Supplementary Material

Appendix A Materials and Methods

Detailed Materials and Methods Used throughout the Experiment

A within-subject experimental study was undertaken with emergency department (ED) physicians, with each assigned four standardized clinical documentation tasks using a commercial electronic health record (EHR). Participants navigated the EHR and documented patient information for simulated patients. The order of task completion was allocated randomly, with half of the tasks assigned to keyboard and mouse (KBM) and half to speech recognition (SR).

The four documentation tasks were representative of those commonly undertaken within an EHR by ED physicians and included patient assignment, patient assessment, diagnosis, orders, and patient discharge. Tasks were chosen in consultation with senior ED clinicians, who did not further participate as subjects in the trials. All simulated patients had active records available in the experimental version of the standard ED EHR.

To allow for variation in task complexity, four of the eight tasks were designed to be simple and four complex. Complexity was measured by the number of subtasks, with the simple tasks having two subtasks and complex tasks having four.

The clinical software used for the experiment was the Cerner Millennium suite with the FirstNet ED component (v2015.01.11) and Nuance Dragon Medical 360 Network Edition UK (v2.4.2) speech recognition software. Both were configured to replicate the operation of the EHR that subjects used daily. All user actions were automatically logged, down to individual keystrokes, with recording software. Session EHR screens and audio were also separately recorded with a high-definition multimedia interface capture device.

Thirty-five participants volunteered from three urban teaching hospitals in Sydney, Australia, from an eligible population of approximately 100 ED clinicians. To be eligible, subjects must have previously completed training in the EHR system, including specific SR training (EHR: 4 hours, SR: 2 hours). Clinicians were excluded if they had a pronounced speech impediment or physical disability that might affect system use.

It was estimated that a sample size of 27 clinicians would be sufficient to test for differences in time efficiency and error rates when using a *t*-test with a significance level of 0.05 and power of 0.95. Calculations were performed using G*Power (v3.1).

A System Usability Scale (SUS) questionnaire was completed at the end of the trial to gather participants' options on the EHR and SR systems. The results of this questionnaire are to be examined in a separate article.

The study was approved by the university and participating hospitals' ethics committees. The trials took place over two separate 2-month periods, commencing March 2015 for Experiment 1 and May 2016 for Experiment 2.

Appendix B Participants' Tasks

Tasks Undertaken by Trial Participants

Chloe Centauri

Chloe Centauri is a 31-year-old female who presented to the emergency department (ED) with neck pain today. She is yet to be seen by a doctor.

Using the **keyboard and mouse**, complete the following tasks:

A. Assign yourself as Chloe's provider—use the "Assign provider" icon.

B. Perform an ED assessment on Chloe—Use the "Documentation" icon.

Enter only the following data within the note:

Chief complaint—Present complaint: Neck pain.

Chief complaint—History of present illness: Aggravation of long-term neck issue.

Histories—Past medical history: 7-year history of degenerative joint disease.

Histories—Family and social history: Lives with elderly mother and father.

Ryan Rocket

Ryan Rocket is a 68-year-old male who presented to the ED with arm pain today. He is yet to be seen by a doctor.

Using **speech recognition** wherever possible, complete the following tasks:

A. Assign yourself as Ryan's provider—Use/say the "Assign provider Speech Rec" command.

B. Perform an ED assessment on Ryan.

- Use/say the "ED Assessment Speech Rec" and "ED Assessment Template" commands.

Enter only the following data within the note:

Chief complaint—Present complaint: Arm pain.

Chief complaint—History of present illness: Short-term stabbing pain in right forearm.

Histories—Past medical history: Removal of ruptured appendix 5 years ago.

Histories—Family and social history: Lives with wife and two children.

Terry Troposphere

Terry Troposphere is a 76-year-old male who presented to the ED with chest tightness today. He is already assigned as your patient and has been triaged as category 3.

