



Apollo Version 1.3

EHR Usability Test Report

Report Based On:

NISTIR 7742 - Customized Common Industry Format Template for Electronic Health Record Usability Testing

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Preface

About this Document

This document is based on certification criterion from the Health Information Technology: Standards, Implementation Specifications, and Certification Criteria for Electronic Health Record (EHR) Technology, 2015 Edition; Revisions to the Permanent Certification Program for Health Information Technology, Final Rule issued by the Department of Health and Human Services (HHS) on October 16, 2015.

This document explains Test procedure for Certification Criteria:

§170.315(g)(3) Safety-enhanced design.

This document focuses on requirements of user-centered design processes that must be applied to each capability an EHR technology includes that is specified in the following certification criteria:

§170.315(a)(1); §170.315(a)(2); §170.315(a)(3); §170.315(a)(4); §170.315(a)(5); §170.315(a)(6); §170.315(a)(7); §170.315(a)(8); §170.315(a)(9); §170.315(a)(14); §170.315(b)(2); and §170.315(b)(3).

Document Owner

MD Synergy Solutions, LLC

Target Audience

This guide is intended for users and potential users of MD Synergy EHR Apollo Version 1.3.

Assumptions

No Assumptions.

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Contents

- Executive Summary..... 5
- Introduction 9
- Method 10
 - Participants 10
 - Study Design 11
 - Tasks..... 11
 - Procedures 17
 - Analyzing Task Time 17
 - Measuring Path Deviation..... 18
 - Recording Errors 19
 - System Usability Scale (SUS) 19
 - Test Location 20
 - Test Environment..... 20
 - Participant Instructions..... 20
 - Usability Metrics 21
 - Data scoring 21
- Results..... 23
 - Data Analysis and Reporting 23
 - Effectiveness 26
 - Efficiency 26
 - Satisfaction..... 26
 - Major findings 26
 - Areas for improvement..... 26
- Task Results..... 26
 - Record, Review and Update Medication List..... 26
 - Record Lab Order 27
 - Record Radiology Order 27
 - Record Implantable Device 27
 - Record Demographics 28

Record, Review and Update Medication Allergy List.....	28
Record, Review and Update Problem List.....	28
Record Medication Order and Drug - Drug Interaction	29
Record Medication Order and Drug - Allergy Interaction.....	29
Inactivate implantable device	29
Clinical Information Reconciliation and Incorporation	30
Clinical Decision Support and Record Lab Order	30
Clinical Decision Support and ePrescribe Medication	30
Generate new CCD file and create a referral	31
Change Demographics	31
Update Medication Allergy and review displayed historical medication allergy list.....	32
Change Current Problems and Review Historical Problem List	32
Change Radiology/Imaging Order.....	32
Change Laboratory Order	33
Review Past Medication List, Create Order, and Adjust the Severity Level of Interaction.....	33
Cancel Prescription	33
Review Clinical Decision Support that are triggered	34
Access the attributes of the Demographics, and Demographics & Medication List interventions triggered.....	34
Review Clinical Decision Support triggered for Medication Allergy	34
Receive and Review Fill Status Notification	35
Refill Prescription.....	35
Request and Import Medication History	36
Change Prescription (Dosage).....	36
Appendix	37
Appendix 1: System Usability Scale Questionnaire	37
Appendix 2: Recruiting Form (Participant Intake Sheet)	38

Executive Summary

A usability test of MD Synergy's EHR - Apollo Version 1.3 was conducted over a period of 8/3/2018 to 8/7/2018 and 8/22/2018 to 8/23/2018. It was conducted at 4 locations. MD Synergy personnel went to each location to conduct the tests. The purpose of this test was to test and validate the usability of the current user interface, and provide evidence of usability in the EHR Under Test (EHRUT). During the usability test, 4 Physicians, 5 Medical Assistants, and 1 Administrative staff members matching the target demographic criteria served as participants and used the EHRUT in simulated, but representative tasks.

This study collected performance data on 28 tasks:

1. Record, Review and Change Medication in the Medication List
2. Record Lab Order
3. Record Radiology Order
4. Record Implantable Device
5. Record Demographics
6. Record, Review and Update Medication Allergy List
7. Record, Review and Update Problem List
8. Record Medication Order and Drug - Drug Interaction
9. Record Medication Order and Drug - Allergy Interaction
10. Inactivate Implantable Device
11. Clinical Information Reconciliation and Incorporation
12. Clinical Decision Support based on Transition of Care/Referral and Record Lab Order
13. Clinical Decision Support based on Transition of Care/Referral and e-Prescribe Medication
14. Generate a new CCDA
15. Change Demographics
16. Change Medication Allergy and review displayed historical medication allergy
17. Change Current Problem and review Historical Problems
18. Change Radiology/Imaging Order
19. Change Laboratory Order
20. Review past medication list. Adjust severity level of displayed drug-drug interaction
21. Cancel Prescription
22. Review the Clinical Decision Support that are triggered for Problem List, Medication List, Demographic, Lab Test, Vitals, Demographic & Medication List

23. Access the attributes of the Demographics, and Demographics & Medication List interventions
24. Review Clinical Decision Support triggered for Medication Allergy
25. Receive and review Fill Status notification
26. Refill Prescription
27. Request and import medication history information from Surescripts
28. Change prescription

During the 60 minutes one-on-one usability test, each participant was greeted by the administrator and asked to review and sign an informed consent; they were instructed that they could withdraw at any time. The administrator introduced the test, and instructed participants to complete a series of tasks (given one at a time) using the EHRUT. During the testing the users were timed and the data was recorded. The administrator did not give the participant assistance in how to complete the task.

The following types of data were collected for each participant:

- Number of tasks successfully completed within the allotted time without assistance
- Time to complete the tasks
- Number and types of errors
- Path deviations
- Participant’s 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. None of the participants were compensated for their participation. 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, were used to evaluate the usability of the EHRUT. Following is a summary of the performance and rating data collected on the EHRUT.

