Electronic Medical Record System Use in Canada: Integrating Physiology Flowsheets

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Research article

**Keywords:** Flowsheet, EMR, EHR, Medical Information Technology, Quality, Improvement, Quality Assurance, Physiology Flowsheet

**Posted Date:** July 20th, 2019

**DOI:** https://doi.org/10.21203/rs.2.11753/v1

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Abstract

Background: Longitudinal data of pulmonary physiology (pulmonary function tests, PFTs) is important in diagnosis and management of both respiratory and non-respiratory diseases that have secondary effects on lungs. Large amounts of data need to be amalgamated in physiology flowsheets within electronic medical records (EMR), which summarize trends of multiple PFT reports in one document. We present the process around evaluation and implementation of a physiology flowsheet with discreet data elements.

Methods: Alberta Health Services (AHS) has chosen a single vendor for its EMR, an Epic-based system (Epic Systems Corporation). A new clinical tool was written and implemented/piloted within the pulmonary department of the EMR. The physiology flowsheet was tested, modified, and real patient data was entered for those followed longitudinally within AHS Pulmonary Function Laboratories. A pre- and post-implementation survey was carried out with different front-line users to evaluate their experiences.

Results: From this pilot implementation, we found that majority of EMR users reported variable ease and satisfaction with the current access to PFT's. Flowsheets were deemed helpful, once longitudinal data was available. Consistently respondents reported that the EMR slows patient encounters. Healthcare providers also reported flowsheets to be useful for patient education and their self-reflection related to disease processes. Patient surveys were not conducted. Conclusions: Current data transfer of PFT results to EMR requires manual entry, which is time-consuming, though clinically useful. The incorporation of raw data from PFT software to EMR is of great importance in both clinical assessments and patient education; however, a systems-based approach is needed.

Background

Incorporation of electronic medical records (EMR) software into day-to-day frontline clinical care in Canada means software must adapt to accept multiple data formats. Both small self-developed and larger proprietary EMRs and electronic health records (EHRs) are used across Alberta and Canada. A study of data types incorporated into EHRs and/or EMRs at the University of Minnesota revealed important findings on their EMR use (Epic Systems Corporation, Verona, Wisconsin). In this review flowsheets within EMRs contributed the largest component of data (34%) (1), twice the volume of second largest EMR data source, physician orders, at 17%, (1). No similar work from Canada appeared after an exhaustive literature search. As early as 1980 physicians and informatics specialists have worked to amalgamate data in flowsheets into electronic formats (2). Maintenance of such data is not only essential to modern clinical care, but also to monitoring healthcare quality, making evidence-based decisions and creating better outcomes (3).

Time-course data derived from serial tests of spirometry, volumes, diffusion and other pulmonary functions, defined as pulmonary physiology data, is imperative to respiratory care. Respirologists rely heavily on multiple assessments of pulmonary physiology for diagnosis and/or longitudinal management of individual patients—including optimization of patients’ clinical status. One or two sets of numeric data from pulmonary function tests (PFTs) is insufficient for clinicians to optimize patient care. Discreet data elements of each index of lung function (as opposed to image files of full PFT reports, see
Figure 1) must exist in data-trending PFT flowsheets to be clinically relevant measures for provision of medical care.

Alberta Health Services (AHS) is the first with a province-wide health region as a leader in introducing large-scale electronic records encompassing an entire province. Thus piloting a process for electronic data entry and trending within eClinician has been a priority, which has broad implications in other areas. Historically, the University of Alberta Hospital (UAH) and associated PFT laboratories performed hand entry into separate software (Excel, Microsoft Corporation) through hospital staff prior to the introduction of EMRs. Between different laboratories the same team conducted calibration, including biocontrol, and thus results across all spirometry and PFT equipment were comparable for trending purposes. These physical copies of graphs produced from trended PFT results were kept as part of each patient’s chart, and maintained by respective clinicians’ team members. With incorporation of AHS’s Epic-based eClinician, a work-around process was developed to support a “paperless environment”—single PFT results were uploaded into a miscellaneous section of the EMR under a chart review tab, where data files were in PDF format as opposed to discrete data bundles available in the standard EMR data format called Health Level (HL–7 Standard, see figure 1). Consequently, the line-by-line entry of each physiology data parameter never occurred by way of this new process, thereby preventing the addition of these new PFT’s to existing flowsheets established in paper charts.