Using the **keyboard and mouse**, complete the following tasks:

A. View Terry's vital signs and note latest BGL—Use "ED Summary MPage" icon.

B. Add a diagnosis for Terry—Use "Diagnosis, Alerts & Problems" icon.

Enter only the following data within the note:

Diagnosis: Chest tightness.

Diagnosis comments: BGL is "X.X"

(X.X = the BGL value found in Terry's vital signs)

C. Add an order for Terry—Use the "Add Order" icon.

Enter only the following data within the note:

Order: Full blood count (FBC).

Current clinical history (mandatory): Chest tightness.

Clinician collect: No, **Collection date/time:** Today/Now.

D. Create a discharge note for Terry—Use the "Depart Process" icon and then "ED Discharge Summary" icon.

Enter only the following data within the note:

Visit information—Summary of care: The patient appeared with chest tightness.

Health status—Add diagnosis: *Include the "Active" diagnosis in the note.*

Emma Eclipse

Emma Eclipse is a 57-year-old female who presented to the ED with chest discomfort today. She is already assigned as your patient and has been triaged as category 3.

Using **speech recognition** wherever possible, complete the following tasks:

A. View Emma's vital signs and note the latest BGL—Use (say) the "ED Summary MPage Speech Rec" command.

B. Add a diagnosis for Emma—Use (say) the "Diagnosis Speech Rec" command.

Enter only the following data within the note:

Diagnosis: Chest discomfort.

Diagnosis Comments: BGL is "X.X."

(X.X = the BGL value found in Emma's vital signs)

C. Add an order for Emma—Use (say) the "Order Speech Rec" command.

Enter only the following data within the note:

Order: Full blood count (FBC).

Current clinical history (mandatory): Chest discomfort.

Clinician collect: No, **Collection date/time:** Today/Now.

D. Create a discharge note for Emma.

– Use (say) the "Discharge Referral Speech Rec" command.

Enter only the following data within the note:

Visit information—Summary of care: The patient appeared with chest discomfort.

Health status—Add diagnosis: *Include the "Active" diagnosis in the note.*

Appendix C Experiment Specifics

Specific Details of Experiment Systems

Materials

Participants were provided physical task sheets (including variables to input) and reference guides. The system usability survey was paper based, provided at the conclusion of each trail.

Software Systems

The system(s) used within the study were established after an investigation of the commonalities and necessities of currently available systems within the Australian marketplace. The chosen software packages were representative of common EHR systems, and speech recognition systems, covered all core elements for standard clinical documentation and were available for both research access and commercial use within Australia.

A test domain (including testing versions of EHR software) was used, with fictional predefined clinician and patient data created that was replicated for each study participant. Clinicians were logged into the system(s) with credentials specifically generated for the trial; no real/live patient data were accessed during the trial.

Permission to utilize these test domains was sought at both the local health district (LHD) level and through State Health.

EHR software

The EHR software used within the trial was FirstNet, the ED information management system component of Cerner's Millennium Health Network Architecture suite of products (E1 v2012.01.30, E2 v 2015.01.11).

Speech Recognition Hardware and Software

The speech recognition software was Nuance's Dragon Medical 360 Network Edition UK (E1 v2.0 - 12.51.200.072, E2 v2.4.2–12.51.214.037/045 with vSync enabled).

Monitoring Software

Data logging/screen capturing software: Specific data logging software allowed real-time monitoring of task steps, completion time, method comparison, and error capturing. TechSmith's Morae (v3.3.3) usability testing software was used throughout the trial.

Display Feed Capturing

An Elgato Game Capture HD60 was utilized as a secondary method of session recording.

