**EHR Usability Test Report of the Sapphire EHR**
Product Version*: 2018-2019*

Report based on NISTIR 7742 Common Industry Format for Usability Test Reports

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Executive Summary

On July 10th through July 12th, 2019, The Usability People, LLC conducted a summative usability test of the Sapphire EHR System. The test was conducted in the Fairfax, Virginia offices of The Usability People over remote tele-conferencing sessions using *GoToMeeting*. The purpose was to test and validate the usability of the current user interface and provide evidence of usability of Sapphire EHR as the EHR Under Test (EHRUT). Ten (10) healthcare providers matching the target demographic criteria participated in the usability test using the EHRUT in simulated, but representative tasks.

The study focused on measuring the effectiveness of, efficiency of, and satisfaction with the Sapphire EHR among a sample of participants representing potential users of the system. Performance data was collected on fifteen (15) tasks typically conducted on an EHR. Tasks created were based upon the criteria specified within the test procedure structure for evaluating conformance of Electronic Health Record (EHR) technology to the certification criteria defined in certification criteria identified in 45 CFR Part 170 Subpart C of the Health Information Technology: 2015 Edition Health Information Technology (Health IT) Certification Criteria[1].

Results of the study indicated that the Sapphire EHR system was quite satisfactory with regards to effectiveness and efficiency and that the participants were satisfied with the system.

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[1] [2015 Edition Health Information Technology (Health IT) Certification Criteria](), 2015 Edition Base Electronic Health Record (EHR) Definition, and ONC Health IT Certification Program Modifications

Introduction

The Electronic Health Record System Under Test (EHRUT) tested for this study, the Sapphire EHR, was specifically designed to present medical information to healthcare providers on desktop computers on an incarcerated population in an ambulatory healthcare setting. This study tested and validated the usability of the Sapphire EHR user interface and provides evidence of the usability of Sapphire Health with representative exercises and in realistic user conditions. To this end, measures of effectiveness and efficiency, such as time on task, number of errors made, and completion rates were captured during usability testing. Satisfaction was assessed and user comments collected using two industry-standard questionnaires: The System Usability Scale (SUS) and the Computer System Usability Questionnaire (CSUQ).

Method

Participants

Ten (10) individuals (3 men and 7 women) participated in the EHRUT. The recruiting process for participants first identified known EHR users of various geographic areas and demographics, targeting a cross-section of the population based on diversification of job role and length of experience with EHRs. Those who responded to the invitation to take part in the study were directed to an online questionnaire that served as the participant screener. (The screening questionnaire is provided as Appendix A.) Participants meeting the criteria for participation in the study were contacted and scheduled via email, or telephone and confirmed for their testing session. Participants in the usability test of the Sapphire EHR had a variety of healthcare backgrounds and demographic characteristics.

Table 1 presents participant characteristics, including demographics, professional experience, computing experience, and previous EHR experience. Participant characteristics reflect the audience of current and future users and meet the criteria designated in the 2015 Edition Certification Companion Guide for Safety-enhanced design - 45 CFR 170.315(g)(3). None of the participants were from the vendor organization (Sapphire Health) that produced and supplied the evaluated system nor did any participant have any direct connection to the testing organization (*The Usability People*). All participants were compensated for their time.

Table 1. Participant Characteristics

Part ID	Gender	Age	Education	Role/Title	Professional Experience (Months)	EHR Experience (Months)	Experience with Sapphire (Months.)	Assistive Tech Needs
P0101	Female	20 to 29	Bachelor's degree	Medical Assistant	60	48	0	None
P0102	Male	50 to 59	Medical Degree	MD	312	96	0	None
P0103	Female	30 to 39	Masters Degree	Registered Nurse	120	120	0	None
P0104	Female	40 to 49	Some college credit, no degree	Office Manager	276	72	0	None
P0105	Female	60 to 69	Medical Degree	MD	348	48	0	None
P0106	Male	40 to 49	Masters Degree	Health Informatic Instructor	48	132	0	None
P0107	Male	60 to 69	Medical Degree	MD	480	60	0	None
P0108	Female	20 to 29	Some college credit, no degree	Certified Medical Assistant	84	84	0	None
P0109	Female	30 to 39	Some college credit, no degree	Clinical Informatics Officer	192	192	0	None
P0110	Female	30 to 39	Bachelor's degree	Clinical Informatics, RN	60	60	0	None

Summary of Participant Characteristics:

Participants had experience with the occupation and expertise that aligns with the capability under testing. The cohort of users who are selected as participants was varied with the product and its intended users and was not limited to clinicians. The demographic characteristics of the test participant characteristics reflected the audience of current and future users.

Gender	
Male	3
Female	7
Age Range	
20 to 29	2
30 to 39	3
40 to 49	2
50 to 59	1
60 to 69	2
70 to 79	0
Education	
Some college credit, no degree	3
Trade technical vocational training	0
Associate degree	0
Bachelors degree	2
Masters degree	2
Doctorate Degree	3
Years of Experience with Sapphire EHR	
None	10

Study Design

The overall objective of this usability test was to uncover areas where the Sapphire EHR system performed well – that is, effectively, efficiently, and with satisfaction – and areas where the system failed to serve the clinical documentation and workflow needs of users. Data from this test may be used as a baseline for future tests of updated versions of Sapphire EHR and/or for comparing Sapphire EHR *w*ith other EHRs presenting the same tasks. In short, this testing serves as both a means to record or benchmark current usability and to identify areas where improvements must be made.

Participants had a range of experience with EHRs in general, and none had any direct experience and/or training with the Sapphire EHR system. Participants completed the test of Sapphire EHR usability during individual 45-60-minute *GoToMeeting* sessions. During the test, each participant interacted with various components of the Sapphire EHR system. Each participant was provided with the same instructions.

The Sapphire EHR was evaluated for effectiveness, efficiency and satisfaction as defined by the following measures collected and analyzed for each participant:

- Number of tasks successfully completed without assistance

- Time to complete the tasks

- Number and description of errors

- Path deviations

- Participant's verbalizations (comments)

- Participant's satisfaction ratings of the *system*

Tasks

The Usability People constructed a total of fifteen (15) tasks in collaboration with the Sapphire Health team, to be realistic and representative of the clinical documentation and workflow activities a user might engage with the Sapphire EHR system in actual medical settings. The fifteen (15) tasks were created based upon a sub-set of the criteria specified within the test procedure structure for evaluating conformance of Electronic Health Record (EHR) technology to the certification criteria as defined in 45 CFR Part 170 Subpart C of the Health Information Technology: Standards, Implementation Specifications, and Certification Criteria for Electronic Health Record Technology.

The tasks focused on the following sub-set of the 2015 Edition certification criteria specified by ONC:

- Section 170.315(a)(1) Computerized provider order entry – medications
- Section 170.315(a)(2) Computerized provider order entry – laboratory
- Section 170.315(a)(3) Computerized provider order entry – diagnostic imaging
- Section 170.315(a)(4) Drug-drug, drug-allergy interaction checks
- Section 170.315(a)(5) Demographics
- Section 170.315(a)(6) Problem list
- Section 170.315(a)(7) Medication list
- Section 170.315(a)(8) Medication allergy list

A copy of the tasks presented to participants in the usability test of the Sapphire EHR system can be found in Appendix C.