Task	Number	Task Success	Path Deviation	Task Time		Errors*	Task Ratings 5=very easy
				Mean (SD)	Deviations (Observed/Optimal)		
	#		Deviation (Observed/Optimal)			Mean	Mean
Record, Review and Update Medication List	10	10 (100%)	1.15	132.70 (14.58)	1.11	0 (0)	5.00
Record Lab Order	10	10 (100%)	1.1	42.00 (6.82)	1.20	0 (0)	5.00

Record Radiology Order	10	10 (100%)	1.16	13.40 (4.86)	1.34	0 (0)	5.00
Record Implantable Device	10	10 (100%)	1.03	32.00 (6.85)	1.28	0 (0)	4.60
Record Demographics	10	10 (100%)	1.03	126.67 (13.65)	1.21	0 (0)	5.00
Record, Review and Update Medication Allergy List	10	10 (100%)	1.1	28.80 (7.30)	1.31	0 (0)	5.00
Record, Review and Update Problem List	10	10 (100%)	1.03	26.50 (9.72)	1.47	0 (0)	5.00
Record Medication Order and Drug - Drug Interaction	10	10 (100%)	1.12	109.2 (14.29)	1.21	0 (0)	4.60
Record Medication Order and Drug - Allergy Interaction	10	10 (100%)	1.06	96.30 (19.04)	1.07	0 (0)	4.60
Inactivate Implantable Device	10	10 (100%)	1.07	15.50 (3.87)	1.29	0 (0)	5.00
Clinical Information Reconciliation and Incorporation	10	10 (100%)	1.06	67.4 (17.04)	1.12	0 (0)	4.7
Clinical Decision Support based on Transition of Care/Referral and Record Lab Order	10	10 (100%)	1.30	17.20 (6.92)	1.72	0 (0)	4.9
Clinical Decision Support based on Transition of Care/Referral and ePrescribe Medication	10	10 (100%)	1.04	83.80 (15.70)	1.2	0 (0)	4.8
Generate new CCDA with	10	9 (90%)	1.15	52.11 (6.90)	1.3	10% (0)	4.4

reconciled data							
Change Demographics	10	10 (100%)	1.05	139.40 (5.8)	1.14	0 (0)	5
Update Medication Allergy and review displayed historical medication allergy	10	10 (100%)	1	25.2 (3.4)	1.26	0 (0)	5
Change Current Problem and review Historical Problems	10	10 (100%)	1.1	41.40 (3.59)	1.16	0 (0)	5
Change Radiology/Imaging Order	10	10 (100%)	1.03	18.50 (1.84)	1.23	0 (0)	5
Change Laboratory Order	10	10 (100%)	1	17.1 (1.2)	1.14	0 (0)	5
Review past medication list. Adjust severity level of displayed drug-drug interaction	10	9 (90%)	1.1	66.33 (18.42)	1.2	10% (0)	4
Cancel Prescription	10	10 (100%)	1	3.60 (0.52)	1.8	0 (0)	5
Review the Clinical Decision Support that are triggered and view Resource Information for Problem List, Medication List, Demographic, Lab Test, Vitals, Demographic & Medication List	10	10 (100%)	1	8.40 (1.43)	1.4	0 (0)	5
Access the attributes of the Demographics, and Demographics & Medication List interventions	10	10 (100%)	1.03	18.40 (1.84)	1.23	0 (0)	4.8

Review Clinical Decision Support triggered for Medication Allergy	10	10 (100%)	1.07	23.80 (3.05)	1.19	0 (0)	4.9
Receive and review Fill Status notification	10	10 (100%)	1.1	7.4 (1.9)	1.48	0 (0)	4.9
Refill Prescription	10	10 (100%)	1.1	36.20 (4.05)	1.21	0 (0)	4.8
Request and import medication history information from Surescripts	10	10 (100%)	1.07	22.70 (3.77)	1.26	0 (0)	4.8
Change prescription (Dosage)	10	9 (90%)	1.06	19 (2.83)	1.27	10% (0)	4.3

**Reporting the % Task Failures.*

The results from the System Usability Scale scored the subjective satisfaction with the system based on performance with these tasks to be: 85.8. In addition to the performance data, the following qualitative observations were made:

Major findings

Participants generally found the MD Synergy software to be intuitive, and were very impressed with its ease of use, consistency and efficiency. Feedback and interactions provided by the software were very helpful, and helped in achieving a very low task failure rate.

Areas for improvement

There are some modules where an Interface Improvement would help in improving usability. Some of the improvements suggested:

- Validation check if the user erroneously clicks outside the box while working in a particular section
- Ability to send an Order by using the right swipe gesture in the CDS alert
- Pre-populate the system with macros for the Direction field while ordering a medication
- Sort the most commonly used Units of ordering medication based on the frequency of use

Introduction

The EHRUT tested for this study was Apollo Version 1.3. The EHRUT is an all-in- one integrated EHR solution that consists of Electronic Health Records, Practice Management, Enterprise Scheduling, Intelligent Billing and Patient Portal. The usability testing attempted to represent realistic exercises and conditions.

The purpose of this study was to test and validate the usability of the current user interface, and provide evidence of usability in the EHR under Test (EHRUT). To this end, measures of effectiveness, efficiency and user satisfaction, such as Number of Participants per task, Task Success, Path Deviation, Task Time Mean, and Task Time Deviations were captured during the usability testing. System Usability Scale matrix was also captured and SUS ratings were calculated.

Method

Participants

A total of 10 participants were tested on the EHRUT(s). Participants in the test were 4 physicians, 5 Medical Assistants/Nurses and 1 administrative staff members. Participants in the test were physicians of various specialties such as Internal Medicine, Cardiology, etc. Participants were selected by MD Synergy and since each participant volunteered for test event participation, none of the participants were provided compensation for their time. Participants were given the opportunity to have the same orientation and level of training as the actual end users would have received.

Recruited participants had a mix of backgrounds and demographic characteristics conforming to participant screener. The following is a table of participants by characteristics, including demographics, professional experience, computing experience and user needs for assistive technology. Participant names were replaced with Participant IDs so that an individual's data cannot be tied back to individual identities.