Numeric data generated from pulmonary physiology testing includes either spirometry alone or full PFTs which include spirometry, lung volume assessments and gas transfer assessments. These results can be collated per patient within the EMR used at our institution and trended over time in a manner similar to blood sugar monitoring in diabetes management to optimize control. The primary objective of the study was to implement a system for generating an automated flowsheet from manually entered pulmonary physiology data, with a secondary objective of evaluating this process with a pre- and post-implementation survey.

**Methods**

This implementation pilot study evaluated process improvements related to incorporation of a physiology flow sheet based on multiple point-in-time pulmonary function assessments to inform the further development of a full proprietary EMR within Alberta Health Services. This included a pre- and post-implementation phase for a new clinical tool applied to the EMR suite used by the AHS outpatient pulmonary EMR department at the University of Alberta (Edmonton, AB). The initial EMR package purchased by AHS in December of 2013 did not include physiology flowsheet capabilities. Grant funding was secured to create and implement flowsheet into clinical workflow, with the initial grant being secured in 2014, creation and implementation of flowsheet over 2015–2016, and survey administration in 2017.

These were important considerations when AHS chose a software suite and later developed this for pulmonary outpatient ambulatory clinics (June 2012 pilot group). An EMR physiology flowsheet was tested, modified and completed for insertion into the production environment of the pulmonary EMR.
department. All AHS PFT lab equipment in use since 2014 makes use of the VMAX system, for which there is interoperability between the pulmonary function laboratory software and the new EMR. The initial Epic Ambulatory EMR software purchase by AHS was in 2006 with the first University of Alberta Hospital implementation in 2008. The UAH Pulmonary department had its implementation in 2012 and while flowsheet functionality existed within the Epic eCLINICIAN software, the specific ‘PFT Results’ flowsheet was not created until 2014.

Once these flowsheets were written into the Epic System, it was piloted with a small group of clinics, predominantly in adult respiratory medicine, where a select group of patients were longitudinally monitored. Subsequently various healthcare providers and allied health staff were surveyed to determine the utility of this intervention in the clinical setting.

The pre-implementation survey was conducted at the time of broader pulmonary EMR department incorporation (December 2013) and post-implementation survey occurred December of 2017. These were designed to evaluate challenges to longer-term utilization, and how these challenges may potentially be addressed through input from various stakeholders. Since implementation, flowsheets have been trialed in respiratory clinics for Severe Asthma, Hereditary Hemorrhagic Telangiectasia, Cystic Fibrosis, Chronic Obstructive Pulmonary Disease (COPD), Bronchiectasis and Interstitial Lung Disease (ILD) clinics. The survey methodology was informed by common metrics utilized in quality improvement practices to measure and evaluate process changes. Questions were geared at determining the utility of flowsheet data and the end user experience with the current EMR. Specific questions, guided by the pre-implementation survey, not only addressed time parameters for finding the necessary data for patient care, but also to determine how the flowsheet information was used (e.g. for patient education, improved compliance). Survey respondents were chosen to be as broad as possible to capture all EMR user roles, including those who are involved in scheduling (secretaries), data input (respiratory therapists, nurses and physiology laboratory technicians), learners, as well as clinicians (nurses and physicians and respiratory therapists) involved in direct patient care. This approach enabled additional feedback to consider a more global user experience than what a survey limited to front line staff would have provided.

**Results**

Key survey details and questions are summarized in Appendix A. Of the seventy individuals who received the survey, we received thirty-two responses over one week from October 2017 for the post-implementation survey while 23 participants responded to the pre-implementation survey in November 2013. We received responses from a wide variety of healthcare providers, learners and support staff from diverse clinical areas in both adult medicine and pediatrics (clinical areas shown in Table 2). Table 1 shows the professional breakdown of all respondents. Figures 2 to 5 shows frequency tables for results of key questions from both surveys.

