

EHR Usability Test Report of Astronaut Version 1709

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1 EXECUTIVE SUMMARY

1.1 EHRUT Astronaut 1709

The EHRUT was evaluated for effectiveness, efficiency, and user satisfaction. Fourteen participants performed tasks aligned to each meaningful use criterion under realistic conditions.

In general, the EHRUT performed well on measures related to all three areas. As expected, more experience with both the EHRUT and the task being performed led to decreased task path and task time variations. Nonetheless, even relatively novice users were able to complete tasks with reasonable effectiveness and efficiency.

Task success ranged from 58 to 98 %. Participants were more successful on tasks with fewer steps and those with which they were familiar. User satisfaction, as measured with the Likert Scale, ranged from 3.8 to 4.8, indicating that participants generally found the system easy to very easy to use. Task errors were relatively rare, suggesting that most participants were able to navigate the system well.

Areas for improvement center on consistency of system behavior and streamlining workflows for tasks performed infrequently.

1.2 e-Prescribing

The e-Prescribing software (NewCrop) was evaluated for effectiveness, efficiency, and user satisfaction. Ten participants performed tasks aligned to each meaningful use criterion under realistic conditions.

Task success ranged from 0 to 90%. Errors were common, both selecting an incorrect path as well as interpreting messages by the software. In general, e-Prescribing performed well on tasks performed frequently by all users, such as prescribing a new medication or looking up medication history. It performed poorly on tasks users had never performed or performed infrequently. No user was able to send a status message to the pharmacy and finding messages from the pharmacy required help. Users provided numerous suggestions for improvement.

2 Introduction

The EHRUT was Astronaut 1709. Designed to present medical information to healthcare providers in both outpatient and inpatient settings, the EHR under test (EHRUT) includes basic EHR functionalities such as patient demographics, clinical notes, and lab ordering as well as clinical decision support (CDS) and e-Prescribing. 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 EHRUT. To this end, measures of effectiveness, efficiency and user satisfaction, such as percent of tasks completed correctly, time on task and user task difficulty rating were captured during the usability testing.

As e-Prescribing is supported through NewCrop, an application separate from Astronaut 1709 itself, further usability testing was performed to satisfy 170.315(b)3 criteria.

3 Method

3.1 EHRUT Testing Participants

A total of 14 participants were tested on the EHRUT. Participants in the test were healthcare providers and office staff in outpatient settings. Participants were recruited by Dr. Willcockson and performed testing during regularly scheduled working hours. In addition, participants had no direct connection to the development of, or organization producing, the EHRUT. Participants were not from the testing or supplier organization. Participants were actual end users.

Recruited participants had a mix of backgrounds and demographic characteristics. Table 1 lists participants by characteristics, including demographics, professional experience, and computing experience. Participant names were replaced with participant IDs so that an individual's data cannot be tied back to individual identities.

Table 1. Participant Demographics

Participant ID	Participant Gender	Participant Age	Participant Education	Participant Occupation/Role	Participant Professional Experience	Participant Computer Experience	Participant Product Experience
BB011	Female	30-39	Master's Degree	Nurse Practitioner	6	240	6
DS002	Male	40-49	Trade/Tech/Vocational	Medical Assistant	84.0	384.0	60.0
BB010	Female	30-39	Trade/Tech/Vocational	Medical Assistant	180.0	240.0	60.0
BB008	Female	30-39	Some college	Admin Assistant	24.0	252.0	36.0
BB009	Female	30-39	Associate's	Admin Assistant	15.0	240.0	15.0
BB006	Female	40-49	Bachelor's	Nurse Practitioner Intern	6.0	192.0	2.0
BB005	Female	40-49	Master's Degree	Nurse Practitioner	60.0	360.0	36.0
BB004	Female	30-39	Bachelor's	TMS Coordinator	120.0	240.0	4.0
BB003	Female	40-49	Associate's	Medical Admin Ass	240.0	360.0	1.0
DJ001	Female	20-29	Some college	Assistant manager	3.0	108.0	3.0
BB007	Female	50-59	Bachelor's	Nurse Practitioner Intern	12.0	360.0	2.0
BB012	Female	40-49	Master's Degree	Nurse Practitioner	6.0	360.0	6.0
BB014	Female	30-39	Trade/Tech/Vocational	Medical Assistant	120.0	240.0	2.0

No participant required assistive technology. Participants were scheduled for 30 min sessions, with 15 min between participants for debrief and reset of the testing environment.

3.2 E-Prescribing Testing Participants

A total of ten participants were tested on the e-Prescribing software. All had at least 18 months of experience with the system and interacted with it in their role as prescriber or medical assistant. No participant required assistive technology. Table 2 lists participants by characteristics, including demographics, professional experience, and computing experience. Participant names were replaced with participant IDs so that an individual's data cannot be tied back to individual identities.