Participant ID	Gender	Age	Education	Occupation/Role	Professional Experience (Years)	Computer Experience (Years)	Product Experience (Months)
001	F	36	Grad	Medical Assistant	8	15	2
002	F	27	Grad	Medical Assistant	5	12	2
003	F	30	Grad	Medical Assistant	2	13	2
004	F	22	School Grad	Medical Assistant	1	12	2
005	F	37	Grad	Medical Assistant	15	27	1
006	F	59	Grad	Admin Staff	12	17	2
007	M	53	MD	Physician	23	25	< 1
008	M	65+	MD	Physician	30	36	1
009	M	68	MD	Physician	40	30	< 1
010	M	64	MD	Physician	40	5	< 1

10 participants were recruited and all participants were able to conduct the test. Participants were scheduled for 60 minute sessions with average 3 minutes in between each scenario for debrief by the administrator.

Study Design

Overall, the objective of this test was to uncover areas where the application performed well – i.e. 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. 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 usability test, participants interacted with only MD Synergy software. Each participant used the system, 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 within the allotted time without assistance = 278
- Time to complete the tasks = Approx. 50 mins
- Number and types of errors = 2
- Path deviations = Average 1.07
- Participant’s satisfaction ratings of the system = 4.82

Tasks

Scenario 1

Erin Andrews, a 52 year old female, comes in for her Annual Physical Exam. Her current complaints are cough, shortness of breath and an elevated blood glucose level.

Task 1: Review Erin’s current medication list, which only contains Lipitor 20 mg. Change the medication to Lipitor 40 mg. Also, add Ibuprofen and Claritin to her medication list. Medication details are given in the tables below:

Drug name	Lipitor 40 MG tablet
Dose	1
Unit	Tablet
Route	Oral
Frequency	1 TAB PO QD
Duration	30 days
Quantity	30
Refills	2

Directions	Take one tablet after meal
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Drug name	Ibuprofen 200 MG tablet
Dose	2
Unit	Tablet
Route	Oral
Frequency	1 TAB PO QD
Duration	30 days
Quantity	30
Refills	0
Directions	Take one tablet after meal

Drug name	Claritin 10 MG tablet
Dose	1
Unit	Tablet
Route	Oral
Frequency	1 TAB PO QD
Duration	30 days
Quantity	30
Refills	0
Directions	Take in the morning

Task 2: To investigate the elevated blood glucose level, create a Lab Order for the following tests:

- Hemoglobin A1c
- Urine Microalbumin

Task 3: To investigate the cough, create a Radiology Order for Chest X-Ray.

Task 4: Open the patient's Implantable Device List. Add a Pacemaker with UDI:

(01)10884521062856(11)141231(17)150707(10)A213B1(21)1234 which was added during a previous procedure.

Scenario 2

Johnathan Williamson, a 33 year old male, presents with cellulitis in his hand from a cut that was sustained last week.

Task 5: Log in to the Practice Management and add the following details to Johnathan’s profile:

- a. Race: Asian and White
- b. Ethnicity: Not Hispanic or Latino
- c. Preferred Language: English
- d. Sexual Orientation: Straight or Heterosexual
- e. Gender Identity: Male

Task 6: Review Johnathan’s Current Allergies list which contains Sulfa and Penicillin. Delete the Penicillin allergy from the list as the patient confirms that he is not allergic to Penicillin. After that, add Tylenol to the list of patient’s allergies.

Task 7: Review Johnathan’s current problem list, which contains Depression and Dry Cough. Remove Dry Cough from the list as the patient confirms that it is Resolved. After that, add a new Problem, Cellulitis of Hand.

Task 8: Review John’s Current Medication List which contains Prozac, which he is taking for Depression. Create a Prescription for Tramadol using details given in the table below. A Drug – Drug Interaction alert will appear warning you of possible interactions between Tramadol and Prozac and prescribe the medication.

Drug name	Tramadol HCl 50 MG Tablet
Dose	1
Unit	Tablet
Route	Oral
Frequency	As directed
Duration	25 days
Quantity	25 tablets
Refills	1
Directions	Take after meal
Start Date	8/3/2018
Substitutions	Allowed
Pharmacy	VA Pharmacy 10.6 MU
Note to pharmacy	Patient is not on any other painkillers

Task 9: Create a Prescription for Bactrim. A Drug – Allergy Interaction alert will appear warning you of possible interactions between Bactrim and Sulfa allergy. Prescribe the medication.

Drug name	Bactrim DS 800-160 MG Tablet
Dose	1
Unit	Tablet
Route	Oral
Frequency	As directed
Duration	10 days
Quantity	20 tablets
Refills	1
Directions	Do not take after 5 PM
Start Date	Today's date
Substitutions	Not allowed
Pharmacy	VA Pharmacy 10.6 MU
Note to Pharmacy	Dispense as prescribed

Task 10: Review the patient's Implantable Device List which contains a Pacemaker. Mark it as Inactive.

Scenario 3

Anderson Andrews, a 65 year old male, presents for his Annual Physical Exam. His last visit was to another practice where he was provided an electronic Summary of Care CCDA file.

Task 11: Import the Summary of Care CCDA file and reconcile the Current Medications, Current Allergies and Current Problems of the patient.

Task 12: Review the patient's Health Maintenance clinical alerts that have been triggered after reconciliation. The first alert is for ordering a Hemoglobin A1c test for the patient's diabetes. Review this alert with the patient and order the test

Task 13: The second alert is to inform that Steven is not taking Aspirin or other antiplatelet medication for Coronary Artery Disease. Review this alert with the patient, and electronically prescribe the medication using details given below:

Drug name	Asprin 81 MG Tablet
Dose	2
Unit	Tablet
Route	Oral

Frequency	1 TAB PO QD
Duration	30 days
Quantity	30 tablets
Refills	2
Directions	Take after meal
Start Date	8/3/2018
Substitution	Not Allowed
Pharmacy	VA Pharmacy 10.6 MU
Pharmacy Notes	Dispense as prescribed

Task 14: Upon further conversation with the patient the patient needs to be referred out to a specialist. Generate a new CCDA for this patient and send it to Marian Greenburg, MD.

Scenario 4

Todd Black, a 70 year old male comes in for an Annual Physical Exam. His complaints are foot pain, ankle pain, and elevated blood glucose level.

