Educational Electronic Health Record System Project

Environmental Scan Report

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BCcampus would like to acknowledge the work, completed between 2014 and 2018, of a special interest group consisting of faculty and staff from the British Columbia Institute of Technology (BCIT), Douglas College, University of British Columbia (UBC), University of Victoria (UVIC), Vancouver Coastal Health (VCH), and the Provincial Health Services Authority (PHSA). They began the research on, and development of, a shareable educational health record system for both learners and instructors in the British Columbia post-secondary education system.

Much of the content of this environmental scan report represents work completed by a team of faculty and students at BCIT, supplemented by research done by Glynda Rees in her capacity as the BCcampus EdEHR Project Coordinator, with input from the EdEHR Project Steering Committee.

The 2018–2019 EdEHR Project Steering Committee members and special advisers include:

British Columbia Institute of Technology
Cheryl Isaak
Rob Kruger
Glynda Rees

Douglas College
Nina Blanes
Patricia Visosky

University of British Columbia
Joseph Anthony
Leanne Currie
Jason Min

University of Victoria
Andre Kushniruk
Elizabeth Borycki

Government of British Columbia
Elietha Bocskei, Ministry of Advanced Education, Skills and Training
Katelyn Ranger, Ministry of Health

Interior Health Authority
Carmen Moore

Vancouver Coastal Health Authority
Lisa Bower

Special Advisors
Christie Newton, UBC
Janet Morrison, BCIT
Kamal Ahuja

BCcampus
Michelle Glubke
Clint Lalonde

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1 Background

Electronic health records (EHR) systems are being widely adopted in Canada and around the world. They allow for immediate and accurate availability of patient health records vital to the delivery of appropriate health advice. Expert interaction with EHR systems is rapidly becoming a mandatory part of the job of health professionals, not only for patient safety but also for employment eligibility. Health sciences students and new graduates will require training in these technologies as part of their education; they will need to know how to use EHR systems in a safe, effective, and patient-centred manner. Their acceptance of, attitudes toward, and proficiency with these systems will be a key factor in their readiness to practise and to practice safely.

Without access to an educational EHR, students are disadvantaged in two ways. Firstly, valuable time is taken from clinical placements to educate students in local EHR use. Secondly, students are taught only the mechanics of EHR use, and not the science behind that use, including the importance of inputting accurate data; use of data for other functions, such as making clinical or population health decisions; and the importance, meaning, and practice of information privacy. In addition, health authorities implementing EHRs are challenged with educating large numbers of staff, and they may be challenged themselves by the new technology.

Laying the groundwork for education on EHR use by giving access to, and interaction with, an educational EHR in class or laboratory settings will allow students to quickly learn a "live" system once they arrive at their clinical placements, and will provide opportunities for enhanced understanding of the benefits and potential pitfalls of and rationale for EHR use. Using a tool that spans all healthcare professions to benefit interprofessional collaboration and leverage knowledge also has the potential for improved safety and quality of care, increased efficiency, and reduced errors. Moving away from reactionary learning provides academia with an opportunity to be active participants in the integration of technologies.

Acronyms used in this report

EdEHR	Educational Electronic Health Record (also used by the BCcampus Project)
EHR	Electronic Health Record
EMR	Electronic Medical Record
MRS	Medical Record System

2 Methodology

Information in this environmental scan was gathered over several years through anecdotal evidence from conversations, meetings with the EdEHR special interest group (2015–2016), and the author's experiences.

Over the course of two semesters in 2016, two open-source EHR/EMR platforms (OpenVista and OpenMRS) were downloaded to BCIT servers. A team that included faculty from the School of Health Sciences, technical staff, librarians, and learning and teaching centre experts accessed and explored the two systems. During the winter semester of 2017, six students from the School of Computing and Academic Studies at BCIT analyzed OpenMRS and provided a report. Over

the same period, several faculty at BCIT in the School of Health Sciences also accessed and explored the educational EHR platforms offered by private vendors and publishing companies.

For the literature review (see Appendix A), a search of online healthcare databases PubMed, CINAHL, and EBSCO, using the terms "academic electronic health record" and "educational electronic health record" over unspecified datelines was conducted.

3 Requirements

The special interest group created an extensive set of requirements for an educational EHR/EMR, against which to assess various platforms. A simplified version of the requirements rubric is included in Appendix B.

In addition to considering the very detailed criteria in the requirements rubric, the group also assessed the platforms against these high-level requirements:

1. Open-source technology – use of open source code that can be shared, built on, and adapted without asking for permission (**Note:** While an open-source technology was a key requirement, several vendor-operated platforms were also reviewed for comparison.)