The post-implementation survey specifically included additional questions on utility of a trending flowsheets as a clinical tool. Of 23 respondents working directly in a patient care capacity, 11 stated they
have shown their patients the physiology flowsheet or other trending data during patient encounters. As well, 16 of 22 respondents stated likely or very likely, when asked “how likely is it that the flowsheet contributed to your patient understanding their condition better?” Overall there was strong support for the trending flowsheets as both clinical and patient education tools.

Conclusions

Comparisons of the pre-and post-implementation surveys highlights interesting trends in different users’ experience with eClinician. Figure 2 shows that users found navigating to the PFT tab of the EMR more difficult four years later. This suggests that with prolonged use, users came to realize that an unsorted media tab with multiple PFTs was getting more challenging to use. Figure 3 supported this as individuals found navigating to PFTs was taking more time than in a paper chart four years after implementation. However, the option of the physiology flowsheet did increase user satisfaction with the process of accessing PFT data in Figure 4. Figure 5 shows that overall there is still strong support for the trending physiology data function, although manual entry continues to be a barrier to wide-scale implementation.

As AHS considers processes in healthcare delivery in Alberta, Connect Care, a proprietary EMR also created by Epic, will be the new system for sharing records. This quality assurance project on implementation of a physiology flowsheet was conducted with consideration towards this new EMR. The dynamic nature of lung function over one’s lifetime requires that pulmonary function laboratories convey data to an EMR with a trending function to ensure EMRs appropriately capture this information for individuals from birth to death within one electronic health repository. For decades, various studies have highlighted the importance of longitudinal numeric pulmonary physiology laboratory data for patient management both to identify those individuals more susceptible to rapid rates of lung function decline early on (5–9) and assessment of changes to therapeutic agents added to a patient’s care. Longitudinal data in the form of pulmonary physiology flowsheets is critical in management of chronic respiratory diseases like asthma and COPD, and the varied forms of ILDs. In addition, it is also useful in related patient education and research. Although there is significant variability in the natural decline of parameters like the forced expiratory volume within the first second (FEV1), disease patterns emerge over several clinic visits that reveal changes due to underlying pathophysiology within disease groups such as asthma, COPD, ILD and normal patients. Longitudinal monitoring of pulmonary physiology is also an essential tool in the management of several other chronic conditions, including connective tissue disorders (i.e. rheumatoid arthritis, lupus) with pulmonary sequelae (4), neuromuscular disorders (i.e. multiple sclerosis, myasthenia gravis), and other conditions. From a public health perspective, longitudinal spirometry and PFT flowsheets allows particular insults to be identified and provide preventive care (i.e. removing an individual from a workplace with an agent to which that person is sensitized as in occupational asthma).

One strength of this report is the relative novelty of this work. It is the first of this nature in Canada, but we are aware of at least two large academic health centers in the United States (Cleveland Clinic, University of Wisconsin) are currently utilizing Epic along with a physiology flowsheet in one (University of
Wisconsin) (17, 18). This pilot highlights a provincial priority that is of national importance as well. Since 1992, the Canadian federal government has discussed the importance of electronic records and the transferability of data between health jurisdictions. National guidance surrounding the development of digital health care is provided by Canada Health Infoway (“Infoway”). This crown corporation, which reports to a board of directors composed of all ten provincial deputy health ministers, has also recently prioritized integration of interoperable EMR's into all aspects of clinical practice (11,12). A 2011 study on the Canadian experience on implementing the Canada Health Infoway plan, a $1.6 billion government funded initiative, identified “the retrieval of laboratory test results and graphing results over time” as a distinct benefit of developing electronic records (12). Similar motivations were echoed by the Pan-Canadian Respiratory Standards Initiative for Electronic Health Records (PRESTINE) working group (10). In the modern clinical environment electronically available data is becoming an expectation.