Task # 15: The patient has requested to update the demographics:

- a. Change DOB to December 29, 1947
- b. Change Preferred Language to Spanish
- c. Change Sex to " Male"
- d. Change Race from White to Spanish American Indian
- e. Change Ethnicity to Hispanic
- f. Change Gender Identity to "Choose not to disclose"
- g. Change Sexual Orientation to "Choose not to disclose"

Task 16: Review patient's Current Medication Allergy list, which includes Allegra and Penicillin. Remove Allegra as the patient reports he is not allergic. Review the historical medication allergy list, which will now include Allegra.

Task 17: Review the Current Problem list, which contains Depression, Knee Pain and Foot Pain. Change the Current Problem from Foot Pain to Foot Arch Pain. Resolve the Knee Pain as patient confirms it is resolved. Review the historical problem list which will now also include Knee Pain.

Task 18: Change the Radiology Order from Foot X-Ray to Foot MRI

Task 19: Change the Lab Order from Complete Blood Count [CBC] to Hemoglobin A1c

Task 20: Review patient current and past medication list and create a prescription for Ultram. A Drug-Drug interaction will appear warning you of possible interaction between Ultram and Prozac. Adjust the severity level to display only High Significance drug-drug interactions

Drug name	Ultram 50 MG Tablet
Dose	1
Unit	Tablet
Route	Oral
Frequency	1 TAB PO QD
Duration	30 days
Quantity	30 tablets
Refills	2
Directions	Take after meal
Start Date	8/22/2018
Substitution	Not Allowed
Pharmacy	VA Pharmacy 10.6 MU
Pharmacy Notes	Dispense as prescribed

Task 21: Cancel the prescription for Ultram

Scenario 5

George Coleman, an 86 year old man, visits the doctor complaining about depression and hypertension.

Task 22: Review George's Health Maintenance clinical alerts, which have been triggered because of Problem List, Medication List, Demographics, Lab Tests, Vital Signs, Demographics & Medication List.

Task 23: Click on the alerts triggered due to Demographics: Elderly Falls Risk and Demographics & Medication and "Acknowledge" the attributes of the intervention.

Task 24: Review the Current Allergies list and add Penicillin. Check the Health Maintenance again and see the intervention triggered due to Penicillin (Medication Allergy)

Scenario 6

Debra Tucker, a 38 year old female, comes in for a follow up visit.

Task 25: Review Debra's Current Medication, which included Lipitor 40 MG tablet and review the fill status notification received from the pharmacy.

Task 26: Go to messages and approve a Refill request from the pharmacy for Xopenex 1.25mg/3mL solution for nebulization

Scenario 7

Teague Rogderson comes in for an annual checkup

Task 27: Download Teague's medication history information

After seeing this patient the get a message in your inbox for a change prescription request for patient David Thrower.

Task 28: Go to your inbox to review the change prescription request and approve the same

Tasks were selected as recommended by study objectives defined by NIST document.

Procedures

Upon arrival, participants were greeted; their identity was verified and matched with a name on the participant schedule. Participants were then assigned a participant ID.

Each participant reviewed and signed an informed consent. A representative from the test team witnessed the participant's signature. To ensure that the test ran smoothly, two staff members participated in this test, the usability administrator and the data logger. The usability testing staff conducting the test was experienced usability practitioners with 5 to 10 years of experience, and Post Graduate backgrounds. The administrator moderated the session including administering instructions and tasks. The administrator also obtained post-task rating data, and took notes on participant comments. A second person served as the data logger and took notes on task time, task success, path deviations, number and type of errors, and comments.

Participants were instructed to perform the tasks:

- As quickly as possible making as few errors and deviations as possible.
- Without assistance; administrators were allowed to give immaterial guidance and clarification on tasks, but not instructions on use
- Without using a think aloud technique

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

The data logger used a stop-watch to calculate the task times and noted it down, along with the path deviations and errors, on the participant's logging sheet.

Analyzing Task Time

The times that were calculated for every participant for each task were all available in the excel spreadsheet as shown below. An averaged value for task time was then calculated for every participant and recorded in the final summarized table:

Participant ID	Task Completed	Task Time (seconds)	Steps Taken	Errors Observed	Task Rating
	1=Yes 0=No				5 = very easy 0 = very hard
1	1	137	12	2	5
2	1	135	10	1	5
3	1	135	9	0	5
4	1	115	8	1	5
5	1	135	8	0	5
6	1	166	9	0	5

Mean and Standard deviations were calculated using the Minitab statistics tool:

Descriptive Statistics: Task 1, Task 2, Task 3, Task 4, Task 5, Task 6, Task 7, Task 8, ...

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Task 1	10	0	132.70	4.61	14.58	113.00	122.50	135.00	135.50	166.00
Task 2	10	0	42.00	2.16	6.82	37.00	37.75	40.00	43.50	60.00
Task 3	10	0	13.40	1.54	4.86	10.00	10.00	11.50	15.00	26.00
Task 4	10	0	32.00	2.17	6.85	25.00	26.50	32.00	33.25	49.00
Task 5	6	0	126.67	5.57	13.65	110.00	110.00	131.00	138.50	140.00
Task 6	10	0	28.80	2.31	7.30	17.00	23.75	28.50	33.50	42.00
Task 7	10	0	26.50	3.07	9.72	11.00	19.50	27.50	34.25	40.00
Task 8	10	0	109.20	4.52	14.29	90.00	93.75	111.50	120.00	131.00
Task 9	10	0	96.30	6.02	19.04	67.00	75.00	100.00	114.00	120.00
Task 10	10	0	15.50	1.22	3.87	12.00	12.75	14.50	17.75	24.00
Task 11	10	0	67.40	5.39	17.04	45.00	51.50	69.50	78.00	100.00
Task 12	10	0	17.20	2.19	6.92	10.00	12.25	16.50	20.00	34.00
Task 13	10	0	74.90	8.79	27.78	9.00	68.75	81.00	88.50	107.00

Measuring Path Deviation

To measure Path deviation, at first an optimal number of steps were recorded labeled as 'Optimal' and then Path deviation was calculated using:

$$\text{Deviations (Observed/Optimal)} = \text{Observed path/Optimal path}$$

For example:

Optimal path: 15 steps

Observed path: 18 steps

This was again done using the same excel spreadsheet. Below screen shows the calculation of the Deviations for Task # 1

Participant ID	Task Completed 1=Yes 0=No	Task Time (seconds)	Steps Taken	Errors Observed	Task Rating 5 = very easy 0 = very hard	Time Deviation (Observed/Optimal)	Path Deviation (Observed/Optimal)
1	1	137	12	2	5	1.142	1.50
2	1	135	10	1	5	1.125	1.25
3	1	135	9	0	5	1.125	1.13
4	1	115	8	1	5	0.958	1.00
5	1	135	8	0	5	1.125	1.00
6	1	166	9	0	5	1.383	1.13
7	1	166	9	0	5	1.383	1.13
8	1	135	9	0	5	1.125	1.13
9	1	113	9	0	5	0.942	1.13
10	1	125	9	0	5	1.042	1.13
Optimal Time (seconds)		120					
Optimal Steps		8					

Recording Errors

To record average errors per task, data was logged for the errors made by participants during each task. Please see above screen shot of how the errors were recorded for a particular task per participant.

System Usability Scale (SUS)

Following the session, the administrator gave the participant the System Usability Scale and thanked each individual for their participation.

Participant ID	SUS
001	67.50
002	80.00
003	80.00
004	80.00
005	85.00
006	90.00
007	100.00
008	75.00
009	100.00
010	100.00

Participants' demographic information, task success rate, time on task, errors, deviations, verbal responses, and SUS were recorded into a spreadsheet

Test Location

The testing was done at 4 locations. MD Synergy personnel traveled to the Practice/location where the users would typically use the system. At each location a separate room was provided for conducting the Usability test. Only the participant, the administrator and the data logger were in the test room. To ensure that the environment was comfortable for users, noise levels were kept to a minimum with the ambient temperature within a normal range.

Test Environment

The EHRUT would typically be used in a healthcare office or facility. In this instance testing was conducted where the users would typically use the EHRUT at their facility. Each test was conducted on an iPad Pro. The participants had the option to use a keyboard attached to the iPad and other gestures of the iPad when interacting with the EHRUT. The application was set up by the MD Synergy staff according to the documentation describing the system set-up and preparation. The application itself was running on a dedicated server using Windows Server 2012 in Azure, using a test database. Technically, the system performance (i.e., response time) was representative to what actual users would experience in a field implementation.

Test Forms and Tools

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

- Informed Consent
- Instructions for Participants
- System Usability Scale Questionnaire

Participant Instructions

The administrator read the following instructions aloud to each participant.

“Thank you for participating in this study. Your input is very important. Our session today will last about 60 minutes. During that time you will use an instance of an electronic health record. I will ask you to complete a few tasks using this system and answer some questions. You should complete the tasks as quickly as possible making as few errors as possible. Please try to complete the tasks on your own following the instructions very closely. Please note that we are not testing you we are testing the system, therefore if you have difficulty all this means is that something needs to be improved in the system. I will be here in case you need specific help, but I am not able to instruct you or provide help in how to use the application.

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

Following the procedural instructions, participants were shown the EHR and as their first task, were given time 10 minutes to explore the system and make comments. Once this was complete, the administrator gave the following instructions:

For each task, I will read the description and instruction to you and I will raise poll which will end as per time associated with task. After task completion, I will raise another poll which will collect data and feedback of the participant.”

Participants were then given 28 tasks to complete.

Usability Metrics

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

1. Effectiveness of MD Synergy by measuring participant success rates and errors
2. Efficiency of MD Synergy by measuring the average task time and path deviations
3. Satisfaction with MD Synergy by measuring ease of use ratings

Data scoring

Measures	Rationale and Scoring
<p>Effectiveness: Task Success</p>	<p>A task was counted as a “Success” if the participant was able to achieve the correct outcome, without assistance, within the time allotted on a per task basis.</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. Observed task times divided by the optimal time for each task is a measure of optimal efficiency.</p> <p>Optimal task performance time, as benchmarked by expert performance under realistic conditions, is recorded when constructing tasks. Target task times used for task times in the Moderator’s Guide must be operationally defined by taking multiple measures of optimal performance and multiplying by some factor that allows some time buffer because the participants are presumably not trained to expert performance. Thus, if expert, optimal performance on a task was 'x' seconds then allotted task time performance was x* some factor seconds. This ratio should be aggregated across tasks and reported with mean and variance scores.</p>

<p>Effectiveness: Task Failures</p>	<p>If the participant abandoned the task, did not reach the correct answer or performed it incorrectly, or reached the end of the allotted time before successful completion, the task was counted as a "Failure." No task times were taken for errors.</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 would be counted as errors. This should also be expressed as the mean number of failed tasks per participant.</p> <p>On a qualitative level, an enumeration of errors and error types should be collected.</p>
<p>Efficiency: Task Deviations</p>	<p>The participant's path (i.e., steps) through the application was recorded. Deviations occur if the participant, for example, went to a wrong screen, clicked on an incorrect menu item, followed an incorrect link, or interacted incorrectly with an on-screen control. This path was compared to the optimal path. The number of steps in the observed path is divided by the number of optimal steps to provide a ratio of path deviation. It is strongly recommended that task deviations be reported. Optimal paths (i.e., procedural steps) should be recorded when constructing tasks.</p>
<p>Efficiency: Task Time</p>	<p>Each task was timed from when the administrator said "Begin" until the participant said, "Done." If he or she failed to say "Done," the time was stopped when the participant stopped performing the task. Only task times for tasks that were successfully completed were included in the average task time analysis. Average time per task was calculated for each task. Variance measures (standard deviation and standard error) were also calculated.</p>
<p>Satisfaction: Task Rating</p>	<p>Participant's subjective impression of the ease of use of the application was measured by administering both a simple post-task question as well as a post-session questionnaire. After each task, the participant was asked to rate "Overall, this task was:" on a scale of 1 (Very Difficult) to 5 (Very Easy). These data are averaged across participants.</p> <p>Common convention is that average ratings for systems judged easy to use should be 3.3 or above.</p> <p>To measure participants' confidence in and likeability of the MD Synergy overall, the testing team administered the System Usability Scale (SUS) post-test questionnaire. Questions included, "I think I would like to use this system frequently," "I thought the system was easy to use," and "I would imagine that most people would learn to use this system very quickly."</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. Participants who failed to follow session and task instructions had their data excluded from the analysis.

