0.38)

Criteria 170.315(a)(14) - Implantable Device List

A14.1 Record UDI	13	100% (0)	7.92/8.00	71.54 (34.00)	71.54/80.00	0.08 (0.28)	5.00 (0.00)
A14.2 Change UDI Status	13	100% (0)	10.00/10.00	48.08 (17.71)	48.08/150.00	0 (0)	5.00 (0.00)
A14.3 Access UDI, Device Description, Identifiers and Attributes	13	100% (0)	7.00/7.00	33.38 (12.93)	33.38/55.00	0 (0)	5.00 (0.00)

Criteria 170.315(b)(2) - Clinical Information Reconciliation and Incorporation

B2.1 Incorporate a CCDA and conduct reconciliation of the medications, medication allergies, and problems in the CCDA with the information currently in the patient's record	13	100% (0)	17.08/17.00	262.33 (95.02)	262.33/195.00	0 (0)	4.17 (1.27)
B2.2 Generate a new CCDA with reconciled data	13	100% (0)	10.92/11.00	207.17 (27.99)	207.17/195.00	0 (0)	4.62 (0.65)

Criteria 170.315(b)(3) - E-Prescribing							
B3.1 E-prescribe New Prescription	13	100% (0)	11.00/11.00	171.77 (28.92)	171.77/180.00	0 (0)	4.38 (1.19)
B3.2 Change Prescription (dosage or duration)	13	100% (0)	9.54/10.00	55.08 (14.81)	55.08/70.00	0 (0)	5.00 (0.00)
B3.3 Cancel Prescription	13	100% (0)	11.46/12.00	80.77 (27.12)	80.77/70.00	0 (0)	5.00 (0.00)
B3.4 Refill Prescription	13	100% (0)	9.69/10.00	75.62 (23.25)	75.62/70.00	0 (0)	4.92 (0.28)
B3.5 Receive Fill Status Notification	13	100% (0)	5.92/6.00	71.69 (20.85)	71.69/60.00	0 (0)	4.92 (0.28)
B3.6 Request and Receive Medication History Information	13	100% (0)	14.54/15.00	92.62 (29.49)	92.62/70.00	0 (0)	4.85 (0.38)

Table 4: Usability Testing Results

The results from the SUS (System Usability Scale) scored the subjective satisfaction with the system based on performance with these tasks to be **96.76**. Broadly interpreted, scores under 60 represent systems with poor usability; scores over 80 would be considered above average. [5]

[5] See Tullis, T. & Albert, W. (2008). Measuring the User Experience. Burlington, MA: Morgan Kaufman (p. 149).

Discussion of Findings

This section provides a narrative discussion of each of the major areas in light of the findings.

Effectiveness

Based on the success, failure, and path deviation data, the overall system is relatively easy to use and provides its users with a straightforward interface to accomplish their goals. There were relatively few failures and sub-optimal path deviations. When they did occur, all users were able to get back on track and accomplish the tasks without assistance from the moderator. This indicates that even an inexperienced user would likely be able to effectively use the system without aid.

Efficiency

Based on the observations of the task time and deviation data, there is a relatively wide range in task efficiencies across users. This is to be expected, as different providers had significantly different levels of comfortability and skill with using an electronic system on a computer. Based on the data and qualitative observations during the test, efficiency deviations were not highly related to the system itself, but rather to the user's skills with computers.

Satisfaction

Based on the task ratings and the SUS results data, all the users were highly satisfied with the system.

Major Findings

- In Medication History Screen, rename label viz. "Recipient" to "Source". These changes are already incorporated in the latest release of the EHR Software i.e. FiEHR (Version 2.0.0.0).

- In CDS Setup screen for creation of new CDS, the drop-down value item viz. "English" should be the first item for "Preferred Language" drop down.   Currently, "English" is appearing Alphabetic wise in the drop down. In order to save time and ease of use the participant suggested moving "English" to be the first item in the Preferred Language Drop down.

  The above two points are considered and modification and testing is already done in the latest release of the EHR Software i.e. FiEHR (Version 2.0.0.0).

Areas of Improvement

- At the time of adding a new medication for creation of new CDS in the CDS Setup Screen, there was a performance issue where in the population of medication in the list box took some amount of time.

  The above performance issue is already solved in the latest release of the EHR Software version i.e. FiEHR (Version 2.0.0.0).

Appendices

The following appendices include supplemental data for this usability test report. Following is a list of the appendices provided:

1. Sample Recruiting Screener
2. Participant Demographics
3. Non-Disclosure Agreement and Informed Consent Form
4. Example Moderator's Guide
5. System Usability Scale Questionnaire

Appendix 1: Sample Recruiting Screener

Recruiting Script for Recruiting Firm

Hello, my name is _____, calling from [Insert name of recruiting firm]. We are recruiting individuals to participate in a usability study for an electronic health record. We would like to ask you a few questions to see if you qualify and if would like to participate. This should only take a few minutes of your time. This is strictly for research purposes. If you are interested and qualify for the study, you will be paid to participate. Can I ask you a few questions?

