

EHR Usability Test Report of Varian ARIA Oncology Information System (for Radiation Oncology) V15.5

Report based on ISO/ IEC 25062:2006 Common Industry Format for Usability Test Reports

Varian ARIA Oncology Information System (for Radiation Oncology) V15.5

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EXECUTIVE SUMMARY

A usability test of Varian ARIA Oncology Information System (for Radiation Oncology), version 15.5, clinic EHR was conducted from June 22, 2017 – July 5, 2017 remotely by Macadamian Technologies. The purpose of this test was to test and validate the usability of the current user interface, and provide evidence of usability in Varian ARIA Oncology Information System (for Radiation Oncology). During the usability test, 13 healthcare providers matching the target demographic criteria served as participants and used ARIA in simulated, but representative tasks.

This study collected performance data on 11 tasks typically conducted with the EHR.

Meaningful Use Criterion Tested	Task
Section 170.315(a)(5) Demographics	1. Document demographic information
Section 170.315(a)(6) Problem List	2. Document an existing problem
Section 170.315(a)(8) Medication Allergy List	3. Document an allergy
Section 170.315(a)(7) Medication List	4. Document a medication from an external provider
Section 170.315(b)(2) Clinical Information Reconciliation and Incorporation	5. Perform clinical information reconciliation
Section 170.315(a)(1) Computer Physician Order Entry – Medications and Section 170.315(a)(4) Drug-Drug, Drug-Allergy Interaction Check	6. Order a medication (favorite) and review interactions
Section 170.315(a)(1) Computer Physician Order Entry – Medications	7. Order a medication (non-favorite)
Section 170.315(b)(3) Electronic Prescribing	8. Send prescriptions to a pharmacy
Section 170.315(a)(2) Computer Physician Order Entry - Laboratory and Section 170.315(a)(3) Computer Physician Order Entry – Diagnostic Imaging	9. Order a lab and diagnostic imaging
Section 170.315(a)(9) Clinical Decision Support	10. Acknowledge CDS rules
Section 170.315(a)(14) Implantable Device List	11. Document an implantable device

During the 60-minute one-on-one usability test, each participant was greeted by the moderator and given a

standardized introduction to the test. All the participants had previous experience with ARIA. The moderator instructed participants to complete a series of tasks (given one at a time) using ARIA. During the testing, the moderator timed the test and, along with the note taker, recorded user performance data on paper and electronically. The moderator provided assistance in completing the task only when participants were unable to go to the next step. The moderator's screen – which participants had control over – and audio were recorded for subsequent analysis.

The following types of data were collected for each participant:

- Number of tasks successfully completed without assistance
- Time to complete the tasks
- Number and types of errors
- Path deviations
- Participants' verbalizations
- Participant's satisfaction ratings of the system

All participant data was de-identified – no correspondence could be made from the identity of the participant to the data collected. Following the conclusion of the testing, participants completed a post-test questionnaire. Various recommended metrics, in accordance with the examples set forth in the *NIST Guide to the Processes Approach for Improving the Usability of Electronic Health Records*¹, were used to evaluate the usability of ARIA.

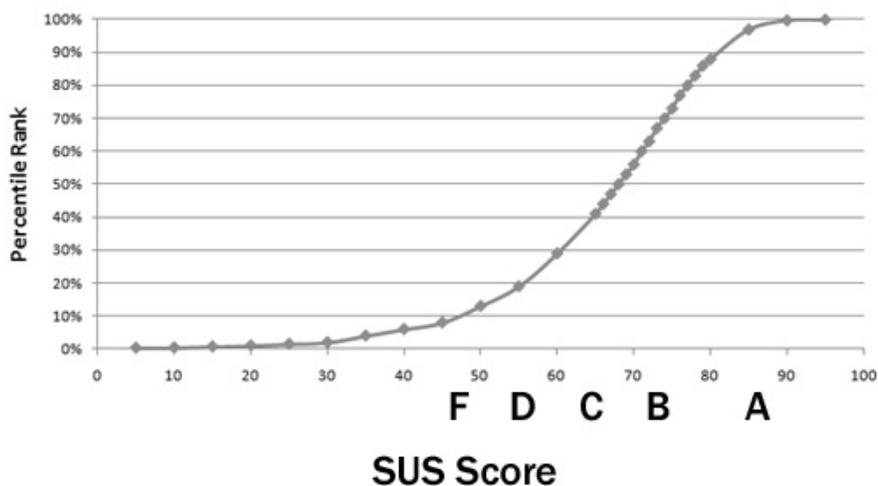
Following is a summary of the performance and rating data collected on ARIA.

¹ NISTIR 7741, R. Schumacher & S. Lowry, (2010) NIST Guide to the Processes Approach for Improving the Usability of Electronic Health Records.

Measure	N	Task Success	Path Deviations	Task Time (seconds)			Errors	Task Ratings 5 = Easy
Task	#	Percentage	Deviations [Observed/Optimal]	Mean (SD)	Optimal	Deviations [Observed/Optimal]	Mean (SD)	Mean (SD)
1. Document demographic information	13	100	1.19	77 (43)	55	1.4	0 (0.0)	4.8 (0.4)
2. Document an existing problem	13	69	1.57	91 (57)	85	1.1	0.3 (0.5)	4.1 (1.0)
3. Document an allergy	13	100	1.10	73 (11)	80	0.9	0.5 (0.8)	4.2 (0.8)
4. Document a medication from an external provider	13	100	1.18	54 (23)	66	0.8	0.3 (0.9)	4.7 (0.8)
5. Perform clinical information reconciliation	13	8	1.00	172 (N/A)	184	0.9	0 (N/A)	4.0 (N/A)
6a. Order a medication (favorite)	13	100	1.69	74 (54)	40	1.8	0.2 (0.4)	4.5 (1.0)
6b. Review interactions	13	85	1.59	61 (25)	37	1.6	0.2 (0.4)	
7. Order a medication (non-favorite)	13	100	1.19	77 (20)	98	0.8	0.2 (0.4)	4.2 (0.8)
8. Send prescriptions to a pharmacy	12	92	1.60	55 (31)	60	0.9	0.2 (0.6)	4.6 (0.5)
9. Order a lab and diagnostic imaging	13	100	1.04	49 (12)	53	0.9	0.6 (1.0)	4.8 (0.4)
10. Acknowledge clinical decision support rules	11	100	1.20	30 (26)	40	0.7	0 (0.0)	4.5 (1.0)
11. Document an implantable device	13	92	1.34	90 (63)	75	1.2	0.4 (0.5)	4.4 (1.0)

The results from the System Usability Scale [SUS] scored the subjective satisfaction with the system based on performance with these tasks to be: 82. Broadly interpreted, scores under 60 represent systems with poor usability; scores over 80 would be considered above average.²

More recent work by Sauro (2011) provides a norming distribution based on 500 comparative SUS scores (from usability tests of a wide range of applications). Based on this distribution, the SUS result of 82 ranks roughly in the 90th percentile or equivalent to a letter grade 'B', see the figure below.



Usability judgments were also collected at the end of each major task. The averages obtained from those task-based usability scores varied between 4.1 – 4.8, quite a bit above the recommendation put forward in NISTIR3 7742. The NISTIR 7742 states that —common convention is that average ratings for systems judged easy to use should be 3.3 or above. This is consistent with the overall SUS ratings at the end of the session.

Major Findings

- Of the 11 tasks that participants attempted, participants completed 10 tasks with success rates over 69%, and most of these tasks were completed with success rates from 85% - 100%.
- Incorporating and reconciling a 'C-CDA Transition of Care' document electronically proved to be the most challenging task for participants, as evidenced by the failure rate. One of the main difficulties was recognizing the additional steps required to reconcile the information from 'C-CDA Transition of Care' document for the task to be considered a success.
- When completing tasks, users were often presented with many options (i.e. 'Ok', 'Save', 'Apply', 'Approve', 'Close). In many instances, users were unsure which selection was the most appropriate to complete a task and selected a combination to ensure they could complete the task successfully.
- In several occasions, the application does not indicate mandatory fields in (e.g. when ordering a non-favorite medication and incorporating a 'C-CCDA Transition of Care' document) and participants received a message for each of the mandatory fields required when attempting to complete the task.
- In many occasions, messages do not provide a clear description of the problem nor guide the participants on the steps to follow.

² See Tullis, T. & Albert, W. (2008). *Measuring the User Experience*. Burlington, MA: Morgan Kaufman (p. 149).

Areas for Improvement

Handling Mandatory Fields & Data Entry

- Consider highlighting all mandatory fields instead of providing messages when required fields are not completed and ensure the actions to complete the task (i.e. 'Approve' or 'Ok') are unavailable until all mandatory fields are completed (e.g. 'Inbound Transition of Care' pop-up window, creating an order).
- Consider explicitly indicating the required data format per field and only allow the entry of the specified data format (e.g. numerical value instead of text) versus generating a message when users use an incorrect data format.

Messaging

- Consider standardizing the messaging system, so that, it contains the following information:
 - Severity
 - Issue or problem description
 - Steps on how to address the issue or problem

Task Completion

- Compare the frequency and importance of 'OK' and 'Apply' versus the confusion it causes for end users when e-prescribing, adding medications and allergies to a patient's history:
 - If 'Apply' needs to stay, ensure that the language used indicates the resulting action
 - If 'OK' and 'Apply' needs to stay, conduct additional user research to ensure that the contrast is clear; the control 'Ok' needs to give users the impression that the application will save their work (i.e. the resulting action is a 'Save' and 'Close' of the pop-up when this button is selected)
- The application allows users to (try to) submit incomplete work, as action buttons to save/ submit data are always available. Consider disabling these buttons until an action has been committed that would allow the action button to do its job.

Computerized Physician Order entry - Medications

- While the system provides drop-down menus for many of the selections during order entry, which alleviates the user from having to type, the application could be more effective and efficient in supporting user actions. For example, auto-populating data that apply for a specific medication, indicating mandatory fields, and not allowing for incorrect data entries to be entered (e.g. text in a numerical field)

Drug-Drug, Drug-Allergy Interaction Check

- Improve noticeability of the impact (i.e. contraindication, interactions) that a specific order has which is triggered by patient demographics or conditions within the 'Medi-Span Medication Screening' pop-up.

Problem List

- Participants found it cumbersome to search for a diagnosis, as diagnoses descriptions are very long and are truncated by the column width. Consider improving the presentation of information within the 'Advanced Search for Diagnosis/ Problem Code' pop-up (e.g. column widths and highlighting similarities or differences of the different diagnosis to provide for easier scanning)

Medication Allergy List

- Consider guiding users to make a selection from the 'Drug Class Allergy Selection' and 'Drug Selection' lists for the corresponding interactions checks to take place.
- Consider the current allergy interaction check mechanism, so that, if a user provides a free text entry in the 'Allergy' field, interactions could be also checked for.

Implantable Devices

- Ensure that the starting point (e.g. the 'New' button) is in a consistent location, as compared to other areas of the application.

- Upon entering a complete UDI, consider auto-completing the fields for the user without a distinct action or with a tab or enter action.

Clinical Information Reconciliation

- Consider guiding the user to reconcile the information after incorporating the information from the 'Transition of Care' document (i.e. prompt the user to the next steps and workspace (s) where reconciliation of information is required).
- Consider simplifying the incorporation and reconciliation of information by joining both activities within one workflow.
- Consider further user research regarding messaging during this workflow (i.e. the difference between 'incorporating' and 'reconciling' is not well understood by end users)

Electronic Prescribing

- Consider including the ability to send all prescriptions in one batch when sending to the same pharmacy.

INTRODUCTION

The EHR tested for this study was ARIA Oncology Information System (for Radiation Oncology), version 15.5. Designed to present outpatient medical information to healthcare providers, the application supports the entire clinical process for radiation oncology practices and comprehensive cancer centers. ARIA is a desktop application that consists of patient care options for recording patient encounters, supporting order entry, and tracking patient histories. Primarily, oncologists, nurse practitioners, nurses, medical assistants, and other related healthcare professions use the application to track all patient interactions and manage their practices. 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 to provide evidence of usability in ARIA. To this end, measures of effectiveness, efficiency and user satisfaction, such as error rates, time on task, ease of use ratings and the SUS, were captured during the usability test.

METHOD

PARTICIPANTS

A total of 13 participants were involved in the usability test of ARIA. Participants in the test were registered nurses, nurse practitioners, a therapist and medical doctors, as they are the primary users' groups for this product and the specific meaningful use criterion being tested. Participants were recruited by Varian from their existing customer base. All participants were located in the United States. In addition, participants had no direct connection to the development of, or the organization producing ARIA; participants were not from the testing or supplier organization. Participants all had some experience with ARIA.

For the test purposes, end-user characteristics were identified and translated into seven pre-test questions asked of participants by the test moderator or via an email questionnaire. The questions are included in the test protocol shown in Appendix 2.

Recruited participants had a mix of backgrounds and demographic characteristics conforming to the recruitment criteria agreed with Varian prior to recruitment. The following is a table of participants by characteristics, including demographics, professional experience, and EHR experience. The included sample was comprised of: nine nurses, one nurse practitioner, one therapist and two medical doctors. All but three were female. The group fell into the following age categories: one is 20 – 29 years, five are 30 – 39 years old, four are 40 – 49 years old, and three are 50 – 59 years old. The included sample was comprised of individuals with the following education levels: three with associate degrees, six with bachelor's degrees, two with master's degrees, and two with doctorate degrees. As a group, the sample had practiced an average of 14 years (with a range between 1 – 40 years in their current roles) and they had an average of 9 years of experience using electronic health records (with a range between 4 – 15 years). Participants had an average of 19 years of experience using a computer for personal or business use (with a range between 7 – 35 years). None of the participants use any assistive technologies to help them with their job.

Participants were scheduled for 60-minute remote test sessions with at least 15 minutes in between each session.

Part ID	Sex	Age Range	Education Level	Role	Professional Experience [years]	Computer Experience [years]	EHR Experience [years]
P0	Female	40-49	Master's degree	Manager-Chief Therapist	9	20	10
P1	Female	30-39	Bachelor's degree	Radiation Oncology Nurse	1	15	12
P2	Female	30-39	Master's Degree	Nurse Practitioner	3	12	4
P3	Female	30-39	Associate Degree	Registered Nurse, Office Manager	9	7	9
P4	Female	50-59	Bachelor's Degree	Registered Nurse	40	35	15
P5	Female	20-29	Bachelor's Degree	Registered Nurse/ Manager	5	15	8
P6	Female	40-49	Bachelor's Degree	Radiation Oncology Nurse	21	25	9
P7	Male	40-49	Medical Doctor	Physician	13	30	15
P8	Female	40-49	Bachelor's Degree	Registered Nurse	11	10	7
P9	Female	50-59	Associate Degree	Staff Registered Nurse	24	20	4
P10	Female	50-59	Associate Degree	Registered Nurse/Charge Nurse Radiation	35	20	15
P11	Male	30-39	Bachelor's Degree	Registered Nurse	7.5	20	8.5
P12	Male	30-39	Medical Doctor	Physician	2	20	6

STUDY DESIGN

Overall, the objective of this test was to uncover areas where the application performed well – that is, effectively, efficiently and with satisfaction – and areas where the application failed to meet the needs of the participants. The data from this test may serve as a baseline for future tests with an updated version of the same EHR and/ or comparison to other EHRs provided the same tasks are used. In short, this testing serves as both a means to record or benchmark current usability, but also to identify areas where improvements must be made.