The usability testing results for the EHRUT are detailed below in table. The data should yield actionable results that, if corrected, yield material, positive impact on user performance and on system improvement.

Task	Number	Task Success	Path Deviation	Task Time		Errors*	Task Ratings 5=very easy
	#			Mean (SD)	Deviations (Observed/Optimal)		Mean
Record, Review and Update Medication List	10	10 (100%)	1.15	132.70 (14.58)	1.11	0 (0)	5.00
Record Lab Order	10	10 (100%)	1.1	42.00 (6.82)	1.20	0 (0)	5.00
Record Radiology Order	10	10 (100%)	1.16	13.40 (4.86)	1.34	0 (0)	5.00
Record Implantable Device	10	10 (100%)	1.03	32.00 (6.85)	1.28	0 (0)	4.60
Record Demographics	10	10 (100%)	1.03	126.67 (13.65)	1.21	0 (0)	5.00
Record, Review and Update Medication Allergy List	10	10 (100%)	1.1	28.80 (7.30)	1.31	0 (0)	5.00
Record, Review and Update Problem List	10	10 (100%)	1.03	26.50 (9.72)	1.47	0 (0)	5.00
Record Medication Order and Drug - Drug Interaction	10	10 (100%)	1.12	109.2 (14.29)	1.21	0 (0)	4.60
Record Medication Order and Drug - Allergy	10	10 (100%)	1.06	96.30 (19.04)	1.07	0 (0)	4.60

Interaction							
Inactivate Implantable Device	10	10 (100%)	1.07	15.50 (3.87)	1.29	0 (0)	5.00
Clinical Information Reconciliation and Incorporation	10	10 (100%)	1.06	67.4 (17.04)	1.12	0 (0)	4.7
Clinical Decision Support based on Transition of Care/Referral and Record Lab Order	10	10 (100%)	1.30	17.20 (6.92)	1.72	0 (0)	4.9
Clinical Decision Support based on Transition of Care/Referral and ePrescribe Medication	10	10 (100%)	1.04	83.80 (15.70)	1.2	0 (0)	4.8
Generate new CCDA with reconciled data	10	9 (90%)	1.15	52.11 (6.90)	1.3	10% (0)	4.4
Change Demographics	10	10 (100%)	1.05	139.40 (5.8)	1.14	0 (0)	5
Update Medication Allergy and review displayed historical medication allergy	10	10 (100%)	1	25.2 (3.4)	1.26	0 (0)	5
Change Current Problem and review Historical Problems	10	10 (100%)	1.1	41.40 (3.59)	1.16	0 (0)	5
Change Radiology/Imaging Order	10	10 (100%)	1.03	18.50 (1.84)	1.23	0 (0)	5
Change Laboratory Order	10	10 (100%)	1	17.1 (1.2)	1.14	0 (0)	5
Review past medication list. Adjust severity	10	9 (90%)	1.1	66.33 (18.42)	1.2	10% (0)	4

level of displayed drug-drug interaction							
Cancel Prescription	10	10 (100%)	1	3.60 (0.52)	1.8	0 (0)	5
Review the Clinical Decision Support that are triggered for Problem List, Medication List, Demographic, Lab Test, Vitals, Demographic & Medication List	10	10 (100%)	1	8.40 (1.43)	1.4	0 (0)	5
Access the attributes of the Demographics, and Demographics & Medication List interventions	10	10 (100%)	1.03	18.40 (1.84)	1.23	0 (0)	4.8
Review Clinical Decision Support triggered for Medication Allergy	10	10 (100%)	1.07	23.80 (3.05)	1.19	0 (0)	4.9
Receive and review Fill Status notification	10	10 (100%)	1.1	7.4 (1.9)	1.48	0 (0)	4.9
Refill Prescription	10	10 (100%)	1.1	36.20 (4.05)	1.21	0 (0)	4.8
Request and import medication history information from Surescripts	10	10 (100%)	1.07	22.70 (3.77)	1.26	0 (0)	4.8
Change prescription (Dosage)	10	9 (90%)	1.06	19 (2.83)	1.27	10% (0)	4.3

The results from the SUS (System Usability Scale) scored the subjective satisfaction with the system based on performance with these tasks to be: 85.8. Broadly interpreted, scores under 60 represent systems with poor usability; scores over 80 would be considered above average.

Effectiveness

MD Synergy EHR proved to be very effective based on overall success reported on all 28 tasks. Effective calculation is around 100%.

Efficiency

Based on observations of the task time and deviation data, most of the participants were able to complete task ahead of time. All the participants were able to finish the given tasks. Efficiency calculation: Average path deviation recorded as 1.07. Average Time deviation recorded as 1.28.

Satisfaction

Participants rated the MD Synergy system as 4.82 out of 5.00. SUS results data indicates a score of 85.8 out of 100.

Major findings

Participants generally found the MD Synergy software to be intuitive, and were very impressed with its naturalness, consistency and efficiency. Feedback and interactions provided by the software were very helpful, and helped in achieving a very low task failure rate.

Areas for improvement

There are some modules where an interface improvement would help in improving usability. The improvements are outlined in the section below.

Task Results

Record, Review and Update Medication List

In this task, participants were asked to record, review and change medications for a specific patient. This was an easy task as all participants successfully completed it.

Major findings

Participants easily located the medication list and had no problem in adding medications to the list. Some users did not make use of the Edit Medication functionality and instead preferred to delete the medication and enter it again. This resulted in a higher standard deviation (14.58 seconds), path deviation (1.15) and task time deviation (1.11).

Areas for improvement:

Since all participants completed this task without any help, no major suggestions for improvement were given by them. However, there were a few participants who took extra steps to complete this task as the right swipe Edit Medication functionality was not evident. This is a training issue and has been duly noted for helping users to use the system more efficiently.

Record Lab Order

In this task, participants were asked to record several Lab Orders for a specific patient. This was an easy task all the participants successfully completed it.