Test Location

All participants were tested on the Sapphire EHR system during remote conferencing sessions using *GoToMeeting*. Each participant was requested in advance to secure a quiet room with minimal distractions and a desktop or laptop computer that could connect to the Internet with a *GoToMeeting* session. Although the type of computer, operating system and display resolution of the remote participant system was unknown, the system that was used by the test administrator and controlled by the remote participant was a Dell Laptop running the Windows 10 professional operating system at a resolution of 1366x768 pixels. During a given *GoToMeeting* session, only the test administrator and participant communicated with one another.

The *GoToMeeting* usability test session was conducted by a test administrator from the testing organization (*The Usability People*) working from a small conference room at The Usability People's Fairfax Virginia location. A data logger from The Usability People observed the sessions, took detailed notes on each session, including user comments and satisfaction ratings following each task and provided technical assistance running the Sapphire EHR. During a session the test administrator, and the data logger representative could see only the participant's screen and hear the participant's comments, questions, and responses.

Test Environment

While the EHRUT typically would be used in a healthcare office, or an incarceration center facility, testing of the Sapphire EHR system was conducted via remote connection during individual GoToMeeting sessions. Each participant connected into a GoToMeeting session and was connected by the test administrator to the application.

The Sapphire EHR application itself ran on a Browser-based platform on a LAN connection using a sample database set up specifically for the test. Participants used a mouse and keyboard when interacting with the EHRUT and were given remote control of the administrator's workstation to perform the tasks.

Test Forms and Tools

As part of the usability test, several documents and instruments were used. Examples of the documents used during the usability test, including an informed consent form, the tasks, and post-test questionnaires, can be found in Appendices B to E, respectively.

Participants' interaction with the Sapphire EHR was captured and recorded digitally using the Morae screen capture software running on the test administrator's workstation. Verbal responses were recorded through either the microphone integrated into the participant's computer or through a telephone connection. This information was electronically transmitted to the administrator and observer(s) during each test session.

Participant Instructions

The administrator read the following instructions aloud to each participant:

Thank you for participating in this study. Our session today will last approximately 45- 60 minutes**.** During this session, you will look at the Sapphire EHR software. The purpose of this study is to gauge the usability of the software. We are interested in how easy (or how difficult) this system is to use, and the features and benefits that would be useful to you. We also want to know how we could improve it.

Please use the software as you would in a real clinical setting. I ask that you save your detailed comments until the end of a task or the end of the session, when we can discuss your thoughts freely.

If you notice an error, just cancel out and continue to the task. Please let me know when you are finished with a task by saying "**I'm done**".

As the moderator, I cannot help you problem-solve the system, itself. I did not have any involvement in its creation, so please be honest with your opinions. If you feel lost or have difficulty completing the scenario, please continue to try as best you can. If you are unable to complete the task, we will stop the task and move you on to the next scenario.

We are <u>recording the audio and screenshots</u> of our session today for further study. All the information you provide will be kept confidential. Your name will not be associated with your comments at any time. At the <u>end of the session</u>, I will ask you additional questions and there will be a survey.

Please understand, we are evaluating the ease of use on the software and not your performance on this system. Do you have any questions or concerns?

Participants were then given fifteen (15) tasks to complete.

Procedure

Upon connection to the online meeting tool (GoToMeeting), each participant was greeted, his or her identity verified, and matched to a name on the participant schedule. Participant names were replaced with participant IDs so that a given individual's data cannot be linked to his/her identity. Prior to beginning testing, each participant reviewed and signed an informed consent form (See Appendix B).

Two staff members of the Usability People, a data logger and a usability test administrator observed the interaction between the participant and the EHRUT. The administrator moderated the session by providing both verbal and written instructions for the overall usability test and for each of the tasks comprising the test. The administrator also monitored task success, path deviations, number and description of errors, and audio-recorded participant verbal comments, etc. The data logger obtained post-task rating data, and took notes on participant comments and administrator feedback.

For each of the fifteen (15) tasks, participants were provided written instructions to their computers. Following the administrator's instructions, each participant performed each task by first reading the task then stating in his or her own words his or her interpretation of the task requirements. When the participant's interpretation matched the actual goal of the task, the administrator instructed the participant to begin and task timing began. Task time was stopped and recorded when the test administrator observed on their workstation that the participant had successfully completed the task. If a participant failed to complete a task before the expected amount of time for each task, that task was marked as "Timed Out." After each task, the test administrator asked the participant, "On a scale from 1 to 5, where 1 is 'Very Difficult and 5 is 'Very Easy,' how satisfied were you with the ease of use for this task?" This same procedure was conducted for each of the fifteen (15) tasks.

Following completion of the fifteen (15) EHR tasks, the administrator electronically presented to the participant two post-test questionnaires (System Usability Scale (SUS), see Appendix D and Computer System Usability Questionnaire (CSUQ), see Appendix E). After the participant completed both questionnaires, the administrator thanked each participant for his or her time and allowed the participant to make any comments on or ask any questions about the system and/or the tasks presented. For each session, the participant's schedule, demographic information, task success rate, time on task, errors, deviations, verbal responses, and post-test questionnaire were digitally recorded. The system was then reset to proper test conditions for the next participant.

Usability Metrics

According to the *NIST Guide to the Processes Approach for Improving the Usability of Electronic Health Records* (NIST IR 7741, November, 2010) EHRs should support a process that provides a high level of usability for all users. The goal is for users to interact with the system effectively, efficiently, and with an acceptable level of satisfaction. To this end, metrics for effectiveness, efficiency and user satisfaction were captured during the usability testing. The goals of the test were to assess:

- Effectiveness of the Sapphire EHR by measuring participant success rates and errors.

- Efficiency of the Sapphire EHR by measuring the average task time and path deviations.

- Satisfaction with the Sapphire EHR by measuring ease-of-use ratings.

Table 2 details how tasks were scored, errors evaluated, and the time data analyzed:

Data Scoring

Table 2. Scoring Protocols for Effectiveness, Efficiency, and Satisfaction

Measures	Rationale and Scoring
Effectiveness:	
Task Success	A task was counted as "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 was calculated for each task and then divided by the total number of times that task was attempted. Results are provided as a percentage.
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 "Fail." No task times were taken for failed attempts. The total number of errors was calculated for each task and divided by the total number of times that task was attempted. Results are presented as the average error rate. Note: Not all deviations are counted as errors
Effectiveness:	
Prompted Successes	Because some tasks are dependent upon the successful completion of previous tasks, participants may receive a limited number of "prompts" to help prepare the system data for the pre-requisites for subsequent tasks. When a participant was able to complete the data entry on a task with 3 or fewer prompts, the task was counted as an "Assisted" competition. No task times were recorded for Assisted completions.
Efficiency:	
Task Deviations	The participant's path (i.e., steps) through the application was recorded. Deviations occur if for example, the participant navigated to an incorrect screen, clicked on an incorrect menu item, followed an incorrect link, or interacted incorrectly with an on-screen control.

Measures	Rationale and Scoring
Efficiency:	
Task Time	Each task was timed from the administrator's prompt "Begin" until said, "Done." If the participant failed to say, "Done," timing 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.
Satisfaction:	
Ease of Use ratings **System Satisfaction**	Participant's subjective impression of the ease of use of the application was measured by administering both a single post-task question as well as two post-session questionnaires. After each task, the participant determined on a scale of 1 to 5 their subjective satisfaction with performance on the task. These data are averaged across participants. To measure participants' confidence in and likeability of the EHR overall, the testing team administered electronic versions of the System Usability Scale (SUS) and the Computer System Usability Questionnaire (CSUQ). See the SUS questionnaire as Appendix D., and the CSUQ as Appendix E.