During the test, participants interacted with the EHR. Each participant used the system remotely using GoToMeeting by means of remote desktop connection and was provided with the same instructions. The system was evaluated for effectiveness, efficiency and satisfaction as defined by measures collected and analyzed for each participant:

- Number of tasks successfully completed without assistance.
- Time to complete the tasks
- Number and types of errors
- Path deviations
- Participant's verbalizations (comments)
- Participant's satisfaction ratings of the system

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

TASKS

A number of tasks were constructed that would be realistic and representative of the kinds of activities a user might do with this EHR and are included in the table below.

Meaningful Use Criterion Tested	Task
Section 170.315(a)(5) Demographics	1. Document demographic information
Section 170.315(a)(6) Problem List	2. Document an existing problem
Section 170.315(a)(8) Medication Allergy List	3. Document an allergy
Section 170.315(a)(7) Medication List	4. Document a medication from an external provider
Section 170.315(b)(2) Clinical Information Reconciliation and Incorporation	5. Perform clinical information reconciliation
Section 170.315(a)(1) Computer Physician Order Entry – Medications and Section 170.315(a)(4) Drug-Drug, Drug-Allergy Interaction Check	6. Order a medication (favorite) and review interactions
Section 170.315(a)(1) Computer Physician Order Entry – Medications	7. Order a medication (non-favorite)
Section 170.315(b)(3) Electronic Prescribing	8. Send prescriptions to a pharmacy
Section 170.315(a)(2) Computer Physician Order Entry - Laboratory and Section 170.315(a)(3) Computer Physician Order Entry – Diagnostic Imaging	9. Order a lab and diagnostic imaging
Section 170.315(a)(9) Clinical Decision Support	10. Acknowledge CDS rules
Section 170.315(a)(14) Implantable Device List	11. Document an implantable device

Tasks were constructed that would sufficiently evaluate the Meaningful Use Stage 3 prioritized Certification Criteria and their frequency of use, criticality of function, and those that might be troublesome for users. Tasks were constructed that would be realistic and representative of the kinds of activities a healthcare provider might do with this EHR. Prior to testing, an expert review was conducted with internal experts of ARIA to assess risk to patient safety based on common interface criteria. As part of the task construction, tasks were prioritized in accordance with the risk associated with use errors. NISTIR 7804; Form for Expert Review Items 1A through 1H was used to create and prioritize tasks based on design areas related to known use errors. The outcome of this review was used as a factor to determine selection of appropriate tasks for this test.

PROCEDURES

A selection of Varian customer contacts were initially sent an email describing the study and asked if they, or their staff, would be willing to participate [see Appendix 1: Invitation]. The contact information for those who responded were sent to the Macadamian research prime who contacted each participant individually to set up a usability test session time and provide the necessary GoToMeeting information and preparation instructions.

When each participant joined the web conference session, the moderator shared her screen and passed keyboard and mouse control to the participant. The moderator then read a standard introduction to him/her and asked for permission to record the session. The moderator then read the first task. After the eleventh task, the SUS was administered in order to acquire a SUS rating [see Appendix 2: Test Protocol].

To ensure that the test ran smoothly, two staff members participated in this test, a moderator and a note taker. The moderator conducting the test is an experienced usability researcher with a master's in applied science in biomedical engineering and nine years of experience conducting usability research. The note taker was also a Macadamian user experience researcher with a bachelor's in human biology and a degree in medical radiation therapy with six years of design and usability research experience.

The moderator facilitated the session including administering instructions and tasks. The moderator also monitored task times, obtained post-task rating data, took notes on participant comments, and documented SUS ratings. The moderator also noted task success. The note taker took detailed notes on paths, participant comments and ratings. The moderator and note taker debriefed after the sessions, if any discrepancies were noted or clarifications were needed.

Participants were instructed to perform the tasks [see Appendix 2: Test Protocol]:

- Without assistance from the moderator [except to repeat task details or give clarification on the tasks]
- Without doing anything more than was asked for each task – specifically, not to enter notes or complete fields not requested

For each participant, the moderator read the task and the participant jotted down details on paper. Task timing began once the participant indicated they were ready to start the task and/ or selected the first action button to start the task. Task timing stopped once the participant indicated they had completed the task and/ or selected the final action button to complete the task. Once the task was completed, the participant was asked to provide an ease of use rating for that task based on their use of the application. Scoring is discussed in the section 'Data Scoring'.

Following completion of the tasks, the moderator administered the SUS³ and thanked each individual for his/her participation.

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

³ Brooke, J.: SUS: A "quick and dirty" usability scale. In: Jordan, P. W., Thomas, B., Weerdmeester, B. A., McClelland (eds.) *Usability Evaluation in Industry* pp. 189--194. Taylor & Francis, London, UK (1996). SUS is copyrighted to Digital Equipment Corporation, 1986.

TEST ENVIRONMENT

ARIA would typically be used in radiation oncology practices and comprehensive cancer centers. In this case, the testing was conducted remotely and via a remote desktop connection to ARIA with test patients and was running version 15.5 of the system. ARIA is in place in the United States and the areas under evaluation are similar, if not identical, for customers. Participants used their own mouse and keyboard to interact with ARIA, once they were passed keyboard and mouse control via GoToMeeting. For testing, the computer hosting the GoToMeeting and ARIA via remote desktop connection was a PC running Windows 10.

The test patients were created by the vendor according to the vendor’s documentation describing the system set-up and preparation. The application itself was running on Windows 10 using test patients. The task times captured for each task were averaged across two experts for all the tasks and the resulting number was used as the optimal time for each task. The optimal time for each task was used for time comparisons to provide a measure of how much longer an average user would take to perform these tasks.

The following table provides the technical data set-up for the test environment.

Connection	Connection into a remote login server running ARIA with test patients.
Provider Desktop Usability Test Environment	<p>A special login was created with the same privileges as a physician. The login had access to the complete EHR including all functions and backend support software that a real implementation would provide.</p> <p>For the test, 13 patients were created to allow each participant to experience the exact same configuration of patient data.</p> <p>It is important to note that while all efforts were made to create a fully functioning test environment, the configuration of menus and menu choices, applications, alerts, prescription lists, etc. were similar but not the same as what any particular healthcare provider would use. All of the customized functions are different from site to site, depending on clinic policies and implementation.</p>
EHR software and version	ARIA Oncology Information System (for Radiation Oncology) version 15.5
Testing software	GoToMeeting

EHR SCENARIO AND PATIENT SETUP

During the usability study, the participants interacted with ARIA in order to treat one patient. The patient was a new patient that needed her demographic information and diagnosis updated, an allergy documented, a transition of care document reconciled, medications, a lab and diagnostic imaging ordered, prescriptions sent to pharmacy, clinical decisions acknowledged and a pacemaker documented. The details of each scenario can be found in the test protocol in Appendix 2. In order to allow each participant to interact with the identical set of data, 13 identical patients were created.

TEST FORMS AND TOOLS

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

- Moderator’s guide

- Post-test SUS

Examples of these documents can be found in the Appendix 2. The moderator's guide was devised to capture the required test data.

The participants' interaction with ARIA and their verbal comments were captured and recorded digitally via GoToMeeting. The note taker observed the session live or from the recording.

PARTICIPANT INSTRUCTIONS

The moderator read precise test instructions to each participant [see Introduction in Appendix 2: Test Protocol].

Following the procedural instructions, participants viewed multiple screens of the EHRUT for a particular patient and were asked whether it looked similar to what they were using at their clinic. They were also shown where to document an implantable device, as that was a newly implanted feature.

Participants were asked to indicate when they were ready to begin each task and when they were finished. Then the first task was read to the participant. The participants were given 11 tasks to complete in this manner. The tasks are detailed in the Test Protocol in Appendix 2.

USABILITY METRICS

According to the *NIST Guide to the Processes Approach for Improving the Usability of Electronic Health Records*⁴, EHRs should support a process that provides a high level of usability for all users. The goal is for users to interact within 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 ARIA by measuring participant success rates and errors
2. Efficiency of ARIA by measuring the average task time and path deviations
3. Satisfaction with ARIA by measuring ease of use ratings

Data Scoring

The following table details how tasks were scored, errors evaluated, and the time data analyzed.

⁴ NISTIR 7741, R. Schumacher & S. Lowry, (2010) NIST Guide to the Processes Approach for Improving the Usability of Electronic Health Records.

Measures	Rationale and Scoring
Effectiveness: Task Success	<p>A task was counted as a "Success" if the participant was able to achieve the correct outcome, without user interface directed assistance. Direction was occasionally provided with understanding task instructions but never in how a task was to be completed.</p> <p>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.</p> <p>Task times were recorded for successes. Optimal task performance times, as benchmarked by expert performance under realistic conditions, were recorded when constructing the tasks. These task times were determined by taking multiple measures of optimal performance and then averaged. No adjustments were made to the optimal times, as there is no generally accepted empirical or principled way to determine meaningful adjustments.</p> <p>All participants were allowed to finish the tasks and the time comparisons provide a measure of how much longer an average user would take to perform these tasks.</p>
Effectiveness: Task Failure	<p>If the participant abandoned the task, did not reach the correct answer or performed it incorrectly, the task was counted as a "Failure". For each task, the percentage of participants who successfully completed it is reported. The failures can be calculated by subtracting the successful completions from 100.</p> <p>The total number of errors was calculated for each task and then divided by the total number of times that task was attempted. Not all deviations were counted as errors. Errors are selections of wrong menu items, wrong list items, or entering wrong data formats. If an error results in a number of corrective steps, only the first actions, resulting in the error is counted as error. All corrective steps are counted as deviations. On a qualitative level, an enumeration of errors and error types was collected.</p>
Efficiency: Task Deviations	<p>The participant's path (i.e., steps) through the application was recorded. Deviations occurred if the participant, for example, went to a wrong screen, followed an incorrect link, interacted incorrectly with an on-screen control, performed any steps to correct a previous error. This path was compared to the optimal path. The number of steps in the observed path was divided by the number of optimal steps to provide a ratio of path deviation.</p> <p>Optimal paths (i.e., procedural steps) along with alternate paths were recorded when constructing the tasks. Deviations were recorded for all tasks completed successfully.</p>
Efficiency: Task Time	<p>Each task was timed from when the participant said, "Ready" or took the first action to start the task until the participant said, "Done." If he or she failed to say, "Done," the time was stopped when the participant stopped performing the task. Only task times for tasks that were successfully completed were included in the average task time analysis. Average time per task was calculated for each task. Variance measures (standard deviation) were also calculated.</p>
Satisfaction: Task Rating	<p>Participant's subjective impression of the ease of use of the application was measured by administering a simple post-task question. After each task, the participant was asked to answer "Overall, this task was:" on a scale of 1 (Very Difficult) to 5 (Very Easy)". This data is averaged across participants.</p> <p>Common convention is that average ratings for systems judged easy to use should be 3.3 or above. To measure participants' confidence in and likeability of Aria overall, the moderator administered the SUS questionnaire. Questions included, "I think I would like to use this system frequently," "I thought the system was easy to use," and "I would imagine that most people would learn to use this system very quickly." See full System Usability Scale questionnaire in Appendix 2.</p>

RESULTS

DATA ANALYSIS AND REPORTING

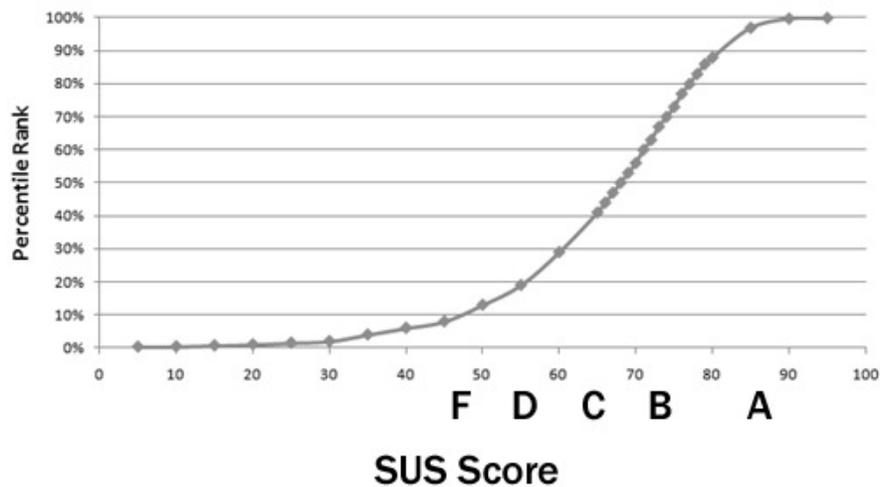
The results of the usability test were calculated according to the methods specified in the 'Usability Metrics' section above. There were no data exclusions for participants not following test instructions. Task 8 could not be completed by one participant because pharmacies were not available for selection in time for the test session. Task 10 could not be completed by two participants because the clinical decisions rules could not be generated in time for the test sessions (i.e. acknowledge CDS rule).

The usability testing results for the ARIA are detailed in the table below. The results should be seen considering the objectives and goals outlined in the section 'Study Design'. The data should yield actionable results that, if corrected, yield material, positive impact on user performance. The following table presents the data such that the tasks can be easily identified and their performance results examined and compared.