2. A Canadian solution – can be stored, hosted, and implemented in Canada and is relevant to Canadian healthcare (e.g., use of metric system, Canadian medication and dosaging, Canadian context and focus, inclusion of Indigenous case studies)

3. Interprofessional characteristics – relevant to all healthcare professionals, providing opportunities for students to access information viewable to all professions as they are entered in the system

4. Pedagogical foundation – based on the Constructivist approach of experiential learning, where learners are actively involved in a process of knowledge construction, as opposed to passively receiving information about Electronic Health Records; the platform would therefore:

    - Be student focused – The learning needs of the student are the primary focus of the system.
    - Include simulated case studies – Fictitious patient case studies are utilized for learning and teaching. Eight health case studies have been developed by a team at BCIT through BCcampus for this purpose. https://pressbooks.bccampus.ca/healthcasestudies/
    - Include laddered case studies – Case studies can be adapted to the level of student accessing the EdEHR. For example, a novice student would work with a simpler case than a more experienced student. As well, the novice student would be required to access, analyze, and respond to data that would be less complex than for a more experienced student.

- Provide decision supports – Students would have electronic access to educational resources, such as guidelines, videos, glossaries, and so on, in real time as they interact with the EdEHR.
- Be customizable – Post-secondary programs can adapt the system and the case studies to accommodate their educational needs. Faculty can adapt the case studies and EdEHR components to accommodate their learning objectives. Students can adapt the case studies and EdEHR components to accommodate their learning needs.

In addition to these key platform requirements, the special interest group also agreed that the platform should:

- Document a patient-centred longitudinal journey – Patients are placed at the centre of the electronic health record and their journey through the health care system is documented as they interact with various members of the healthcare team.
- Include a communication component – Communication between various members of the healthcare team and patients and their families is integrated in the case studies, and the electronic documentation of patient data is shared across health care professions. For example, an interprofessional care plan is developed for each case study.
- Be cost-efficient – Providing this system as an open-source educational resource would provide post-secondary healthcare programs with the potential to access and customize the case studies at minimal cost.

4 Review of existing technologies

The special interest group reviewed five open-source platforms and six vendor-operated platforms, assessing them on the basis of the four high-level platform requirements identified above. The reviews are summarized briefly in the tables below.

4.1 Open-source EHR/EMR platforms

The following open-source EHR/EMRs were reviewed:

- OpenEMR
- OpenMRS
- OpenVista
- OSCAR
- VistA

Table 1: Assessment of open-source EHR/EMRs

HER/EMR	Open source	Canadian-based	Inter-professional	Customizable case studies
OpenEMR • U.S.-based • Similar to OSCAR, but not as advanced or stable • Aimed at clinics and doctor's offices, so does not offer full health record capability • Website requests donations to support additional development efforts	Y	N	Y	N
OpenMRS • Originally developed for developing countries; now used around the world • Aimed at public health • Created by multiple developers, each with their own technology	Y	N	Y	N
OpenVista • Owned by a private company; subscription service	N	N	Y	N
OSCAR • Canadian-based, created at McMaster University • Aimed at outpatient medical clinics and does not offer full health record capability • Currently used by UBC Faculty of Pharmaceutical Sciences	Y	N	Y	N
VistA • Veterans Health Information Systems and Technology Infrastructure • Developed and maintained by U.S. Department of Veterans Affairs	Y	N	Y	N

4.1.1 OpenEMR

OpenEMR is a U.S.-based platform, similar to OSCAR but not as advanced or as stable. The website requests donations to support additional development efforts.

4.1.2 OpenMRS

OpenMRS seemed the most feasibly customizable EHR. However, several challenges were identified.

4.1.3 OpenVista

OpenVista uses "open" in its name, but it is owned by a private company, Medsphere. The business model includes a subscription service.

4.1.4 OSCAR

OSCAR, a Canadian-based open source Electronic Medical Record, was created at McMaster University in 2001. It is aimed at outpatient medical clinics and therefore does not offer the full health record capability. OSCAR is currently used by the UBC Faculty of Pharmaceutical Sciences. This system requires users to host their own instance of OSCAR software, which adds significantly to the overhead cost, accessibility and integration between other EdEHR users, and consistency between users. The development and and reengineering of this existing open-source software comes with significant challenges. OSCAR instances need to be supported by OSCAR-approved service providers that may vary in ability to offer technical development and further customization. As well, the current license agreement with OSCAR requires all new code to be submitted and vetted back through OSCAR Canada, which adds a cumbersome and potentially limiting step. From a technical point of view, OSCAR lacks a comprehensive database schema.