Table 2. Demographics for e-Prescribing Testing Participants

Participant ID	Gender	Age	Education	Role	Professional Experience (months)	Computer Experience (months)	Product Experience (months)
101	Female	40-49	Master's	Nurse practitioner	36	240	34
102	Female	30-39	Master's	Nurse practitioner	120	240	60

103	Male	50-59	Doctoral	Medical Doctor	240	480	36
104	Female	30-39	Trade/Tech/Voc	Certified medical assistant	12	360	96
105	Female	50-59	Bachelor's	Nurse	324	240	48
106	Male	50-59	Doctoral	Medical Doctor	312	360	24
107	Female	40-49	Master's	Nurse practitioner	48	360	18
108	Female	60-69	Master's	Nurse practitioner	216	360	18
109	Male	50-59	Doctoral	Osteopathic Doctor	372	288	18
110	Male	40-49	Master's	Nurse practitioner	312	312	48

3.3 Study Design for EHRUT

Overall, the testing was designed to uncover areas where the software performed well - effectively, efficiently, and to the user's satisfaction- and areas where improvements may be needed. The data from this test can serve as a baseline for future tests of the same software, or to compare this software to others, provided the same tasks are used.

During the testing, participants interacted with the EHRUT. Each participant used the software on the same laptop computer, with the same login, and was provided with the same instructions. A private setting was used at each user's place of employment to maximize user comfort and minimize disruptions. The system was evaluated for effectiveness, efficiency and satisfaction as defined by measures collected for each participant:

- Number of tasks successfully completed within the allotted time without assistance
- Time to complete the tasks
- Number and types of errors
- Participant verbalizations (comments)
- Participant's satisfaction rating of each component

Additional information about the various measures can be found in Section 3.9 on Usability Metrics.

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During the testing, participants interacted with the e-Prescribing software. Although each participant used their own device to access GTM and control the software, the software was running on the same computer, with the same test doctor login credentials. Each participant was also provided with the same instructions. The system was evaluated for effectiveness, efficiency and satisfaction as defined by measures collected for each participant:

- Number of tasks successfully completed within the allotted time without assistance
- Time to complete the tasks
- Number and types of errors
- Participant verbalizations (comments)
- Participant's satisfaction rating of each component

Additional information about the various measures can be found in Section 3.9 on Usability Metrics.

3.5 Tasks for EHRUT

A total of twelve tasks were created to address the required criteria. Below are the detailed descriptions.

Task 1 (170.315a5) involved adding a new patient to the EHRUT. Sample demographics were provided, and participants were asked to enter them into the applicable fields.

Task 2 (170.315a2) involved ordering a laboratory test, using parameters provided.

Task 3 (170.315a3) involved ordering an imaging test, using parameters provided.

Task 4 (170.315a4) involved entering an allergy into the patient's chart, using the description provided.

Task 5 (170.315a4) asked participants to prescribe a medication to which the pt was allergic to. For task success, participants were required to view the allergy warning in the e-prescribing window.

Task 7 (170.315a1) asked participants to prescribe a medication.

Task 9 (170.315a14) asked participants to enter an implantable device id into a patient's record.

Task 10 (170.315a14) asked participants to retrieve the list of a patient's implantable devices.

Task 11 (170.315a9) had participants respond to a clinical reminder based on patient's information and a CDS rule.

Task 12 (170.315a9) asked participants to evaluate a CCD summary and incorporate it into the patient's record.

Task 13 (170.315a4) asked participants to prescribe two medications that interact. For task success, participants were required to view the interaction warning in the e-prescribing window.

3.6 Tasks for e-Prescribing

The tasks used to evaluate e-Prescribing were based on the required tests in the ONC Certification Test Plan, NIST HealthCare Test Version 1.2.35, dated April 1st, 2021. Because the prescriber's actions were similar for each type of scenario, only one of each type was tested, and all participants used the same test doctor login. For tasks with multiple sub-tasks (Cancel, Change, and Renewal), each participant was prompted to attempt all sub-tasks.

- Cancel Scenario: Prescriber successfully cancels new prescription before dispensing
 - Patient: Susanne Adirondack
 - Medication: Hydrochlorothiazide 50 mg
 - Prescribe Rx
 - See Pharmacy Status Msg
 - See Pharmacy Verify Msg
 - Prescriber sends Status Msg
 - Prescriber sends cancel Rx
 - See Pharmacy Status Msg
 - See Pharmacy Cancel Rx Msg
- Change Scenario: Pharmacist requests authorization for generic substitution
 - Patient: Sophia Biscayne
 - Medication: Procardia XL 30
 - Prescribe Rx
 - See Pharmacy Status Msg
 - See Pharmacy Rx Change Request
 - Prescriber sends Status Msg
 - Prescriber sends Rx change response
 - See pharmacy status msg
 - See pharmacy rx refill msg

- Prescriber sends Status Msg
- Medication History Scenario: Pharmacy returns medication history in a single response
 - Patient: John Yosemite
 - Prescriber sends medication history request to pharmacy
 - See patient medication history msg
- Renewal Scenario: Prescriber authorizes the number of refills requested by the pharmacy
 - Patient: Elizabeth Itasca
 - Medication: Lanoxin 125 mcg
 - Prescribe Rx
 - See Pharmacy Status Msg
 - See Pharmacy Rx renewal request
 - Prescriber sends status msg
 - Prescriber sends Rx renewal response
 - See pharmacy status msg

3.7 Procedure for EHRUT

The usability test administrator arrived at each location and was assigned a private location. She established internet access and logged into the EHRUT using the test login. After arriving, each participant was greeted and introduced to the goal of the testing. Participants were assigned an ID number.

