

Electronic Medical Records for Use in the Family Medicine Teaching Environment

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Abstract — Accreditation of family medicine (FM) teaching facilities in Canada requires that health care informatics and electronic medical records (eMR) be taught to FM residents¹. In order to comply with these requirements the FM center (FMC) of St. Mary's Hospital Center (SMHC) conducted an analysis of available systems with respect to their ability to support the education, research and service mandates of the post-graduate teaching environment.

A comparative metric was established by assembling a set of functional criteria for each of the three mandates through interviews with clinical and administrative staff at SMHC's FM unit². Matching the available systems to the comparative metric, a representative subset of eMR applications were selected for further analysis. This subset consisted of two commercial, one open source, one research and one experimental candidate eMR. The analysis found that none of the commercially available candidates met more than half of the functional requirements set by the comparative metric. It was concluded that any of the available systems would need to be heavily adapted in order to meet the needs of SMHC's FM program.

Further, while any one of the applications could theoretically be developed to meet post-graduate training requirements, specific barriers applied in most cases. These included: a) commercial vendor reluctance to invest in an application with a small, economically unviable market; b) variable certification and hence provincial funding support across jurisdictions; c) a narrow focus of usability; and d) high developmental costs.

Absence of reliable national standards for the clinical information and process content of the patient record and the use of formal systems modeling techniques makes investment in software coding too risky for commercial developers to be innovative and has led to the electric paper that is at the core of most products today. If all we do is replicate the paper record we will have missed

the point of computerization. To achieve success in using the computerized patient record to improve healthcare and it's teaching its content must be semantically computable.

To overcome these hurdles physicians must show leadership in defining the clinical information and process content of the eMR. The College of Family Physicians of Canada is in a unique position along with its fellow accreditation bodies to oversee a mechanism, funded by Health Canada Health, that establishes national information and process standards for the clinical content of future "Computer-Based Patient Records"⁵

Keywords — Electronic Medical Recors, Metrics, Teaching, Mentor, Guidelines

I. BACKGROUND

The "teaching of Family Medicine Informatics" was mandated in the 2006 edition of the CFPC Standards for Accreditation of Residency Training Programs Red Book¹ and specifies;

- i. "Providing residents and faculty with ready access to the tools of information management in the areas where they usually conduct patient care."
- ii. "Developing, implementing and evaluating a resident curriculum and faculty development program in family medicine informatics."

Informatics is the science concerned with gathering, manipulating, storing, retrieving, and classifying recorded information¹⁶.

II. INTRODUCTION

The academic Family Medicine teaching environment has three distinct mandates to satisfy; the delivery of healthcare services to its patient community, the education of medical

graduates training in family medicine and research into domains relevant to family medicine, primary care and healthcare systems¹⁷

Clinicians have always been prodigious consumers of information and along with librarians have participated in the development of medical knowledge data bases such as PubMed and the Unified Medical Language System (UMLS). The first attempts to use computational technology for clinical records were carried out by Weed and Schults from 1964 to 1982⁴ at the Problem Oriented Medical Information Systems (PROMIS) Laboratory of the University of Vermont. The principles of clinical information structure as envisioned by Weed, a Family Physician and inventor of the S.O.A.P. note, remain foundational to the informatics of Family Medicine today as is clear from these objectives first stated in 1967.

- “1) Facilitate good patient care by making immediately available (in minutes) to the individual physician a complete, updated list of problems on any patient and by providing simultaneously, as a unit, all the data in sequence (narrative, laboratory, etc.) pertinent to any of these problems.
- 2) Make possible epidemiological studies and other research endeavors in terms of problems, having all the data on any given problem immediately available.
- 3) Make possible a medical audit whereby the standards of care being provided for a given entity {e.g. hypertension} can be rapidly assessed because of the specific orientation of all the data.
- 4) Make possible a business audit to assess the physical, financial and time resources that go into the solution and management of a given problem.”