1. [If not obvious] Are you male or female?

2. Have you participated in a focus group or usability test in the past xx months?

3. Do you, or does anyone in your home, work in marketing research, usability research, web design [...etc.]?

4. Do you, or does anyone in your home, have a commercial or research interest in an electronic health record software or consulting company?

5. Which of the following best describes your age? [23 to 39; 40 to 59; 60 - to 74; 75 and older]

6. Which of the following best describes your race or ethnic group? [e.g., Caucasian, Asian, Black/African American, Latino/a or Hispanic, etc.]

7. Do you require any assistive technologies to use a computer? [If so, please describe]

Professional Demographics:

8. What is your current position and title?

      a. RN: Specialty _____

      b. Physician: Specialty _____

      c. Resident: Specialty _____

      d. Administrative Staff

      e. Other

9. How long have you held this position?

10. Describe your work location (or affiliation) and environment? [e.g., private practice, health system, government clinic, etc.]

11. Which of the following describes your highest level of education? [e.g., high school graduate/GED, some college, college graduate (RN, BSN), postgraduate (MD/PhD), other (explain)]

Computer Experience

12. Besides reading email, what professional activities do you do on the computer? [e.g., access EHR, research; reading news; shopping/banking; digital pictures; programming/word processing, etc.]

13. About how many hours per week do you spend on the computer? [Recruit according to the demographics of the intended users, e.g., 0 to 10, 11 to 25, 26+ hours per week]

14. What computer platform do you usually use? [e.g., Mac, Windows, etc.]

15. What Internet browser(s) do you usually use? [e.g., Firefox, IE, AOL, etc.]

16. In the last month, how often have you used an electronic health record?

17. How many years have you used an electronic health record?

18. How many EHRs do you use or are you familiar with?

19. How does your work environment patient records?

      a. On paper

      b. Some paper, some electronic

      c. All electronic

Contact Information

These are all the questions I have for you. Your background matches the people we're looking for. Would you be able to participate on [date, time]?

May I get your contact information?

- Name of participant

- Address

- City, State, Zip

- Daytime phone number

- Evening phone number

- Alternate phone number

- Email address

Before your session starts, we will ask you to sign a release form allowing us to videotape and screen record your session. The videotape will only be used internally for further study if needed. Will you consent to these recordings?

This study will take place at ADS Technologies. I will confirm your appointment in a couple of days before your session and provide you with directions to our office.

What time is best to reach you?

Appendix 2: Participant Demographics

Following is a high-level overview of the participants in the study.

Gender:

1. Men: 4
2. Women: 9
3. Total (participants):   13

Occupation/Role:

1. Office Manager: 1
2. Operations Consultant: 2
3. Coder: 1
4. System Administrator: 1
5. Training & Implementation: 2
6. CMA: 3
7. MD: 1
8. Front Desk Manager: 2
9. Total (participants):   13

Years of Experience:

1. Years' experience: 18

Facility Use of EHR:

1. All paper: 13
2. Some paper, some electronic: None
3. All electronic: None
4. Total (participants):   13

Appendix 3: Non-Disclosure Agreement and Informed Consent Form

This Agreement is entered into as of _____, 2018, between _____ ("the Participant") and the testing organization **ADS Technologies** located at *174, Waterfront Street, Suite 330, National Harbor, MD 20745.*

The Participant acknowledges his or her voluntary participation in today's usability study may bring the Participant into possession of Confidential Information. The term "Confidential Information" means all technical and commercial information of a proprietary or confidential nature which is disclosed by **ADS Technologies**, or otherwise acquired by the Participant, in the course of today's study.

By way of illustration, but not limitation, Confidential Information includes trade secrets, processes, formulae, data, know-how, products, designs, drawings, computer aided design files and other computer files, computer software, ideas, improvements, inventions, training methods and materials, marketing techniques, plans, strategies, budgets, financial information, or forecasts.

Any information the Participant acquires relating to this product during this study is confidential and proprietary to **ADS Technologies** and is being disclosed solely for the purposes of the Participant's participation in today's usability study. By signing this form, the Participant acknowledges that s/he will receive monetary compensation for feedback and will not disclose this confidential information obtained today to anyone else or any other organizations.

Participant's printed name: _____

Signature: _____ **Date: _____**

Informed Consent

ADS Technologies would like to thank you for participating in this study. The purpose of this study is to evaluate an electronic health records system. If you decide to participate, you will be asked to perform several tasks using the prototype and give your feedback.

Agreement

I understand and agree that as a voluntary participant in the present study conducted by ***ADS Technologies***. I am free to withdraw consent or discontinue participation at any time. I understand and agree to participate in the study conducted and videotaped by ***ADS Technologies***.