The administrator moderated the session including administering instructions and tasks. Participants were instructed to perform the task as quickly as possible, to the best of their ability, and without a think aloud technique. After receiving each task both written and verbal, participants were timed. Once the task was completed, the time was noted along with participant's feedback on the ease of task completion (Likert Scale; 5 - very easy to 1 - very hard). Scoring is discussed in section 3.9. Any other participant feedback was also recorded.

Participants were also administered the System Usability Scale (see Appendix 5.1).

3.8 Procedure for ePrescribing

Due to Covid-19 procedures, e-Prescribing was tested remotely. Participants and the usability testing administrator used audio, screen sharing, and passing mouse and key board control capabilities of (GTM). Participants were provided with instructions to download the desktop version of GTM, and a meeting link. They used their own devices to log into GTM. Each participant was provided the same instructions, verbal and through onscreen file sharing, as appropriate.

The administrator moderated the session including administering instructions and tasks. Participants were instructed to perform the task as quickly as possible, to the best of their ability, and without a

think aloud technique. After receiving each task both written and verbal, participants were timed. Once the task was completed, the time was noted along with participant's feedback on the ease of task completion (Likert Scale; 5 - very easy to 1 - very hard). Scoring is discussed in section 3.9. Any other participant feedback was also recorded.

Participants were also administered the System Usability Scale (see Appendix 5.1).

3.9 Test Location for EHRUT

The usability test administrator traveled to the work location of each participant. Testing was completed in a private setting at the participant's place of work. To ensure a comfortable environment for users, noise levels were kept to a minimum with the ambient temperature within the normal range. Safety instructions and evacuation procedures were in place.

3.10 Test Location for e-Prescribing

Participants performed the testing from a location of their choice. The usability test administrator worked from home.

3.11 Test Environment for EHRUT

The EHRUT would be typically used in a healthcare office or facility. In this instance, testing was conducted in outpatient facilities, both physician offices and intensive outpatient (IOP) programs. For testing, the computer used was a laptop running the Windows operating system. The screen size was 15 inches, resolution set to 1366x768 with standard color settings. The participants used a touch pad and keyboard when interacting with the EHRUT. The EHRUT was installed on the laptop, connecting to the test database via wireless LAN. The EHRUT was used with its default font size and color scheme.

The test environment was set up by the usability test administrator.

Technically, the system performance (i.e., response time) was representative of what actual users would experience in a field implementation. Additionally, users were instructed not to change the default settings.

3.12 Test Environment for e-Prescribing

The e-Prescribing software would be typically used by a prescriber, either a medical doctor or a mid-level provider, for example a nurse practitioner. The e-Prescribing software was running on a desktop computer running the Windows operating system. The desktop computer's display screen was a HP 23bw IPS LED Backlit Monitor with 1920x1080 resolution. Each participant used their own device to

interact with GTM, and were able to control the mouse and keyboard. Technically, the system performance (i.e. response time) was representative of what users would experience in the field.

3.13 Test Forms and Tools

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

1. Moderator's guide
2. System Usability Scale

Examples of these documents can be found in Appendices 5.1 and 5.2. The Moderator's guide was devised so as to be able to capture required data.

The participant's interaction with the EHRUT was observed by the administrator, who made notes on both the participant's path through each task as well as any participant comments.

3.14 Participant Instructions

The administrator provided the following instructions to each participant.

Thank you for participating in this study.

I will ask you to complete certain tasks using Astronaut Vista (e-Prescribing). We are interested in how easy or difficult this software is to use, and how we could improve it. You will be asked to complete tasks on your own, trying to do them as quickly as possible with the fewest errors.

We are testing the software, not you. All information collected will be confidential and your comments will not be associated with your name at any time.

(After completing the task) On a scale of 1 to 5 with 5 being very easy and 1 being very hard, how would you rate this task?

Any participant's comments were recorded along with administrator notes.

3.15 Usability Metrics

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 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:

1. Effectiveness of Astronaut VistA/e-Prescribing by measuring participant success rates and errors
2. Efficiency of Astronaut VistA/e-Prescribing by measuring the average task time and path deviation
3. Satisfaction with Astronaut VistA/e-Prescribing by measuring ease of use ratings.

3.15.1 Data Scoring

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

Table 2

Measures	Rationale and Scoring
Effectiveness: Task Success and standard deviation	A task was counted as “Success” if the participant was able to achieve the correct outcome. 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.
Effectiveness: Average # of errors and standard deviation	If the participant entered data into the wrong field or forgot to enter required data, this was counted as an error. The average number of errors and the standard deviation are reported for each task.
Efficiency: Task Path Deviations	The participant’s path through each task was observed. Deviations occur if the participant, for example, went to the wrong screen, clicked on an incorrect menu item, or interacted incorrectly with an on-screen control. Path deviations were recorded quantitatively. The average number of steps taken was subtracted from the average optimal number of steps.
Efficiency: Task Time Deviation	Each task was timed from when the administrator said “Start” to when the participant either stated “Done” or the administrator observed task completion. Task times were only recorded for tasks that were completed successfully. The optimal task time was subtracted from each participant’s time to obtain task time deviation. Average and standard deviation are reported.

