Chapter 9
Utilising Mobile Electronic Health Records in Clinical Education

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9.1 Introduction

Health information technologies (HIT) are increasingly being used in clinical environments to manage patient care (Graham-Jones, Jain, Friedman, Marcotte, & Blumenthal, 2012). The use of electronic health records (EHRs) in particular is now considered an integral part of primary care and hospital practice (Blumenthal & Glaser, 2007). The potential advantages of EHRs in health care are numerous, but importantly include greater efficiencies, and improved quality of care and patient safety.

Despite the increasing use of EHRs in clinical practice, explicit teaching of EHR-related skills to trainee clinicians is often lacking (Ellaway, Graves, & Greene, 2013). A recent review of the implementation and evaluation of e-Health education in entry level degrees that prepare students to enter clinical practice found little evidence of formal curriculum initiatives (Gray, Dattakumar, Maeder, Butler-Henderson, & Chenery, 2014). While the study took a broad approach to e-Health competencies, defining e-Health as "the combined use of electronic communication and information technology in the health sector" (Gray et al., 2014, p. 7), teaching efforts specifically aimed at EHR-related competencies are also scarce.

Medical schools would be hard-pressed to find formal recommendations for the teaching and assessment of EHR-related competencies. The American Accreditation Council for Graduate Medical Education (ACGME), for example, describes six

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core competencies that residents are required to master at key stages of their medical training, none of which are specifically related to EHR skills (Wald, George, Reis, & Scott Taylor, 2014). Within an Australian context, the Australian Medical Council (AMC) lists only one general EHR-related requirement in its graduate outcome statements—"Retrieve, interpret and record information effectively in clinical data systems (both paper and electronic)" (AMC, 2012, p. 3). While the Australian Curriculum Framework for Junior Doctors (CPMEC, 2012) provides more detail on the EHR-related competencies expected of a junior medical officer, it fails to provide an integrated view of EHR-related skills. Instead it makes a questionable distinction between electronic skills and health record skills and places them in different learning areas, for example:

> Electronic
> - Uses electronic resources in patient care e.g. to obtain results, populate discharge summaries, access medicines information.
> - Complies with policies regarding information technology e.g. passwords, e-mail & internet, social media (CPMEC, 2012, 'Communication, Managing Information, Electronic,' para. 1).

> Health Records
> - Complies with legal/institutional requirements for health records.
> - Uses the health record to ensure continuity of care.
> - Provides accurate documentation for patient care (CPMEC, 2012, 'Communication, Managing Information, Health Records,' para. 1).

Despite the lack of recommendations from national standards and assessment bodies, the use of EHRs is viewed as "an exciting and welcome advance in patient care" (Peled, Sagher, Morrow, & Dobbie, 2009, p. 4) that, with appropriate implementation and training, can enhance medical education. Using EHRs for patient care involves numerous skills. Peled et al. (2009) recommend that students be taught the mechanics of documenting electronic patient cases, for example:

- Efficient management of data within electronic systems (e.g. using drop-down menus and free-text fields for data entry, ensuring records are saved, navigating through systems)
- Accurate recording of information (e.g. accurate typing/keyboarding) and in sufficient detail to ensure continuity of patient care
- Effective retrieval of specialist medical information (e.g. medicines information)

Increasingly, the literature points to the importance of EHR skills that are necessary to maintain patient- and relationship-centred care (Duke, Frankel, & Reis, 2013; Silverman et al., 2014; Wald et al., 2014), for example:

- Effective integration of the computer into the consultation (e.g. optimising the position of the device, introducing the computer while logging in, verbalising shifts to the computer, integrating data entry around patients' needs).
- Using EHRs in a manner that encourages patient engagement, particularly in viewing and reviewing information.
- Articulating the benefits of EHRs to patients.

Recent initiatives to incorporate EHR-related skills training into medical education include a communication skills checklist for first-year medical students

(Morrow et al., 2009) and an online self-directed module for second year medical students (Han, Lopp, & Walters, 2012). Wald et al. (2014) also describe the iterative, systematic development of a longitudinal EHR curriculum for undergraduate medical education. The curriculum includes: an initial training session on EHR use for third-year clinical skills clerkship students, which introduces the computer into the clinician–patient interaction; a second advanced EHR training module for fourth year internship preparation and an expanded behaviour grid for introductory and advanced EHR training. Our own efforts to incorporate EHR-related skills training into the curriculum of our university's new Doctor of Medicine (MD) programme, have focused on the implementation of a student-centred EHR system for clinical education. The rationale, design and development of the EHR system are described further in Sect. 9.2.4.

The novelty of incorporating EHR-related skills training into medical education means there is currently little evidence on its effectiveness. As Wald et al. (2014) point out in relation to implementation of their EHR curriculum,

> We have planned rigorous analyses of survey construction and validation practices, though at introductory stages of a much-needed curriculum, achieving the desired educational impact may take precedence over accessing validity and reliability data over the long term (p. 383).

Preliminary evaluation of a desktop application of our EHR system showed that students appreciated the learning benefits of the system and were positive about its functionality, yet they often found it impractical to use in the clinical environment because of inadequate access to hospital computers (Elliott, Judd, & McColl, 2011). These initial findings were encouraging in terms of the potential of the EHR system as a tool for learning EHR-related skills, yet at the same time they raised questions about the system's accessibility that warranted further investigation.

Clinicians are increasingly using mobile technology to access up-to-date information, communicate with colleagues around the world, and directly enter information into healthcare systems (Burdette, Herchline, & Oehler, 2008). Mobile devices have the potential to overcome issues of accessibility and to enhance point-of-care use of EHRs; they are portable, enable anytime/any place connectivity, offer flexible and timely access to resources, and provide immediacy of communication (JISC, 2005). Given the affordances of mobile technology, we proposed that by implementing our EHR system on mobile devices, students would be better supported to create and access health records either during or immediately after bedside interactions with patients.