Measure	N	Task Success	Path Deviations	Task Time (seconds)			Errors	Task Ratings 5 = Easy
Task	#	Percentage	Deviations [Observed/Optimal]	Mean (SD)	Optimal	Deviations [Observed/Optimal]	Mean (SD)	Mean (SD)
1. Document demographic information	13	100	1.19	77 (43)	55	1.4	0 (0.0)	4.8 (0.4)
2. Document an existing problem	13	69	1.57	91 (57)	85	1.1	0.3 (0.5)	4.1 (1.0)
3. Document an allergy	13	100	1.10	73 (11)	80	0.9	0.5 (0.8)	4.2 (0.8)
4. Document a medication from an external provider	13	100	1.18	54 (23)	66	0.8	0.3 (0.9)	4.7 (0.8)
5. Perform clinical information reconciliation	13	8	1.00	172 (N/A)	184	0.9	0 (N/A)	4.0 (N/A)
6a. Order a medication (favorite)	13	100	1.69	74 (54)	40	1.8	0.2 (0.4)	4.5 (1.0)
6b. Review interactions	13	85	1.59	61 (25)	37	1.6	0.2 (0.4)	
7. Order a medication (non-favorite)	13	100	1.19	77 (20)	98	0.8	0.2 (0.4)	4.2 (0.8)
8. Send prescriptions to a pharmacy	12	92	1.60	55 (31)	60	0.9	0.2 (0.6)	4.6 (0.5)
9. Order a lab and diagnostic imaging	13	100	1.04	49 (12)	53	0.9	0.6 (1.0)	4.8 (0.4)
10. Acknowledge clinical decision support rules	11	100	1.20	30 (26)	40	0.7	0 (0.0)	4.5 (1.0)
11. Document an implantable device	13	92	1.34	90 (63)	75	1.2	0.4 (0.5)	4.4 (1.0)

The results from the System Usability Scale [SUS] scored the subjective satisfaction with the system based on performance with these tasks to be: 82. Broadly interpreted, scores under 60 represent systems with poor usability; scores over 80 would be considered above average.⁵

More recent work by Sauro (2011) provides a norming distribution based on 500 comparative SUS scores (from usability tests of a wide range of applications). Based on this distribution, the SUS result of 82 ranks roughly in the 90th percentile or equivalent to a letter grade 'B', see the figure below.



Usability judgments were also collected at the end of each major task. The averages obtained from those task-based usability scores varied between four and five, quite a bit above the recommendation put forward in NISTIR3 7742. The NISTIR 7742 states that —common convention is that average ratings for systems judged easy to use should be 3.3 or above. This is consistent with the overall SUS ratings at the end of the session.

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

DISCUSSION OF THE FINDINGS

The results for each of the twelve areas under evaluation will be discussed separately. For each area, the results are discussed based on the tasks' effectiveness, efficiency and satisfaction. The satisfaction ratings are subjective responses provided by each participant at the end of each task. The 'Major Findings' section includes discussion of the participants' comments, qualitative findings such as errors and deviations made during the performance of tasks, and moderator observations of participant performance patterns. The 'Areas for Improvement' section provides suggestions for improving the areas under evaluation and reducing errors.

Participants began their test session on the 'Patient Summary'. Only one participant reported that it looked very different from what they use in their current system.

COMPUTERIZED PHYSICIAN ORDER ENTRY - MEDICATIONS

Two tasks were included to evaluate computerized physician order entry [CPOE] for medications. These included:

- Order a favorite medication
- Order a non-favorite medication

Analysis Notes

Task Description

Task 6 was a simple favorite medication order that included the review and approval of an interaction alert. Task 7 was a non-favorite medication order with similar alerts and interactions.

These tasks were included to evaluate the participants' workflows of submitting orders electronically. The participants had to navigate to 'Drug Orders', review clinical decision support contents, complete the order screen, and approve the orders.

Scoring Notes

All participants followed instructions, as expected. There were no difficulties resulting in exclusions.

Effectiveness

All 13 participants successfully completed the task of ordering a favorite medication.

The following errors were observed: creating a new favorite, starting to document a new medication, and documenting a new medication.

One participant created a new favorite. Then s/he attempted to order the favorite medication using the newly created favorite by selecting 'New' in the 'Drug Orders' window (instead of selecting 'Favorites') and then selecting 'Favorites'. Once a user selects 'New' and then selects 'Favorites', the system is in the mode to add a new medication and does not allow a user to change the selection of a drug from new to 'Favorites'. The system provided a 'Data Validation Error' as follows: "Agent name is required". This message provides no guidance to the user on the next steps required to cancel the new medication and use 'Favorites' instead. The participant attempted twice to select 'Favorites' producing the same message and then ordered the medication using a non-favorite medication. This participant provided the following comment:

"Just a little confusion with the 'Favorites'. When I went to 'Favorites', I expected it to be there. When I went to select 'Favorites', I got an error and then needed to enter it twice."

Participants provided the following comment regarding effectiveness:

"It is relatively intuitive. I like the favorite feature"

"It is quite easy. Information is not over redundant and information comes up automatically."

"I really like the 'Favorites' categories that the medications you prescribe frequently can be there with all the details"

All 13 participants successfully completed the task of ordering a non-favorite medication.

One out of the five participants that selected 'Take as directed' checkbox commented:

"There are some blocks that come up, that is confusing as to what to put in it. Many times, I would put 'Take as directed' to bypass those squares that would not allow approval until you fill them out."

Based on the comment above, it is not clear to users the fields required to order a medication.

The following error was recorded: the 'Dose' field was left blank and participants were required to complete the 'Dose' field, these participants did not previously select the strength of "1 mg" in the 'Dispensed As' area within the 'Drug Selection' pop-up.

Participants provided the following comments regarding effectiveness after completing this non-favorite medication order:

"Pretty easy. It gives the ability to put the dose in different areas. It gives me different options depending what I wanted to do."

"It is pretty easy. It would be nice if the dose would automatically be the dose of the tablet you are prescribing."

"It's confusing. I put "1 mg" and then there was the 'Dose' [field]. Why would I have to put the dose twice?"

"If I do have a question for spelling I go to internet but most of the drugs are in there. I find very few that are not there versus going from brand names to generic."

Efficiency

For the favorite medication order, eight participants started the task by going to the 'Drug Orders' tab. Once on the 'Select Favorite Drug' screen, seven participants completed the order by working through the same optimal path (i.e. they selected the 'New' button at the top, followed by accessing a list of favorites to select the appropriate medication, and finished the order by selecting 'Approve'). One participant did not use the favorite list to create the order.

Two participants started the task by going to the 'Current Medications' tab. One of the participants asked for clarification about whether the task was to document or order a medication. Once the participant learnt that the medication was to be ordered, the participant cancelled the new current medication entry and started the order by going to 'Drug Orders' tab and followed the optimal path and finished the order by selecting 'Approve'. The other participant, after entering a new medication under 'Current medications' realized that it was not an order and started

the order by going to 'Drug Orders' tab, then followed the optimal path, and finished the order by selecting 'Approve'.

Two participants started the task by going to the 'E-Prescribing' tab, one of them visited briefly the navigation icon. After the 'E-Prescribing' tab, both participants continued the task by going to the 'Drug Orders' tab and completed the order by working through the same optimal path and finished the order by selecting 'Approve'.

One participant started the task by selecting the prescription icon and then continued the task by going to the 'Drug Orders' tab, completed the order by working through the same optimal path, and finished the order by selecting 'Approve'.

The following deviations were observed: ordering a medication without using 'Favorites', correcting an error for documenting a new medication, correcting an error for starting to document a new medication, approving a drug order twice (after canceling the 'Medi-Span Medication Screening' pop-up when checking for interactions), starting the task by selecting the 'E-Prescribing' tab, selecting the 'Navigation' icon, and starting the task by selecting the 'Prescription' icon.

There was considerable variability in task times across all 13 successful participants; only two participants finished with no deviations in less than the optimal time. Four participants had no deviations, but took longer than the optimal time to finish the task since they were reviewing the order before approval. The remaining 7 participants that finished with deviations and errors took longer than the optimal times. Two out of the six participants took considerable longer because one of them created a new favorite and then entered the drug order without using 'Favorites' and the other participant entered a new medication and then created an order by using 'Favorites'.

It was also noted during this ordering task that several participants really appreciate the 'Favorites' medication list feature, as it allows them to move through the task more efficiently:

"It helps when the drug is in 'Favorites' and with one click, it auto-populates multiple fields and it saves time... makes it easy to use."

"It is just as easy of course. Saves steps having it as favorite. There are no obvious difficulties or redundancies."

Participants provided the following comments regarding recommendations to increase efficiency:

"That 'Favorites' list should automatically populate instead of an extra click on the '+' sign."

"Too many blanks to fill in and many clicks and approval. Once you entered something it should automatically pop up. It can be time consuming."

For the non-favorite medication order, 11 participants started the task by selecting 'New' in the 'Drug Orders' tab and 'New' in the 'Drug Orders' pop-up. One participant re-selected the 'Drug Orders' tab and 'New', then 'New' in the 'Drug Orders' pop-up, even though the participant was already in the 'Drug Orders' workspace.

After selecting 'New' from the 'Drug Orders' tab, participants completed the order by first typing in the 'Drug' field or selecting the lookup button associated with that field. Most participants (ten) selected an associated strength from the 'Dispensed As' area within the 'Drug Selection' pop-up. Once the medication was selected and participants were back on the 'Drug Orders' screen, nine participants completed the order by working their way from top-to-bottom and left-to-right (i.e. they worked their way down the form by completing the dose, unit, frequency, duration, unit duration and quantity, approving the order and approving the interactions). The other four participants, completed

the order by selecting the 'Take as Directed' checkbox and typing "1 mg tablet daily for 30 days" under the 'Admin Instructions' comment field. When taking this path, participants were only required to complete the 'Quantity' field before approving the order and the interactions; this was deemed the most optimal path.

Three participants did not select the strength of "1 mg" in the 'Dispensed As' area within the 'Drug Selection' pop-up and got the message "Dose is required" upon approving the drug order. They were required to complete the 'Dose' field and the associated 'Unit' field on the 'Drug Orders' screen (i.e. they needed to indicate "1 mg") before approving the order. One of these participants was unsure what information to complete in the 'Dose' field and the meaning of the 'Dose Calculator'.

The following behavior was observed: once the 'Strength' =1 and associated 'Unit'= mg and 'Dose'=1, participants could either set the 'Unit' =tablet or 'Unit'= mg for the 'Dose' and could still complete the task by approving the order and the interactions.

The following deviations were recorded: to correct for the error of leaving the 'Dose' field blank, selecting 'Dose Calculator' popup, selecting 'New' button at the bottom left corner of the 'Drug Orders' screen, and selecting 'Dose Calculator' next to 'Dose' field.

Eleven participants finished the task successfully under the optimal time, this included two participants who committed errors and deviations. The remaining two participants successfully finished the task slower than the optimal time for which errors and deviations were recorded.

Participants provided the following comments regarding recommendations to increase efficiency after completing this non-favorite medication order:

"It should auto-populate how many days instead of manually having to go through and check all these [fields]."

"That is a lot of data entry to do since not a favorite."

"The 'Dose' field is confusing. There seems to be some redundancy... seems I had to put the dose and duration in multiple times."

Satisfaction

The task satisfaction rating for CPOE for ordering a favorite medication was 4.5 and ordering a non-favorite medication was 4.2. These average ratings are well above the 'easy to use' threshold [3.3]. Many participants commented on the ease of creating an order, especially when it is for a favorite medication.

Major Findings

- When a user creates an order, the system does not indicate mandatory fields and this slows the user down. For example, if a user does not indicate 'Quantity', s/he receives a warning upon selecting 'OK'.
- The 'Dose/ Range' field and associated 'Unit' field was a pain point for participants when trying to complete the order, as many committed extra work thinking it was necessary to complete both fields. For example, indicating "1 tablet" when "tablet" was already captured as a 'Form' and indicating "1 mg" when "1 mg" was already captured as a 'Strength'.
- Two of the errors observed during the order entry tasks (one time for each task) were due to a home medication being partially or completely documented rather than an order being placed; these errors both had a corresponding deviation to correct the error.

- One observed error was the creation of a new favorite with a corresponding deviation to correct the error. Once a user selects 'New', the system does not allow the user to select a medication from 'Favorites' until the new order is completed or cancelled (i.e. the validation messages did not guide the participant and led her/him to enter a new non- favorite medication instead).
- The favorite medication order worked well for users, as there is very little typing required to place the order.
- All participants successfully ordered a favorite and non-favorite medication and the favorite order scored slightly higher for ease of use.
- There are only less than four seconds difference for the mean times recorded to order a medication that is a favorite versus a non- favorite (taking into considerations that for both tasks the same number of errors were recorded).

Areas for Improvement

Based on the results, the following potential improvements are suggested:

- Consider disabling 'Approve' and 'Ok' buttons instead of providing a message when mandatory fields have not been completed, so that, actions buttons become available once an order is complete.
- Consider highlighting mandatory fields when creating an order, e.g. 'Unit' (along 'Dose' field), 'Quantity'.
- Consider auto-populating data that apply for a specific medication, streamlining the fields required when entering an order and avoid repetition i.e. units in the 'Drug Orders' screen.
- Consider defaulting expanded list for 'Frequently Prescribed Medication'.

COMPUTERIZED PHYSICIAN ORDER ENTRY - LABORATORY

One task was included to evaluate CPOE for a laboratory and was paired with the task of ordering diagnostic imaging. It included:

- Order a CA-125 test and a mammogram

Analysis Notes

Task Description

Task 9 was a simple lab order that included ordering a CA-125 from a list of lab tests 'By next visit' and approving the order.

This task was included to evaluate the participants' workflow of submitting lab orders electronically. The participants had to navigate to 'Physician Orders', select the appropriate lab, and select 'Approve' to submit the order.

Scoring Notes

All participants followed instructions, as expected. There were no difficulties resulting in exclusions.

Effectiveness

All 13 participants successfully completed the task of ordering a lab test.

The following errors were observed: two participants selected 'Just prior to' and two other participants selected 'On next visit' for the lab test.

Participants provided the following comments regarding effectiveness after completing a lab order:

"I do like that there is a clearly stated option 'For next visit'."

“Ordering the test was easy. When we do order a lab or test, we cannot print the lab and mammogram and there is no place to document that this test can be done in another hospital. It would be nice to select another hospital and send a fax order for these tests.”

“We link our orders with tasks to remind us to read the results and I wish we could do the orders and tasks at the same time. If I put the order together for the lab and mammogram and the patient did not get an exam in the same day, I cannot complete the task and I have to wait for all exams to be done. That is why we do [the type of order] separately in our clinic.”

“Pretty slick. The labs were all listed.”

Efficiency

For the lab order, all participants started the task by going to the ‘Physicians Orders’ tab. Once the lab order had been appropriately chosen, all participants completed the order by working through the same optimal path (i.e. they selected the ‘Approve’ button at the bottom-right). There were no deviations observed during this test task.

The task time did not vary greatly for this task, as participants were able to very efficiently complete the task. Ten participants completed the task faster than the optimal time.

Participants provided the following comments regarding efficiency after completing a lab order:

“You did not have to type the name for labs and I could easily see and selected them.”

“It is a lot to sort through; visually not easy to read.”

Satisfaction

Overall, the task satisfaction rating for this task was 5.0 for CPOE – Laboratory and Diagnostic Imaging. This average rating is well above the ‘easy to use’ threshold [3.3]. As noted above in the previous section and below, many participants also commented on the ease and efficiency of creating a lab order:

“The whole process is easy.”

“It is quite easy. With the layout and service, we use right now, ‘Physician Orders’ is a separate tab. This layout is easier than the current format I use.”