Satisfaction	5 point scale of ease of use rating (5 very easy to 1 very hard), collected for each task.
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3.15.2 Systems Usability Scale Scoring

The Systems Usability Scale (SUS) was scored as described by Brooke. To calculate the SUS score, the score contributions from each item was first summed. Each item's score contribution ranged from 0 to 4. For items 1,3,5,7,and 9 the score contribution is the scale position minus 1. For items 2,4,6,8 and 10, the contribution is 5 minus the scale position. Then, the sum of the scores was multiplied by 2.5. SUS scores have a range of 0 to 100.

4 Results

4.1 Data Analysis and Reporting for EHRUT

4.1.1 Task 1 (170.315a5) involved adding a new patient to the EHRUT.

Table 3. Results for Task 1

Measure	Results
Effectiveness: Task Success	95 % (SD = 7.8)
Effectiveness: Task Errors	1 (SD = 1)
Efficiency: Observed # of Steps	9.8 (SD= 1.2)
Efficiency: Optimal # of Steps	9
Efficiency: Task Path Deviation	0.8 (SD = 1.1)
Efficiency: Observed Task Time (sec)	268 (SD = 76.4)
Efficiency: Optimal Task time (sec)	190
Efficiency: Task Time Deviation (sec)	78.4 (SD = 76.4)
Satisfaction	4.8 (SD = 0.4)

Comments: Participants with limited experience entering detailed demographics made errors related to entering race and ethnicity.

4.1.2 Task 2 (170.315a2) involved ordering a laboratory test, using parameters provided.

Table 4. Results for Task 2

Measure	Results
Effectiveness: Task Success	98 % (SD = 4.2)
Effectiveness: Task Errors	0.3 (SD=0.7)

Efficiency: Observed # of Steps	4.4 (SD = 0.7)
Efficiency: Optimal # of Steps	4
Efficiency: Task Path Deviation	0.4 (SD = 0.7)
Efficiency: Observed Task Time (sec)	63.8 (SD = 22.5)
Efficiency: Optimal Task time (sec)	26
Efficiency: Task Time Deviation	37.8 (SD = 22.5)
Satisfaction	4.7 (SD = 0.7)

Comments: None

4.1.3 Task 3 (170.315a3) involved ordering an imaging test, using parameters provided.

Table 5. Results for Task 3

Measure	Results
Effectiveness: Task Success	97 % (SD = 7.1)
Effectiveness: Task Errors	0.3 (SD=0.5)
Efficiency: Observed # of Steps	7.6 (SD = 0.7)
Efficiency: Optimal # of Steps	7
Efficiency: Task Path Deviation	0.6 (SD = 0.7)
Efficiency: Observed Task Time (sec)	60.9 (SD = 17.8)
Efficiency: Optimal Task time (sec)	41
Efficiency: Task Time Deviation	20 (SD = 17.8)
Satisfaction	4.4 (SD = 0.7)

Comments: None

4.1.4 Task 4 (170.315a4) involved entering an allergy into the patient's chart, using the description provided.

Table 6. Results for Task 4

Measure	Results
Effectiveness: Task Success	91 % (SD = 7.4)
Effectiveness: Task Errors	1.2 (0.6)
Efficiency: Observed # of Steps	10.5 (SD = 1.1)
Efficiency: Optimal # of Steps	9
Efficiency: Task Path Deviation	1.5 (SD = 1.1)
Efficiency: Observed Task Time (sec)	98.8 (SD = 30.3)
Efficiency: Optimal Task time (sec)	34
Efficiency: Task Time Deviation	65 (SD = 30.3)

Satisfaction	4.1 (SD = 1.1)
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Comments: None

4.1.5 Task 5 (170.315a4) asked participants to prescribe a medication to which the pt was allergic to. For task success, participants were required to view the allergy warning in the e-prescribing window.

Table 7. Results for Task 5

Measure	Results
Effectiveness: Task Success	58% (SD = 50.1)
Effectiveness: Task Errors	0.1 (SD=0.3)
Efficiency: Observed # of Steps	5.3 (SD = 0.9)
Efficiency: Optimal # of Steps	5
Efficiency: Task Path Deviation	0.3(SD = 1.0)
Efficiency: Observed Task Time (sec)	56.7 (SD = 34.5)
Efficiency: Optimal Task time (sec)	65
Efficiency: Task Time Deviation	-8 (SD = 34.5)
Satisfaction	4.0 (SD = 1.5)

Comments: Users with prescribing experience did not like the absence of a warning window when prescribing a medication to which pt is allergic. Other users failed to see the allergy warning due to its position in the window, which led to lower average task success. e-Prescribing software vendor NewCrop has updated its interface to make allergy information more apparent.