Furthermore, there is growing evidence that mobile learning, or the use of mobile technologies to enhance students' learning experiences, can improve student performance of skills in the clinical environment. For example, the case presentation performance of fourth year medical students in the emergency department was significantly improved by the use of just-in-time mobile educational videos delivered via iPods (Tews, Brennan, Begaz, & Treat, 2011). Students also reported that they preferred this method of dissemination. Similarly, medical students who used iPods to view a video on chest tube insertion immediately prior to a simulated task, scored better on the skills checklist than the control group (Davis et al., 2012). Mobile technology has also been used successfully to deliver learning resources and

support to students on hospital placement. The use of iPods to access lecture materials and video podcasts of clinical skills as well as mobile phones to access library resources and tutor and peer support "was perceived as a positive and exciting development by students, offering them access to information and support where previously unavailable or where access to IT was limited" (Lea & Callaghan, 2011, p. 140). Pimmer, Linxen, Grohbiel, Jha, and Burg (2013) also found students used mobile technology to enrich educational practices in a resource-constrained environment. Personal digital assistants (PDAs) loaded with high-quality educational resources and given to students for the duration of their clinical studies, tended to be used 'on the go'—between patients or scheduled teaching activities and on the wards for quick access to references (Davies et al., 2012).

The studies described above primarily examine the effectiveness of mobile learning in the clinical environment from the perspective of information retrieval for educational purposes. To our knowledge, no studies have investigated a mobile tool for the clinical environment, which incorporates data entry in support of EHR creation and management, and that has been designed for students to use while directly interacting with patients. When it comes to teaching EHR-related skills, it is unclear which methods or tools, particularly mobile tools, are effective. Nor is it clear at which stage of their clinical training students would gain the most benefit from EHR-related skills training.

For these reasons, we undertook a mixed methods study that aimed to build on the literature about recent initiatives to incorporate EHR-related skills training into medicine education. The study had two major aims; firstly, it sought to investigate the effectiveness of a student-centred EHR system as a tool for learning EHR-related skills, focusing on how medical students used the tool to scaffold their patient interviews. Secondly, the study sought to explore the perceptions and use of a mobile version of the EHR system as a learning tool in the clinical environment, with a particular focus on how students used it for data entry in support of record creation and management while directly interacting with patients.

9.2 Method

The study was conducted with approval from the host university's human research ethics committee.

9.2.1 Participants

A cohort of fourth year medical students on clinical placement ($n = 47$) were invited to participate in the study. These students were enrolled in a 6-year undergraduate medical programme and this was their first clinical placement. At this time, our

university was running two medical programmes; an existing undergraduate programme that was scheduled to end in 2013 and a new 4-year masters level MD programme that commenced in 2011. Thirty-nine students initially agreed to participate: five participants withdrew during the study, giving a final participation rate of 72 %. Equal numbers of female and male students completed the study with an average age of 22.9 years (*min* = 20.9; *max* = 28.0).

9.2.2 Procedure

A longitudinal crossover study design was adopted to investigate student perceptions and clinical use of the EHR system implemented on mobile devices. The study took place in a metropolitan teaching hospital over one teaching semester from July to November 2011—19 weeks in total.

The EHR software was installed on two classes of mobile devices—iPads and Netbook computers—as well as being provided on USB memory stick. These memory sticks were 'mobile' in the sense that they could be carried around the clinical environment, but their use is better characterised as 'fixed' in that they needed to be plugged into a hospital or clinical school computer in order to access the EHR software, which could be run directly from the memory stick without any additional installation.

Students had access to a high performance wireless network in the clinical school, but prior testing across hospital locations showed varying levels of connectivity to the G3 mobile network and the hospital's wireless network. WiFi access was freely available in some areas of the hospital, but was restricted in others. To overcome this, the iPads and Netbooks used in the study were both WiFi and 3G enabled, so that if students had difficulty accessing one network they could swap to the other. Students were shown how to do this during the training session described below.

Participants were randomly allocated to three groups according to the design outlined in Table 9.1, which was dictated by the number of available iPads and Netbooks. Students allocated to these groups used each device for 5 weeks before crossing over to another, ensuring they had the opportunity to use and compare all three devices (i.e. iPad, Netbook and USB memory stick). The remaining nine students, who were not assigned to one of the three crossover groups, were assigned to an ancillary group and each provided with the EHR software on a USB stick to use during the course of the study.

At the beginning of week 1, students attended a training session facilitated by the researchers to introduce the EHR software, demonstrate its functionality and explain how each device operated. Students had the remainder of the week to test devices, trial the EHR software and create test records. At the end of week 1, all test records were cleared from the system. Timely technical support via e-mail was provided to students for the duration of the study. In a small number of cases, a technical person

Table 9.1 The study design

Week(s)	Group 1 ($n=8$)	Group 2 ($n=8$)	Group 3 ($n=9$)
1	Training session and testing		
2–6	iPad	Netbook	USB drive
7	Focus groups and device crossover		
8–12	USB drive	iPad	Netbook
13	Focus groups and device crossover		
14–18	Netbook	USB drive	iPad
19	Focus groups and device collection		

visited the study site to resolve individual issues that couldn't be resolved via e-mail. Students were encouraged to enter at least one patient record per week. At the time of the study, the use of the mobile EHR system and the creation of patient records was not formally integrated into the clinical curriculum. This meant that students' submissions were not formally monitored or assessed.