Results

The results of the usability test of the Sapphire EHR system were analyzed according to the methods described in the Usability Metrics section above and are detailed below. Note that the results should be evaluated relative to the study objectives and goals, as outlined in the study design section above. The data should yield actionable results that, if corrected, yield material, positive impact on user performance.

Reliability

During the entire data collection phase, it was observed that the system provided a consistent and reliable interface to each participant as they completed their tasks. As each participant completed their assigned tasks, the system provided the same information and responded to their input with the same verbiage and using the same mode of communication (e.g. Pop-up message, or embedded assistance).

Effectiveness and Efficiency

Table 3 presents a summary of overall task performance showing task, mean time on task, task completion rates, mean path deviations and mean task satisfaction:

Table 3. Usability Test Results

Task	Mean Task Time	SD	Completion Rate (%)	Mean # Path Deviations	SD	Mean Task Satisfaction	SD
Task 1 (a.5) Demographics	1:40	1:01	90%	2.00	1.90	4.40	0.92
Task 2 (a.5) Demographics - Modify	0:42	0:09	100%	0.10	0.30	4.80	0.40
Task 3 (a.6) Problem List	2:50	0:48	70%	3.60	2.01	3.50	0.67
Task 4 (a.6) Problem List - Modify	1:18	0:28	90%	1.50	1.63	4.30	0.46
Task 5 (a.1, a.7) Record Medication	3:10	1:05	50%	5.20	1.72	2.30	0.90
Task 6 (a.1, a.7) Change medication	2:48	1:21	80%	3.50	1.91	3.30	0.90
Task 7 (a.2) Record Lab order	1:34	0:24	100%	2.20	0.98	4.00	0.45
Task 8 (a.2) Modify Lab order	1:31	0:16	100%	1.80	1.08	3.50	0.92
Task 9 (a.3) Diagnostic Imaging order	1:05	0:19	100%	1.10	0.83	4.10	0.54
Task 10 (a.3) Modify Diagnostic Imaging Order	1:24	0:17	90%	1.30	1.95	3.90	0.54
Task 11 (a.4) Drug-drug interaction check	0:41	0:10	100%	0.00	0.00	4.90	0.30
Task 12 (a.4) Drug-allergy interaction check	0:35	0:10	100%	0.00	0.00	4.90	0.30
Task 13 (a.4) Drug/Allergy interaction adjustment	0:58	0:18	100%	0.80	1.17	4.50	0.50
Task 14 (a.8) Display active medication allergy list	0:16	0:07	100%	0.10	0.30	4.80	0.40
Task 15 (a.8) Add an allergy	0:33	0:05	100%	0.00	0.00	4.80	0.40

As Table 3 shows, relative to optimal performance standards as defined by Sapphire Health and The Usability People, participant performance in the Sapphire EHR usability test was satisfactory. The overall average task completion rate was ninety-one (91) percent.

Satisfaction

Individual Task Satisfaction

Participants verbally indicated their satisfaction with the ease of use for each task using a scale of "1" ("Very Difficult") to "5," ("Very Easy"). As Figure 1 shows individual task satisfaction ranged from a low of 4.9 out of 5 on Task 11 and 12 *(Drug-Drug and Drug-Allergy interaction checks)*.

Figure 1. Satisfaction Ratings of Individual Tasks
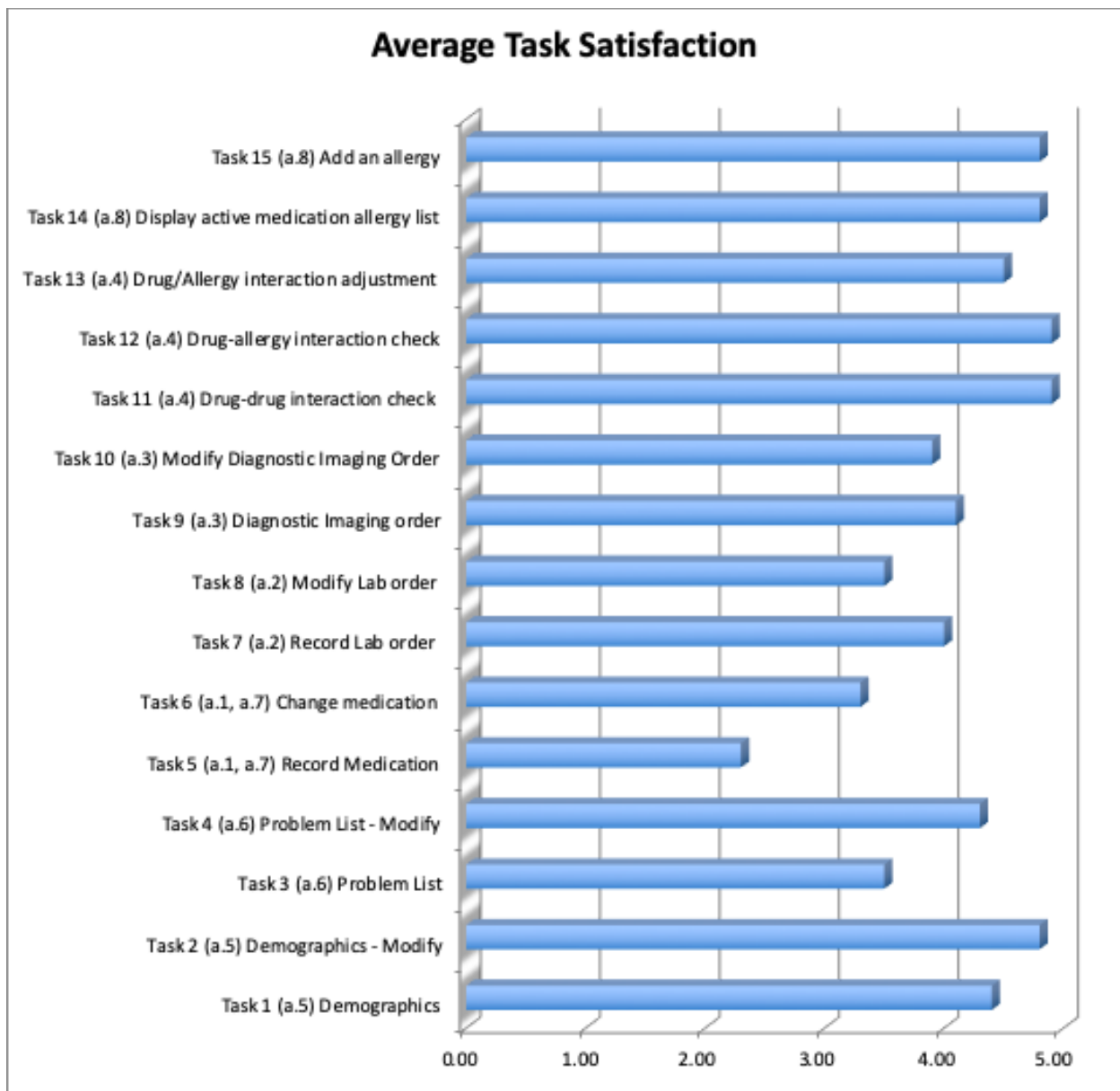
System Usability Scale

The System Usability Scale (SUS) is a simple, 10-item Likert-type attitude scale providing a global subjective assessment of usability from the user's perspective (John Brooke at Digital Equipment Company developed the SUS in 1986). The SUS scale is scored from 0 to 100; scores under 60 represent systems with less than optimal usability, scores over 80 are considered better than average.   See Appendix D for a copy of the SUS.