4.1.5 VistA

WorldVistA offers a free, open-source medical software system known as VistA, the Veterans Health Information Systems and Technology Architecture. The U.S. Department of Veterans Affairs developed and continues to maintain and use VistA; it is also currently used by the U.S. Department of Defense Military Health System. The review of this system found that although it offered many patient examples, the interface was "clunky" and the patient case records were inconsistent in their naming and content.

4.1.6 BCIT review of OpenMRS

A group of BCIT Computing and Academic Study students reviewed OpenMRS in early 2017, mostly in relation to access control and the interdependence plus diversity of all the code incorporated in all the various modules. They found multiple glaring and critical problems.

The system was vulnerable by design and did not include any form of advanced role-based access for the documentation. This means that a user can edit another user's documentation without authentication (such as a password). As well, a user can search for, view, and even delete another user's records and data. A previous role-based plugin was created for v.1 of the software; however, it is neither maintained nor compatible with the new system, and porting it to the new system is a very large task.

The system was created by multiple developers, each with their own technology. This has created integration and development problems, as all code written will have to work properly with different languages that have little overlap. Further down the road, this will create large-scale technical debt, and any update will be cumbersome.

All modules and their respective database tables are interdependent of each other. Any change in one module may cascade into other modules and can break the whole system. Even if not in use, these modules have to be retained or the system will not function at all. This, too, will generate large problems in the future.

More reviews

In July 31, 2017, the pros and cons of Practice Fusion, OpenMRS, VistA, FreeMED, OpenEMR and One Touch EMR were reviewed in the Capterra Medical Software Blog (https://blog.capterra.com/top-7-free-open-source-emr-software-products/).

(The full report is a BCIT document, "OpenMRS Documentation, v1.9, April 2017.")

4.2 Vendor-operated EHR/EMR platforms

An open-source educational EHR will be shareable, scalable, and adaptable, while providing opportunities for collaboration with other educators to enhance the system. However, the special interest group also reviewed some of the currently available educational EHR systems developed by publishing companies (e.g., NEEHR perfect) and vendors (e.g., Cerner) for comparison with open-source platforms. They found that these systems have several limitations that make them impractical for use in a teaching environment.

For example, they are largely designed for use in the U.S. context (i.e., to meet U.S. health laws, practice guidelines, and measurement units), and most are proprietary, so would require licensing. More importantly, they do not support strategies that allow educators to tailor cases for both novice students and students nearing graduation (i.e., the flexibility to foster higher-order critical thinking in students specific to their learning levels and their field).

In addition to these and other significant limitations involving the challenges of interprofessional communication and collaboration in an EHR, they have no capability for "batch-uploading" a class list in order to:

- create individual student accounts
- add multiple copies of a single (fictional) patient record so that students may have their own copy to work with
- store clean copies of fictional records outside the EHR to allow repopulation of the EHR from one year to the next
- arrange for the patient to not age from year to year

As mentioned above, the special interest group reviewed six vendor-operated EHR/EMRs for comparison with the open-source platforms. The six platforms reviewed were:

- Cerner
- Docucare
- EHR Tutor
- Meditech
- NEEHR Perfect
- SimChart

Note: Meditech does not offer an educational EHR and is therefore not included in the Table 2.

Table 2: Assessment of vendor-operated EHR/EMRs

HER/EMR	Open source	Canadian-based	Inter-professional	Customizable case studies
Cerner • Cerner previously offered an Academic EHR Solution, but it is not currently available in Canada • Nurse/MD focused	N	N	Y	N
Docucare • A simulated EHR offered by Wolters Kluwer/Lippincott • Nurse/MD focused • Any edits/additional case studies become vendor-owned	N	N	Y	Y
EHR Tutor • Academic EHR offered by F.A. Davis • Nurse/MD focused • Any edits/additional case studies become vendor-owned	N	N	Y	Y
NEEHR Perfect • U.S.-based company, • Uses VistA as its template • Nurse/MD focused • Shared case studies become vendor owned	N	N	Y	Y
SimChart • An EHR for nursing, developed for students and offered by Elsevier • Nurse/MD focused	N	N	Y	?

5 Recommendation to the EdEHR Project Steering Committee

The special interest group concluded that the existing EdEHR systems capture some of the requirements it identified but are lacking in Canadian content and context, educational components, and pedagogical underpinnings.

The group's recommendation to the EdEHR Project Steering Committee is therefore to design and develop an open-source, student-focused, and Canadian-based educational electronic health record system (EdEHR) that can be customized to accommodate and maximize student learning across the health professions.