9.2.3 Data Collection and Analysis

Throughout the study, participants' movements and activities within the EHR system were electronically recorded. This dataset was analysed to determine frequency and location of use by students.

Students were interviewed in small groups (3–4 students) about their use and perceptions of the EHR system at the end of each 5-week period and at the end of the study. Interview questions focused on: general usability of the EHR system (e.g. system functionality, which components students used, did components operate as expected, potential improvements); general usability of the mobile device on which the EHR software was implemented (e.g. functionality, connectivity, ease of use, usage challenges, use in the hospital environment, use at home) and the usefulness of the EHR system for learning.

Focus group interviews were audio-taped, transcribed and the written transcripts manually analysed to identify emerging themes. One researcher (KE) undertook an initial coding of the data with constant comparison of the 19 datasets (one from each focus group session). The coding categories were then discussed amongst the research team and modified until agreement of the major themes was reached. Using this process, student comments related to the usefulness of the EHR system for learning were categorised into four major themes: record content and structuring; patient management; case presentations and electronic health record skills. Student comments related to the use of the mobile EHR system in the hospital setting were categorised into three major themes: portability; network connectivity; and patient encounters. Selected quotes have been used to illustrate the key themes identified.

9.2.4 The EHR System

The EHR system used in this study was developed to facilitate the learning and teaching of EHR-related skills to medical students on clinical placement. The rationale behind its development was that EHR use is better learned through direct hands-on practice than through classroom or lecture activities (Zelnick & Nelson, 2002). It was thought that through using the system, students would develop expertise in the practice of documenting high quality electronic patient records, and would develop an awareness of the potential benefits of EHR use in patient care.

The system was considered to be student-centred because it was explicitly designed for the purpose of clinical education: it did not play any role in authentic hospital administration or management. The initial design was based on commercially available clinical software products currently used for general practice and hospital pre-admission clinics, which was modified or simplified for student use. Further adaptation and refinement for educational purposes, such as the addition of prompts, functionality that allowed clinical supervisors to provide feedback on students' patient records, and a section for student reflection, were made using an iterative design process, informed by medical and clinical educators, educational designers and students.

The system was secure, requiring students to sign in using their university username and password and all patient information entered into records was de-identified. A message reminding students they were required to obtain patient consent before entering any patient information was presented each time a new record was created. By dismissing this message, students were formally agreeing that patient consent has been obtained. Students were then free to enter data about their patient in a section entitled 'Basic Details' via a series of drop-down menus and text fields (Figs. 9.1 and 9.2).

Further patient information was entered mostly via a series of free-text fields organised under the following sections: Presenting Problem, Past Medical History, Family History, Social History, Medications, Health Maintenance, Physical Examination, Investigations, Diagnosis, Management, and Notes (see Fig. 9.1). The Medications section allowed users to add new medications using a predictive entry field linked to a comprehensive list of available drugs and pharmaceutical preparations from the Australian Medicines Handbook (2014). Drugs could be entered using either their generic or trade names. Each new medication was automatically linked to the appropriate drug information sheet from the Australian Medicines Handbook (2014), which could be accessed and viewed within the EHR software. The Notes section was intended to be a space for reflection where students could enter personal reflections about a patient, their condition, treatment and management, as well as broader issues such as the healthcare system, or the students' own learning.

The EHR software also captured a record of the location where the patient record was entered (e.g. home; clinical school; hospital ward; other areas of the hospital including, emergency department, ambulatory care, library, computer room, public areas).

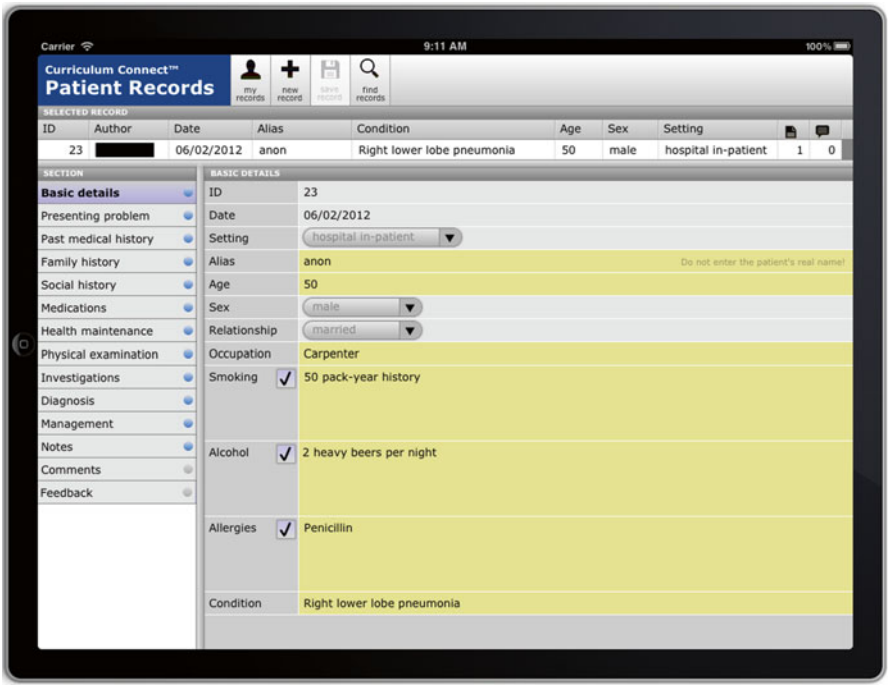

Fig. 9.1 The EHR software interface for entering patients' basic details (*Note*: Other sections of the patient record are listed in the left hand side menu)

9.3 Results

9.3.1 A Useful Learning Tool

Student perceptions of the EHR system as a learning tool were generally positive. For example:

> *It was useful for me because the first time I did my history … it was the first Monday that we got here. One doctor just said, 'Go take a history' and I was so lost. I went back and I put my thing [USB drive] into the system and I realised this is what I should have done. And after that… when I'm taking a history it's still messy… and I guess as I go along I'll get more organised. So I don't know how useful the system will be in the future, but it is definitely helping me organise my notes right now*. (Female student A, Group 3, Interview 1)

Thematic analysis of the student interview data revealed four major themes relating to the usefulness or helpfulness of the EHR system for learning: record content and structuring; patient management; case presentations; and electronic health record skills.