4.1.6 Task 7 (170.315a1) asked participants to prescribe a medication.

Table 8. Results for Task 7

Measure	Results
Effectiveness: Task Success	95.8 % (SD = 6.7)
Effectiveness: Task Errors	0.08 (SD=0.3)
Efficiency: Observed # of Steps	7.1 (SD = 0.3)
Efficiency: Optimal # of Steps	7
Efficiency: Task Path Deviation	0.1(SD = 0.3)

Efficiency: Observed Task Time (sec)	102 (SD = 44.5)
Efficiency: Optimal Task time (sec)	65
Efficiency: Task Time Deviation	29.2 (SD = 51.1)
Satisfaction	4.8 (SD = 0.5)

Comments: Participants unfamiliar with the prescribing interface had more difficulty navigating it.

4.1.7 Task 9 (170.315a14) asked participants to enter an implantable device id into a patient's record.

Table 9. Results for Task 9

Measure	Results
Effectiveness: Task Success	86.4 % (SD = 5)
Effectiveness: Task Errors	0.1 (SD=0.3)
Efficiency: Observed # of Steps	13.2 (SD = 0.6)
Efficiency: Optimal # of Steps	13
Efficiency: Task Path Deviation	0.2(SD = 0.6)
Efficiency: Observed Task Time (sec)	91 (SD = 21.8)
Efficiency: Optimal Task time (sec)	61
Efficiency: Task Time Deviation	30.4 (SD = 21.8)
Satisfaction	4.4 (SD = 0.8)

Comments: Participants with clinical experience liked the ability to record implantable devices.

4.1.8 Task 10 (170.315a14) asked participants to retrieve the list of a patient's implantable devices.

Table 10. Task 10 Results

Measure	Results
Effectiveness: Task Success	91.8 %(SD = 4)
Effectiveness: Task Errors	0.1 (SWD=0.3)
Efficiency: Observed # of Steps	4.1 (SD = 0)
Efficiency: Optimal # of Steps	4
Efficiency: Task Path Deviation	0 (SD = 0)

Efficiency: Observed Task Time (sec)	17.5 (SD = 8.2)
Efficiency: Optimal Task time (sec)	18
Efficiency: Task Time Deviation	-0.5 (SD = 8.2)
Satisfaction	4.6 (SD = 0.5)

Comments: None

4.1.9 Task 11 (170.315a9) had participants respond to a clinical reminder based on patient's information and a CDS rule.

Table 11. Results for Task 11

Measure	Results
Effectiveness: Task Success	88 %(SD = 7.5)
Effectiveness: Task Errors	0.1 (SD=0.3)
Efficiency: Observed # of Steps	9.2 (SD = 0.6)
Efficiency: Optimal # of Steps	9
Efficiency: Task Path Deviation	0.2 (SD = 0.6)
Efficiency: Observed Task Time (sec)	99 (SD = 26.4)
Efficiency: Optimal Task time (sec)	88
Efficiency: Task Time Deviation	11 (SD = 26.4)
Satisfaction	4.6 (SD = 0.5)

Comments: Users with clinical experience liked being able to record smoking status of patients.

4.1.10 Task 12 (170.315a9) asked participants to evaluate a CCD summary and incorporate it into the patient's record.

Table 12. Results for Task 12

Measure	Results
Effectiveness: Task Success	87 % (SD = 7.9)
Effectiveness: Task Errors	0.1 (SD=0.3)
Efficiency: Observed # of Steps	15.4 (SD = 0.8)
Efficiency: Optimal # of Steps	15

Efficiency: Task Path Deviation	0.4 (SD = 0.8)
Efficiency: Observed Task Time (sec)	102 (SD = 43.9)
Efficiency: Optimal Task time (sec)	57
Efficiency: Task Time Deviation	44.7 (SD = 43.9)
Satisfaction	4.5 (SD = 0.5)

Comments: None

4.1.11 Task 13 (170.315a4) asked participants to prescribe two medications that interact. For task success, participants were required to view the interaction warning in the e-prescribing window.

Table 13. Results for Task 13

Measure	Results
Effectiveness: Task Success	100 %(SD=0)
Effectiveness: Task Errors	0.2 (SD=0.4)
Efficiency: Observed # of Steps	13.4 (SD = 0.8)
Efficiency: Optimal # of Steps	13
Efficiency: Task Path Deviation	0.4 (SD=0.8)
Efficiency: Observed Task Time (sec)	113 (SD = 43.4)
Efficiency: Optimal Task time (sec)	97
Efficiency: Task Time Deviation	15.8 (SD=43.4)
Satisfaction	4.8 (SD=0.4)

4.1.12 Cancel Scenario

Measure	Results
Effectiveness: Task Success	0
Effectiveness: Task Errors	N/A
Efficiency: Observed # of Steps	N/A
Efficiency: Optimal # of Steps	9
Efficiency: Task Path Deviation	N/A
Efficiency: Observed Task Time (sec)	N/A
Efficiency: Optimal Task time (sec)	N/A

Efficiency: Task Time Deviation	N/A
Satisfaction	3.6 (SD=1.2)

Comments: While all participants were able to send a prescription to the pharmacy successful, no participant was able to send a status message to the pharmacy. One participant tried using the Pharmacist Message on the prescription screen to send a message to the pharmacy, which was judged not appropriate for canceling the prescription. Two participants used the discontinue (D/C) function instead of cancel. Only one participant commented that they had seen the cancel button previously.