I understand and consent to the use and release of the screen capture by ***ADS Technologies*** I understand that the information and screen capture is for research purposes only and that my name and image will not be used for any purpose other than research. I relinquish any rights to the screen capture and understand the screen capture may be copied and used by ***ADS Technologies*** without further permission.

I understand and agree that the purpose of this study is to make software applications more useful and usable in the future.

I understand and agree that the data collected from this study may be shared with outside of ***ADS Technologies*** and ***ADS Technologies'*** client. I understand and agree that data confidentiality is assured, because only de-identified data – i.e., identification numbers not names – will be used in analysis and reporting of the results.

I agree to immediately raise any concerns or areas of discomfort with the study administrator. I understand that I can leave at any time.

Please check one of the following:

☐ YES, I have read the above statement and agree to be a participant.

☐ NO, I choose not to participate in this study.

Signature: _____

Date: _____

Administrator: _____

Data Logger: _____

Date: _____   Time: _____

Participant #: _____

Location: _____

Prior to Testing

- Confirm schedule with Participants
- Ensure EHRUT lab environment is running properly
- Ensure lab and data recording equipment is running properly

Prior to each participant

- Reset Application
- Start session recordings

Prior to each task

- Reset application to starting point for next task

After each participant

- End session recordings

After all testing

- Back up all video and data files

Orientation (10 minutes)

Thank you for participating in this study. Our session today will last 240 minutes. During that time, you will take a look at an electronic health record system.

I will ask you to complete a few tasks using this system and answer some questions. You should complete the tasks as quickly as possible making as few errors as possible. Please try to complete the tasks on your own following the instructions very closely. Please note that we are not testing you we are testing the system. I will be here in case you need specific help, but I am not able to instruct you or provide help in how to use the application.

Overall, we are interested in how easy (or how difficult) this system is to use, what in it would be useful to you, and how we could improve it. All the information that you provide will be kept confidential and your name will not be associated with your comments at any time. Should you feel it necessary you are able to withdraw at any time during the testing.

For each task, I will read the description to you and say "Begin." At that point, please perform the task and say "Done" once you believe you have successfully completed the task.

I will ask you your impressions about the task once you are done.

The product you will be using today is in the final stages of development. Some of the data may not make sense as it is placeholder data.

We are recording the audio and screenshots of our session today. All of the information that you provide will be kept confidential and your name will not be associated with your comments at any time.

Do you have any questions or concerns?

Preliminary Questions (5 minutes)

What is your job title?

How long have you been working in this role?

What are some of your main responsibilities?

Tell me about your experience with electronic health records.

This is the application you will be working with it. Have you heard of it? If so, tell me what you know about it.

Show test participant the EHRUT

Please don't click anything just yet. What do you notice? What are you able to do here? Please be specific.

Task 2: Patient Summary Screen (*XXX Seconds*)

Take the participant to the starting point for the task.

Before going into the exam room and you want to review *Patient's* chief complaint, history, and vitals. Find this information.

Success:
☐ Easily completed
☐ Completed with difficulty or help :: Describe below
☐ Not completed

Comments:

Task Time: Seconds

Optimal Path: *Screen A* → *Screen B* → *Drop Down B₁* → *"OK" Button* → *Screen X…*

☐ Correct
☐ Minor Deviations / Cycles :: Describe below
☐ Major Deviations :: Describe below

Comments:

Observed Errors and Verbalizations:

Comments:

Rating:
Overall, this task was:

Show participant written scale: "Very Difficult" (1) to "Very Easy" (5)

Administrator / Notetaker Comments:

Final Questions (10 minutes)

What was your overall impression of this system?

What aspects of the system did you like most?

What aspects of the system did you like least?

Were there any features that you were surprised to see?

What features did you expect to encounter but did not see? That is, is there anything that is missing in this application?

Compare this system to other systems you have used. Would you recommend this system to your colleagues?

Appendix 5: System Usability Scale Questionnaire

In 1996, Brooke published a "low cost usability scale that can be used for global assessments of systems usability" known as System Usability Scale of SUS. Lewis and *Sauro (2009) and others have elaborated on the SUS over the years. Computation of the SUS score can be found in Brooke's paper, at* http://www.usabilitynet.org/trump/documents/Suschapt.doc *, or in Tullis and Albert (2008).*

1. I think that I would like to use this system frequently

Strongly   Strongly
Disagree   Agree

1	2	3	4	5

2. I found this system unnecessarily complex

1	2	3	4	5

3. I thought the system was easy to use

1	2	3	4	5

4. I think that I would need the support of a technical person to be able to use this system

1	2	3	4	5

5. I found the various function in this system were well integrated

1	2	3	4	5

6. I thought there was too much inconsistency in this system

1	2	3	4	5

7. I would imagine that most people would learn to use this system very quickly

1	2	3	4	5

8. I found the system very cumbersome to use

1	2	3	4	5

9. I felt very confident using the system

Strongly   Strongly
Disagree   Agree

1	2	3	4	5

10. I needed to learn a lot of things before I could get doing with this system

1	2	3	4	5