ID	Author	Date	Alias	Condition	Age	Sex	Setting		
15	cewert	06/02/2012	BB	Colorectal adeno-carcinoma	49	male	hospital in-patient	1	0
23	pnaimo	06/02/2012	anon	Right lower lobe pneumonia	50	male	hospital in-patient	1	0
25	cewert	06/02/2012	anon	infective exacerbation of COPD, rig	50	male	hospital in-patient	1	0
31	pnaimo	07/02/2012	Bowl cancer	Bowl cancer	49	male	hospital in-patient	1	0
34	cewert	07/02/2012	ABDO PAIN 1	Pseudomembranous collitis	32	male	hospital in-patient	0	0
35	pnaimo	08/02/2012	Geoff Aaronson		85	male		0	0
36	cewert	08/02/2012	Geoff Aaronson	Cellulitis	85	male	hospital in-patient	0	0
38	pnaimo	08/02/2012	Joe Coronary	Unstable Angina	67	male	hospital in-patient	1	0
39	cewert	08/02/2012	Mr P	STEMI	50	male	hospital in-patient	0	0
40	pnaimo	08/02/2012	Mr MI	post STEMI	50	male	hospital in-patient	0	0
41	cewert	08/02/2012	Joe Coronary	Unstable angina	67	male	hospital in-patient	0	0
42	pnaimo	08/02/2012	AC (test)	Skin/tissue infection	55	male	hospital in-patient	0	0
43	cewert	08/02/2012	AF	Fractured Right foot (multiple)	47	male	hospital in-patient	1	0
44	pnaimo	08/02/2012	P.H	Well-looking, alert, no pain/distres	41	male	hospital in-patient	1	0
48	cewert	08/02/2012	CA	Prostate cancer		male	hospital in-patient	1	0
49	pnaimo	08/02/2012	MA	5 fractures in foot	47	male	hospital in-patient	1	0
51	cewert	09/02/2012	KA	Bruising/fracture of R lateral chest	65	male	hospital in-patient	0	0
53	pnaimo	09/02/2012	D	Suspected subclinical internal blee		male	hospital in-patient	1	0
56	cewert	09/02/2012	Mr. D			male	hospital in-patient	1	0
57	pnaimo	09/02/2012	BH	Atrial Fibrillation	64	male	hospital in-patient	1	0
58	cewert	09/02/2012	Mr NS	Ascites secondary to chronic liver c	63	male	hospital in-patient	0	0

Fig. 9.2 The EHR software interface displaying a summary list of patient records

9.3.1.1 Record Content and Structuring

A number of students in the study reported using the EHR system as a template for patient interviews, describing how this helped them to determine what sort of patient information to record and how detailed this information needed to be:

It really helped with me thinking about the whole history taking framework. It had everything I needed to take down. I basically developed my history taking from the software (*Male student A*, *Group 2*, *Interview 1*)

… because this is the first time we've been interviewing patients I thought the programme was really helpful because when we started I did the history, but I didn't realise what segments were important and the programme had past history, medications, issues and so on and so forth. So when I was typing it in I realised that I didn't ask that … I didn't do that section and I should have. (Female student A, Group 3, Interview 1)

Students also reported that the software was useful for structuring patient information into a comprehensible record, and for identifying information gaps in their records that could be repaired by re-interviewing a patient:

I kind of found it a good exercise to sort of write patient notes in a coherent manner. Just typing it out I sort of wrote it as if I were writing admissions for emergency… so I found it quite useful. (Male student B, Group 2, Interview 1)

In terms [*of*] *being useful… it provides a template for us to put everything in there. If you've forgotten something you can … when you're typing into the software … you can see* '*Oh I forgot the alcohol or the allergies*.' *You can go back to the patient and ask them again*. (Male student A, Group 1, Interview 2)

Features of the Medications, such as predictive typing, and the linking of drug entries to the Australian Medicines Handbook (2014), seemed particularly valued by students.

B: *But I do think there is a lot of potential with the drugs*. (Male student B, Group1, Interview 1)
C: *Yeah I loved that*. (Female student C, Group 1, Interview 1)
B: *Because sometimes you see in* [*hospital*] *progress notes that someone has scribbled something down. It's like*, *Sal … buta … something. Type it in* [*the programme*] *it comes out eh*!
I quite like the fact that the drugs, *you click on them and they link you to the Australian Medicines Handbook and it teaches you about each drug*. (Male student C, Group 3, Interview 1)

9.3.1.2 Patient Management

The EHR system helped students to organise and manage information from multiple patients they had seen during their hospital placement:

It's a good way of keeping track of the patients you see. Because usually I write it on notepaper and it gets lost, *or I write it really messy and write it all over the page. So it's good to enter it all into a database*. (Female student B, Group 1, Interview 1)

…and in some cases, it actually prompted students to interview more patients.