The mean total SUS score for the Sapphire EHR was eighty-four (84) and ranged from a low of fifty-five (55) and a high of ninety-five (95). Overall, participant-users rated their satisfaction with the Sapphire EHR system to be within the better than average range of a usable and satisfying EHR.

The following chart shows the SUS score by each participant:
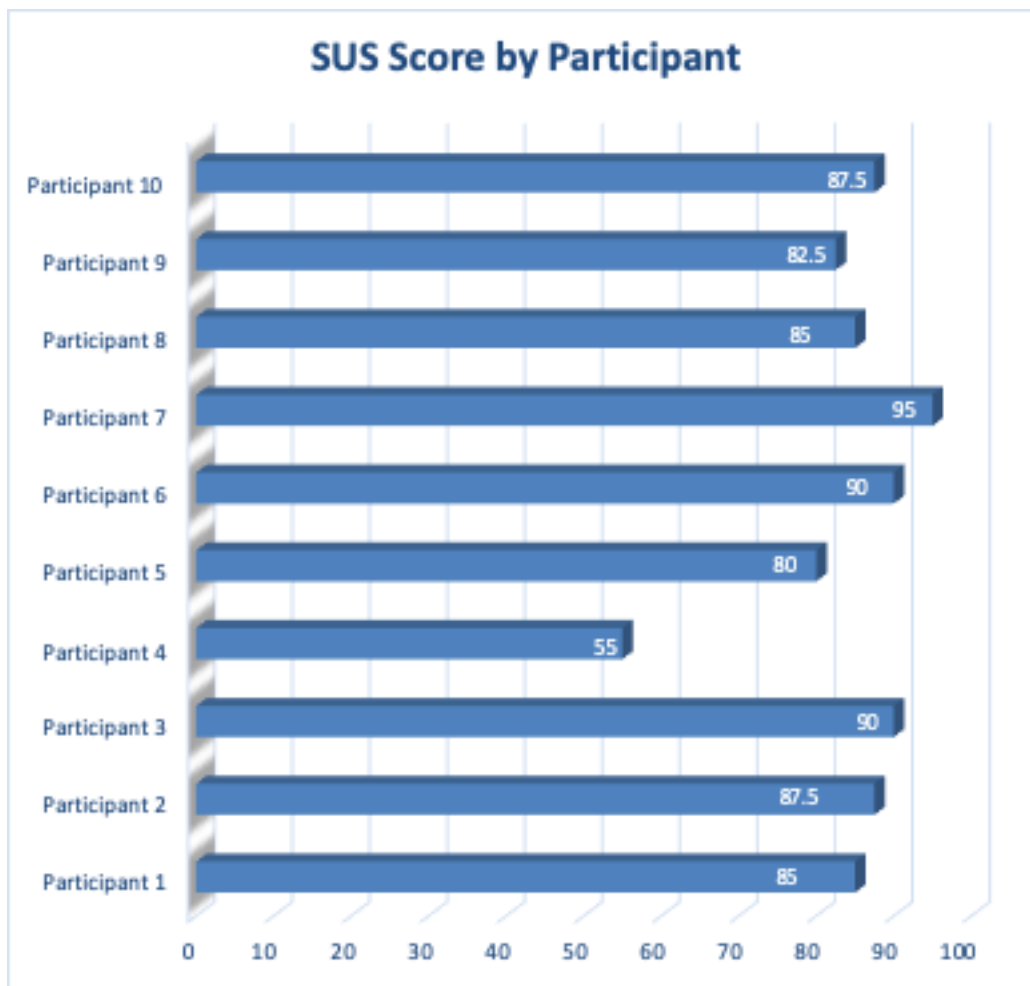
Computer System Usability Questionnaire

Using the Computer System Usability Questionnaire (CSUQ; Lewis, J. R. (1995). (See: IBM Computer Usability Satisfaction Questionnaires: Psychometric Evaluation and Instructions for Use. International Journal of Human-Computer Interaction, 7:1, 57-78).), participants rated each of 19 items of the CSUQ questionnaire on a scale from 1 to 7, with a rating of 7 being most in agreement with the positively-worded item. Responses for each item were summed and averaged to four scales – Interface Quality, Information Quality, System Usefulness- and an overall scale. See Appendix E for a copy of the CSUQ.

Figure 2 displays CUSQ ratings for each of the four scales. In general, participants in the Sapphire Health study rated system usability to be acceptable. On Interface Quality, the average score for the participants was 5.57/7; on Information Quality, the average score 3.76/7; on System Usefulness, the average score was 5.40/7; and the overall average CUSQ score was 4.83/7.

Figure 2: Computer System Usability Questionnaire
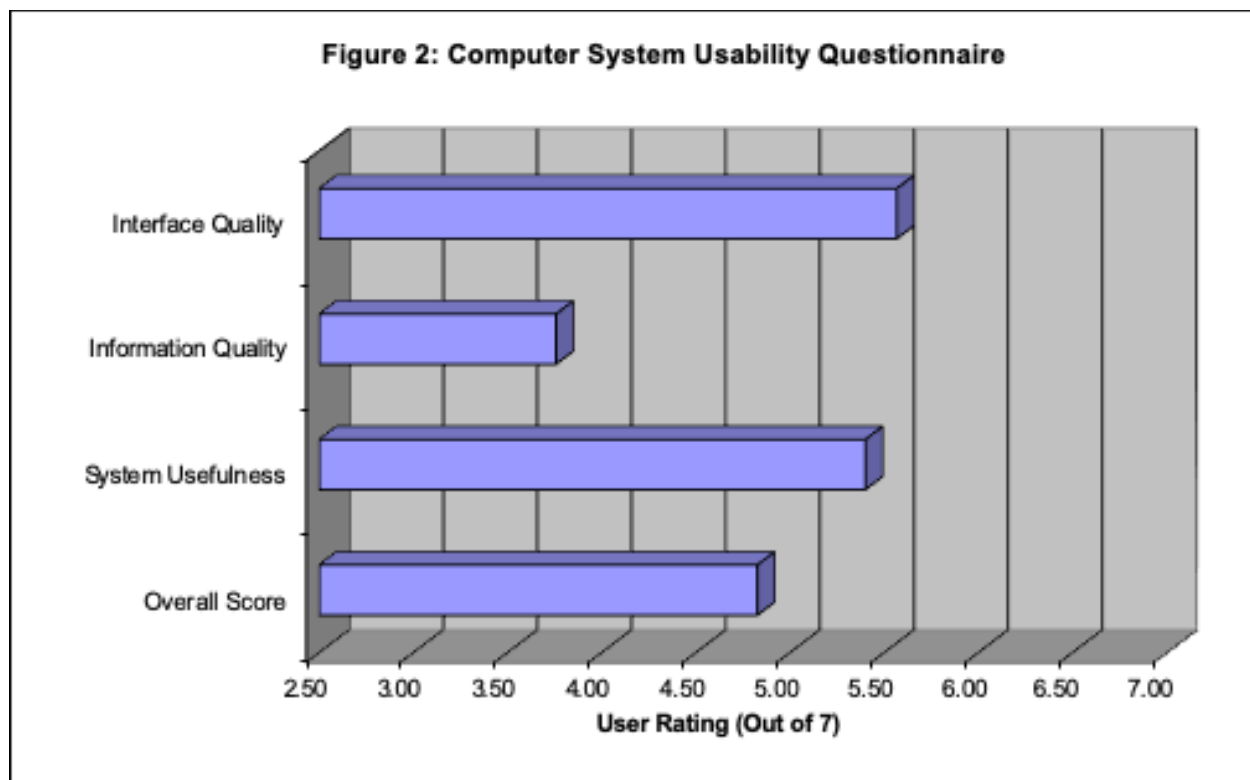
Specific Task Result Details