4.1.13 Change Scenario

Measure	Results
Effectiveness: Task Success	0
Effectiveness: Task Errors	N/A
Efficiency: Observed # of Steps	N/A
Efficiency: Optimal # of Steps	10
Efficiency: Task Path Deviation	N/A
Efficiency: Observed Task Time (sec)	N/A
Efficiency: Optimal Task time (sec)	N/A
Efficiency: Task Time Deviation	N/A
Satisfaction	3.9 (SD=1.4)

Comments: While all participants were able to send a prescription to the pharmacy successful, no participant was able to send a status message to the pharmacy. One participant commented that the ACCEPT button in the change request should be larger. Another comment was that the list of messages includes messages for all providers, not just the person who is logged in.

4.1.14 Medication History Scenario

While no participant sent a message to the pharmacy, nine out of ten were able to retrieve the complete medication history of the patient. The table below reflects this.

Measure	Results
Effectiveness: Task Success	90 %
Effectiveness: Task Errors	0.5 (SD=0.9)
Efficiency: Observed # of Steps	3.3
Efficiency: Optimal # of Steps	3
Efficiency: Task Path Deviation	N/A
Efficiency: Observed Task Time (sec)	62.9 (SD=29.5)
Efficiency: Optimal Task time (sec)	32
Efficiency: Task Time Deviation	38.7 (SD=29.5)

Satisfaction	4.5 (SD=0.9)
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Comments: Seven out of ten participants completed this task effectively and efficiently on their own, one participant required a little help, one did not complete the task. Two participants commented that the Surescripts link stands out. The participant who was unsuccessful looked for the information under the tabs (Compose Rx, Review/Transmit, etc).

4.1.15 Renew Scenario

Measure	Results
Effectiveness: Task Success	0
Effectiveness: Task Errors	N/A
Efficiency: Observed # of Steps	N/A
Efficiency: Optimal # of Steps	9
Efficiency: Task Path Deviation	N/A
Efficiency: Observed Task Time (sec)	N/A
Efficiency: Optimal Task time (sec)	N/A
Efficiency: Task Time Deviation	N/A
Satisfaction	3.6 (SD=1.6)

Comments: While all participants were able to send a prescription to the pharmacy successful, no participant was able to send a status message to the pharmacy. Six participants did find the pharmacy renewal message, one was able to reply.

4.1.16 Systems Usability Scale

Table 14. Results for EHRUT Systems Usability Scale

Measure	Results
Average	87.0
Standard Deviation	11.7
Minimum	62.5
Maximum	100

Comments: None

Table 17. Results for e-Prescribing Systems Usability Scale

Measure	Results
Average	60
Standard Deviation	30.6
Minimum	12.5
Maximum	100

Comments: Some participants rated the e-Prescribing software as easy to use despite being unable to complete three out of four tasks.

4.2 Narrative interpretation of task results

The EHRUT performed well overall in effectiveness. Effectiveness was measured using two criteria, task success and task errors. In general, effectiveness was high. Efficiency, measured using task path deviation, was good. Efficiency as measured through task time deviation was more variable. Participants with little prior experience for a given task took longer to complete it than those with more experience.

A patient has to be registered in the EHRUT before any other task can be completed. Patient registration is performed by staff with a wide variety of education and experience. The high task success and high satisfaction suggest that this EHRUT supports this function well.

Ordering a lab test and an imaging procedure proved both effective and efficient. However, entering an allergy into the patient's record was more difficult for novice users. The ability to right click in the Allergy field is not obvious, and there are several required fields in the allergy screen that could be overlooked.

Prescribing a medication relies on New Crop software. While the task success for tasks 7 and 13 was high, the task success for task 5 was much lower. Since testing began, NewCrop has updated its interface to make allergy information easier to find and more apparent. Note that medication reconciliation for this EHRUT is accomplished using the prescribing to a test pharmacy function in NewCrop. Therefore it was not tested explicitly separately, as it is the same as Task 7.

None of the participants had prior experience with implantable devices. Retrieving the implantable device id was easy, recording the id proved more challenging. Another function participants were unfamiliar with was clinical reminders, specifically the tobacco use screening reminder. However, because it uses a common workflow with other types of clinical notes, it was both effective and efficient.

Task 12 required working with a CCD reading software as well as Astronaut. Since it used otherwise familiar workflows, most participants found it fairly easy to perform the task.

In contrast, the effectiveness of the e-Prescribing software was much lower. Tasks involving sending messages to the pharmacy were not completed. Displaying a patient's complete prescribing history proved both effective and efficient, although participants used Surescripts and PDMP rather than messaging the pharmacy to complete the task. Work-arounds for the cancel, change, and renew scenarios mentioned included having the patient request a refill, calling the pharmacy to cancel or change a prescription, and generally responding to faxes and emails from the pharmacy.

4.3 Major findings for EHRUT

Several major findings emerged from the testing of this EHR. Firstly, tasks which are performed frequently and by a variety of users are well supported. These include registering patients, ordering tests, and medication-related tasks. Tasks which are performed rarely and/or by few users are less well supported. These include for example implantable device recording.