It helped me to remember to clerk patients and interview patients. That's one of the other things that it helped me do. I'd be doing things and I'd be like, *oh yeah*, *I've forgotten to put in this week's*, *so I'd go and see a patient*. (Female student A, Group 1, Interview 1)

9.3.1.3 Case Presentations

The act of entering and structuring patient information into a comprehensive record appears to have been beneficial for several reasons. Firstly, several participants identified that sitting down and entering information into the EHR after interviewing a patient had given them the opportunity to reflect on the patient and rethink the patient's condition. Secondly, students commented that the process had assisted with case presentations because as they entered information they thought about how best to present it. For example:

It helps you with your presentation. Because when you write it, *you say*, *I should say this first …* (Female student D, Group1, Interview 1)

However, one participant felt that the process was helpful only during the early stage of case development because later it required input from a medical expert:

One of the hardest things right now is my long case[*s*] *and trying to organise it and this programme has helped me refine it along the way. I think I'm at the point where the aspects of my long case that need refining can't be refined by the programme. It needs input from other doctors. We have to present it as a summary, which requires more thinking than just typing something up. So the typing helps you at the beginning*. (Female students A, Group 3, Interview 1)

9.3.1.4 EHR Skills

Students were aware that the EHR system was allowing them to practice EHR skills:

I met a registrar. He showed me a very thick history [*paper-based*]—'*This is my patient. I haven't finished. I have to take six months to finish it.' I think that using this software maybe will train you to directly type* [*in*] *your work*. (Female student B, Group 3, Interview 1)

It was good because electronic health records are happening already and they're going to happen. It's good to get used to putting things in online. (Female student B, Ancillary group, Interview 1)

I just kind of viewed it as another administrative task… it was useful, but really only because it's good to learn another system and to wrap your head around putting records in electronically. (Female student A, Ancillary group, Interview 1)

Finally, several noteworthy observations were made by students, which did not fall into the major themes. The first of these was that the EHR system enabled reflection on learning progress:

It was kind of cool that I could see how my history taking had improved over time. (Female student A, Group 3, Interview 1)

The second was the excitement created by the potential benefits of an EHR system:

[*I was*] *a bit excited that this would work, in the sense that you don't have to struggle reading the ugly handwriting of the medical records of the random consultants. Like you could really see what letters they wrote instead of trying to interpret …* (Male student B, Group 2, Interview 1)

Although not all participants reported that the EHR system was helpful at this stage of their clinical training:

How useful it is for me personally. I don't know. I guess it's good to have a record of all of the patients I have seen. But having said that I haven't really gone back to look over them and I don't know if come closer to exam time, it would be something that I would do. (Male student B, Group 3, Interview 1)

…not something which I found that I felt like I really needed to use to supplement my learning. Maybe not at this stage. It's only been the first block at hospital. It's all been sort of getting used to everything. (Male student D, Group 3, Interview 1)

Table 9.2 Timing of patient records created by students in the three rotating groups

Group	1 ($n=8$)	2 ($n=8$)	3 ($n=9$)	Total ($n=25$)
End of first block	40	40	56	136
End of second block	77	84	97	258
End of third block	125	120	148	393
Average per student	15.6	15.0	16.4	15.7

9.3.2 Record Creation

By the completion of the study, students had created a total of 480 electronic records of patient encounters during their first clinical teaching semester. Those students in the three crossover groups created a combined total of 393 records, an average of 15.7 records per student (mean 15.7; *min* = 6; *max* = 22) (Table 9.2).

The cumulative frequencies of records created by students in each group are presented in Fig. 9.3. Each group followed a similar pattern of record creation over time, although there was a time lag in record creation by group 2 during the second and third block with most records being created in the last/latter week(s) of the block.

The number of records created by each device type and group are presented in Table 9.3. Overall, similar numbers of records were created by students in groups 1 and 2 regardless of device type: students in group 3 created slightly more records, particularly when they were using the iPad or the USB stick.

The number of records entered by students did not vary significantly between devices (iPad, 34 %; USB, 33 %; Netbook, 33 %), despite clear individual preferences being reported by students, for example:

The iPad itself, I didn't have any problems. I actually loved it … I took it to clinicals. I took it to the hospital. I took it to the ward (Female student A, Group 1, Interview 1)

I found myself carrying the iPad around much more than the Netbook (Male student B, Group 2, Interview 2)

After I got the iPad I went to the wards to try to use it [*to*] *record patients. It was difficult* (Male student A, Group 2, Interview 2)

If I [*was*] *given a choice between the Netbook and the iPad to enter data at the patient's bedside, I would prefer the Netbook because it's more feasible* (Male student C, Group 2, Interview 2)

… the easiest, quickest way to put in data was to hook up the USB and to type on a keyboard that we're used to. Rather than on the iPad which was slower and the Netbook, which was, you know, not too bad, but still it was half-way in-between (Male student A, Group 3, Interview 3)

I didn't mind using the USB … I mean I didn't find it an inconvenience to plug it in, type it up (Male student B, Group 3, Interview 1)