Major Findings

- The lab order worked well for users, as there is no typing required to place the order.
- Ordering a lab was an easy task for the participants, as proved by the success rate and satisfaction score.
- The errors observed were selecting an incorrect timeframe for the lab test to be performed.

Areas for Improvement

- Consider a method to indicate when the lab test will be performed in another institution.
- Consider a customized template for most common lab test orders per diagnosis.
- Ensure a mechanism to remind users to read test results as results are made available.

COMPUTERIZED PHYSICIAN ORDER ENTRY – DIAGNOSTIC IMAGING

One task was included to evaluate computerized physician order entry [CPOE] for laboratory and was paired with the task of ordering diagnostic imaging. It included:

- Order a CA-125 test and a mammogram

Analysis Notes

Task Description

Task 9 was a simple lab and diagnostic imaging order that included ordering a mammogram by the next visit and to indicate, as a note, to compare this mammogram to the last mammogram.

This task was included to evaluate the participants' workflow of submitting diagnostic imaging orders electronically. The participants had to navigate to 'Physician Orders', select the appropriate option from the 'Diagnostics' section and select 'Approve' to submit the order.

Scoring Notes

All participants followed instructions, as expected. There were no difficulties resulting in exclusions.

Effectiveness

All 13 participants successfully completed the task of ordering an imaging test.

The following errors were observed: two participants selected 'Just prior to', and two other participants selected 'On next visit' for the diagnostic imaging test.

Efficiency

For the diagnostic imaging order, all participants started the task by going to the 'Physicians Orders' tab. One deviation was observed during this task, as one participant selected 'Compare to last' from the menu, typed "compare to last" in the comment field and removed one of the entries from the comment field. Once a mammogram had been appropriately chosen, all participants completed the order by working through the same optimal path (i.e. they selected the appropriate note followed by the 'Approve' button at the bottom-right).

Participants provided the following comments regarding efficiency after completing an imaging order:

"I like the drop-down boxes, if you do an ultrasound, diagnostic screening and so on."

"I can see the list and checkbox besides [the mammogram order] and it is easy. The notes are there (i.e. 'Compare to last') and there is no free text typing."

Satisfaction

Overall, the task satisfaction rating for this task was 5.0 for CPOE – Laboratory and Diagnostic Imaging. This average rating is well above the 'easy to use' threshold [3.3]. As noted above in the previous section and below, many participants also commented on the ease and efficiency of creating an imaging order:

"Very easy and intuitive."

Major Findings

- The diagnostic imaging order worked well for users, as there is no mandatory typing required to place the order.
- Ordering diagnostic imaging was an easy task for the participants, as proved by the success rate and satisfaction score.
- The errors observed were when selecting the timeframe for the imaging test to be performed.

Areas for Improvement

- Consider a method to indicate when the diagnostic imaging test will be performed in another institution.
- Consider a customized template for the most common imaging tests per diagnosis.
- Consider a mechanism to remind users to read test results individually when they are made available.

DRUG-DRUG, DRUG-ALLERGY INTERACTION CHECK

One task was included to evaluate drug-drug, drug-allergy interaction checks and was paired with the task of ordering a favorite medication. It included:

- Order a favorite medication

Analysis Notes

Task Description

Task 6 was a simple favorite medication order that included a interaction alerts that required participants to check for interactions in the 'Medi-Span Medication Screening' pop-up, read the interactions out loud and approve them.

This task was included to evaluate the participants' workflows of submitting medication orders electronically and reviewing and addressing drug-drug and drug-allergy alerts.

Scoring Notes

All participants followed instructions, as expected. There were no difficulties resulting in exclusions.

Effectiveness

Eleven participants successfully reviewed the interactions when ordering a favorite medication. Two participants did not successfully review the interactions, as they had the following errors:

- one participant did not check for interactions,
- one participant could not find where the interactions were recorded and commented:

One participant provided the following comment regarding effectiveness:

"I do not see here where I can see the interactions."

Efficiency

For reviewing the interactions, seven participants started the task by selecting the 'Interactions tabs' in the 'Medi-Span Medication Screening' window once the drug order was approved and successfully finished the task by approving the interactions. Five participants went the extra step to review more information beyond interactions as follows: three participants reviewed the information in the 'Contraindications' tab before successfully approving all interactions, two other participants reviewed the information in the 'Prior Adverse Reactions' and 'Disclaimer' tab before successfully finishing the task by approving the interactions.

The following deviations were observed: cancelling and returning to the 'Medi-Span Medication Screening' pop-up, visiting the 'Interactions' tab twice, visiting the 'Prior Adverse Reactions', visiting the 'Contraindications' tab, visiting the 'Summary' tab twice and visiting the 'Disclaimer' tab.

There was considerable variability in task times across the 11 successful participants when reviewing the drug-drug, drug-allergy interactions, except one participant that finished below the optimal time. The other nine participants

took more time than the optimal time, many participants took time reading in detail all interactions, and deviations were recorded for five participants.

Satisfaction

The task satisfaction rating for drug-drug and drug-allergy interaction checks was paired with ordering a favorite medication and was 4.5. This average rating is well above the 'easy to use' threshold [3.3]. Many participants commented on the ease of creating a favorite medication order which included the drug-drug and drug-allergy interaction check.

Major Findings

- The drug-drug and drug-allergy interactions check worked well for most participants
- Drug-drug and drug-allergy interactions check was an easy task for most participants, as proved by the success rate and satisfaction score
- Errors were recorded when two participants did not check for interactions.

Areas for Improvement

Based on the results, the following potential improvements are suggested:

- Consider including a high-level summary of 'Interactions', 'Contraindications' and 'Prior Adverse Reactions' on the 'Summary' tab of the 'Medi-Span Medication Screening' to avoid users an extra click and allow to dive into detail as required.
- Improve noticeability of the impact (i.e. contraindication, interactions) that a specific order has which is triggered by patient demographics or conditions within the 'Medi-Span Medication Screening' pop-up.

DEMOGRAPHICS

One task was included to document demographic information. It included:

- Document the ethnicity, race and primary language in a patients' record

Analysis Notes

Task Description

Task 1 was a simple demographics task that included documenting the race, ethnicity and primary language in a patients' record during an initial consult.

The participants had to navigate to 'Registration', select 'Demographics' and correctly select the appropriate options for race, ethnicity and primary language from the 'Race', 'Ethnicity' and 'Language' fields, select 'OK' and 'Save'.

Scoring Notes

All participants followed instructions, as expected. There were no difficulties resulting in exclusions.

Effectiveness

All participants successfully documented the ethnicity, race and primary language in a patients' record.

No errors were observed during this task.

Participants provided the following comments regarding effectiveness after completing the task:

"[The options] were listed clearly to select and hit 'Ok'."

"[The options were] easy to find in the patient chart and all the categories are right there."

"It is pretty intuitive to register a patient."

The following behaviors were observed during this task:

- One participant tried to type twice in the 'Race' field, even though it was grayed out,
- One participant highlighted the race and ethnicity options without adding them to the record before selecting 'OK'; the participant, realized the error, corrected for it, and commented:
"It is cumbersome the extra step to move with the arrow instead of just clicking once."

Efficiency

For documenting the ethnicity, race and primary language in a patients' record, nine participants started the task by going to 'Registration' in the top menu, seven participants completed the task by going to the 'Demographic' tab and working through the same optimal path (i.e. they individually selected the lookup in the 'Race' and 'Ethnicity' field, followed by accessing a popup window containing a list of options, selecting the appropriate race and ethnicity, selecting the arrow and 'OK', then selecting the lookup in the 'Language' field, followed by accessing a popup window containing a list of alphabetized languages which included search functionality and finished the task by selecting 'Save'). The remainder of the participants selected different menus, icons and tabs before completing the task by following the optimal path as follows:

1. Two participants started the task by selecting the 'Navigation icon', one of them selected the 'Demographics' from this menu; the other participant closed the 'Navigation' menu, continued by selecting 'Registration', selecting "Married" under 'Marital' status, and then 'Demographics'.
2. One participant started the task by selecting 'Refresh' in the 'Summary' workspace, continued to 'Registration', selected the 'Contact' tab, 'Personal' tab, 'Registration' from the top menu and 'Demographics'.
3. One participant started the task by selecting the patients name in the 'Summary' workspace and continued to 'Demographics'.
4. One participant started the task by selecting 'Registration' from the top menu, selected the 'Status icon' tab, opened and closed the 'Navigation' icon, selected the 'Personal' tab and continue to 'Demographics'
5. One participant moused over and read the tooltips for the 'CDS', 'Prescription' and 'Refills' icons, selected 'Registration' from the top menu, 'More' tab, and continue to 'Demographics'

Based on the above path descriptions, it was evident that for many participants (who do not usually performed this task) had to do some searching in different workspaces and tabs before successfully finishing the task of documenting the ethnicity, race and primary language in a patients' record. This is well expressed by the participants comments after completing the task:

"I had to familiarize myself with different tabs and finding the right tab to put that information. On the home page where you have address and insurance, I was looking to put that information there."

"I could not find the 'Demographics' tab, but other than that, it is easy."

The following deviations were observed: mouse over and reading the 'CDS', 'Refill', 'Prescription' and 'Navigation' icon tooltips, selecting 'Cancel' to the 'Race' popup window and returning back to it to make a selection, visiting 'Contact' tab, visiting 'Personal' tab, visiting 'Status' tab, adding marital status, and missed selecting the arrows in the 'Race' and 'Ethnicity' popup window to move the listed options from left to right before selecting OK.

Nine participants expressed they do not usually perform this task in their current role: four participants performed the task with no deviations, two participants had one or two deviations, the remainder three participants had more than two deviations recorded. Overall, out of 13 participants, deviations were recorded for the paths followed by seven participants.

There was considerable variability in task times across all 13 successful participants when documenting demographic information. Five participants finished the task below the optimal time. The remainder eight participants were above the optimal time, as they searched for the correct place to enter the demographics information.

Satisfaction

The task satisfaction rating for documenting the ethnicity, race and primary language in a patient's record was 4.8. This rating is well above the 'easy to use' threshold [3.3]. Many participants commented on the ease of documenting the race, ethnicity, and language demographics as follows:

"Pretty easy."

"[I rated the task high because of] the ease of use of the drop-down menus."

"Everything was listed easily and self-explanatory."

Major Findings

- Documenting the ethnicity, race and primary language in a patients' record was an easy task for all participants, as proved by the success rate and satisfaction score, even though, many participants do not usually perform this task in their current role and had to do some searching before completing the task successfully.

Areas for Improvement

- Consider incorporating a method of adding demographic information that is more consistent with other spaces (e.g. checkboxes as in the 'Allergy' space) to decrease the number of selections needed.

PROBLEM LIST

One task was included to document an existing problem. It included:

- Documenting a malignant neoplasm of the upper-outer quadrant of left female breast

Analysis Notes

Task Description

Task 2 was a simple documentation task that included documenting a breast cancer diagnosis, specifically a malignant neoplasm of the upper-outer quadrant of left female breast.

This task was included to evaluate the participants' workflows of documenting an existing problem in the patient's record. The participants had to navigate to 'Diagnosis', select 'New' and search and select the correct diagnosis from the list in the 'Advanced Search for Diagnosis/Problem Code', select 'Ok' and 'Save'.

Scoring Notes

All participants followed instructions, as expected. There were no difficulties resulting in exclusions.

Effectiveness

Nine participants successfully completed the task of documenting the breast cancer diagnosis. Four participants did not successfully document the malignant neoplasm of the upper-outer quadrant of the left female breast diagnosis. Three of these four participants were unable to find how to start entering the diagnosis once in the 'Diagnosis' workspace and were trying to enter information in the 'Code' field, 'Code description' field, and 'Clinical Description' comment field even though they were grayed out (i.e. they did not select 'New'). It was evident by their several attempts that they did not understand that these fields were unavailable and eventually asked for help to finish the task.

These participants were either unfamiliar with the 'Diagnosis' workspace or usually do not perform this task:

"I am not very familiar with the codes and the screen. It is new to me, but it is fairly simple."

"For me it was hard but if I had done it before, it would be easy."

"Difficult for me since I do not usually do this."

The following behavior was observed: a third of the participants that successfully finished the task, when searching for a diagnosis in 'Advanced Search for Diagnosis/Problem Code' window, selected the 'Search' button and then 'OK'. This produced an audio error alert, then the list was populated, and the participant could continue selecting the diagnosis and 'OK'.

At the end of the task, another observed behavior was that several participants did not select 'Save' after correctly selecting the diagnosis. These participants were prompted to save the diagnosis at the beginning of the following task when trying to leave the 'Diagnosis' workspace. Many participants spent time searching for the 'Save' button and were looking at the bottom right corner of the screen and not the middle-left where is currently located.

The following errors were observed: two participants recorded the diagnosis under 'Medical Problems', one participant selected the incorrect diagnosis, and one participant entered the diagnosis with no associated ICD10 code.

Participants provided the following comments regarding effectiveness after successfully completing the task of documenting a diagnosis:

"Just being able to type [a diagnosis in 'Advanced Search for Diagnosis/Problem Code' window] in and do not have to be that specific and gives you choices."

"In English language, you go from left to right and I started on the right side [of the screen] with the diagnosis category" ['Cancer Dx' checkbox in the middle of the screen and 'Save' in the upper left corner]."

"Fine no problem. This particular diagnosis is easy."

Efficiency

For documenting the malignant neoplasm of the upper-outer quadrant of the left breast diagnosis, five participants started the task by going to 'Diagnosis' and 'New' and worked their way down following the optimal path and finished the task by selecting the correct diagnosis from the 'Advanced Search for Diagnosis/Problem Code' window, 'Ok' and 'Save'. One participant started the task by going to 'Diagnosis', then selecting the field 'Code' lookup and then 'New'. Once there, the participant followed the optimal path but selected the incorrect diagnosis. The participant realized the mistake and marked the current diagnosis as an error and followed the optimal path selecting the correct diagnosis all the way to 'Save'. One participant entered the diagnosis under 'Medical Problems' and once the participant realized the mistake followed the optimal path to select the correct diagnosis.

One participant followed an alternative path and started the task by going to 'Diagnosis', 'New' and then selected the 'Cancer Dx' checkbox which disclosed new fields in the 'Diagnosis' workspace which were completed correctly: selected 'Dx Site' drop down, 'Dx category' drop down, ICD-0- Site, 'Laterality' and finished the task by typing the correct diagnosis in the 'Clinical Description' comment field and selecting 'Save'.

The following deviations were observed: a correction for selecting an incorrect diagnosis, a correction for entering the diagnosis under 'Medical Problems', selecting unavailable controls ,and trying to type text in unavailable fields such as the 'Code' lookup, 'Clinical Description' comment field and 'Code' field.

There was some variability in task times across all nine successful participants. Six participants finished the task below the optimal time and half of them took less than half the optimal time to finish the task. Three participants took considerably longer than the optimal time, this is explained by one of the participants documenting the diagnosis under 'Medical Problems', the other participants took quite some time to figure out to enter the diagnosis by selecting 'New', and the other participant refined the text in the search field for the diagnosis several times before selecting the correct diagnosis.