Major findings

The participants generally found MD Synergy's use of favorite and recent lists to be very helpful and this helped them easily select the correct lab test.

Areas for improvement

Since almost all participants completed this task without any help, no major suggestions for improvement were given by them.

Record Radiology Order

In this task, participants were asked to record a Radiology Order for a specific patient. This was an easy task as all participants successfully completed it.

Major findings

Since recording radiology orders is very similar to recording lab orders, participants were appreciative of the interface consistency throughout MD Synergy.

Areas for improvement

No major suggestions of improvement were given by the users.

Record Implantable Device

In this task, participants were asked to record an implantable device using the newly developed Implantable Devices module. This was an easy task as all the participants were able to complete this task.

Major findings

Participants found the workflow easy to use, and were appreciative of the simplicity and ease in the design of adding the implantable device. Some errors were recorded as the users erroneously clicked outside the box and had to go through the process again. This also led to a higher task time deviation (1.28).

Areas for improvement

Since most of the participants completed this task without any help, no major suggestions for improvement were given. However, some participants did mention that the system was sensitive and if they touched out of the box by mistake they had to go through the steps again. This is great feedback and an area of improvement

Record Demographics

In this task, participants were asked to record demographics for a specific patient. This was an easy task as all participants successfully completed it.

Major findings

Participants found the demographics page easy to understand and had no problem in adding the required demographics. They liked the interface to add multiple race/ethnicity.

Areas for improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them.

Record, Review and Update Medication Allergy List

In this task, participants were asked to record, review and update allergies for a patient. This was an easy task as all participants successfully completed it.

Major findings

Participants had no problems with the Allergies card, as its interface was similar to that of other cards of MD Synergy. They liked the right swipe gesture feature to Inactive/Resolve/Delete an allergy as it is similar to an iPhone gesture.

Areas for improvement

Since almost all participants completed this task without any help, no major suggestions for improvement were given by them.

Record, Review and Update Problem List

In this task, participants were asked to record, review and update problems for a specific patient. This was an easy task as all participants successfully completed it.

Major findings

Participants were able to easily find the required problems and add / update them. They were appreciative of the system's favorite and recent features and of the ability to find problems based on either the name/ICD-10/SNOMED.

Areas for improvement

Since almost all participants completed this task without any help, no major suggestions for improvement were given by them.

Record Medication Order and Drug - Drug Interaction

In this task, participants were asked to record a medication order, view the drug interaction alerts, and override them and e-prescribing the medication. This was an easy task as all participants successfully completed it.

Major findings

Participants had no problem in completing this task due to the very clear drug interaction notification. The standard deviation of this task was high (14.29 seconds) as while recording the medications some of the participants did click on the “Done” button erroneously or clicked outside the box by mistake. And they had to edit the medication to complete the order.

Areas for improvement

The system should give a validation if the user clicks outside the box so the user does not have to go through the steps to edit the medication again.

Record Medication Order and Drug - Allergy Interaction

In this task, participants were asked to record a medication order, view the drug interaction alerts, and override them by entering required comments. This was an easy task as all participants successfully completed it.

Major findings

Participants had no problem in completing this task due to the very clear drug interaction notification. Because some users erroneously clicked the “Done” button too soon or clicked outside the box in the previous task they were more cognizant while recording the medication here. However, that still happened as seen by the standard deviation of 19.04 seconds.

Areas for improvement

Since almost all participants completed this task without any help, no major suggestions for improvement were given by them. But the same improvement that was suggested in the above task applies here.

Inactivate implantable device

In this task, participants were asked to inactivate an already entered implantable device for a specific patient. This was an easy task as all participants successfully completed it.

Major findings

Participants easily located the implantable devices card and had no problem in marking the device as inactive.

Areas for improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them.

Clinical Information Reconciliation and Incorporation

In this task, participants were asked to import a CCD file for a patient. After importing the file, they needed to perform reconciliation for the patient's current allergies / medications / problems. This was a relatively tougher task for some users as seen by the high standard deviation (17.02 seconds). However all of the participants successfully completed it.

Major findings

Participants generally liked the CCD import interface and how it automatically added the allergies, medications and problems to the respective cards. The users also like right swipe gesture to do the reconciliation.

Areas for improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them.

Clinical Decision Support and Record Lab Order

In this task, participants were asked to review the patient's CDS alerts, and order a Hemoglobin A1c test. All participants successfully completed it.

Major findings

Most of the Participants were able to locate the patient's CDS alerts and were impressed with how it was tightly integrated with MD Synergy's clinical components. However, the participants still had to go to the Orders card to actually order the lab.

Areas for improvement

A lot of users recommended giving the users the ability to order the labs by using a right swipe gesture on the clinical alert. The users really thought that the right swipe gesture in this card would make the system even more efficient.

Clinical Decision Support and ePrescribe Medication

In this task, participants were asked to review the patient's CDS alerts, and ePrescribe the required medication. All the participants successfully completed it.

Major findings

Most of the Participants were able to locate the patient's CDS alerts and were impressed with how it was tightly integrated with MD Synergy's clinical components making it easy to e-Prescribe the

medication. Again, the participants still had to go to the Orders card to actually order the medication. While e-prescribing the medication the users suggested some efficiency enhancements.

Areas for improvement

A lot of users recommended giving the users the ability to order the labs by using a right swipe gesture on the clinical alert. The users really thought that the right swipe gesture in this card would make the system even more efficient.

Following are the areas for improvement suggest by some users while e-prescribing the medication.

- For Unit have the most commonly used units at the top (for example Tablet, Capsule etc.)
- Have a few macros already built in for the Directions

Generate new CCDA file with reconciled data

In this task the users were asked to generate a new CCDA file for the same patient for whom reconciliation was done and then send a referral.

Major Findings

Most of the participants were able to complete the task. This was a relatively difficult task as seen from the success of only 90%. Participants like the ease of generating the new CCDA as it was intuitive. Participants were appreciative of the consistency in design.

Areas of Improvement

A lot of users recommended that it would be helpful to have a '+' button in each of the different section of the Orders Card rather than a single '+' under the Orders Card.

Change Demographics

In this task the users were asked to change the demographics for a patient

Major Findings

This was an easy task and all of the participants completed the change successfully. The average time taken was a little higher than the optimal time suggesting that some of the fields were spread out and not easy to find.