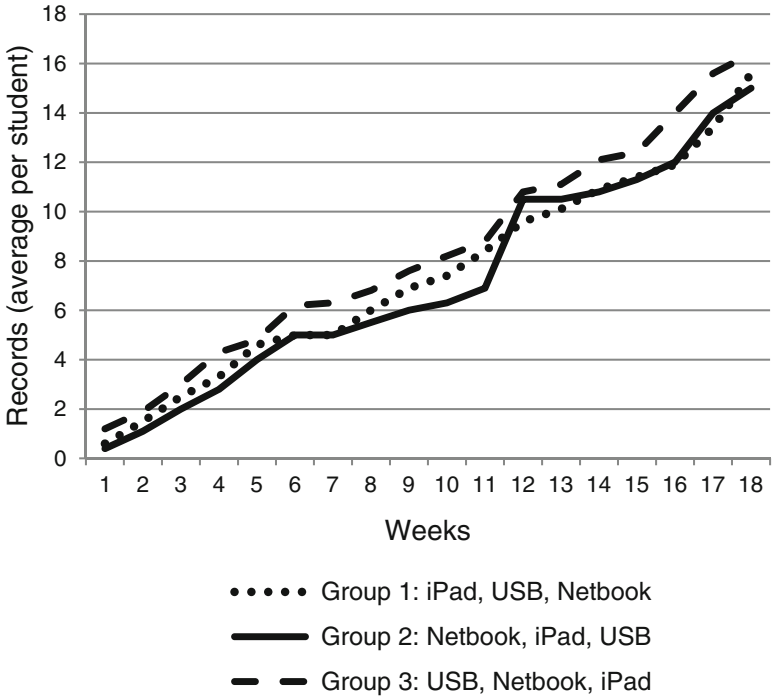

Fig. 9.3 Cumulative frequencies of records created by students in each rotating group

Table 9.3 Frequencies of records created using each device type in the three rotating groups

	Number of records (average per student)				
	Group 1 ($n=8$)	Group 2 ($n=8$)	Group 3 ($n=9$)	Total ($n=25$)	Total (%)
iPad	40 (5.0)	44 (5.5)	51 (5.7)	135 (5.4)	34
Netbook	48 (6.0)	40 (5.0)	41 (4.5)	129 (5.2)	33
USB	37 (4.6)	36 (4.5)	56 (6.2)	129 (5.2)	33
Total	125 (15.6)	120 (15.0)	148 (16.4)	393 (15.7)	

The main locations where students entered records are shown in Fig. 9.4. Unexpectedly, and somewhat disappointingly, the majority of records were entered at home (68 %), rather than in the clinical school (22 %) or hospital (6 %). Of the hospital locations, only 2 % of records were created on the wards: The remaining 'other' 4 % were created in either the Emergency Department, Ambulatory Care, library, computer rooms, or public areas such as the cafe. A few students reported entering records while on public transport.

The devices that were used to create records at each location are shown in Fig. 9.5. Of the three devices, iPads were most likely to be used to create records in locations outside the home or clinical school.

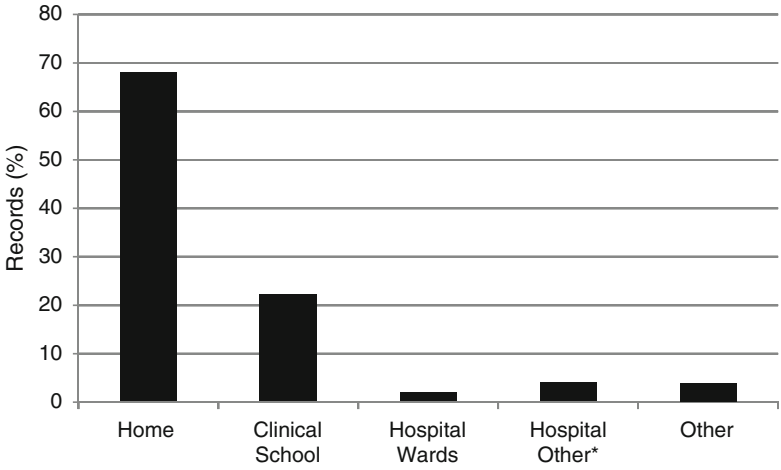

Fig. 9.4 Main locations where students entered patient health records. **Hospital Other* combines data for emergency department, ambulatory care, library, computer rooms and other public areas of the hospital

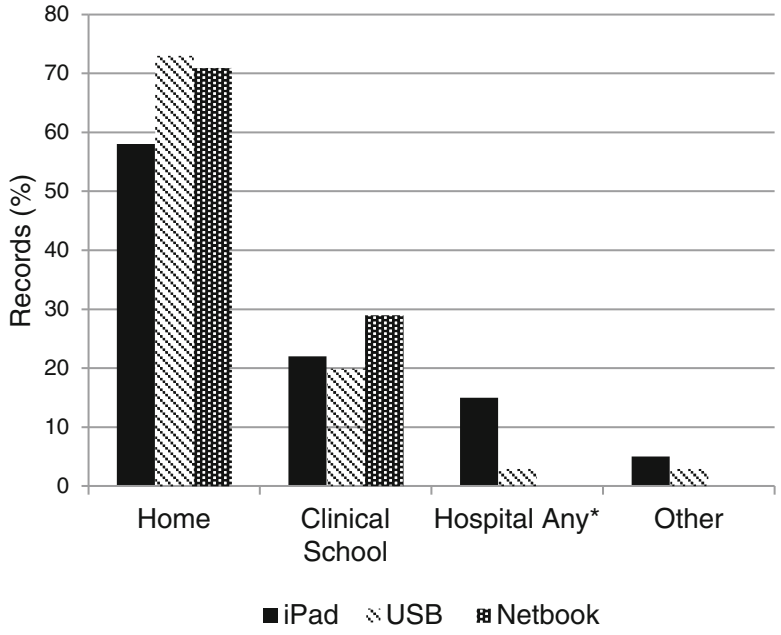

Fig. 9.5 Frequencies of records entered by location and device. **Hospital Any* refers to any location in the hospital, including wards

9.3.3 Use in the Clinical Environment

Students reported a number of concerns about the use of the mobile EHR system in the hospital setting, which were related to portability, network connectivity and their interactions with patients at the bedside.