In this pilot project to implement pulmonary physiology discreet data elements into our health region-wide EMR, we found the potential for clinical utility, patient education and research to be significant; however, the logistics are still problematic. Utilization of a pulmonary physiology flowsheet is feasible and useful in selected ambulatory respiratory clinics. The majority of end users found it useful in their clinical practice. Our pre-implementation process review highlighted the biggest area of concern, lack of time in a busy clinical practice for manual entry needed to generate flowsheets for trending. PFT incorporation into the EMR as physiology flow sheet data within this dedicated area should be prioritized. It is an important tool for both clinical assessments and patient education and compliance. However, this pilot implementation demonstrated that raw data from the PFT software must be incorporated directly into the EMR to allow EMR-generated flow sheets for PFTs so busy clinicians can use the flowsheets efficiently without manual data entry into flowsheets. Otherwise this process improvement is hindered by the limitations on efficiency of the end-users of this software. As well, PFTs should have a dedicated area in the EMR (instead of being buried under a menu one of various types of media files) as toggling between screens increases the time required to assess a patient.

Clinicians must have the ability to usefully trend available data to utilize it effectively for treatment decisions, patient education and research. Our current EMR does not automate PFT data entry and instead a PDF copy is uploaded into the media section. While it provides access to current data, clinicians cannot trend data easily to understand the trajectory of lung disease. The current inability to acquire, trend and share pulmonary function physiology data de-emphasizes the importance of lung function to the detriment of quality patient care, education and safety (9). As such physicians maintaining health records have a duty to ensure the record is as complete as possible and this includes effective documentation of changes in data trends (13).

Through this process we learned of several limitations of our study. One factor is the restricted generalizability of the study findings to other health systems or other EMR departments as we only studied a relatively limited setting—single site, pediatric and adult departments and only ambulatory care settings. As well, this study ran over a relatively short period of time of only one week, which may bias respondents if they were experiencing unusually higher clinic volumes during that time of the year. The
response rate was approximately 50% for this survey-based study, which is relatively high. Part of what may have increased the response rate was increased awareness of EMR related changes and spending in the health region at that time with the roll out of a new inpatient EMR in the near future. Lastly, our study ran using a methodology that would not be supported under usual clinical care conditions in that an external individual was hired for data entry. Although manual numeric data entry from individual spirometry / PFT tests is currently being done, the Epic EMR system has the ability to have data integration with the PFT laboratory equipment software to allow automatic data integration through a specialized proprietary software's (“V-Link”). This software provides translation of data point into the existing physiology flowsheet structure (using the HL–7 standard computer language). This V-Link software has already purchased and is in use within certain areas of AHS. However, this software was not in use at the time within the pulmonary EMR department because at the time of this pilot study, there was no mechanism within the EMR to accept data from V-link. Thus manual entry of PFT data was utilized to create flowsheets to gauge user support for incorporation of this software.

Despite these limitations, the concept of the physiology flowsheet was well received. This would still require manual data entry, which is a major barrier to this tool in the clinical setting where time is limited. Data from the physiology flowsheet tool can be helpful in formulating clinical decisions and documenting results of care in patients with any pulmonary disease. The flowsheets illustrate that longitudinal pulmonary function results may be regarded as quantitative data, analogous to laboratory tests or vital signs, that reveal a larger clinical picture than single point in time assessments alone. If the clinician can access this longitudinal physiology data before seeing the patient, particularly comparative data from previous visits on a flowsheet, he or she can formulate a clinical plan more accurately as improvement or regression from baseline can be visually confirmed and measured (i.e. “airways obstruction is improved 30% this year as compared to last year on medication x”).

While care providers are considering interoperability between PFT and spirometry device software and EMR or EHR software, device manufacturers have been producing products geared towards this transition. Such technical statements on specifications of devices, central servers and network requirements are appearing in publications geared at the respiratory equipment sales community (15). It behoves governments and other publicly funded institutions to know how to best utilize taxpayer dollars to optimally purchase and use these new technologies for improved access and patient care.