Secondly, satisfaction with the EHRUT was high for all tasks, regardless of the length of time users had experience with the software. The task with the lowest user satisfaction was task 5, related to prescribing a medication to which a pt is allergic. Since this task is performed in NewCrop, the lower satisfaction related more to the NewCrop interface than to the EHRUT.

4.4 Major findings for e-Prescribing

Several major findings emerged from the testing of this e-Prescribing software. Users had experience prescribing medication and looking for a patient's prescription history. These tasks were completed efficiently and effectively. Messaging between the provider and pharmacy was difficult to find and

respond to. Ambiguity in wording led some users to mis-interpret system messages. The software does not provide enough prompting and status messages for less experienced users.

4.5 Areas for Improvement for EHRUT

Two areas for improvement are noted, related to system behavior and user interaction consistency as well as workflow simplification. For example, the cover sheet is sometimes updated as soon as the user performs the action, for other actions, it requires a manual 'Refresh patient information' step. For efficiency, having the EHR automatically update the cover sheet once a user performs any action would be preferable. User interaction inconsistency is exemplified by the EHR's response to right clicking the mouse. Right clicking does not produce consistent results, which can be confusing for novice users. Creating consistent right click interaction would be helpful. This was apparent for users trying to enter an allergy, for example.

The workflows for tasks performed less frequently tended to involve many steps and require users to remember how to interact with certain fields. As the number of users increases, these workflows need to be streamlined such that users can be both effective and efficient with minimal training requirements.

4.6 Areas for improvement for e-Prescribing

The software requires clinicians to find incomplete tasks rather than presenting them with a personalized list. Messaging from the pharmacy should be more obvious, with response options clearly indicated. Overall navigation should be improved, with a clearer distinction between buttons and links from the rest of the text on the screen.

5 Appendices

5.1 Systems Usability Scale

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	Strongly disagree						Strongly agree
1. I think that I would like to use this system frequently	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
2. I found the system unnecessarily complex	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
3. I thought the system was easy to use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	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	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
5. I found the various functions in this system were well integrated	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
6. I thought there was too much inconsistency in this system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
7. I would imagine that most people would learn to use this system very quickly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
8. I found the system very cumbersome to use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
9. I felt very confident using the system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		
10. I needed to learn a lot of things before I could get going with this system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	1	2	3	4	5		

5.2 Moderator Guide

Orientation (2 min)

Thank you for participating in this study.

I will ask you to complete certain tasks using Astronaut Vista. We are interested in how easy or difficult this software is to use, and how we could improve it. You will be asked to complete tasks on your own, trying to do them as quickly as possible with the fewest errors.

We are testing the software, not you. All information collected will be confidential and your comments will not be associated with your name at any time.

Demographics (5 min)

Participant Identifier: _____

Age: _____

Gender: _____

Education:

- No high school degree
- High school graduate, diploma or the equivalent (for example: GED)
- 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)

Role/Job:

Professional Experience (time in months):

Astronaut Experience (time in months):

Computer Experience (time in months):

Assistive Technology:

Task 1 - Add a new patient to Astronaut (170.315a5)

Add the following patient to Astronaut.

Name: zztest, meaningful, _____ (Participant first and last initial)

DOB: _____ (Moderator generated)

SSN: System generated

Gender: Male

Race: White

Ethnicity: Non-Hispanic

Preferred language: English

Sexual Orientation: Heterosexual

Gender Identity: Male

Success:

Comments:

Easily Completed

Completed with difficulty or help

Not Completed

Task time _____ min _____ sec

Optimal Task Time: 190 sec

Optimal Path: Patient Selection Screen --- Add new patient ----Enter data ---- Add Patient --- Ok --- Patient button on cover sheet ---- edit patient demographics ----- enter data ---- Click Apply

Observed # of Steps:

Optimal # of Steps: 9

of errors:

Comments:

Observed Errors and Verbalizations:

Task Rating (5 - Very easy to 1 - very hard): _____

Task 2 - Order a lab (170.315a2)

For the patient created in task 1, order a BUN test using default settings.

Success:

Comments:

- Easily Completed
- Completed with difficulty or help
- Not Completed

Task time _____ min _____ sec

Optimal Task Time: 26 sec

Optimal Path: Cover sheet ---Orders tab ---Lab test on left menu -- enter BUN in popup --- Accept Order

Observed # of Steps:

Optimal # of Steps: 4

of errors:

Comments:

Observed Errors and Verbalizations:

Task Rating (5 - Very easy to 1 - very hard): _____

Task 3 - Order an imaging procedure (170.315a3)

For the patient created in task 1, order an abdomen 1 view, desired today, reason pain.

Success:

Comments:

- Easily Completed
- Completed with difficulty or help
- Not Completed

Task time _____ min _____ sec

Optimal Task Time: 41 sec

Optimal Path: Cover sheet ---Orders tab ---Imaging on left menu -- select general radiology---select abdomen 1 view --- enter date and reason --- accept order.