Such a system not only will ensure that students learn to use and navigate an EHR, but also will provide opportunities for exploring and developing knowledge around the impact of EHRs within clinical information system on the patient experience, the clinician experience, interprofessional collaboration, and workflow. Additionally, the EdEHR will introduce students to the concept of data collection and the impact of that data on patient outcomes for real-time patient care and research in the short, medium, and long term.

The EdEHR system will provide faculty with the ability to author and develop case studies with relevant patient health data. Educators will then have access to a bank of case studies, with the ability to customize and adapt them as needed to optimize student learning. In addition, the system will be able to log and track student activities, allow access to quizzes and tutorials, and link to relevant online content. The EdEHR could also potentially have the ability to work on different platforms and on mobile devices, and be hosted in the "cloud" and/or integrated with (or as) the school's learning management system.

There will be opportunities to provide and/or use this tool collaboratively with other post-secondary health sciences institutions. Since this will be an open-source program, the potential exists for expansion to include several health disciplines, such as physiotherapy, medicine, pharmacy, and others, in order to develop interprofessional patient care planning. A fully functional EdEHR will also provide a platform for the teaching and learning of data analytics.

A design-based research method will be used to discover and define applicable design principles for an EdEHR. Once initial principles have been generated, they will be tested and evaluated in an open-source health record platform through an iterative process.

6 Learning outcomes

The learning outcomes for students in health sciences programs using the recommended open-source, Canadian-based EdEHR system have been adapted from the Canadian Association of Schools of Nursing's Entry-to-Practice Nursing Informatics Competencies (https://www.casn.ca/2014/12/casn-entry-practice-nursing-informatics-competencies/). They fall under three themes:

6.1 Information and knowledge management

- Uses patient data accessed from the EdEHR and from other sources to support decision making in the classroom, simulation lab, and clinical practice
- Understands the role of electronic health records and clinical information systems in the Canadian health care system
- Understands the importance of using standardized patient data to advance knowledge and articulate the work of healthcare professionals
- Evaluates data from multiple sources to inform practice
- Assists patients and families in using Information and Communication Technologies (ICTs) to manage their health
- Applies classification systems ICD - 9, ICD-10-CA and CCI
- Applies nomenclatures (e.g.SNOMED CT, ICNP, C-HOBIC)
- Applies group and case weighting methodologies – Case Mix Groups (CMG), Resource Intensity Weight (RIW), Day Procedure Groups and Comprehensive Ambulatory Classification System

6.2 Professional and regulatory accountability

- Understands the impact that electronic health records have on patient privacy and confidentiality
- Advocates for ICTs to deliver safe, quality patient care
- Identifies and reports system failures/problems and provides suggestions for improvements
- Is able to provide and document safe care if system is unavailable
- Uses professional judgment with ICTs
- Recognizes the need for clinician input into clinical information systems
- Applies regulations and legislation pertaining to minimum documentation requirements, custodianship or record, privacy and consent
- Evaluates tools used to support and operationalize e-health statutes
- Applies tools used to control and monitor access to systems that hold personal health information
- Analyzes electronic systems to log and track access to and disclosure of health information

6.3 Information and communication technologies

- Identifies and appropriately integrates EdEHR in patient care
- Uses decision-support tools to assist with judgment and deliver safe, quality care
- Uses ICTs to support and not interfere with healthcare provider–patient relationships
- Describes a variety of information systems (CPOE, clinical documentation, MARs)
- Describes the benefit of informatics in improving health systems and quality of interprofessional patient care
- Identifies and describes the role of interprofessional collaboration as part of an electronic health record
- Analyzes internal and external standards to support a health information management system (internal standards including facility requirements for data collection and maintenance, and external standards including CIHI standards, HL7, LOINC, DICOM)

Appendix A: Literature Review

Note: The literature review was compiled by Janet Morrison RN PhD (BCIT Faculty).