Overall, most participants spent a large part of their time searching for the correct diagnosis listed in the 'Advanced Search for Diagnosis/Problem Code' which was dependent on the text search criteria they used (i.e. the more detail they entered, the smaller the list): if less details were entered, the larger the list caused participants to scroll up and down the list several times and/ or hover over search results to review tooltips containing the full diagnosis name. When participants selected the 'Cancer code only' checkbox in the 'Advanced Search for Diagnosis/Problem Code' window, it shortened the list facilitating and speeding the selection of the correct diagnosis.

Participants provided the following comments regarding efficiency when searching for the diagnosis in the 'Advanced Search for Diagnosis/Problem Code' window:

"I usually do not do this task. I did like that could type the "upper outer left" and it shrunk down a lot of options."

"[I rate it a] 4 [for ease of use] because in the search criteria, I want to quickly type "female left breast" and quickly get that."

"Would be nice if it would be more search savvy."

Satisfaction

The task satisfaction rating for documenting a malignant neoplasm of the upper-outer quadrant of the left female breast diagnosis was 4.1. These average ratings are above the 'easy to use' threshold [3.3]. Some participants commented on the ease of entering a diagnosis as follows:

"Ease of use of the drop-down menus."

"Once I figured it out it was easy."

Major Findings

- For the participants that did not successfully pass the task, they tried to enter information in fields that were grayed out and could not figure out to select 'New' to enter the diagnosis.
- Most participants were slowed down when searching for the correct diagnosis in the 'Advanced Search for Diagnosis/Problem Code' and this was dependent on the amount of information they entered in the search criteria.
- All participants made use of the tooltips, as they provided the full diagnosis name, to read through the list of diagnosis.

- Participants were slowed down when looking for the 'Save' button at the end of the task, many of them searched the bottom right corner of the screen first before finding it in the upper left corner of the screen.
- Two of the errors observed were documenting the diagnosis under 'Medical Problems', selecting an incorrect diagnosis, and documenting a diagnosis with no associated ICD10 code.

Areas for Improvement

Based on the results, the following potential improvements are suggested:

- Consider disclosing the fields to enter the diagnosis information once the user selects 'New' (e.g. when adding new allergies). This will prevent users from attempting to enter information in fields that are displayed but unavailable or disabled.
- Consider providing better tools to search for diagnosis (e.g. if a cancer diagnoses are the most prevalent, check the 'Cancer code only' checkbox by default to make the diagnosis list much shorter therefore, facilitating user search and selection and/ or suggesting a minimum text search criterion for a more efficient search).
- Participants found it cumbersome to search for a diagnosis, as diagnoses descriptions are very long and are truncated by the column width. Consider improving the presentation of information within the 'Advanced Search for Diagnosis/ Problem Code' pop-up (e.g. column widths and highlighting similarities or differences of the different diagnosis to provide for easier scanning).
- Consider making the 'OK' button unavailable in the 'Advanced Search for Diagnosis/Problem Code' window until the user makes a selection.
- Ensure action buttons remain in a consistent location for starting and completing tasks (e.g. 'Save', 'Cancel' and 'Close').
- Upon selecting the 'Save' button, the new diagnosis appears above but the form stays filled with the same information and does not become blank and participants were uneasy as to task completion.

MEDICATION LIST

One task was included to document a medication from an external provider. It included:

- Documenting a medication from an external provider

Analysis Notes

Task Description

Task 4 was a task focusing on documenting a medication from an external provider, specifically that the patient is taking Coumadin 4 mg tablet daily.

This task was included to evaluate how a participant would document a medication from an external provider. The participants had to select 'Current Medications', select the medication in the 'Drug selection' window, and complete the 'Current Medications' screen.

Scoring Notes

All participants followed instructions, as expected. There were no difficulties resulting in exclusions.

Effectiveness

All 13 participants documented the current medication successfully.

The following behavior was observed: several participants searched for 'qd' in the 'Frequency' drop down menu to indicate daily:

"When you go to choose whether it is daily (i.e. a frequency), those choices are not always complete."

"We have 'qd' instead of using daily."

At the end of the task, in the 'Current Medications' window, participants selected either 'OK', 'Apply' or 'Apply and OK' distributed as follows: only one participant selected 'Apply', for the remainder participants; half of them selected 'Apply and OK' and the other half selected 'OK'. It is unclear in the current interface the meaning of 'Apply' and 'OK' given that any combination between 'OK' and 'Apply' results in adding the medication correctly.

The following errors were observed: typing "4 mg" in the 'Dose' field (i.e. instead of typing "4" in the 'Strength' field and "mg" in the 'Unit' field for strength), typing 'tab' in the 'Tablet' field (i.e. instead of making a selection from the drop-down menu).

When the participant typed "4 mg" in the 'Dose' field and then selected the 'Unit' field the following message appeared: "The dose value must be numeric". This participant commented:

"It was not very intuitive. There were many places you can put "mg" [there are two places in 'Current Medications' window] and when trying to fix the error the messages did not tell you how to fix the error."

Similarly, when the other participant typed "tab" in the 'Unit' field for dose instead of selecting "tablet" from the 'Unit' drop down menu. The system allowed participants in both occasions, for the 'Dose' and 'Unit' fields, to enter a data format that is not allowed and provided messages that did not guide the participants on how to fix the problem.

Participants provided the following comments regarding effectiveness after completing the entry of a medication from an external provider:

"I have all the appropriate options to select what I need it."

"Fairly easy to navigate through and in 'Current Medications', the tab says 'New' and everything was there when searching the drug."

"It prompted on the type of 'Coumadin' and I did not have to type the entire name for coumadin to search for it."

"I wish there was a way that it would take some of the medications completely. Sometimes if the patient goes back to the medication, you must enter it again and put it as active with the new instructions."

Efficiency

For documenting Coumadin as a medication from an external provider, all participants started the task by going to 'Current Medications' and 'New'. Nine participants continued the task following the most optimal path by typing Coumadin in the 'Drug' field or selecting the 'Drug field lookup' and typing Coumadin in the 'Drug Name' field of the 'Drug Selection' popup window, selected "Coumadin Tablet Oral" and "4 mg" in the 'Dispensed as' area, and finished the task by entering the frequency and selecting either 'Apply', 'OK' or 'Apply and OK'.

Two participants committed to extra work by adding dose, dose unit, form and route and one participant that did not previously select the strength in the 'Drug Selection' popup window, added strength and unit in the 'Current Medications' window. One of these participants commented:

"It is a little cumbersome since you have to choose "tablet" more than once and it seems you have to do 'Apply' and then 'New' and it seems to do lot of clicks to save it and move on to the next one."

The following deviations were observed: correcting the error of typing "4 mg" in the 'Dose' field by deleting the entry, correcting the error of typing 'tab' in the 'Tablet' field instead of making a selection from the drop-down menu.

Eleven out of 13 participants finished the task of documenting a medication from an external provider considerably faster than the optimal time; only two participants finished the task above the optimal time due to the correction of three errors or entering more data than required.

Participants provided the following comments regarding efficiency after completing the entry of a medication from an external provider:

"When you search for the medicine and automatically it gives you the dose [it's easy]. When things populate with one click it tends to make the system easy."

"I like to put in a short explanation of the drug [in the 'Drug' field] and search for that and then find the "mg" and click for that and puts everything where it needs to be."

Satisfaction

The task satisfaction rating for the entry of a medication from an external provider was 4.7. This average rating is way above the 'easy to use' threshold [3.3]. This is supported by the comments above and below and the success rate.

"It is pretty use to use. This *particular* drug is easy."

Major Findings

- Documenting a medication for an external provider worked well for users, as there is little typing required to document the medication once the user finds the medication in the 'Drug Selection' popup window.
- Documenting a medication for an external provider was an easy task, as proved by the success rate and satisfaction score.
- It is unclear to users the meaning of 'Apply' and 'OK' when documenting a medication, as proved by the different combinations used at the end of the task resulting in the successful addition of the medication.
- The errors observed during this task were due to the use of the wrong data format in the 'Dose' and 'Unit' fields. The system does not indicate to users the data format allowed for different fields and only provides a message indicating there is a problem without explicitly indicating the reason and how to fix the problem.

Areas for Improvement

- Consider explicitly indicating the required data format per field and only allow the entry of that specific data format, e.g. 'Dose' and 'Unit' instead of generating a message when users enter incorrect data format.
- Consider providing message notifications indicating the error and specific instructions on how to fix a problem.
- Compare the frequency and importance of 'OK' and 'Apply' versus the confusion it causes for end users when adding medications to a patient's history:
 - If 'Apply' needs to stay, ensure that the language used indicates the resulting action (i.e. in this case 'Save' and 'Edit').

- If 'OK' and 'Apply' need to stay, conduct additional user research to ensure that the contrast between them is clear; the control 'Ok' needs to give users the impression that the application will save their work (i.e. the resulting action is a 'Save' and 'Close' of the pop-up when this button is selected).

MEDICATION ALLERGY LIST

One task was included to document an allergy. It included:

- Documenting an allergy

Analysis Notes

Task Description

Task 3 was a simple documentation task that included documenting a Penicillin allergy based on a reaction to Amoxicillin. This task was included to evaluate how a participant would document a Penicillin allergy as a 'Drug Class' and indicate a mild skin and nausea reaction.

This task was included to evaluate the participants' workflows of documenting a current allergy and two reactions in the 'Allergies' portion of the patient's record. The participants had to select 'Allergies', select the 'Allergy Type' as a 'Drug Class' for Penicillins and complete the 'Allergies' screen by indicating the allergy response and severity for that allergy. Alternatively, the participants could have chosen to keep the 'Allergy Type' as 'Drug' and chose a Penicillin drug or Amoxicillin for this task instead.

Scoring Notes

All participants followed instructions, as expected. There were no difficulties resulting in exclusions

Effectiveness

Eleven participants successfully documented the Penicillin allergy, two participants did not successfully document this allergy.

The following errors were observed: missing documenting severity for the skin and nausea reactions, missing documenting severity for the skin reaction, missing documenting severity for the nausea reaction, selecting 'Drug' instead of 'Drug Class' for 'Allergy Type'.

The two participants that did not successfully document the Penicillin allergy, documented the allergy as a 'Drug' instead of a 'Drug Class'. Once they selected the lookup in the 'Allergy' field, a 'Drug Selection' popup window displayed a long list of detailed Penicillins and they provided the following comments:

"It is cumbersome to select from the long list with the different names of the Penicillins and the patient will not usually know which penicillin they are allergic to."

"This is something I don't normally do. The challenging part is to identify which Penicillin variety that patient is allergic to, as patients do not often know. It would be helpful to just document Penicillin as a drug class."

The following behavior was observed when documenting the Penicillin allergy: three participants documented the Penicillin allergy added a description in the 'Allergy' comment field and did not selected Penicillin from the 'Drug Class Allergy Selection' popup window invoked by the lookup of the 'Allergy field'. At the end of the task, once the user selects 'OK' in the 'Allergies' window, the system produces the following confirmation message: "The drug Class

allergy "Penicillin" could not be found in the drug database. This will cause no interaction checking to take place. Do you wish to continue?"

The confirmation message does not clearly indicate that the user needs to make a selection from the 'Drug Class Allergy Selection' window popup (invoked by the 'Allergy' lookup) for interactions to be checked. Similarly, if the user types "Penicillin" in the 'Allergy' field and selects 'Drug' in the 'Allergy Type' field, the following message is produced: "The Drug allergy "Penicillin" could not be found in the drug database. This will cause no interaction checking to take place. Do you wish to continue?"

One of the participants provided the following comment:

"Why wouldn't it find the drug class Penicillin? That is a common allergy."

Based on the comment above, there is not enough clarity and explanation in the current confirmation message, as this participant thought he had selected Penicillin as a 'Drug Class' when in fact he selected 'Drug'. After reading this message, participants were unsure of what actions to take; some continued and others went back and made a selection from the 'Drug Selection' popup window. The confirmation message does not indicate that for the system to check for interactions, the user must select the 'Allergy type' as a 'Drug Class' instead of 'Drug' and select the 'Drug Class' from the 'Drug Class Allergy Selection' popup window. One of the participant that seemed bothered by this message and qualified the task harder than previous one, provided the following comment:

"If I am not choosing something from the list here ['Drug Selection' popup window] then it asks me the additional clarifying question about if I am sure I want to enter the information."

The following behaviors were observed when documenting the response of the Penicillin allergy: three participants documented the severity of the allergic reactions in the 'Comment' section under 'Response'; four participants selected 'Other' in the 'Description' column for 'Response' and typed both the allergy response and associated severity instead of selecting the listed options from the 'Description' and 'Severity' columns (in the 'Allergies' window). Participants provided the following comments:

"I like the drop-down boxes but sometimes as a nurse, I would like to have more separation, like 'skin rashes' versus 'hives' and to put a comment. I wonder why there is no 'anaphylactic' [option]?"

"The biggest thing for me when I clicked 'rash' or 'nausea' to the right is it did not give me a visible drop down-options for severity."

"I typically use free text specially when not all [responses] applies."

In some instances, the current options listed for response descriptions contained more than one descriptor (i.e. Skin Rashes/Hives, Nausea/Vomiting/ Diarrhea) which describes very different response types and leaves no choice for the user other than to select 'Other' and enter a new response description and severity or add clarification in free text form under the 'Comment' field (i.e. below the 'Response' table). One disadvantage of using the 'Comment' field with free text is the impact in regard to data mining, searchability and reporting of responses. On the other hand, the 'Other' descriptor category provides the user the advantage to add a new allergy response as required.

At the end of the task in the 'Allergies' window, participants selected either 'OK', 'Apply', 'Apply and OK' before finishing the task. It is unclear in the current interface the meaning of 'Apply' and 'OK' given that any combination between 'OK' and 'Apply' results in adding the allergy correctly.

Efficiency

For documenting Penicillin as an allergy, all participants started the task by going to 'Allergies', 'New', eleven participants selected 'Drug Class' for 'Allergy Type', two participants selected 'Drug' for 'Allergy Type'. Three participants followed the most optimal path by selecting the 'Allergy' lookup and selecting Penicillin from the 'Drug Class Allergy Selection' popup window and working all the way down to finishing the task by documenting the responses from the listed options and finishing the task by selecting 'Apply and OK' or 'OK'. Six participants typed different combination for Penicillin (i.e. "PCN", "pen", "penicillin") in the 'Allergy' field and selected Penicillin from the 'Drug Class Allergy Selection' popup window invoked by the lookup and continue documenting the response description and severity from the listed options (except one participant documented the response in the 'Comment' field and two participants selected 'Other' to do the same) before finishing the task by selecting either 'OK' or 'Apply and OK'. Three participants after selecting 'Drug Class' for 'Allergy Type' typed either "PCN-Amoxicillin", "Penicillin" or "PCN" in the 'Allergy' field and proceeded to document the response description and severity before finishing the task by selecting 'OK'.