9.3.3.1 Portability of Mobile devices

Students often felt that the iPads and Netbooks were not easy to carry around on the hospital wards. They reported having nowhere to put them while doing a physical examination and were concerned that they might be damaged or lost:

I found the iPad a lot easier to carry around… but I didn't actually use it at the bedside with a patient. I just felt it was too awkward (Female student B, Group 2, Interview 2)

But the Netbook itself is quite large… I just left it in my locker or at home. I didn't often bring it around. I would never bring it to the wards (Female student C, Group 3, Interview 2)

[*The USB drive*] *can be quite small and it was on my mind that I didn't want to lose it and I nearly did. That was annoying*. (Male student B, Group 3, Interview 1)

9.3.3.2 Network Connectivity

Students reported experiencing problems with network connectivity in the hospital. They encountered varying levels of connectivity to both the G3 mobile network and the wireless network at different times, which resulted in a slower or unreliable connection to the Internet.

I had the same internet problem… I found the signal too weak sometimes. There were times when it worked well and there were times when it didn't work. (Female student A, Group 1, Interview 3)

9.3.3.3 Mobile Device Use During Patient Encounters

When attempting to use the mobile EHR system during a patient interview at the bedside, students reported that the mobile devices created a barrier between themselves and the patient that impacted on their interactions with the patient.

… if you have a Netbook or an iPad that always acts as a barrier between you and the patient (Male student B, Group 1, Interview 1)

… the first time I tried entering a record while I was trying to talk to a patient—it made the interaction with the patient less personal… (Male student D, Group 3, Interview 3)

When you are there [*in the wards*] *you have to try and make eye contact with the patient … and there's nowhere to put the iPad when you are going through the examination* (Male student A, group 2, Interview 2)

Several students also raised concerns about bringing the iPad, which they perceived as a luxury item, to the wards and using it in front of patients from low socio-economic backgrounds.

I don't feel comfortable bringing the iPad to the ward… A lot of the patients are lower socio-economic status and I wouldn't want to bring an iPad and type on it in front of them. (Female student C, Group 3, Interview 2)

9.4 Discussion

Medical students have always learnt how to interview and manage patient encounters at the bedside; however, the use of a mobile EHR system that has the potential for direct entry and retrieval of patient information at the point-of-care presents new learning opportunities as well as challenges for students working within a framework of patient-centred care. The findings from this study of situated learning in a hospital setting provide valuable insights into how a student-centred EHR system functioned as a learning tool for EHR-related skills, but showed that its implementation on mobile devices did not result in students creating patient records at the bedside.

The findings from our interviews with students showed that the EHR system supported the learning of EHR-related skills by: scaffolding patient interviews; providing a means of managing information gathered from multiple patients seen on hospital placement; providing opportunities to practice EHR-specific skills; and raising awareness of the potential benefits of EHRs for patient care. The ways in which the system provided educational support for patient interviews, included:

- As a template for conducting the interview
- To clarify what information to seek from patients to record
- How to structure patient information into a comprehensible record
- To identify missing information in patient records

The ways that the EHR system supported the learning of EHR-related skills suggests that it went some way towards helping students develop the ability to manage data within an electronic system, and to record patient information in sufficient detail to ensure continuity of care.

The effectiveness of the system for learning, however, went beyond EHR-related skills. We identified that it also supported students in preparing key cases for presentation, prompted students to seek out more patient interviews, and allowed students to reflect on learning gains made throughout their hospital placement.

The diversity of ways that the mobile EHR system assisted students in the clinical environment, reflects the multifaceted nature of clinical learning when EHR-related

skills training, mobile learning and bedside pedagogy converge. Our findings provide a starting point for medical educators to understand these interactions and to leverage them for education opportunities. While the primary purpose of the mobile EHR system was for EHR-related skills training, we identified other education opportunities that it provided in the study. For example, key features of the system when combined with the mobile capabilities of portable devices, meant that students were able to access valuable diagnostic and treatment information (such as comprehensive drug listings and information sheets) 'on the go', in a similar manner to students using PDAs in the clinical environment (Davies et al., 2012). Some students in our study also reported accessing apps and web sites via the iPad for just-in-time learning, a brief educational experience targeting a specific need or clinical question (Kahn, Ehlers, & Wood, 2006). Although the majority of students used the mobile EHR system at home for record creation, some students did take the mobile devices to the clinical school and hospital to access information for educational purposes. Learning in the clinical environment, however, is not always immediate. One participant noted that sitting down and entering information after interviewing a patient at the bedside gave them an opportunity to reflect on the patient and their condition. In this case, the EHR system created an opportunity for learning that was not related to its mobility.

While many students in the study perceived the mobile EHR system to be a useful learning tool for the clinical environment, electronic monitoring data showed that the majority of patient records were not created in hospital locations. Moreover, this lack of in-situ use occurred irrespective of which type of mobile device students had access to. Our findings point to a number of reasons for this unexpected pattern of use. Firstly, network connectivity issues meant that WiFi or 3G connectivity was not always available across all hospital locations. Despite connectivity and internet speed previously being identified by students as barriers to the successful implementation of mobile technology (Vafa & Chico, 2013), a supportive technological infrastructure for educational purposes is often difficult for large work organisations, such as hospitals to achieve. Secondly, concerns about the size of the mobile devices, the ease of carrying them, or that they might be lost, meant they were often not taken to the wards. Similar concerns around theft and loss emerged as a barrier to the use of PDAs for accessing learning resources in the clinical environment by a cohort of undergraduate medical students (Davies et al., 2012). Of greater concern for students, however, appears to be their unfamiliarity with patient encounters. For example, a number of students commented that the system was not particularly helpful at that stage of their clinical training—their first clinical placement—when they were not accustomed to the hospital setting and not experienced with patient interactions. Some of these students were also worried that the mobile devices would negatively impact their bedside interactions with patients, or that they might appear disrespectful. These findings resonate with previous findings reported in the literature about mobile device use in clinical environments, which can cause concerns for both students and practice staff around professionalism, distraction, patient confidentiality, consent, data security and infection control (Lea & Callaghan, 2011; Phelps et al., 2013). Students feel that patients will think they are 'playing video

games or listening to music', rather than accessing learning resources (Tews et al., 2011). Davies et al. (2012) note that '… the etiquette of using a PDA whilst with patients was of concern, and the students had to learn how to incorporate it into their consultations without harming their relationship with the patient' (p. 7). Medical students express similar concerns about their ability to effectively integrate EHR use in clinical encounters (Rouf, Chumley, & Dobbie, 2008).