Participant Number	Task 1 (a.5) Demographics			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	1:41	Success	1	4
P0102	1:35	Success	1	5
P0103	1:09	Success	2	4
P0104	3:09	Success	4	4
P0105	4:14	Fail	6	2
P0106	0:58	Success	0	5
P0107	1:03	Success	0	5
P0108	2:13	Success	3	5
P0109	1:04	Success	0	5
P0110	2:11	Success	3	5

		(SD)
Expected Time on Task	2:00	
Average Time on Task	1:40	1:01
Average Task Satisfaction	4.40	0.92
Average #Path Deviations	2.00	1.90
Percent Success	90%	

Participant Number	Task 2 (a.5) Demographics - Modify			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	1:01	Success	0	4
P0102	0:54	Success	0	4
P0103	0:31	Success	0	5
P0104	0:35	Success	0	5
P0105	0:43	Success	0	5
P0106	0:39	Success	0	5
P0107	0:34	Success	0	5
P0108	0:48	Success	1	5
P0109	0:38	Success	0	5
P0110	0:42	Success	0	5

		(SD)
Expected Time on Task	0:30	
Average Time on Task	0:42	0:09
Average Task Satisfaction	4.80	0.40
Average #Path Deviations	0.10	0.30
Percent Success	100%	

Participant Number	Task 3 (a.6) Problem List			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	3:27	Success	4	3
P0102	2:37	Success	2	3
P0103	2:10	Success	1	4
P0104	3:53	Success	4	3
P0105	3:38	Success	4	4
P0106	2:44	Fail	6	3
P0107	2:05	Success	0	5
P0108	4:25	Fail	6	4
P0109	2:02	Success	3	3
P0110	3:38	Fail	6	3

Expected Time on Task	2:00	(SD)
Average Time on Task	2:50	0:48
Average Task Satisfaction	3.50	0.67
Average #Path Deviations	3.60	2.01
Percent Success	70%	

Participant Number	Task 4 (a.6) Problem List - Modify			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	2:02	Success	1	4
P0102	0:59	Success	1	4
P0103	1:25	Success	2	4
P0104	0:56	Success	0	5
P0105	1:12	Success	1	5
P0106	1:20	Success	2	4
P0107	1:22	Success	1	4
P0108	2:30	Fail	6	4
P0109	1:04	Success	0	5
P0110	1:21	Success	1	4

Expected Time on Task	1:30	(SD)
Average Time on Task	1:18	0:28
Average Task Satisfaction	4.30	0.46
Average #Path Deviations	1.50	1.63
Percent Success	90%	

Participant Number	Task 5 (a.1, a.7) Record Medication			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	4:12	Fail	6	2
P0102	3:05	Success	4	2
P0103	3:12	Success	4	3
P0104	6:29	Fail	7	2
P0105	5:05	Fail	8	1
P0106	3:49	Fail	7	3
P0107	3:36	Success	3	3
P0108	4:09	Fail	6	1
P0109	2:24	Success	3	4
P0110	3:35	Success	4	2

Expected Time on Task	3:00	(SD)	
Average Time on Task	3:10	1:05	
Average Task Satisfaction	2.30	0.90	
Average #Path Deviations	5.20	1.72	
Percent Success	50%		

Participant Number	Task 6 (a.1, a.7) Change medication			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	4:28	Success	3	2
P0102	3:24	Success	3	3
P0103	1:30	Success	1	4
P0104	2:26	Fail	6	3
P0105	5:38	Fail	8	2
P0106	3:35	Success	3	3
P0107	3:02	Success	2	3
P0108	1:35	Success	3	5
P0109	1:07	Success	3	4
P0110	3:41	Success	3	4

Expected Time on Task	2:00	(SD)	
Average Time on Task	2:48	1:21	
Average Task Satisfaction	3.30	0.90	
Average #Path Deviations	3.50	1.91	
Percent Success	80%		

Participant Number	Task 7 (a.2) Record Lab order			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	2:03	Success	3	3
P0102	1:04	Success	2	4
P0103	1:16	Success	2	4
P0104	1:48	Success	3	4
P0105	2:12	Success	4	4
P0106	1:35	Success	2	4
P0107	0:58	Success	1	4
P0108	1:54	Success	1	5
P0109	1:23	Success	3	4
P0110	1:29	Success	1	4

Expected Time on Task	2:00	(SD)
Average Time on Task	1:34	0:24
Average Task Satisfaction	4.00	0.45
Average #Path Deviations	2.20	0.98
Percent Success	100%	

Participant Number	Task 8 (a.2) Modify Lab order			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	1:41	Success	2	3
P0102	1:38	Success	3	2
P0103	1:21	Success	1	2
P0104	1:12	Success	3	4
P0105	1:43	Success	1	5
P0106	1:24	Success	0	4
P0107	0:59	Success	1	4
P0108	1:43	Success	3	4
P0109	1:54	Success	3	3
P0110	1:38	Success	1	4

Expected Time on Task	1:00	(SD)
Average Time on Task	1:31	0:16
Average Task Satisfaction	3.50	0.92
Average #Path Deviations	1.80	1.08
Percent Success	100%	

Participant Number	Task 9 (a.3) Diagnostic Imaging order			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	1:46	Success	2	3
P0102	1:26	Success	1	4
P0103	0:52	Success	1	4
P0104	0:53	Success	0	5
P0105	1:09	Success	2	4
P0106	0:57	Success	1	4
P0107	0:47	Success	0	4
P0108	0:59	Success	2	4
P0109	0:43	Success	0	5
P0110	1:20	Success	2	4

Expected Time on Task	2:00	(SD)	
Average Time on Task	1:05	0:19	
Average Task Satisfaction	4.1	0.54	
Average #Path Deviations	1.10	0.83	
Percent Success	100%		

Participant Number	Task 10 (a.3) Modify Diagnostic Imaging Order			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	1:14	Success	0	3
P0102	1:26	Success	0	4
P0103	1:09	Success	0	4
P0104	2:02	Success	3	4
P0105	1:22	Success	3	4
P0106	1:13	Success	0	4
P0107	1:32	Success	1	4
P0108	1:46	Fail	6	3
P0109	1:34	Success	0	5
P0110	1:06	Success	0	4

Expected Time on Task	1:30	(SD)	
Average Time on Task	1:24	0:17	
Average Task Satisfaction	3.9	0.54	
Average #Path Deviations	1.3	1.95	
Percent Success	90%		

Participant Number	Task 11 (a.4) Drug-drug interaction check			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	0:52	Success	0	4
P0102	0:42	Success	0	5
P0103	0:41	Success	0	5
P0104	0:29	Success	0	5
P0105	0:36	Success	0	5
P0106	0:39	Success	0	5
P0107	0:43	Success	0	5
P0108	0:52	Success	0	5
P0109	0:21	Success	0	5
P0110	0:54	Success	0	5