The following deviation was observed: selecting 'No' to the confirmation message "The drug class PCN- amoxicillin cannot be found in the drug database. This will cause no interactions checking to take place."

The following system behavior was observed: once a user selects the 'Allergy Type' as a 'Drug Class' and types the keyword or the first few letters and selects the lookup, the list in the 'Drug Class Allergy Selection' popup window defaults to an alphabetical order and the user needs to scroll down to the section starting with "P" to select Penicillin. In this case, typing in the 'Allergy' field had no effect on this list which forces users to scroll down the list and slows them down when documenting an allergy. Participants provided the following comments about the behavior of the list in the 'Drug Class Allergy Selection':

"It could be easier, if it had smart search capabilities."

"When you do the search, it does not go to the drug class and instead goes from A to Z. I have to find it and browse up and down with scroll bar."

"When you type it and it does not automatically go down to "P" [participant entered "pen"] that would be my only complaint."

The following behavior was observed when documenting the description of the Penicillin allergy: four participants selected "Other" in the 'Description' column for 'Response' and typed both the allergy response and associated severity instead of selecting the listed options from the 'Description' and 'Severity' columns, slowing them down by creating new responses instead of selecting from pre-existing options. One of these participants commented:

"Lots of different clicks."

Nine participants successfully completed the task of documenting an allergy below the optimal time, only two participants completed the task above the optimal time since they were slowed down by documenting the allergy severity in the 'Comment' field and documenting the response and severity under 'Other'.

Satisfaction

The task satisfaction rating for documenting a Penicillin allergy was 4.2. This average rating is above the 'easy to use' threshold [3.3]. This is supported by the comments below and the success rate.

"It is pretty easy to enter"

"Everything was right there I did not have any issues trying to navigate to add that penicillin allergy."

Major Findings

- Documenting a Penicillin allergy worked well for most users, as there is little typing required to document the allergy once the user types in the 'Allergy' field or finds the drug in the 'Drug Class Allergy Selection' popup window.
- Documenting an allergy and associated response was an easy task, as proved by the success rate and satisfaction score.
- The errors observed during documenting an allergy were missing documenting severity for one or both reactions.
- When users do not select 'Drug Class' in the 'Allergy Type' field or only type the drug in the 'Allergy' field without making a selection from the 'Drug Class Allergy Selection' list, the confirmation message produced does not guide the user nor clearly indicates that for the system to check for interactions. The user must select the 'Allergy type' as a 'Drug Class' instead of 'Drug' and select the 'Drug Class' listed in the 'Drug Class Allergy Selection' popup window. Participants were hesitant to select either 'Yes' or 'No' to this message before continuing the task.
- If 'Drug Class' is selected for 'Allergy type' the alphabetical entry in the 'Allergy' field does not affect the list in the 'Drug Class Allergy Selection', which always defaults to an A to Z alphabetical order, forcing the user to scroll up and down the list to make the appropriate selection.
- The current selection listing response descriptions for an allergy contains many descriptors with different levels of reactions under one item (i.e. Skin Rashes/Hives, Nausea/Vomiting/ Diarrhea) forcing the user to enter a new descriptor by selecting 'Other' or use free text in the 'Comment' section slowing the user down.
- The user can quickly enter a new response description by selecting 'Other' in the 'Response' table.
- It is unclear to users the meaning of 'Apply' and 'OK' when documenting an allergy, as proved by the different combinations used at the end of the task resulting in the successful addition of the Penicillin allergy and associated response.

Areas for Improvement

- Consider providing message notifications clearly indicating the cause and recommended steps to follow to solve any outstanding issues.
- Consider guiding users to make a selection from the 'Drug Class Allergy Selection' and 'Drug Selection' lists for the corresponding interactions checks to take place.
- Consider the current allergy interaction check mechanism, so that, if a user provides a free text entry in the 'Allergy' field, interactions could be also checked for.
- Consider presenting the list in the 'Drug Class Allergy Selection' window based on the alphabetical entry in the 'Allergy' field.
- Consider providing an itemized list of allergy responses that only contains one descriptor (i.e. nausea, vomiting, and diarrhea instead of Nausea/Vomiting/ Diarrhea).
- If a list of allergy responses becomes extensive, consider providing a template with categorized list of allergy responses per body site (e.g. skin, gastrointestinal) to ease and speed the process of documenting allergies.
- Compare the frequency and importance of 'OK' and 'Apply' versus the confusion it causes for end users when adding an allergy to a patient's history:
 - If 'Apply' needs to stay, ensure that the language used indicates the resulting action (i.e. in this case 'Save' and 'Edit').
 - If 'OK' and 'Apply' needs to stay, conduct additional user research to ensure that the contrast between 'Ok' and 'Apply' is clear; the control 'Ok' needs to give users the impression that the application will save their work (i.e. the resulting action is a 'Save' and 'Close' of the pop-up when this button is selected).

CLINICAL DECISION SUPPORT

One task was included to acknowledge a Clinical Decision Support rule. It included:

- Acknowledging pain assessment and allergy CDS rules

Analysis Notes

Task Description

Task 10 was a very simple task to evaluate how a participant would acknowledge CDS rules. The participants had to select the 'CDS' icon or 'Clinical Decisions' from the top menu, select 'Edit' or double-click on a rule, acknowledge them by selecting the checkboxes, and finish the task by selecting 'OK'.

Scoring Notes

Eleven participants followed instructions, as expected. The following exclusions were recorded: two participants were unable to complete this task because the clinical decisions rules could not be generated in time for the test sessions.

Effectiveness

All participants successfully documented the CDS rule.

No errors were observed during this task.

Participants provided the following comments regarding effectiveness after acknowledging a CDS rule:

"With CDS, I was not aware that is something you have to sign off or mark off to acknowledge. To me I was just thinking that it was there for reference like a plan of care. That was just a little confusing. I thought that was a reference for me to go in and look at past clinical decisions. I did not know that it was something that I would need to acknowledge at time of visit"

"We do everything through 'Encounters' and there is a popup notice in the corner. A lot of them are easier to do through 'Encounters'."

Efficiency

For acknowledging a CDS rule, all participants, except one, started the task by going to the 'Clinical Decisions' top menu or selecting the 'CDS' icon. The subsequent steps included selecting 'Edit' or the listed CDS rule, selecting the 'Acknowledge' checkbox and finishing the task by selecting 'OK'. Only one participant started the task by selecting the 'Navigation' icon and then selecting 'Clinical Decision' and following the optimal task.

The following deviations were observed: selecting 'Clinical Decisions' window twice and closing it without acknowledging the CDS rule.

Nine participants successfully completed the task of acknowledging a CDS rule considerably faster than the optimal time, only two participants completed the task significantly above the optimal time for which deviations were recorded. These participants were slowed down by reading each of the rules to be acknowledged and opening and closing the 'Clinical Decisions' window and reading the information both times.

Participants provided the following comments regarding efficiency after acknowledging a CDS rule:

"I like the checkbox. If you have multiple clinical decisions, you can do it all at once."

Satisfaction

The task satisfaction rating for acknowledging a CDS rule was 4.5. This average rating is above the 'easy to use' threshold [3.3]. This is supported by the comments below and the success rate:

"It was fairly easy."

"It was self-explanatory."

"It is easy to navigate it is at the top easy open acknowledge and you are done."

"It is fairly intuitive the way it popped out."

Major Findings

- Acknowledging CDS rules worked well for all users.
- Acknowledging CDS rules was an easy task, as proved by the success rate and satisfaction scores.

Areas for Improvement

- There were no errors observed during this task and participants found CDS worked well overall.

IMPLANTABLE DEVICE LIST

One task was included to document a pacemaker as an implantable device. It included:

- Document an implantable device

Analysis Notes

Task Description

Task 11 was a task focusing on documenting a pacemaker using the unique device identifier (UDI) and indicating the date of the implant as June 8, 2016. This was a new workflow for all test participants so it was introduced to them at the beginning of the test session.

This task was included to evaluate the participants' workflows of documenting an implantable device in the patient's history. The participants had to navigate to 'History', select the 'Implantable Devices' line item or 'Edit', select the 'Implantable Devices' tab, and select 'New' to begin documenting a new implantable device. Upon selecting 'New', the participants had to paste the unique device identifier (UDI) provided to them via the GoToMeeting or remotely via MS Notepad and indicate the correct 'Date of Implantation'. Participants could either select the UDI lookup button to have the application auto-complete the rest of the data fields or select 'Ok' followed by addressing the confirmation pop-up asking them if they wanted to review or not review the auto-completed fields before saving.

Scoring Notes

All participants followed instructions, as expected. There were no difficulties resulting in exclusions.

Effectiveness

Twelve participants successfully documented the pacemaker as an implantable device, only one participant did not successfully document it.

The following errors were observed: not documenting the date of implantation, selecting an incorrect date of implantation and documenting the pacemaker under 'Surgical Procedures'.

The following behavior was observed when documenting an implantable device: three participants attempted several times to select or type information when fields were grayed out and unavailable before selecting 'New'. This included the following fields: 'UDI' field, 'UDI' lookup and 'Device Description' comment field. Once these participants selected the 'Implantable Device' tab, they omitted to select 'New' and went straight to fill in the information to document the pacemaker, it took them some time to realize they needed to select 'New'. The participants that were not able to figure out how to start the task felt they were not supported or guided by the system and provided the following comments:

"It seems 'New' is usually in the upper-left corner but then it was in upper-right corner but I figured it out."

"I like things that kind of tell you next step, that prompt you for next steps and help you and guide you through it."

There were only three participants that selected the 'UDI' field lookup after pasting the 'UDI' number, the rest of the participants selected 'OK' when finishing the task. After pasting the 'UDI' number, once the user selects the lookup in the 'UDI' field or selects 'OK', the information of the device gets automatically populated in the rest of the 'Implantable Device' window. Participants reacted favorably to this behavior and provided the following comments:

"I did not know if it would populate. It is neat that it does that when populating."

"That was pretty cool."

"It was nice that it auto populates all fields."

Several participants were unsure how this implementation would work using the UDI number in their clinical practice and expressed their concerns as follows:

"I was walked through that and you gave me the code. If you didn't give me this, how would I search that code? It was easy now since I have this information."

"I had the [UDI] number so it was a 5 [for ease of use]. If you did not have this number, search might be more difficult."

"It is quite easy having the number. I wonder how I would implement that daily? Where would I get that number if I would not get it from you?"

Participants provided the following comments about effectiveness when documenting an implantable device:

"The only thing is that it might be nice in 'Medical Problems' and 'Implantable Devices' to have them linked. Have pacemaker hyperlink in 'Medical Problems' instead. It would be nice to have it customized and send a task to Physics from there for any implantable device."

"It kind of follows the flow with 'History'. It is not something new; it is adding to what you already doing."

"I've never done it before but it seems pretty straightforward."

Efficiency

For documenting a pacemaker, most participants started the task by going to 'History', 'Edit', 'Implantable Devices', 'New', copying and pasting the UDI number in the 'UDI field'. Only two participants followed the most optimal path by selecting the 'UDI field' lookup, entering the date of implantation and finishing the task by selecting 'OK'. The remainder of participants, after entering the date of implantation, selected 'OK' and then all of them except one selected 'Yes' to the confirmation message to verify the implant information and finished the task by selecting 'OK'. Two participants did extra work by typing 'pacemaker' in the 'General Comment' field. Three participants started the task by either trying to paste the UDI number and the 'UDI' field or selecting the 'UDI' lookup before selecting 'New';

once they selected 'New', they worked all the way down the 'Implantable Devices' window and finishing the task by selecting 'OK'. One participant documented the implantable device under 'Surgical Procedures' without the use of the UDI number.

The following deviations were observed: trying to select the grayed out 'UDI' lookup, trying to paste the UDI number when 'UDI' field was grayed out, trying to type when 'Device Description' field was grayed out, selecting the 'UDI' lookup before pasting the UDI number.

The following behavior was observed: four participants highlighted 'Implantable Devices' in the 'Category' list under 'History' before selecting 'Edit'. Participants were expecting to make a selection from this list to document the pacemaker, instead, they had to select 'Edit' and select the 'Implantable Devices' tab to complete the task of documenting the pacemaker. This assumption was probably supported by the fact that the first item on the 'Category' list, named 'Medical Problems', was highlighted giving users the impressions that they can make a selection from this list instead of selecting 'Edit'.

Several participants spent a considerable amount of time selecting the correct date of implantation by browsing through the date picker, without noticing they could change the 'Precision', to speed up the date selection which included going back to a previous year.

Seven participants successfully completed the task of documenting an implantable device below the optimal time, five participants finished the task above the optimal time and three of them took considerable more time to complete the task. Deviations were recorded for interacting with fields when they were grayed out and unavailable which caused participants to slow down.

Participants provided the following comments about efficiency when documenting an implantable device:

"I did not know if it would populate. It is neat that it does that when populating."

"That is cool, the auto-completion. Very useful but that is something we have been doing manually and would save a lot of time."

Satisfaction

The task satisfaction rating for documenting an implantable device was 4.2. This average rating is above the 'easy to use' threshold [3.3]. This is supported by the comments below and the success rate:

"It was simple steps to fill in it out and the rest automatically fills."

"Very easy."

Major Findings

- Documenting a pacemaker worked well for users, as there is little typing required to document the device once the user enters the UDI number in the 'UDI' field.
- Documenting a pacemaker was an easy task for most users, as proved by the success rate and satisfaction score.
- Some participants were unable to easily figured out to select 'New' to document the implantable device and tried to interact with various fields that were grayed out and unavailable.
- The errors observed during this task were due to missing or selecting an incorrect date of implantation and documenting the pacemaker under 'Surgical Procedures'.
- Only three out of 12 participants selected the 'UDI' lookup after adding the UDI number to automatically populate the 'Implantable Device' window.

- Participants were impressed when the information for the pacemaker was automatically populated and the only concern they had is how they would get the UDI number in their clinical practice.

Areas for Improvement

- Ensure that the starting point (i.e. the 'New' button) is in a consistent location, as compared to other areas of the application.
- Upon entering a complete UDI, consider auto-completing the fields for the user without a distinct action or with a tab or enter action.
- Incorporate a date picker that has a stronger affordance for the 'Precision' selection so that users are aware that they can choose from:
 - yyyy
 - m/yyyy
 - m/d/yyyy
 - Unknown

CLINICAL INFORMATION RECONCILIATION AND INCORPORATION

One task was included to perform clinical information reconciliation (CIR). It included:

- Perform CIR

Analysis Notes

Task Description

Task 5 was a complex documentation task that included incorporating the information of an electronic 'C-CDA Transition of Care' document and reconciling any additional allergies, problems and medications into the patient's record based on this document. This task was included to evaluate how a participant would incorporate all the information from an electronic C-CDA Transition of Care document into the patient's record.