### Abbreviations

Pulmonary Function Test (PFT), Electronic Medical Record (EMR), Alberta Health Services (AHS), Electronic Health Record (EHR), University of Alberta Hospital (UAH), Health Level Standard 7 (HL–7), Chronic Obstructive Pulmonary Disease (COPD), Interstitial Lung Disease (ILD), Forced Expiratory Volume in one second (FEV$_1$)

### Declarations
Ethics approvals: This project involved a process review within existing EMR flow sheet trending graphics as a Quality Assurance (QA) project. QA projects do not need institutional research ethics board approvals.

Consent for publication: Not applicable

Availability of data and material: All data generated or analysed during this study are included in this published article

Competing interests: The authors declare that they have no competing interests

Funding: Alternative Relationship Plan EMR Innovation Grant (AHS)

Author’s contributions:

FC—Drafting initial manuscript with supervisor / senior author, survey design with supervisor along with survey administration and collation of data.

SS—Project implementation within the AHS EMR information technology team and information technology writing lead.

NH—Data entry, input into reviewing manuscript draft.

TG and RH—Physician leads for electronic medical record implementation team; developing protocol and study design, manuscript preparation and review

MK and EW—Grant development and reviewing final manuscript

DV—Project development and supervision, assistance with writing first draft of manuscript, further manuscript development and manuscript revisions; also survey development and revisions to same.

Acknowledgements: Ms. Iris de Guzman for her administrative support.

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Tables

Table 1
### Which of the following diseases do you manage?

| Pre-implementation Survey Participants | Post-implementation Survey Participants |
|----------------------------------------|----------------------------------------|
| Obstructive Airway Diseases             | Severe Asthma                           |
|                                        | Interstitial Lung Disease               |
| Pulmonary Vascular Diseases             | Hereditary Hemorrhagic Telangiectasia   |
|                                        | Sleep Medicine Clinic                   |
| Interstitial Lung Diseases              | Adult Pulmonary Clinic                  |
|                                        | Pediatric Respiratory Clinic            |
|                                        | Pediatric Cystic Fibrosis Clinic        |
|                                        | Adult Cystic Fibrosis Clinic            |
|                                        | General Respirology                     |
|                                        | General Asthma                          |
|                                        | COPD                                    |
|                                        | Other                                   |

| Table 2                                 |
|----------------------------------------|
| pre | post |
|-----------------|------|
| Physician – Resident | 1    | 2   |
| Physician – Family Physician  | 0    | 2   |
| Physician – Specialist             | 7    | 8   |
| Medical Secretary – AHS            | 1    | 5   |
| Medical Secretary – U of A         | 7    | 4   |
| Registered Nurse                  | 2    | 5   |
| Registered Respiratory Therapist (RRT) | 2    | 2   |
| Physiology Laboratory Technician (PLT) | 0    | 1   |
| PLT-RRT                            | 0    | 3   |
| Administrator                      | 1    | 0   |
| Medical Transcriptionist           | 2    | 0   |
| No answer                          | 0    | 2   |
| **TOTAL**                          | **23** | **32** |

### Figures
Figure 1

Process for automated versus manual longitudinal pulmonary function test (PFT) trending on eClinician electronic medical record (EMR). a) Screenshot from eClinician of a patient from the ILD Clinic who is steady on treatment. The table on the left shows manual line entries from PFT results by date. Currently this chart is populated by manual entry of PFT results. This chart could be automatically populated if PFT data entered the EMR as a Health Level 7 (HL-7) message file. In HL-7, rather than having the PFT as an image, each line on this chart would enter the EMR as a discrete data element. b) The graph above shows the data output of longitudinal data with the capacity to show a single test or superimpose multiple results on the same graph.

Figure 2

How would you rate the ease of navigating the EMR to locate PFT results?
Figure 3

Compared to non-EMR patients (ie. patients with hard copy charts), how would you rate the amount of time you spend looking for pulmonary physiologic data for patients on the EPIC eClinician EMR?

Figure 4

How satisfied are you with the accessibility of pulmonary physiologic data such as PFTs through the EMR system?

Figure 5
How useful do you think longitudinal monitoring of PFT values such as FVC, FEV1 and TLC would be in patient care?