Expected Time on Task	1:00	(SD)
Average Time on Task	0:41	0:10
Average Task Satisfaction	4.90	0.30
Average #Path Deviations	0.00	0.00
Percent Success	100%	

Participant Number	Task 12 (a.4) Drug-allergy interaction check			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	1:02	Success	0	4
P0102	0:33	Success	0	5
P0103	0:29	Success	0	5
P0104	0:26	Success	0	5
P0105	0:35	Success	0	5
P0106	0:41	Success	0	5
P0107	0:32	Success	0	5
P0108	0:30	Success	0	5
P0109	0:28	Success	0	5
P0110	0:31	Success	0	5

Expected Time on Task	1:00	(SD)
Average Time on Task	0:35	0:10
Average Task Satisfaction	4.90	0.30
Average #Path Deviations	0.00	0.00
Percent Success	100%	

Participant Number	Task 13 (a.4) Drug/Allergy interaction adjustment			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	0:45	Success	0	4
P0102	0:36	Success	0	5
P0103	0:38	Success	0	5
P0104	1:05	Success	3	4
P0105	1:15	Success	0	5
P0106	0:59	Success	1	4
P0107	0:48	Success	0	5
P0108	1:39	Success	3	4
P0109	0:59	Success	0	5
P0110	1:01	Success	1	4

Expected Time on Task	1:00	(SD)
Average Time on Task	0:58	0:18
Average Task Satisfaction	4.50	0.50
Average #Path Deviations	0.80	1.17
Percent Success	100%	

Participant Number	Task 14 (a.8) Display active medication allergy list			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	0:34	Success	1	4
P0102	0:17	Success	0	5
P0103	0:14	Success	0	5
P0104	0:17	Success	0	5
P0105	0:18	Success	0	5
P0106	0:09	Success	0	5
P0107	0:12	Success	0	5
P0108	0:11	Success	0	5
P0109	0:17	Success	0	4
P0110	0:16	Success	0	5

Expected Time on Task	0:30	(SD)
Average Time on Task	0:16	0:07
Average Task Satisfaction	4.80	0.40
Average #Path Deviations	0.10	0.30
Percent Success	100%	

Participant Number	Task 15 (a.8) Add an allergy			
	Task Time	**Outcome**	**# Path Deviations**	**Task Satisfaction**
P0101	0:31	Success	0	4
P0102	0:32	Success	0	5
P0103	0:29	Success	0	5
P0104	0:35	Success	0	5
P0105	0:42	Success	0	5
P0106	0:28	Success	0	5
P0107	0:32	Success	0	5
P0108	0:38	Success	0	5
P0109	0:26	Success	0	4
P0110	0:40	Success	0	5

Expected Time on Task	1:00	(SD)
Average Time on Task	0:33	0:05
Average Task Satisfaction	4.80	0.40
Average #Path Deviations	0.00	0.00
Percent Success	100%	

Discussion of Findings

In general, the participants performed very well and felt satisfied with the Sapphire EHR system. A few of the participants had minor difficulties with some portions of a few tasks but in general most were able to successfully complete a most of the tasks with little or no problems. Participants were mostly able to perform all tasks successfully on their own with no assistance or external documentation. The participant average performance rate was acceptable, as were the overall participant satisfaction rates. The Sapphire EHR system appears to be a usable EHR.

Effectiveness

Of the fifteen (15) tasks presented, a majority of the tasks were successfully completed by all of the participants. Over all of participants, the mean successful task competition rate was high with an overall average rate of ninety-one (91) percent indicating that in general the participants had little or no difficulty completing the tasks.

The amount of prior experience with other EHR systems was related to successful task performance; participants with more prior experience were more likely to successfully complete tasks more quickly than those less prior experience.

Efficiency

Participants who successfully completed tasks generally completed those tasks within an acceptable time. Some tasks were completed more quickly than the calculated optimal time, while several tasks took slightly longer than expected. The tasks that took the longest required the participants to navigate to a particular unfamiliar portion of a page, interact with a workflow, locate and select specific actions.

Some participants made errors when attempting to navigate toward solving their assigned tasks. These errors may be associated with those participants not being familiar with the specific function, and/or not understanding the presented information architecture of the Sapphire EHR system. As noted above, prior experience with EHR systems was related to successful task completion. Similarly, additional experience and practice with the given system may have positive effects with regard to user efficiency.

Satisfaction

Participants were very satisfied with the Sapphire EHR system; ratings on the SUS (mean = 84 out of a possible 100) and the CSUQ (Overall score 4.83 out of a possible 7.0) demonstrated a high level of satisfaction with the system.

On the CSUQ, participants ranked the scale "(Interface Quality)" highest of the three scales, suggesting that the system provided an effective and efficient user interface. Individual task satisfaction ratings were related to individual user performance. Those participants who were able to successfully complete tasks were also more likely to rank those tasks as satisfying, while those participants who did poorly or were not able to complete a task ranked those tasks as less satisfying. Overall however, the participant satisfaction with the Sapphire EHR was about what was expected given the higher than average performance data.

Summary of Major Findings

This evaluation demonstrated that the Sapphire EHR system is a usable system with a relatively short learning curve. Most participants, even without any experience using the Sapphire EHR system before the study, experienced little initial difficulty understanding the navigation and information architecture. Participants with more EHR experience were able to solve tasks without difficulty or error.

Risk Analysis

The following table presents a prioritized list of tasks prioritized by the risk of error as observed during the testing.

Table 5. Risk Analysis

Task	Description	Percent Complete	Risk Status
Task 1 (a.5) Demographics	Access and enter Demographic Information	90%	Low
Task 2 (a.5) Demographics - Modify	Modify Demographic Information	100%	None
Task 3 (a.6) Problem List	View Problem List; add problems	70%	Medium
Task 4 (a.6) Problem List – Modify	Modify Problem list	90%	Low
Task 5 (a.1, a.7) Record Medication	Record Medications	50%	High
Task 6 (a.1, a.7) Change medication	Modify Medication order	80%	Low
Task 7 (a.2) Record Lab order	Enter lab order	100%	None
Task 8 (a.2) Modify Lab order	Modify lab order	100%	None
Task 9 (a.3) Diagnostic Imaging order	Enter imaging order	100%	None
Task 10 (a.3) Modify Diagnostic Imaging Order	Modify imaging order	90%	Low
Task 11 (a.4) Drug-drug interaction check	View Drug-drug interaction warning	100%	None
Task 12 (a.4) Drug-allergy interaction check	View Drug-Allergy interaction warning	100%	None
Task 13 (a.4) Drug/Allergy interaction adjustment	Modify Allergy severity	100%	None
Task 14 (a.8) Display active medication allergy list	Display Allergy list(s)	100%	None
Task 15 (a.8) Add an allergy	Add an allergy	100%	None

Areas for Improvement

The following is a partial list of potential areas for improvement. Making these and other minor enhancements will improve the overall user experience of the Sapphire EHR system and increase the effectiveness, efficiency, and satisfaction for both experienced and novice users.

- **Indication of Required Fields**

  A frequent error was caused when participants attempted to submit a form that contained required fields that were not completed. This is likely because the system did not provide a clear indication of which fields are required. Adding a constant visual indication of required fields would likely eliminate many of these errors observed.

- **Missing labels on the "Sig" portion of the Medication description**

  A number of participants experienced errors when entering the "sig" portion of the medication description because the labels for each of the items were not presented. The system presented error messages that explained what should be entered into each item, but that information was too late. User's should always be prompted as to which information that they are expected to enter and where.