Dragon Medical 360 Network Edition Data

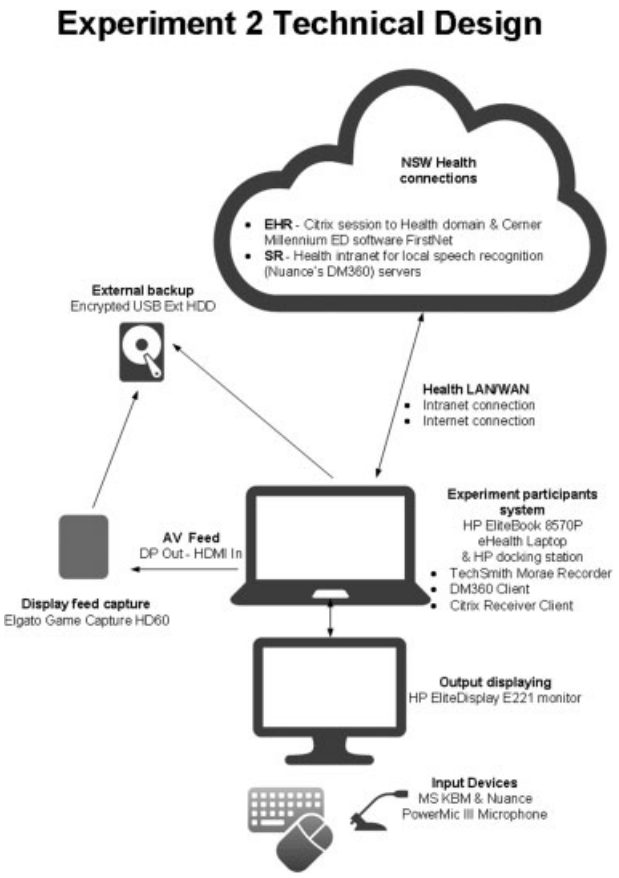
Trends or very simple usage statistics were available within the speech recognition software management console.

Hardware

A State Health laptop was configured to access the test domain (HP EliteBook 8570p). A microphone (E1 Nuance PowerMic II, E2 Nuance PowerMic III), USB keyboard and mouse (Microsoft Wired Desktop 600), and display monitor (HP EliteDisplay E221) were utilized by participants throughout the study.

Appendix D Experiment Technical Design

Diagram of Experiment Technical Configuration



Appendix E: Issues and Errors Observed

Summary of Issues and Errors Observed during Experiment 1

	Observed errors and issues
01	Incorrect patient
02	Incorrect patient—user corrected
03	No BGL entered
04	Incorrect BGL entered
05	Incorrect order collection date/method entered
06	Section of EHR missed
07	Data entered in incorrect EHR field
08	Section of EHR missed
09	Clinician closed EHR
10	User added trivial word (e.g., "and")
11	Omitted trivial word (e.g., "is")
12	Incorrect trivial word entered
13	Incorrect trivial word entered—user corrected
14	Incorrect significant word entered (diagnostic)
15	Omitted significant word (diagnostic)
16	Template brackets not removed (accept defaults missed)
17	Incorrect method of EHR menu navigation used
18	Word mangled (letters repeated or cut off)
19	Word mangled—user corrected (letters repeated or cut off)
20	Additional unnecessary word(s) (e.g., "and")
21	Misrecognition of word by SR
22	Misrecognition of word by SR—user corrected
23	All elements of command did not complete
24	Navigational command went nowhere or to wrong place/chart
25	EHR slow—system lag
26	EHR crashed
27	Element of EHR down, e.g., vitals
	Typographical errors
28	Missing full stop
29	Capitalization error
30	Missing comma(s)
31	Hyphen error
32	Plural form error (missing/added "s")
33	Spelling error