The first functional electronic medical record system used widely in clinical practice was developed by Clem Mac Donald et. al. in 1972 at the Regenstreif Institute along with Logical Observation Identifiers Names and Codes (LOINC) which is the universal standard for identifying medical laboratory data used in Canada today. Many academic centers in the U.S. along with the Veterans Administration of the U.S. Federal government developed their own in-house eMR systems, many of which persist to this day, such as the Veterans Health Information Systems and Technology Architecture (VISTA) System. By 1991 the Institute of Medicine (IOM) published the first overview that outlined the full potential of what they called the “Computer Based Patient Record”⁵. Since then there have been many acronyms used to refer to what in most instances is a vaguely defined idea of what the computer can do with clinical information. They include EMR, EHR, CPR, and eMR. A widely accepted definition is that of the Health Information Management Systems Society’s (HIMSS):

“The Electronic Health Record (EHR) is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. Included in this information are patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data, and radiology reports. The EHR automates and streamlines

the clinician's workflow. The EHR has the ability to generate a complete record of a clinical patient encounter, as well as supporting other care-related activities directly or indirectly via interface—including evidence-based decision support, quality management, and outcomes reporting.”⁶

This definition is typical of current thinking around the subject and is long on intent but short on know-how.

By 1999 the healthcare systems of the western world were under severe critique for their safety, quality and efficiency. Ninety thousand mortalities a year in North America due to preventable medication errors⁷; almost fifty percent of care delivered having no basis in guidelines or evidence⁸. Added to this came critique from Starfield and others that we suffer from more than one million patient injuries per year due to broken healthcare processes and system failures⁹. Not to mention the waste of resources related to overuse, underuse, misuse, duplication, systems failures, unnecessary repletion, poor communication and inefficiency that consumes up to forty percent of every dollar spent on healthcare¹¹. The response to these critiques by third party payers such as insurance companies and ministries of health has been to point to the dramatic improvements in efficiency and productivity achieved in the other sectors of society by computerization and the assumption that the same improvements are possible in healthcare if we buy some electronic records.

Canada’s response was initiated in 1994 following the multibillion dollar cuts in Federal healthcare transfer funds by the [Information Highway Advisory Council](#) followed by [Advisory Council on Health Infostructure](#) in 1999. This led to the creation of Canada Health Infoway (CHI) with funding of over two billion dollars from the Federal government and provinces. The” 2009 Fall Report of the Auditor General of Canada” points out many of the difficulties that have been encountered by Infoway in the last decade. Many are similar to those that have led to the recent announcement of the dismantling of the British National Health Service National Programme for IT¹², the largest civilian software development project in history, after spending 11 billion pounds sterling. This should give pause for reflection about what actually is required to take advantage of computational technology in healthcare in general and clinical medicine in particular.

Early in its mandate CHI referenced Gartner Group Consultants’ (<http://www.gartner.com/technology/home.jsp>) overview of eMR evolution. The resultant five generation model is illuminating²⁷.

Generation **ONE** “The Collector” is a simple system to allow viewing of digitized data from multiple sources such as laboratories and imaging. It is what is currently installed at McGill’s teaching Hospitals.

Generation **TWO** “The Documenter” allows input of clinical encounter data. What exists today for the most part is free text entry either typed or scanned cursive documents and a basic electronic prescriber.

Generation **THREE** “The Helper” includes pharmaceutical management and the beginnings of evidence

based decision support. (Very few are currently in use but much work is being done in this area)

Generation **FOUR** “The Colleague” integrates the care team of doctors, nurses, pharmacists, other healthcare professionals and the patient and brings high level of evidence and sophistication to its decision support functions.

Generation **FIVE** “The Mentor” is an artificial intelligence application that includes diagnostic, therapeutic and management capabilities that can guide clinical care. DXPlain from the Laboratory of Computer Science at the Massachusetts General Hospital (<http://www.lcs.mgh.harvard.edu/projects/dxplain.html>) is an example of the diagnostics software possible at this level.

Experiences to date with eMR implementations have had mixed results and evidence of benefit is minimal. Added to this is physician resistance to adoption that has been linked to a variety of factors including, 1) well-publicized eMR failures; 2) limited computer literacy on the part of physicians; 3) concerns over productivity (i.e., fear that an eMR would slow physicians down); 4) patient satisfaction, and 5) unreliable technology^{13,14,15}.