Areas of Improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them. However, the system could be made more effective is some of the fields are clubbed together and easy to locate on the page.

Update Medication Allergy and review displayed historical medication allergy list

In this task the participants were asked to update the medication allergy and then view the historical list

Major Findings

All participants completed this task. The participants like the right swipe feature that allowed them to update the medication allergy without making too many clicks. This can be seen by the low standard deviation of this task (3.4 seconds)

Areas of improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them.

Change Current Problems and Review Historical Problem List

In this task the participants were asked to change the current problem and then review the historical problem list of the patient

Major Findings

All the participants were able to successfully complete the task. The path deviation was high as there were 2 ways in which the users could change the problem. Some participants followed a longer path with additional clicks.

Areas of improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them. However, the system can be more intuitive in suggesting that the user can change the problem by clicking on that problem and using the right swipe gesture.

Change Radiology/Imaging Order

In this task the participants were asked to change the radiology order. All participants were able to successfully complete the task

Major Findings

This was an easy task and the participants like the functionality to quickly change the order.

Areas of improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them.

Change Laboratory Order

In this task the participants were asked to change a lab order. All participants were able to successfully complete the task

Major Findings

This was an easy task and the participants like the functionality to quickly change the order.

Areas of improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them.

Review Past Medication List, Create Order, and Adjust the Severity Level of Interaction

In this task the participants were asked to create a medication order after reviewing the past medication history and adjust the severity level of the interaction displayed. This was a relatively difficult task as only 9 of 10 were able to complete it successfully.

Major findings

Participants found this task difficult and there was a large variability in the times as seen from the high standard deviation (18.42 seconds). The path deviation (1.1) was also relatively higher. Most of the participants did manage to complete the task.

Areas of improvement

The system can be improved to adjust the severity in a more user-friendly way not prompting so many steps from the users.

Cancel Prescription

In this task the participants were asked to cancel a prescription that was created. All participants were able to successfully complete the task.

Major Findings

The participants liked the right swipe feature, which is consistent through the Apollo app and makes it intuitive to take actions.

Areas of improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them.

Review Clinical Decision Support that are triggered

In this task the participants were asked to review the CDS that were triggered due to Problem List, Medication List, Demographic List, Lab Test, Vital Signs, Demographics & Medication List. All participants were able to complete the task successfully.

Major Findings

The participants like the manner in which the CDS were triggered. They were appreciative of the ease with which they were able to complete this task. The participants also like the fact that they could take actions easily based on the CDS.

Areas of improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them.

Access the attributes of the Demographics, and Demographics & Medication List interventions triggered

In this task the users were asked to locate and acknowledge the attributes of the intervention that included bibliographic citation, developer, funding source, release/revision date. All participants were able to complete the task successfully

Major Findings

Participants were able to easily locate the attributes and were appreciative of the layout of the attributes and the consistency of it's the design compared to the other modules of the system.

Areas of improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them.

Review Clinical Decision Support triggered for Medication Allergy

In this task the participants were asked to add an Allergy and review the CDS triggered. All participants completed the task.

Major Findings

Participants were able to easily locate the CDS that was triggered after they added the allergy. It was an easy and intuitive task.

Areas of improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them.

Receive and Review Fill Status Notification

In this task participants were asked to review a received fill status notification from the pharmacy. All participants were able to complete the task successfully.

Major Findings

The participants loved how easy it was to receive and review the notification. The design icon stood out and it was intuitive to the users to know where to go to see this notification. The participants were appreciative of the seamless flow of this task.

Areas of Improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them.

Refill Prescription

In this task participants were asked to refill a prescription for a patient. All participants were able to complete the task successfully.

Major Findings

Participants had no problem in completing this task due to the very clear message that was received prompting them where to go to refill the prescription. Some of the participants did take additional steps to complete this task as seen from the path deviation (1.1)

Areas of Improvement

Since most of the participants were able to complete the task without any help no major improvements were suggested by them. However, the system can be optimized and streamlined in a way to guide the users to the refill screen without the extra clicks that some of the participants performed.

Request and Import Medication History

In this task participants were asked to import medication history of a patient from Surescripts. All the participants successfully completed the task.

Major Findings

Participants were very appreciate of how easy it is to access and download the medication list. The workflow is very similar to other areas of the system and makes it intuitive for all the users as seen from the low standard deviation (3.7 seconds).

Areas of Improvement

Since all participants completed this task without any help, no major suggestions for improvement were given by them.

Change Prescription (Dosage)

In this task the participants were asked to change the dosage on a prescription. 9 out of 10 participants completed this task successfully.

Major Findings

Most of the participants were able to complete this task. The participants liked the simplicity of the workflow via the messages section to perform the task. They found the system to be very intuitive as its interface was similar to that of other cards of the product.

Areas of Improvement

Since most of the participants completed this task without any help, no major suggestions for improvement were given by them.

Appendix

Appendix 1: System Usability Scale Questionnaire

(1 = Strongly Disagree 5 = Strongly Agree)

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

Appendix 2: Recruiting Form (Participant Intake Sheet)

Name: _____

Gender: _____

Age: _____

Organization: _____

Phone Number: _____

Email: _____

What is your Current Position?

- Licensed Nurse
- Medical Assistant
- Physician
- Physician Assistant
- Administrative Staff Member
- Other: _____

How long have you held this position? (Years) _____

Which of the following describes your highest level of education?

- High School Graduate/GED
- College Graduate
- Post Grad (MD/PhD etc.)

Do you also work in a hospital setting?

- No, I only work in clinics.
- Yes, I work in both hospitals and clinics

Do you have a research interest in any EHRs or related companies?

- Yes
- No

What sort of activities do you perform on a computer/tablet? (Select all that apply)

- Email
- Access EHR
- Research
- Word Processing

- Reading News
- Social Networking
- Shopping/Banking
- Other: _____

How many years have you been using a computer/tablet? (Years)

- 0-5
- 5-10
- 11-25
- 26-35
- 36+

How many years have you been using MD Synergy EHR? _____

What other EHRs have you used? : _____