Online databases related to health care, PubMed, CINAHL, and EbSCO were searched using the terms "academic electronic health record" and "educational electronic health record." There is limited research pertaining to nursing and allied health students. Topics in this area have focuses on using an academic EHR from the perspectives of:

- gathering student and faculty perspectives (Burke & Ellis, 2016; Chung & Cho, 2017; Kowitlawakul, Chan, Wang & Wang, 2014; Kowitlawakul, Chan, Pulcini & Wang, 2015)
- identifying and selecting systems (Gloe, 2010)
- system implementation and integration into the curriculum (Borycki et al., 2009;Borycki, Kushniruk, Armstrong, Joe & Otto, 2010; Borycki, Frisch & Moreau, 2015; Curry, 2011; De Gagne, Bisanar, Makowski & Neumann, 2012; Johnson & Bushey, 2011; Titzer & Swenty, 2014)
- system design, development, prototyping, and usability testing (Booth, Sinclair, Brennan & Strudwick, 2017; Borycki et al., 2009; Gray & Christov, 2017; Hoyt, Adler, Ziesemer & Palombo, 2013; Kushniruk et al., 2014; Mountain, Redd, O'Leary & Giles, 2005; Wyatt, Li, Indranoi & Bell, 2012)
- challenges and success strategies (Brooks & Erickson, 2012; Burke & Ellis, 2016; Herbert & Connors, 2016)

There is only a small body of research on the use of an EdEHR in interdisciplinary education (Borycki et al., 2009; Gray & Christov, 2017; Schaar & Wilson, 2015; Titzer, Swenty, & Wilson, 2015). Leapaldt (2016) also provides an overview.

The literature review identified the following issues:

1. Issues with currently available EdEHR systems:
    - Currently available EdEHR systems tend to be physician-centric and not interdisciplinary. While considerable research has been conducted on the use of electronic health records in medical education, little research has been done on the use of EdEHRs in interdisciplinary health education in the allied health fields (e.g., nursing, laboratory, medical imaging, physiotherapy,).
    - Systems that have been studied are seldom fully functioning; rather, they have focused on specific areas, such as medication administration, or documentation in specific areas of the medical record.
    - The currently available systems are expensive to purchase or license, and they are proprietary – that is, the systems are not open source and the IP is owned by large corporations.

- The currently available systems are U.S.-centric – that is, they relate to professional practice as it exists in the U.S. For example, lab results are reported in SI units rather than metric units.
- The servers for these systems reside in the U.S., which raises student privacy and security issues. As well, internal controls are needed to protect student privacy.

2. Implementation and social informatics issues:
    - A common research finding is that there are significant issues related to social informatics – mainly faculty resistance due to lack of experience with EHR systems, workload issues, and lack of technical support. Faculty training and support is cited as necessary for successful implementation.
    - Both technical and academic support is needed to keep the systems operating effectively.
    - Interface and usability issues are also commonly noted; the systems are often not intuitive or user friendly and there is a substantial learning curve associated with them, requiring time that faculty may not have allocated to them.
    - Proprietary systems have limited configurability, and therefore cannot be easily customized to suit specific learning goals.

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Appendix B: Requirements Rubric

In 2015, the special interest group developed a table of requirements for an educational EHR, with the intention of assessing the availability of these criteria in existing open-source EdEHR systems. The table below shows the rubric in a simplified version for the purposes of this report.

Requirement group	Requirement category	Requirement	Capability
A. IP Collaboration	1. IP Documentation	Interprofessional progress notes – visible to all professions	All professions should document in the same location, and all IP notes should be visible to all team members
		Interprofessional orders	All HPs should be able to document orders in the same location in the chart
		Medication Administration Record	An MAR should be available
	2. IP Ease of Use	Filter progress notes by date (range)	Allows HPs to easily check notes based on date query
		Filter progress notes by profession (single/multiple)	Allows HPs to easily follow one or more professional's notes
	3. Research Capability	Pull data by query for single or multiple patients (lab visits, meds, etc.)	Useful for research projects
		Interprofessional care plan	
B. Ease of Use in Teaching	4. Administration	Batch upload/retire students for individual accounts	Currently not practical to give each student their own login, unless the program is quite small
		Multiple copies of single patient file	To allow students to have their own copy of a file to work with in an exercise/project
		Store clean copy of patient file for reuse	To allow the EHR to be "cloned" as a clean copy for use in subsequent academic years
	5. Teaching Function	Patient age remains static from year to year	Especially for pediatric patients – the age of the case should remain static from one academic year to the next
		Allows iterations of patient file – release more complex versions during learning	This will allow exercises to become more complex as they unfold
		Students can author patient files	Allows instructors to build up a bank of cases/files
		Link out to relevant online content	Would be nice to have
		Fully functional on mobile devices	Would be nice to have

	4. Administration	Ability to create deep links to a record to integrate with LMS	Will make integration with LMS possible
C. EHR Functionality	1. IP Documentation	ICNP or NANDA International available	
		C-HOBIC (outcomes) available	
		IDNT available	
		ICF available	
		SNOMED available	
		NP encounter codes	
	6. IP Computerized Decision Support	Ability to interact with clinical guidelines	
	5. Teaching Function	Ability to create technology-mediated adverse event case	