- **Inconsistent workflow(s) across the application(s)**

  Several participants complained about both the visual and functional differences in the system workflow for items that they felt should have a similar look and feel. Entering a lab order, or entering a radiology order should have both a visual and functional similarity. Several other system inconsistencies also exist.

Appendices

1. Are you male or female?
2. Have you participated in a focus group or usability test in the past 6 months?
3. Do you, or does anyone in your home work in marketing research, usability research, and/or web design?
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?

   20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-89, 90-99, 100 and older.
6. Which of the following best describes your education level?
   - No high school diploma
   - High school graduate, diploma or the equivalent
   - Some college credit, no degree
   - Trade technical vocational training
   - Associate degree
   - Bachelor's degree
   - Master's degree
   - Doctorate degree (e.g., MD, DNP, DMD, PhD)
7. Do you require any assistive technologies to use a computer?
8. Please describe your medical or nursing credentials
9. What is your current job title?
10. How long have you held this position? (number of years):
11. What type of facility do you work in and what is your role there?
12. How are medical records handled at your (main) workplace?

    ____All Paper   ____Some Paper/Some Electronic   __All Electronic

13. How many EHRs do you use or have you worked with?
14. How many years have you used an electronic health record?
15. How many years have you used the Sapphire Health EHR system?

16. About how many hours per week do you spend using a computer?

17. What computer platform(s) do you usually use?

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

____Did not use last month   __Every day   ____A few times a week.

Appendix B: Informed Consent Form

The Usability People 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. The study will last about *45-60* minutes.

Agreement

I understand and agree that as a voluntary participant in the present study conducted by The Usability People. I am free to withdraw consent or discontinue participation at any time. I understand and agree to participate in the study conducted and recorded by The Usability People.

I understand and consent to the use and release of the video recording by The Usability People. I understand that the information and video 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 video and understand the video recording may be copied and used by The Usability People 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 outside of The Usability People. 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 _____

Appendix C: Participant Guide

ORIENTATION and INTRODUCTION

Thank you for participating in this study. The session today will last approximately 45- 60 minutes**.** During this session, you will look at the Sapphire EHR software.

The purpose of this study is to gauge the *usability* of the software. We are interested in how easy (or how difficult) this version is to use, and the features and benefits that would be useful to you. We also want to know how we could improve it.

The moderator will guide you through the testing process. Please use the software as you would in a real clinical setting. You will be asked to save your comments until the end of a task or the end of the session to discuss your thoughts freely. Here are some things you should know about your participation in this session:

- The Moderator will guide you through each task.
- **Please do not work ahead**.
- If you notice an error, just cancel out and continue to the task. If you feel lost or have difficulty completing the scenario, please inform the Moderator.
- The Testing session will be audio recorded the audio for further study.
- All information will be kept confidential. Your name will not be associated with your comments at any time.

Fictitious patient scenarios have been created and pre-loaded in the Sapphire Health software. The Moderator will ask you to complete a several tasks using the system. You will be asked to answer some questions and to complete some tasks on your own. Try to complete tasks as quickly as possible, with the fewest possible errors or deviations.

Please do not do anything more than asked.

<Patient Name>, has arrived for their scheduled appointment.

They have been referred to the clinic for issues related to drug addiction.

The patient is currently taking Duloxetine 20 mg cap once a day oral, and Suboxone 12 mg-3 mg sublingual film once a day as medications.

The patient has also indicated that they bruise easily, are allergic to penicillin, and indicated has recently stopped injecting heroin.

The patient also reveals taking ibuprofen (Advil 200mg) for headaches about once a week.

Task 1 (a.5) Demographics

Before beginning their appointment, you need to verify or enter some of the Patient information and details (demographic information) that is stored within the system

Date of Birth   **01/10/1985**
Client Ethnicity   **Not Hispanic or Latino**
Client Race   **Asian**
Sexual Orientation   **Unknown**
Gender Identity   **Male**

Verify and/or Enter and save this information into the EHR. Verify that the changes have been saved.

Task 2 (a.5) Demographics - Modify

After talking with the client about the information that is entered into the EHR, the patient verbally indicates that the following changes are needed:

Date of Birth   **10/01/1985**
Race   **Black, or African American**
Ethnicity   **Not Hispanic or Latino**
Sexual Orientation   **Heterosexual**

Make any necessary changes and Enter or Verify that this information is saved into the EHR.

Task 3 (a.6) Problem List

During the evaluation, a psychiatrist agrees with the primary care physician's (ICD-10) diagnosis of:

(F33.2) Major depressive disorder.

(F11.19) Opioid abuse with unspecified opioid-induced disorder.

Make sure that you add those diagnoses into this patient's record as the type: **Chronic**.

Additionally, during the review of symptoms you notes some bumps on the patient's elbow

Add:

(S50.329A) Blister (nonthermal) of unspecified elbow.

Make sure that you enter this as the type: **Acute** to the problem list.

Verify and/or Enter and save this information into the EHR. Verify that the changes have been saved.

Task 4 (a.6) Problem List - Modify

The psychiatrist asks the nurse practitioner to look at the marks on the client's arms. The nurse practitioner determines the marks are insect bites that have become infected.

Use the system to update the problem list to remove the incorrect diagnosis of S50.329A so that it instead contains the diagnosis of:

(**S50.361A) Insect bite (nonvenomous) of right elbow**

Make sure that you enter this as the type: **Acute** to the problem list.

Verify and/or Enter and save this information into the EHR. Verify that the changes have been saved.

Task 5 (a.1, a.7) Record medication

You notice by examining the patient's medication list that the Duloxetine 30 mg they take once a day orally has already been entered into the system. However, the other medication has not been entered into the system.

Add the following medication to their medication list using the MedpassRX

Suboxone 12 mg-3 mg sublingual film,

as a current medication taken **Orally once a day**. They should be allowed to keep a **30**-day supply of the medication on person (**KOP**). Use the provider **Mohamad Ali** for this medication (and for all other tasks)

Enter and save this information into the EHR. View the active medication list to verify that the information has been entered.

Task 6 (a.1, a.7) Change medication

The patient states that their Duloxetine is actually taken twice per day. This is supported by the primary care physician's notes.

Update the medication Duloxetine to reflect a twice daily administration.

Verify and/or Enter and save this information into the EHR. View the active medication list to verify that the changes have been saved.

Task 7 (a.2) Record a Lab order

All patients are required to be scheduled for normal drug screening panel. After meeting with the patient, order:

'**Drug Screen Urine'** with a Collection Date of **July 15th 2019** at **11:00am**.

Verify and/or Enter and save this lab request into the EHR. Verify that any changes have been saved.

Task 8 (a.2) Modify Lab order

Upon reviewing the lab order just entered, you realize that you selected an incorrect lab order.

You need to change the pending lab order from above to:

Drugs of Abuse Screen with the same Collection Date of **July 15th 2019** at **11:00am**.

Verify and/or Enter and save this information into the EHR. Verify that the changes have been saved.

Task 9 (a.3) Diagnostic Imaging order

The psychiatrist noticed during the examination that the patient had exhibited some speech and facial abnormalities that could be either stroke or apraxia and wants to create a Radiology Order for a brain imaging study.

Order a:

CT scan Brain/Head without contrast

for tomorrow at 8AM

Verify and/or Enter and save this information into the EHR.

Task 10 (a.3) Modify Diagnostic Imaging order

Oops, you meant to have the previous radiology order to be **<u>with</u>** contrast.