Observed # of Steps:

Optimal # of Steps: 7

of errors:

Comments:

Observed Errors and Verbalizations:

Task Rating (5 - Very easy to 1 - very hard): _____

Task 4 - Enter an allergy (170.315a4)

For the patient created in task 1, add an allergy to aspirin. The patient stated that he has had hives and itches in the past.

Success:

Comments:

- Easily Completed
- Completed with difficulty or help
- Not Completed

Task time _____ min _____ sec

Optimal Task Time: 34 sec

Optimal Path: Cover sheet ---Right click in allergy field -- select enter new allergy -- enter first few letters-- select aspirin--check historical--nature of reaction allergy--select itching and hives --- click ok.

Observed # of Steps:

Optimal # of Steps: 9

of errors:

Comments:

Observed Errors and Verbalizations:

Task Rating (5 - Very easy to 1 - very hard): _____

Task 5 - Prescribe aspirin (170.315a4)

For the patient created in task 1, attempt to prescribe aspirin.

Success:

Comments:

Easily Completed

Completed with difficulty or help

Not Completed

Task time _____ min _____ sec

Optimal Task Time: 65 sec

Optimal Path: Cover sheet --- Tools - EPrescribing - View Imported Allergies -- STOP

Observed # of Steps:

Optimal # of Steps: 5

Comments:

of errors:

Observed Errors and Verbalizations:

Task Rating (5 - Very easy to 1 - very hard): _____

Task 6 Add a problem to the problem list (170.315a6)

For the patient created in task 1, add depression to pt problem list.

Success:

Comments:

- Easily Completed
- Completed with difficulty or help
- Not Completed

Task time _____ min _____ sec

Optimal Task Time: 40 sec

Optimal Path: Cover sheet --- Problems tab -- type depression--select depression--enter depression in ICD search window--select major depressive, recurrent severe without psychosis--click ok--click ok.

Observed # of Steps:

Optimal # of Steps: 9

of errors:

Comments:

Observed Errors and Verbalizations:

Task Rating (5 - Very easy to 1 - very hard): _____

Task 7 - Prescribe trazodone (170.315a1)

For the patient created in task 1, prescribe trazodone, 50 mg, 1x/day, at night.

Success:

Comments:

Easily Completed

Completed with difficulty or help

Not Completed

Task time _____ min _____ sec

Optimal Task Time: 65 sec

Optimal Path: Cover sheet --- Tools - EPrescribing - type first few letters --click search--select trazodone 50 mg --select QHS----select 30 day supply--review--transmit.

Observed # of Steps:

Optimal # of Steps: 7

of errors:

Comments:

Observed Errors and Verbalizations:

Task Rating (5 - Very easy to 1 - very hard): _____

Task 9 - Implantable Device (170.315a14)

Enter an implantable device id.

(01)12345678901234(17)140102(11)100102(10)A1234(21)1234

Success:

Comments:

Easily Completed

Completed with difficulty or help

Not Completed

Task time _____ min _____ sec

Optimal Task Time: 61 sec

Optimal Path: Cover sheet --Notes--new note--select first template--click ok--click Encounter--health Factors tab--Other health factors button--uid pacemaker--switch windows to desktop--copy device id --paste device id into comment box - click ok

Observed # of Steps:

Optimal # of Steps: 13

of errors:

Comments:

Observed Errors and Verbalizations:

Task Rating (5 - Very easy to 1 - very hard): _____

Task 10 - Implantable Device (170.315a14)

Retrieve a patient's implantable device id.

Success:

Comments:

Easily Completed

Completed with difficulty or help

Not Completed

Task time _____ min _____ sec

Optimal Task Time: 18 sec

Optimal Path: Cover sheet -- tools--view implantable devices--view device characteristics

Observed # of Steps:

Optimal # of Steps: 4

of errors:

Comments:

Observed Errors and Verbalizations:

Task Rating (5 - Very easy to 1 - very hard): _____

Task 11- CDS (170.315a9)

Receive a CDS intervention based on data in patient record.

Success:

Comments:

- Easily Completed
- Completed with difficulty or help
- Not Completed

Task time _____min _____sec

Optimal Task Time: 194 sec

Optimal Path: Cover sheet - notes - new note - tobacco cessation --- fill out-- Encounter -- view Entries under selected health factors -- cover sheet -- refresh patient information -- verify that reminder is not shown on cover sheet

Observed # of Steps:

Optimal # of Steps: 9

of errors:

Comments:

Observed Errors and Verbalizations:

Task Rating (5 - Very easy to 1 - very hard): _____

Task 12- CDS (170.315a9)

View CCD in viewer software and use it to perform a CDS intervention, then import the CCD.

Success:

Comments:

- Easily Completed
- Completed with difficulty or help
- Not Completed

Task time _____ min _____ sec

Optimal Task Time: 57 sec

Optimal Path: Open Backbeach software - open CCD file-- shrink window so both Backbeach and Astronaut are visible -- Cover sheet --check for current allergy information --notes tab--new note -- select first template--click ok--click add attachment--select other--select file.xml--upload-sign note-- verify that attachment is visible.

Observed # of Steps:

Optimal # of Steps: 15

of errors:

Comments:

Observed Errors and Verbalizations:

Task Rating (5 - Very easy to 1 - very hard): _____