So what is at the heart of this impasse for the last 40 years? The early pioneers worked with hardware and software that was expensive and slow so their progress and results were understandably limited. By 2000 as the biennial doubling of silicone chip processing capacity continued its exponential growth¹⁸ and the relational database became widely available there was no longer a horse power limitation to computational technology to justify being unable to computerize the patient record.

The electronic patient/health/medical records in use around the world today are for the most part document managers attached to prescription and billing software applications. The billing applications have the capacity to code diagnoses as required by third party payers in one of the accepted coding lexicons such as the International Classification of Disease 9th edition (ICD9)¹⁹ or the Systematized Nomenclature of Medicine Clinical Terms (SNOMED-CT)²⁰. The former is a public health tool and is unsuited for clinical medicine and the later, a unification of the work done by Roger Cote a pathologist at the University of Sherbrooke Canada and James Read, a British general medical practitioner, is more suited to clinical medicine but to date lacks the ontological rigor necessary for reliable high level computerized reasoning²¹

Finally, to date no eMR applications are instantiating adequate referent tracks paradigms to ensure accurate individuation of similar medical problems occurring at different points in time (e.g. a fracture of the femur)²². As such the data generated from eMRs in use today requires manual reconciliation to make it usable and reliable for third party analysis and research by agents such as the Canadian Primary Care Sentinel Surveillance Network (CPCSSN) and the Canadian Institute for Health Information (CIHI).

III. METHODS

- a. An awareness of the state of the art in bio-medical informatics and eMR was achieved through attendance at the proceedings of the International Medical Informatics Association (IMIA), the American Medical Informatics Association and the Canada Health Infoway Partnership Conferences of 2009, 2010 and 2011.
- b. A review was conducted of the following standards
 - i. ISO 13606-5:2010 Health informatics -- Electronic health record communication -- Part 5: Interface specification
 - ii. ISO 18308:2011 Health informatics -- Requirements for an electronic health record architecture
 - iii. ISO/HL7 10781:2009 Electronic Health Record-System Functional Model, Release 1.1
 - iv. ISO/CD 13940-1 Health informatics -- System of concepts to support continuity of care -- Part 1: Basic concepts
- c. A discovery and review of the eMR systems currently used in Canada was conducted and they were allocated to one of three categories; commercial, open source and research and development.
- d. The Family Medicine Center of McGill University at St. Mary's Hospital Center was analysed using the Integration Definition Method (IDEFØ) function modeling formalism of the Computer Systems Laboratory of the [National Institute of Standards and Technology \(NIST\)](#)²³
- e. A list of functional criteria was constructed to reflect the “state of the art”, “best practice” and “foreseeable” advances^{24,25} that incorporated the three mandates of the teaching environment; Service, Education and Research.
- f. A subset of available eMRs was selected based on representative characteristics of their category. There were two commercial, one open source and two research and development eMRs selected.
- g. A comparison matrix was created to indicate which eMRs satisfied which functional criteria.
- h. These candidates were then evaluated for compliance against several grids designed to highlight their compliance to the FMC's needs.
- i. In each case the scores obtained by the candidates in each evaluation was normalized to a simple range of:
 - 0 = does not comply;
 - 1 = can be made to comply; and
 - 2 = complies.
- j. The final score for each candidate EMR consisted in a weighted sum of the scores in each evaluation category.

IV. RESULTS AND DISCUSSION

The functionality assessments show that the most compliant candidate (EAN [Early Adopters Network], candidate number 3, a research and development application

created by MEDbASE Research Inc.) scored 111 of a possible 136 points. This represents an 82% compliance with the criteria while the next highest candidate (OACIS Clinical) scored 75 points for a compliance of 55%. The high compliance of the EAN can be attributed to the developmental nature of the product as opposed to the other candidates which are, for the most part, set commercial offerings or dynamic open source systems.

What is painfully evident is that the accreditation standard for teaching "the tools of informatics" cannot be achieved with the commercial and open source applications as available at the time of the study. (N.B. this analysis was done in 2010 and the open source systems are evolving in many different iterations).

Special note is made of the lack of support for resident scheduling, achievement of competency documentation and results management in the context of dual (resident and staff) order authorship.