Change the Radiology Order from CT scan Brain/Head without contrast to:

CT scan Brain/Head with contrast

for tomorrow at 8AM

Verify and/or Enter and save this information into the EHR. Verify that the changes have been saved.

Task 11 (a.4) Drug-drug interaction check

The patient reports an increase in depression and anxiety. As a result, you decide to add a new drug to the drug therapy component of the client's care.

Add the Medication:

Fluoxetine 10mg Tab once per day using the EHR system

The system will display a warning message regarding this new medication. Review the warning details. You decide to not continue with the selection.

Verify and/or Enter and save this information into the EHR. Verify that the changes have been saved.

Task 12 (a.4) Drug-allergy interaction check

As described above, the patient presented with infected sores on his elbow. The infection needs to be treated. Add the following medication:

Penicillin VK potassium 250 (VEETIDS) for the infection.

The system will display a warning message regarding this new medication. Review the warning message(s) and do not continue with the order.

Verify and/or Enter and save this information into the EHR. Verify that the changes have been saved.

Task 13 (a.4) Drug/Allergy interaction adjustment

During the visit, the patient reported breaking out in "very bad hives" after taking penicillin.

Change their Penicillin Drug-Drug interaction from '**Moderate** to '**Severe'** with an **Adult** onset.

Verify and/or Enter and save this information into the EHR. Verify that the changes have been saved.

Task 14 (a.8) Display medication allergy lists

Display the current medications and allergies and determine if any allergies have been recorded.

The **Penicillin VK** above triggered a Drug Allergy warning by the system. The nurse practitioner wants to know if the client is allergic to any other medications

Display the **Allergy History Log** and review any medication allergies that have been previously reported.

Task 15 (a.8) Add an allergy

The patient has reported some itching after taking some Citalopram.

Add **Citalopram Hydrobromide** as a **mild** allergy with **Adult** onset.

Verify and/or Enter and save this information into the EHR. Verify that the changes have been saved.

Appendix D: System Usability Scale Questionnaire

Strongly disagree .... Strongly agree

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

| 1 | 2 | 3 | 4 | 5 |

2. I found the system unnecessarily complex

| 1 | 2 | 3 | 4 | 5 |

3. I thought the system was easy to use

| 1 | 2 | 3 | 4 | 5 |

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

| 1 | 2 | 3 | 4 | 5 |

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

| 1 | 2 | 3 | 4 | 5 |

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

| 1 | 2 | 3 | 4 | 5 |

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

| 1 | 2 | 3 | 4 | 5 |

8. I found the system very cumbersome to use

| 1 | 2 | 3 | 4 | 5 |

9. I felt very confident using the system

| 1 | 2 | 3 | 4 | 5 |

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

| 1 | 2 | 3 | 4 | 5 |

Appendix E: Computer System Usability Questionnaire

Please provide your impression of the usability of the system by answering each of the questions below:

1. Overall, I am satisfied with how easy it is to use this system
   Strongly   1 2 3 4 5 6 7 NA   Strongly
   Disagree   Agree

2. It was simple to use this system
   Strongly   1 2 3 4 5 6 7 NA   Strongly
   Disagree   Agree

3. I can effectively complete my work using this system
   Strongly   1 2 3 4 5 6 7 NA   Strongly
   Disagree   Agree

4. I am able to complete my work quickly using this system
   Strongly   1 2 3 4 5 6 7 NA   Strongly
   Disagree   Agree

5. I am able to efficiently complete my work using this system
   Strongly   1 2 3 4 5 6 7 NA   Strongly
   Disagree   Agree

6. I feel comfortable using this system
   Strongly   1 2 3 4 5 6 7 NA   Strongly
   Disagree   Agree

7. It was easy to learn to use this system
   Strongly   1 2 3 4 5 6 7 NA   Strongly
   Disagree   Agree

8. I believe I became productive quickly using this system
   Strongly   1 2 3 4 5 6 7 NA   Strongly
   Disagree   Agree

9. The system gives error messages that clearly tell me how to fix problems
   Strongly   1 2 3 4 5 6 7 NA   Strongly
   Disagree   Agree

10. Whenever I make a mistake using the system, I recover easily and quickly
    Strongly   1 2 3 4 5 6 7 NA   Strongly
    Disagree   Agree

11. The information (such as online help, on-screen messages, and other documentation) provided with this system is clear
	Strongly 1 2 3 4 5 6 7 NA Strongly
	Disagree Agree

12. It is easy to find the information I needed
	Strongly 1 2 3 4 5 6 7 NA Strongly
	Disagree Agree

13. The information provided for the system is easy to understand
	Strongly 1 2 3 4 5 6 7 NA Strongly
	Disagree Agree

14. The information is effective in helping me complete the tasks and scenarios
	Strongly 1 2 3 4 5 6 7 NA Strongly
	Disagree Agree

15. The organization of information on the system screens is clear
	Strongly 1 2 3 4 5 6 7 NA Strongly
	Disagree Agree

16. The interface of this system is pleasant
	Strongly 1 2 3 4 5 6 7 NA Strongly
	Disagree Agree

17. I like using the interface of this system
	Strongly 1 2 3 4 5 6 7 NA Strongly
	Disagree Agree

18. This system has all the functions and capabilities I expect it to have
	Strongly 1 2 3 4 5 6 7 NA Strongly
	Disagree Agree

19. Overall, I am satisfied with this system
	Strongly 1 2 3 4 5 6 7 NA Strongly
	Disagree Agree

Appendix F. References

NISTIR 7741 - NISTER 7741 Guide to the Processes Approach for Improving the Usability of Electronic Health Records, Robert M. Schumacher, User Centric, Inc., Svetlana Z. Lowry, Information Access division, Information Technology Laboratory, National Institute of Standards and Technology, U.S. Department of Commerce, National Institute of Standards and Technology, Version 0.2, 15-Nov.2010.

NISTIR 7742 - NISTER 7742 Customized Common Industry Format Template for Electronic Health Record Usability Testing, Robert M. Schumacher, User Centric, Inc., Svetlana Z. Lowry, Information Access division, Information Technology Laboratory, National Institute of Standards and Technology, U.S. Department of Commerce, National Institute of Standards and Technology, Version 0.2, 15-Nov.2010.

NISTIR 7804 - NISTER 7804 Technical Evaluation, Testing, and Validation of the Usability of Electronic Health Records, Svetlana Z. Lowry, Matthew T. Quinn, Mala Ramaiah, Robert M. Schumacher, Emily s. Patterson, Robert North, , Information Access division, Information Technology Laboratory, National Institute of Standards and Technology, U.S. Department of Commerce, National Institute of Standards and Technology, Version 0.2, 15-Feb.2012.

ONC - 2015 Edition Certification Companion Guide Safety- Enhanced Design - 45 CFR 170.315(g)(3) 3/30/2016

ONC - 2015 Edition Certification - Test Procedure for §170.315(g)(3) Safety Enhanced Design

CSUQ - Lewis, J. R. (1995). IBM Computer Usability Satisfaction Questionnaires: Psychometric Evaluation and Instructions for Use. International Journal of Human-Computer Interaction, 7, 57-78.

SUS - Brooke, J. (1996) SUS: a "quick and dirty" usability scale. In P. W. Jordan, B. Thomas, B. A. Weerdmeester & A. L. McClelland (eds.) Usability Evaluation in Industry. London: Taylor and Francis.