The participants had to select 'Communications' from the top menu, 'New' from the 'Transition of Care' section, select 'Other Electronic' as 'C-CDA Document Source', select 'Referral Date', select 'Referred by', select 'New Patient' from 'Visit type' and browse to find the document. To complete the incorporation, they had to then 'Approve' and select 'OK' in the 'Incorporating C-CDA' pop-up. Afterwards, participants were required to select 'Reconciliation' for: 'Current Medications', 'Allergies' and 'Diagnosis' by selecting each item from each category and incorporating them into the patient's record.

Scoring Notes

All participants followed instructions, as expected. There were no difficulties resulting in exclusions.

Effectiveness

Only one participant out of 13 successfully completed the incorporation of information from an electronic 'C-CDA Transition of Care' document. Five participants reported that they do not usually perform this task in their current roles.

The following behaviors were observed: five participants thought that after selecting 'OK' in the 'Incorporating C-CDA' popup window that the task was finished. This can be explained by the current behavior and language used in the 'Incorporating C-CDA' popup window as follows: at the top of the popup window the user is presented with the following statement: "C-CDA information is being incorporated into the patients record", then for each of the items

being incorporated a green checkmark indicates the incorporated along with the message in the 'Results' column and "Incorporation complete!" statement at the bottom of this popup window. After the user selects 'OK', the 'Incorporating C-CDA' popup window closes, the system does not prompt the user to reconcile any of the items that were incorporated and returns to the 'Communications' workspaces. This is a behavior, that for previously performed tasks, it indicated the task was finished, that is, returning to the workspace where the task was started from. The system does not provide any guidance, prompting or suggesting that the user needs to go to three different workspaces, in this case 'Allergies', 'Diagnosis' and 'Medications' to reconcile the information accordingly. One participant commented:

"Alright I found it [Incorporating C-CDA' popup window], I think I am done."

"It looks like it was incorporated into the document. It looks like an automatic process."

One of these participants did check the 'Allergies', 'Current Medications' and 'History' workspaces to verify whether any information has been incorporated and did not know that she also needed to reconcile the information.

This participant provided the following comment:

"It says, "incorporated" something [Incorporating C-CDA' popup window] but I do not see anything new."

From the participants mentioned above, three participants were prompted to select 'New' in the 'Inbound Transition of Care' section, one participant was prompted to select 'Browse' in the 'Inbound Transition of Care' window to get the 'C-CCDA Transition of Care' document and one participant finished the task after selecting 'OK' to the 'Incorporating C-CDA' popup window.

Another behavior observed was participants trying unsuccessfully to select the 'Medications Reconciled' checkbox before selecting 'Approve' in the 'Inbound Transition of Care' window. Most participants attempted more than once to select this checkbox that was available but it could not be checked.

One participant finished the task after selecting the 'C-CDA document' and selecting 'OK' in the 'Inbound Transition of Care' window, three other participants were prompted to select 'Approve'. In the pop-up, users have three options to select from: 'Approve', 'OK' and 'Cancel' and it was not clear to these participants they had to select 'Approve' to incorporate the document. The system does not guide the user to the next step which is approval, participants commented:

"Usually when you browse through a file and hit 'OK' and get a bar telling you that is something is happening, something visually on the screen that the task is complete. Did not see anything that says is complete."

"When I was in there I was not sure if I need to print the document to manually enter the information or by selecting and approving will automatically go to the record."

In the 'Inbound Transition of Care' window, users need to select and input data from six different fields before selecting 'Approve', however the system does not indicate that any of these fields are mandatory. Instead the system produces 'Warning' messages once the user selects 'Approve' indicating which fields need to be completed (i.e. "Referral Date' is required").

At the beginning of the task, several participants were searching and expecting to find the Transition of Care document under 'Documents' (from the 'Navigation menu), some of them were looking for the 'Documents' tab and provided the following comments:

"You said it came electronically but there is nothing in 'Documents'."

"I go straight to 'Documents' I do not see it."

"I am looking for the 'Documents' tab."

"In our current system, I will select 'Documents' and go from there."

Once in the 'Communications' workspace, many participants were expecting to see a document listed in the 'Transition of Care' section and did not expect to fetch the document:

"There is nothing in 'Inbound' and 'Outbound' of the 'Transition of Care' [area]."

"Initially looking at it, I would go to 'Communications' tab. I thought there would be something to open so to me I thought I was looking at inbound to open and then reconcile. I did not that know I would be adding and pulling that out. That was confusing."

"I guess I was expecting to be already listed and just click on it and approve it."

Participants provided the following favorable comments about the effectiveness of using electronic Transitions of Care documents:

"I think it could be helpful, honestly we get information from offices and are not as accurate and need to figure out which ones are accurate or not."

"I can choose whether I have this information and choose to add it or not. This is helpful."

Efficiency

For incorporating and reconciling an electronic C-CDA Transition of Care document, four participants started the task by going to 'Communications' from the top menu, only one participant followed the optimal path by selecting 'New' from 'Transition of Care', selecting 'Other Electronic' as 'C-CDA Document source' and working her way down and to the right to select 'Browse' to find the document and 'Approve'. This participant then selected 'OK' in the 'Incorporating C-CDA' pop-up, selected 'Current Medications' and 'Reconciliation' button, selecting each medication on the left to the right of the 'Current Medications list' by using the arrow and 'OK'. She repeated the same steps to reconcile allergies and diagnoses by selecting 'Allergies' followed by 'Reconciliation' and 'Diagnosis' followed by 'Reconciliation' and bringing each item listed using the arrow button and finished the task by selecting 'OK'.

The only participant that successfully completed the task of incorporating and reconciling a 'C-CDA Transition of Care' document, finished the task below the optimal time, no deviations were recorded.

Participants provided the following comments about efficiency when incorporating and reconciling an electronic C-CDA Transition of Care document into a patient's record:

"There are multiple steps and I cannot do everything from same screen. When in 'Inbound Transition of Care' pop up, it should have a link, or pop-up for all three [areas to reconcile] and I do not need to go to 'Diagnosis', 'Allergies' and 'Current Medications'. Can easily get distracted from where you need to go."

"Anytime there is a task that you need to go to multiple screens for one task, if doing this multiple time, for different patients, that is a lot of wasted time."

"It should be in one place to reconcile. Too many areas to go to."

Satisfaction

The task satisfaction rating for incorporating and reconciling an electronic C-CDA Transition of Care document into a patient's record was 4.0. This is not an average rating and is the reflection of the only participant that successfully completed the task.

Major Findings

- Incorporating and reconciling an electronic C-CDA Transition of Care document into a patient's record proved to be a very difficult task for users. Only one participant successfully completed the task without help. Five participants commented they were unfamiliar with this task.
- Five participants thought the task was finished after only incorporating the information from the Transition of Care document. The system provided no guidance to participants to complete the task and participants behaved as if the task was finished by closing the 'Inbound Transition of Care' window and returning to the 'Communications' workspace. This is the system behavior previously encountered when completing and finishing tasks.
- Most participants were trying unsuccessfully to select the 'Medications Reconciled' checkbook before selecting 'Approve' in the 'Inbound Transition of Care' window.
- Many participants had to be prompted to select 'Approve' after selecting the Transition of Care document; the system provided no guidance on what the next steps should be.
- Several participants were expecting to find the Transitions of Care document under 'Documents'.
- In the 'Inbound Transition of Care' window, several participants encountered warning messages upon approval since some fields were not completed, even though, they were not indicated as mandatory fields.

Areas for Improvement

- Consider guiding the user to reconcile the information after incorporating the information from the 'Transition of Care' document, i.e. prompt the user to the next steps, workspace (s) where reconciliation of information is required.
- Consider simplifying the incorporation and reconciliation of information by joining both activities within one workflow.
- Consider highlighting all mandatory fields in the 'Inbound Transition of Care' window instead of providing messages when required fields are not completed and making the actions buttons (i.e. 'Approve' and 'OK') grayed out and unavailable until all mandatory fields are completed.
- Consider guiding the user to make the appropriate selection between 'Approve' and 'OK' once the 'Transition of Care' document is fetched and all mandatory fields are completed
- Consider further user research regarding messaging during this workflow (i.e. the difference between 'incorporating' and 'reconciling' is not well understood by end users).

ELECTRONIC PRESCRIBING

One task was included to send prescriptions electronically. It included:

- Send prescriptions to a pharmacy

Analysis Notes

Task Description

Task 8 was an e-prescribing task that included sending two prescriptions to a pharmacy of choice. This task was included to evaluate how a participant would select Tamoxifen and Granisetron prescriptions from the 'E-prescribing' tab, selecting the Walgreens in Tarzana California from the 'Pharmacy' drop down menu, and completing the task by selecting 'Send'.

Scoring Notes

Twelve participants followed instructions, as expected. The following exclusion was recorded: one participant was unable to complete this task because pharmacies were not available for selection in time for this test session.

Effectiveness

Eleven participants successfully sent prescriptions electronically. One participant did not successfully send the prescriptions and reordered Tamoxifen and Granisetron from 'Drug Orders'.

The following behaviors were observed at the end of the task when participants were trying to send the prescriptions electronically: selecting 'Apply and Send', 'Apply and OK' and 'Send' or 'Apply' and 'OK' instead of 'Send'. One participant provided the following comment:

"It looked like I put the information and it was not clear: there was 'OK', there was 'Apply' and 'Send'. I am sure, if I would use this frequently, I would understand the differences between those but was not immediately intuitive."

In the 'E-Prescribing Drugs' window before a pharmacy has been chosen, there are three choices to choose from: 'Apply', 'OK' and 'Cancel'. Once a pharmacy has been chosen, the choices change to: 'Send', 'Apply', 'OK' and 'Cancel'. When the user is sending a prescription, it is unclear which combination of 'Send', 'Apply' or 'OK' will successfully send the prescriptions electronically. Many participants went back and forth between 'Send' and 'Apply' before making a selection. There were two participants that commented about being unsure if the prescriptions have been sent or not and one of them double checked by selecting 'All' under 'Show Sent Status', the other participant provided the following comment:

"They are both queued, then we have to see if they are sent."

The amount of choices, i.e.: 'Send', 'Apply', 'OK' and the unclear definitions of the terms makes it difficult for the user to effectively make the appropriate selection; for this task was 'Send'. 'Apply' only adds the pharmacy to that prescription and it does not change the prescription status, 'Send' adds the pharmacy to that prescription and changes the prescription status to 'Queued'.

When selecting a pharmacy, some participants commented that the system is very picky when typing the name of the pharmacy or city, making the search of the appropriate pharmacy cumbersome:

"This particular time it was easy. In the past I have problems to find the pharmacy by the city."

"I've had trouble looking for a pharmacy when it was not a favorites since I must type the exact name. It is sensitive to hyphenation and capitals, even though I have the zip code and street; but when the pharmacy is in the list (Favorites) is a 5 [Ease of Use rating]."

The following error was observed: reordering Tamoxifen and Granisetron from 'Drug Orders'. The participant provided the following comment after reordering both prescriptions:

"I wanted to change that prescription that I ordered to give them a paper prescription...I hit 'Edit' on that prescription. It would have been nice if I could have changed it right then.

Select 'Edit', select the pharmacy and hit 'Approve' versus reordering the drug. It looks like I gave two prescriptions on the same day for both drugs."

Efficiency

For sending prescriptions electronically, all participants except one started the task by going to 'E-Prescribing', selecting one of the prescriptions listed from the 'Unsent Prescriptions', then three participants followed the most

optimal path by selecting the pharmacy from the 'Pharmacy' drop down menu and finishing the task by selecting 'Send' for each of the prescriptions. Two participants selected the 'Pharmacy' lookup and typed the name of the pharmacy and name of the city, selected the pharmacy and 'OK' and worked the way down to selecting 'Send' in the 'E-Prescribing Drugs' window. The remainder of participants, after selecting the prescriptions, selected a combination of 'Apply', 'Send', 'OK' and 'Close' to send the prescription. One participant finished the task by selecting 'All' checkbox from 'Show Sent Status' while another one selected 'All' checkbox at the beginning of the task. One participant selected and unselected 'Do not send' checkbox above the 'Pharmacy' drop down menu before continuing to select the pharmacy and send the prescriptions. One participant selected 'Drug Orders' and reordered the two drugs instead of sending the prescriptions electronically to a pharmacy.

The following deviations were observed: selecting 'Apply' instead of 'Send' to send a prescription, selecting 'Apply and OK' instead of 'Send' to send a prescription, selecting 'OK' instead of 'Send' to send a prescription, selecting 'Favorite Pharmacies' button and closing popup without making a selection, selecting the navigation icon and visiting 'Drug Orders'.

Eight participants successfully completed the task of sending electronic prescriptions to a pharmacy below the optimal time, deviations were recorded for five of these participants. Three participants finished the task above the optimal time, deviations were recorded for only one of them.

Many participants expected and wished to send all prescriptions simultaneously. They provided the following comments regarding efficiency when sending prescriptions electronically:

"It would be nice to do all prescriptions at the same time. If you have many of them, it would be nice to do all of them in one step."

"I like that it is easy to get here and search the pharmacy and I do not like that you have to send one at the time. I want to send all at once rather than one at the time. If there are several medications, then it takes more time to do one at the time."

"I did not know how to send both simultaneously. I am sure there is a way to do that. I would like to do a batch send of orders"

Satisfaction

The task satisfaction rating for sending prescriptions electronically was 4.6. This average rating is way above the 'easy to use' threshold [3.3]. This is supported by the comments below and the success rate.

Participants provided the following comments regarding ease of use when sending prescriptions electronically:

"I do like that you can have a preferred pharmacy there and it is nice that you can have two since patients can alternate between pharmacies."

"It is pretty good system."

"Once the prescriptions are in, it is not difficult."

"I am familiar with it so it was easy."

Major Findings

- Sending prescriptions electronically to a pharmacy of choice worked well for users, as there is no typing required to send the prescriptions
- Sending prescriptions electronically to a pharmacy of choice was an easy task for most users, as proved by the success rate and satisfaction score except for one participant that did not successfully completed the task and reordered both prescriptions under 'Drug Orders'.

- One error was observed during the task when a participant reordered Tamoxifen and Granisetron from 'Drug Orders'.
- It is unclear to many users the meaning of 'Apply' and 'OK' along with 'Send' as proved by the different combinations used at the end of the task.
- Many participants expected to send all prescriptions at once instead of selecting one by one.
- Several participants commented how cumbersome it is to search for the correct pharmacy or city if they do not use the exact hyphenation, upper and lower case as per the names stored in the system.