The short falls found can be attributed to three domains:

- a. Provider and vendor reluctance to expense the coding of applications for a small market.
- b. The absence of national standards for the clinical information and process content of the eMR to which vendors and promoters can build.
- c. Lack of the type of formal systems description of the Family Medicine teaching center environment, and the healthcare delivery sector in general, that is required for coding complex integrated software applications.

eMR applications are large, complex software systems that are expensive to develop. This leads their promoters and vendors to focus on the largest user segment, service, for economic reasons. The vendor group resists change because of past investments in coding that could be nullified and is reluctant to instantiate new ideas because of the lack of a national standard for eMR clinical information and process content that that can be followed and hence ensure compliance with the market's needs.

The subject of healthcare systems is the human being, arguably the most complex entity in the known universe. Clinicians navigate the healthcare system with a hard earned facility the belays its complexity. "We make it look to easy"²⁸. In the transformation of clinical know how into computer code clinicians must assert their pre-eminence as masters of the clinical domain and demand the appropriate cognitive support for the massive information loads that they manage³⁰ BUT they must also accept "disruption"²⁹.

"It is vain to expect any great progress in the sciences by super inducing or engrafting new materials on old. An instauration must be made from the very foundations, if we do not wish to revolve forever in a circle, making only some slight and contemptable progress"

*Francis Bacon*²⁹

Bacon's words of wisdom were reflected in the Institute of Medicine publication of 1994 entitled "The Computer-Based Patient Record: An Essential Technology for Health Care" and again in 2009 by Stead and Herbert in

"Computational Technology for Effective Health Care: Immediate Steps and Strategic Directions" also published by the National Academy of Science.

"Merely automating the form, content and procedures of the current patient records will perpetuate their deficiencies and will be insufficient to meet emerging user needs"

*R.S. Dick; E.B. Stein*⁵

If all we do is encode our current processes and methodologies we will have missed the opportunity that computational technology provides to healthcare.

V. CONCLUSIONS AND RECOMMENDATIONS

The CFPC is currently actively following the work being done to integrate the terminology sets of the ICPC-2 (International Classification of Primary Care, Second edition)³³, SNOMED CT and ICD9. These initiatives are the equivalent of establishing the lexicon of the medical language as would be seen in Stedman's Medical Dictionary minus the semantic component of the definitions. The International Health Terminology Standards Development Organization (HTSDO) which oversees the work being done on SNOMED CT is working to establish a veridical ontological organization of its lexicon of terms that now exceeds 350,000. A veridical ontological organization of terms provides the semantic of the definition plus the hierarchical parent-child relationships of the entities represented. This step is crucial to establishing computer process-able semantics and reasoning capabilities which are required to reach even "The Helper Generation" of eMR.

It is probable that "The Documenter Generation" eMR can reduce medical errors by up to forty percent²⁷. However to reach more than eighty percent reduction will require at least "The Colleague Generation" application. To go beyond improved safety to achieve the increased efficiency, and effectiveness foreseen by the [Advisory Council on Health Infostructure](#) will require "The Mentor Generation" of applications.

To achieve the higher generation functionality and benefits requires that the clinical information and process content of the eMR must be public, standardized and maintained consistently across all sites where the eMR is used.²⁶

- a. Physicians must show leadership in this process of defining the clinical information and process content of the eMR. The skills necessary to define the clinical content and use of eMRs to the benefit of our patients must be taught to medical students and residents in training if we are to avoid another forty years of impasse.

As the accreditors of the standards for teaching clinical medicine our national accreditation bodies are in a unique position to advance these standards at a national level and contribute to the successful adoption and meaningful use of the computerized patient record.

- b. We recommend that the CFPC start the process of the standardization of clinical content for the eMR by

supporting a working group in Family Medicine Informatics with a mandate to establish, in collaboration with the other Canadian healthcare accreditation bodies, the terms and conditions of a sustainable entity funded by Canada Health Infoway to create and curate the standards for the clinical content of the computer based patient record.

ACKNOWLEDGMENT

The authors wish to thank St. Mary's Research Center and the Family Medicine Center at St. Mary's Hospital for their support in providing the 'living laboratory' in which this research will be conducted.

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