A substantial limitation of this study is that the use of the mobile EHR system and a requirement for patient records to be created were not yet, at the time of the study, formally integrated into the clinical curriculum. This meant that there was no explicit connection between EHR-related activities and other clinical learning resources or activities such as case presentations. Nevertheless, it is interesting to note how some students in the study independently integrated their preparation for case presentations with their EHR-related activities. A lack of integration with the formal curriculum also meant that students' submissions were not formally monitored or assessed. Clinical supervisors were informed of the study (with one attending the training session), however, despite our best efforts to persuade otherwise, time pressures prevented them from monitoring student progress with the system and providing feedback on their patient records. Considering this, the overall level of student engagement was very encouraging with over 400 unique patient records created over the course of the study.

Subsequent to the study described here, an online version of the EHR system was implemented for the second year cohort of our masters level MD programme ($n=328$). In this later implementation, use of the EHR system was explicitly integrated into the formal curriculum as a hurdle assessment requirement, with students required to enter 24 records of their patient encounters over the year. Also, clinical supervisors began using the system as an avenue for feedback to students on their records. We identified six different levels of feedback that clinical supervisors provided: positive encouragement of performance; factual knowledge about conditions; identification of gaps in record; writing style; case reflection and learning progress. (Elliott, Judd, & Tse, 2013). Further research efforts are required to determine if feedback provided to students via the EHR system encouraged more reflective learning and practice. As of this year, use of the system has also been extended to final year MD students ($n=326$) in their preparation for practice subject, during which students also complete an online, self-study module on incorporating EHRs and mobile devices into the medical consultation. The module emphasises how this can be achieved with minimal impact on patient- and relationship-centred care.

The EHR software continues to be refined and we recently released a smartphone version of the system to students. Ownership of smartphones among out students is extremely high (well over 90 % according to our most recent 2012 survey) and it is hoped that the smartphone app will provide students with greater flexibility when using the EHR system, as well as helping to reduce some of the portability and connectivity issues identified by students using the iPads and Netbooks in this study. Connectivity, is 'solved' in this case by allowing the user to create records offline and then sync them later when the device has access to a reliable network connection.

Based on the results of this and other studies, we believe that EHR-related activities have an important role to play in contemporary medical curricula. For maximum benefit, it is critical that their use is strongly embedded in the curriculum and is linked to established learning activities and objectives. Wherever possible, student contributions should be regularly assessed and students provided with effective feedback on their progress. We recommend a spiral curriculum for the teaching of EHR-related skills where there is an iterative revisiting of topics at different stages of the programme, with deepening layers of complexity at each visit (see Bruner, 1960). While calls have been made to introduce and instruct students on the use of EHRs from their earliest patient encounters so that it becomes a natural part of the training environment (Peled et al., 2009), at the same time students need to have in place the skills to effectively manage a patient-centred interview at the bedside while integrating EHR use. A spiral curriculum for the teaching of EHR-related skills would address the four objectives of a EHR training curriculum proposed by Wald et al. (2014): (1) introducing students to the presence of a computer within a clinical encounter, (2) training students in EHR-related skills, (3) empowering patient- and relationship-centred interviewing skills while incorporating EHR skills, and (4) fostering student' appreciation for added value of integrated computer use within the clinical encounter. Our findings build on published EHR curriculum innovation by underscoring the importance of sequencing in EHR-related skills training, especially when the EHR learning tool is mobile. In this context, consideration must be given to the order in which students receive instruction on (1) patient-centred interviewing skills, (2) incorporating mobile devices into the consultation so as not to harm patient relationships, and (3) incorporating EHR-related activities into the consultation so as not to harm patient relationships. For example, performing mobile EHR-supported patient encounters before students are sufficiently proficient at patient-centred interviewing while incorporating mobile devices and EHR-related activities, means students are less likely to benefit from the potential efficiencies afforded by mobile EHRs (e.g. direct capture of patient information at point-of-care).

9.5 Conclusion

This study has shown that a student-centred EHR system can support medical student learning of EHR-related skills in the clinical environment. Students reported that the EHR system helped them to scaffold patient interviews, provided a means of managing information gathered from multiple patients, allowed them to practice EHR-related skills, and allowed them to consider the potential benefits of EHRs for health care. The study also identified learning benefits that students derived from the system, which extended beyond EHR-related skills, such as preparation for case presentations, increased patient encounters, and general reflection on learning progress made throughout the hospital placement. The findings from this study provide medical educators with valuable insights into understanding the multifaceted nature

of clinical learning when EHR-related skills training, mobile learning and bedside pedagogy converge. In this context, we found that a mobile version of the EHR system did not encourage students to create and access health records either during or immediately after bedside interactions with patients. Network connectivity issues and student concerns about the portability of the mobile devices were identified as potential barriers to its adoption and use in the clinical environment. Further, concerns that the mobile devices would negatively impact their bedside interactions with patients, or that they might appear disrespectful, suggest that some students in this study were focused on the quality of the medical interview at the bedside, rather than potential efficiencies afforded by mobile devices.

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