Areas for Improvement

- Consider defining and guiding the user to make the appropriate selection of 'Send', 'Apply' and 'OK' when sending electronic prescriptions, i.e. in some instances, if only one response is required, like 'Send', the other responses should not be available or grayed out.
- Compare the frequency and importance of 'OK' and 'Apply' versus the confusion it causes for end users when e-prescribing:
 - If 'Apply' needs to stay, ensure that the language used indicates the resulting action (i.e. in this case adding the pharmacy).
 - If 'Send', 'Apply' and 'OK' needs to stay, conduct additional user research to ensure that the contrast between 'Send', 'Apply' and 'OK' is clear; the control 'Ok' needs to give users the impression that the application will save their work (i.e. the resulting action is a 'Save' and 'Close', saves the pharmacy and closes the pop-up when this button is selected).
- Consider including the ability to send all prescriptions in one batch when sending to the same pharmacy.
- Consider employing a smoother user experience from the 'E-Prescribing' tab to the 'E-Prescribing Drugs' pop-up, as selecting one or two prescriptions from the tab does not change anything in the pop-up after selecting the 'View' button or either of the prescriptions from the tab (i.e. all prescriptions are available for the user in the pop-up even if s/he only selected one in the tab).

APPENDIX 1: INVITATION

Subject: Aria Usability Test

Dear [participant name],

On behalf of Varian Medical Systems, we are pleased to invite you to participate in a usability study organized by the Varian User Experience team to evaluate ARIA.

To conduct the study, we will be working with Macadamian, a user research company, to learn from you how usable and effective the system is and what can be done to improve it further. With this objective in mind, we kindly request that you share your valued professional experience during the study. Please note that there is no need for you to share any confidential, proprietary or patient information.

What is involved?

The study will be conducted remotely via phone and web meeting that you can dial into using your computer at your preferred location (office or home). The study will last about an hour during which you will navigate through the system by completing a few tasks (e.g. updating and reviewing patient information) and provide us with your feedback.

The study session can be done outside of normal working hours. All study sessions will be recorded (with the participant's consent) for reference during the analysis and reporting phase. All comments and feedback will remain anonymous.

In exchange for your participation in this one-hour study and as a thank you for your time, Macadamian will provide you with \$150 to compensate you for your time.

We will be scheduling interviews to take place at the end of June.

Please reply to this e-mail indicating your interest in participating in this study and Anneliis Tosine (atosine@macadamian.com), a Macadamian representative, will get in touch with you soon after to schedule your study session.

We look forward to the opportunity to talk with you and learn from your professional experience.

Thank you very much,

[Varian Project Manager]

APPENDIX 2: TEST PROTOCOL AND POST-TEST QUESTIONNAIRE

Summative Test Protocol: VARIAN ARIA RadOnc

Created by:	Annelis Tosine Alessandra Smircich
Date:	June 2017

Background and Introduction

Thank you for agreeing to participate in this research. Our session today will last for approximately 60 minutes. During this time, I will ask you to complete some tasks using Aria and answer some questions. One thing to keep in mind here is that it is the software that is being tested. You are not being tested in any way. We are interested in how easy or how difficult this system is to use, what in it is useful to you, and how we could improve it. You will be asked to complete these tasks on your own trying to do them as quickly as possible with the fewest possible errors or deviations. Please, do not do anything more than asked for each task. Specifically, do not enter any notes unless asked to. If you get lost or have difficulty, I cannot help you with anything to do with the system itself. Please save your detailed comments until the end of the task or the end of the session as a whole when we can discuss freely.

Varian has requested Macadamian Technologies, an independent research firm that I work for, to conduct these sessions, so I am here as an objective researcher today.

For our session, you may notice that the layout and some details of the system may vary from the product that you currently use. Also, you will see some sample patient data that may not be consistent with your system patient data.

It would be helpful for you to have a pen and paper handy to write the details of the tasks as I read them to you. If you do not have that ready please get it now.

We are recording the audio and computer screen of our session today but I'd like to ensure you that all of the information that you provide will be kept confidential and your name will not be associated with the feedback I provide in a report. You are also one of several people providing feedback for this process. Any questions before we get started?

Note: we are accessing the application through VPN and remote desktop connection so you will probably experience delays when selecting certain menu items and buttons.

[Confirm demographics and train on Implantable Devices]

Today, please assume you have a physician's login and that your name is Dr. Jack Shephard.

[Press record on GoToMeeting]

First Impressions

This is the application you will be working with today. Does this look similar to what you are using currently? Anything in particular that you notice is different?

- Yes
- No

Task 1 Demographics: document demographic information

Once I read each task, please tell me when you are ready to begin and when you have finished each task.

Start point: Summary workspace

[Open: Lucy Smith or Amanda Jones]. Today, we'll be working with this patient record and let's assume this is an initial consult for a new patient with breast cancer. Please show me how you would document the following demographic information in her record: her ethnicity is not Hispanic or Latino, race is Native Hawaiian, and her primary language is Spanish. Once you have completed this first task, please let me know.

Optimal Path:

1. Select 'Registration' from top menu
2. Select 'Demographics' tab
3. Select the lookup button for the 'Race' field
4. Select 'Native Hawaiian or Other Pacific Islander' and the arrow button
5. Select the 'Ok' button
6. Select the lookup button for the 'Ethnicity' field
7. Select 'Not Hispanic or Latino' and the arrow button
8. Select the 'Ok' button
9. Select the lookup button for the 'Language' field
10. Select 'Spanish' and the arrow button
11. Select 'Ok' button
12. Select the 'Save' button

End point:

End point: 'Demographics' tab updated

Deviation(s)

Task Time: _____seconds

Success:

- Successfully Completed (i.e. all fields in 'Demographics' were correctly completed)
- Completed Incorrectly/ Abandoned

Observed Errors and User Comments:

On a scale of 1 to 5, how would you rate your experience with the application when completing this task?

Very difficult to use

1

2

3

4

Very easy to use

5

Moderator Comments:

Task 4 Medications List: document a medication from an external provider

Start point: Allergies workspace

During the examination, your patient indicates that she is taking Coumadin 4 mg tablet daily. Please show me how you would record that information.

Optimal Path:

1. Select 'Current Medications' from the top menu
2. Select the 'New' button
3. Select the lookup button for the 'Drug' field
4. Type 'Coumadin' in the 'Drug Name' field
5. Select 'Coumadin – (Tablet Oral)' from the search results
6. Select the 'Ok' button
7. Enter '4' in the 'Strength' field
8. Select 'Daily' from the 'Frequency' drop-down
9. Select 'Ok' button

Alternate Path:

1. Select 'Current Medications' from the top menu
2. Select the 'New' button
3. Select the lookup button for the 'Drug' field
4. Type 'Coumadin' in the 'Drug Name' field
5. Select 'Coumadin – (Tablet Oral)' from the search results
6. Select the 'Ok' button
7. Enter '4' in the 'Strength' field
8. Select 'mg' from the 'Unit' drop-down
9. Select 'Daily' from the 'Frequency' drop-down
10. Select 'Ok' button

End point:

End point: Medication successfully documented and participant back on the 'Current Medications' workspace

Deviation(s)

Task Time: _____seconds

Success:

- Successfully Completed (i.e. all fields in the order were correctly completed)
- Completed Incorrectly/ Abandoned

Observed Errors and User Comments:

On a scale of 1 to 5, how would you rate your experience with the application when completing this task?

Very difficult to use

1

2

3

4

Very easy to use

5

Moderator Comments:

Task 5 CIR: perform CIR

Start point: Current Medications workspace

For this patient, you have received her 'CCDA – Transition of Care' document electronically (but not by direct message) from a referring specialist, Robert Jones. Using this document, you need to bring in any additional allergies, problems and medications into her record. Please find this document and incorporate the information into this patient's record. [Note: the 'Transition of Care' document is called User ^ Varian ^ Desktop ^ Summary of Care records - "Transition of Care – Jones, Amanda or Transition of Care – Smith, Lucy".]

Optimal Path:

1. Select 'Communications' from the top menu
2. Select the 'New' button from the 'Transition of Care' section
3. Select 'Other Electronic' as 'C-CDA Document Source'
4. Select today's date as 'Referral Date'
5. Select 'Dr. Albert Davis' from the 'Referred by' drop-down
6. Select 'New patient' from the 'Visit Type' drop-down
7. Select the 'Browse' button to find document
8. Select the document
9. Select the 'Open' button
10. Select the 'Approve' button
11. Select the 'Ok' button in the 'Incorporating C-CDA' pop-up

12. Select 'Current Medications' from the top menu
13. Select the 'Reconciliation' button from the top
14. Select each medication on left to move to 'Current Medications' list using the arrow button
15. Select the 'Ok' button
AND
16. Select 'Allergies' from the top menu
17. Select the 'Reconciliation' button from the top
18. Select each allergy on the left to move to 'Current Allergies' list using the arrow button
19. Select the 'Ok' button
AND
20. Select 'Diagnosis' from the top menu
21. Select the 'Reconciliation' button from the top
22. Select each problem on the left to move to 'Current Diagnosis' list using the arrow button
23. Select a code from the 'Search for Diagnosis/ Problem Code'
24. Select the 'Ok' button
25. Select the 'Ok' button

End point:

End point: CIR successfully completed and participant back on Diagnosis/Current Medications/ Allergies workspace

- Deviation(s)

Task Time: _____seconds

Success:

- Successfully Completed
- Completed Incorrectly/ Abandoned

Observed Errors and User Comments:

On a scale of 1 to 5, how would you rate your experience with the application when completing this task?

Very difficult to use

1

2

3

4

Very easy to use

5

Moderator Comments:

Task 7 CPOE (Medications): order a medication (non-favorite)

Start point: Drug Order workspace

Next, please prescribe Granisetron HCl (1 mg) Tablet Oral daily for 30 days. This medication is not one of your favorites.

Optimal Path

1. Select the 'New' button
2. Select the 'New' button
3. Select the lookup button for the 'Drug Name' field
4. Type 'Granisetron' in the 'Drug Name' field
5. Select 'Granisetron HCl Tablet Oral' from the search results
6. Select the 'Ok' button
7. Select 'Take as Directed' checkbox
8. Types in Admin instructions: Take 1 tablet daily for 30 days
9. Enter '30' in the 'Quantity' field
10. Select the 'Approve' button
11. Select the 'Approve' button in the 'Medi-Span Medications Screening' pop-up

Alternate Path

1. Select the 'New' button
2. Select the 'New' button
3. Select the lookup button for the 'Drug Name' field
4. Type 'Granisetron' in the 'Drug Name' field
5. Select 'Granisetron HCl Tablet Oral' from the search results
6. Select the 'Ok' button
7. Enter '1' for the 'Dose' field
8. Select 'Tablet' from the 'Unit' drop-down
9. Select 'Daily' from the 'Frequency' drop-down
10. Enter '30' for the 'Duration' field
11. Select 'days' for the 'Unit' field
12. Enter '30' in the 'Quantity' field
13. Select the 'Approve' button
14. Select the 'Approve' button in the 'Medi-Span Medications Screening' pop-up

End point:

End point: medication successfully ordered and participant back on 'Drug Orders' workspace

- Deviation(s)

Task Time: _____seconds

Success:

- Successfully Completed
 Completed Incorrectly/ Abandoned

Observed Errors and User Comments:

On a scale of 1 to 5, how would you rate your experience with the application when completing this task?

Very difficult to use

1

2

3

4

Very easy to use

5

Moderator Comments:

Task 9 CPOE (labs and imaging): order a lab and diagnostic imaging

Start point: E-prescribing workspace

You decide to order CA-125 test and a mammogram for this patient, both by the next visit. You also want to indicate as a note to compare this mammogram to the last mammogram. [Nurse: Please approve this order.]

Optimal Path:

1. Select 'Physicians Order' from the top menu
2. Select the 'New' button
3. Select 'CA-125'
4. Select 'By next visit'
5. Select 'Mammogram'
6. Select 'Compare to Last' from the note drop-down
7. Select 'By next visit'
8. Select the 'Approve' button

End point:

End point: orders successfully completed and participant back on 'Physician Orders' workspace

Deviation(s)

Task Time: _____seconds

Success:

- Successfully Completed
- Completed Incorrectly/ Abandoned

Observed Errors and User Comments:

On a scale of 1 to 5, how would you rate your experience with the application when completing this task?

Very difficult to use

1

2

3

4

Very easy to use

5

Moderator Comments:

Task 11: Implantable Device List: document an implantable device

Start point: Clinical Decisions workspace

During the examination, your patient indicates the she has a pacemaker. Please show me how you would record that information. (Supply the participant with the unique device identifier (UDI) in the GoToMeeting chat window). The date of the implant was June 8, 2016.

Optimal Path:

1. Select 'History' from the top menu
2. Select the 'Edit' button
3. Select the 'Implantable Devices' tab
4. Select the 'New' button
5. Paste the UDI # in the 'UDI' field
6. Select the lookup button
7. Indicate 'Date of Implantation'
8. Select 'Ok' button

End point:

End point: implant successfully recorded and participant back on the 'History' workspace

Deviation(s)

Task Time: _____seconds

Success:

- Successfully Completed
- Completed Incorrectly/ Abandoned

Observed Errors and User Comments:

On a scale of 1 to 5, how would you rate your experience with the application when completing this task?

Very difficult to use

1

2

3

4

Very easy to use

5

Moderator Comments:

System Usability Scale Questionnaire

For each of the following statements please rate them on a scale from 1 to 5 where 1 means strongly disagree and 5 means strongly agree. Please note, for some statements 'strongly agree' is a negative assessment.

	Strongly Disagree				Strongly Agree
1. I think that I would like to use this application frequently	1	2	3	4	5
2. I found the application unnecessarily complex	1	2	3	4	5
3. I thought the application 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 application	1	2	3	4	5
5. I found the various functions in this application were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this application	1	2	3	4	5
7. I would imagine that most people would learn to use this application very quickly	1	2	3	4	5
8. I found the application very cumbersome to use	1	2	3	4	5
9. I felt very confident using the application	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this application	1	2	3	4	5



Compensation Information

Personal Cheque

PayPal Account

Thank you for your participation today! Your feedback is greatly appreciated!

Demographic Questionnaire: VARIAN ARIA

Created by:	Melanie Rodney User Experience Researcher
Date:	June 2017

GENERAL DEMOGRAPHICS

- Female
- Male

1. Which of the following categories best describes your age?

- 20-29
- 30-39
- 40-49
- 50-59
- 60-69
- 70+

2. Which of the following categories best describes your education level?

- No high school degree
- High school graduate [diploma or 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]

3. What is your current role/occupation?

4. How long have you been practicing as a ...[role]?

_____ [years /months]

TECHNOLOGY USE

5. How long have you used a computer?

_____ [years /months]

6. How long have you used an EHR?

_____ [years /months]

7. Do you use assistive technology to help you in your job [screen reader like VoiceOver, etc.]

- No
- Yes Please Describe: _____