Appendix F Error Classification Tables

Errors Observed and Their Assigned Labels

	Potential patient harm errors			Integration/System, user or comprehension (error type)			Omission or commission errors (user error type)	
Observed error	**Minor**	**Moderate**	**Major**	**Integration/ System**	**User**	**Comprehension**	**Omission**	**Commission**
Incorrect patient—user corrected		X			X			X
No BGL entered		X			X		X	
Incorrect BGL entered			X		X			X
Data entered in incorrect EHR field			X		X			X
Section of EHR missed			X		X		X	
User-added trivial word (e.g., "and")	X					X		X
Omitted trivial word (e.g., "is")	X					X	X	
Incorrect significant word entered (diagnostic)			X		X			X
Omitted significant word (diagnostic)			X		X		X	
Template brackets not removed (accept defaults missed)	X				X		X	
Incorrect method of EHR menu navigation used	X				X			X
Additional unnecessary word (e.g., "and")	X			X		X		
Misrecognition of word by SR			X	X				
Misrecognition of word by SR—user corrected		X		X				
All elements of command did not complete	X			X				
Command went nowhere or to wrong place/chart	X			X				
EHR crashed	X			X				
Element of EHR down, e.g., vitals			X	X				
Typographical errors								
Missing full stop								
Capitalization error								
Hyphen error								
Plural form error (missing/added "s")								
Spelling error								
Space error								

Appendix G Repeat Participants Error Summary Table

Error Summary Table for Repeat Participants

Errors								
Experiment 1			**Experiment 2**			**M-W Experiment 1 vs. Experiment 2**		
	KBM	**SR**		**KBM**	**SR**		**KBM**	**SR**
Total errors observed	**103**	**142**	**Total errors observed**	**62**	**84**		***p*-Values**	
Non-typographical	**18**	**51**	**Non-typographical**	**8**	**49**	**Non-typographical**		
Simple	9	23	Simple	2	31	Simple	0.457	0.682
Complex	9	28	Complex	6	18	Complex	0.473	0.106
Potential patient harm	***18***	***51***	***Potential patient harm***	***8***	***49***	***Potential patient harm***		
Major	**6**	**22**	**Major**	**4**	**20**	**Major**		
Simple	2	12	Simple	1	15	Simple	0.317	0.589
Complex	4	10	Complex	3	5	Complex	0.564	0.096
Moderate	**2**	**6**	**Moderate**	**2**	**3**	**Moderate**		
Simple	0	1	Simple	1	3	Simple	0.317	0.317
Complex	2	5	Complex	1	0	Complex	0.317	0.025
Minor	**10**	**23**	**Minor**	**2**	**26**	**Minor**		
Simple	7	10	Simple	0	13	Simple	0.109	0.608
Complex	3	13	Complex	2	13	Complex	0.655	1.000
Error mechanism	***18***	***57***	***Error mechanism***	***8***	***49***	***Error mechanism***		
Integration/System	**1**	**28**	**Integration/System**	**0**	**33**	**Integration/System**		
Simple	0	16	Simple	0	18	Simple	1.000	0.952
Complex	1	12	Complex	0	15	Complex	0.317	0.477
Use errors	**11**	**22**	**Use errors**	**8**	**13**	**Use errors**		
Simple	5	7	Simple	2	10	Simple	0.257	0.317
Complex	6	15	Complex	6	3	Complex	1.000	**0.006**
Comprehension	**6**	**7**	**Comprehension**	**0**	**3**	**Comprehension**		
Simple	4	0	Simple	0	3	Simple	0.196	0.392
Complex	2	7	Complex	0	0	Complex	0.277	0.406
Error genotype	***17***	***23***	***Error genotype***	***8***	***17***	***Error genotype***		
Omission	**5**	**12**	**Omission**	**1**	**8**	**Omission**		
Simple	2	7	Simple	1	8	Simple	0.317	0.655
Complex	3	5	Complex	0	0	Complex	0.083	0.059
Commission	**12**	**11**	**Commission**	**7**	**9**	**Commission**		
Simple	7	0	Simple	1	6	Simple	0.131	0.034
Complex	5	11	Complex	6	3	Complex	0.783	**0.005**
Typographical	***85***	***91***	***Typographical***	***54***	***35***	***Typographical***		
Simple	56	46	Simple	37	20	Simple	0.143	**0.010**
Complex	29	45	Complex	17	15	Complex	0.022	0.002